NIST SPECIAL PUBLICATION 1800-9

Access Rights Management for the Financial Services Sector

Includes Executive Summary (A); Approach, Architecture, and Security Characteristics (B), and How-To Guides (C)

James Banoczi
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DRAFT

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National Institute of Standards and Technology
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August 2017

U.S. Department of Commerce
Wilbur Ross, Secretary

National Institute of Standards and Technology
Kent Rochford, Acting Undersecretary of Commerce for Standards and Technology and Director

NIST SPECIAL PUBLICATION 1800-9A

Access Rights Management for the Financial Services Sector

Volume A:
Executive Summary

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Executive Summary

- The NCCoE has developed an example design that demonstrates ways in which a financial services company can improve their information and information system security by limiting employee access to only the information they need to do their job, at the time they need it, and nothing more. Essentially, enabling a company to give the right person the right access to the right resources at the right time.
- Specifically, this project provides an example solution that describes how to execute changes and coordinate employee access to data and systems quickly, simultaneously, and consistently—and in accordance with corporate access policies.
- Today's threat landscape has created ever-increasing challenges for financial services companies as they work to protect important financial assets and customer data. Financial services companies are under a high and sustained level of attack, in some instances experiencing a direct loss. Costs associated with these cyber attacks are growing and have reached an average loss of one million dollars per incident.[*]
- Complicating efforts to protect important data is the highly complex infrastructure that established financial services companies must manage. Disparate, legacy systems that run on different operating platforms are difficult to manage and ensure appropriate levels of access management.
- To combat these challenges, various regulatory organizations, such as the FFIEC as well as other federal, state, and other industry organizations, have developed a range of compliance mandates for financial services companies. As an example, financial services companies should apply the principles of least privilege to grant employee access to systems and data. This guide acknowledges these compliance requirements.
- A properly implemented and administered Access Rights Management (ARM) system can help your organization meet compliance requirements, limit opportunity for and reduce the damage of an attack, and improve enforcement of enterprise information system access policies.

CHALLENGE

Managing user access in a fast-moving industry such as the financial services sector requires frequent changes to user identity and role information and to user access profiles for systems and data. Employees using these various ARM systems may lack methods to coordinate access across the corporation effectively to ensure that ARM changes are executed consistently throughout the enterprise. This inconsistency is inefficient and can result in security risks. See Section 1.3 for the risk factors addressed by the solution.

Many financial services companies use ARM systems that are fragmented and controlled by numerous departments. For example, changes to user identity and role information should be managed by an ARM system within the Human Resources department; changes to user access profiles may be managed by IT system administrators; and changes to user access profiles for specific resources or data may be managed by still other systems under the control of various business unit managers.

In collaboration with experts from the financial services sector and technology collaborators that provided the requisite equipment and services, we developed representative use-case scenarios to describe user

[*] *Kapersky Lab Report 2017, New Technologies, New Cyberthreats: Analyzing the state of IT Security in financial sector* https://go.kaspersky.com/rs/802-IJN-240/images/Financial_Survey_Report_eng_final.pdf

access security challenges based on normal day-to-day business operations. The use cases include user access changes (e.g., promotion or transfer between departments), new user onboarding, and employees leaving an institution.

SOLUTION

The NCCoE developed an ARM system that executes and coordinates changes across the enterprise ARM systems to change the employee's access for all data and systems quickly, simultaneously, and consistently, according to corporate access policies. The example implementation provides timely management of access changes and reduces the potential for errors. It also enhances the security of the directories. Generally, an ARM system enables an institution to give the right person the right access to the right resources at the right time. The ARM reference design and example implementation are described in this NIST Cybersecurity "Access Rights Management" practice guide.

Financial services companies can use some or all of the guide to implement an ARM system. The guide references NIST guidance and industry standards, including the Federal Financial Institutions Examination Council Cybersecurity Assessment Tool (FFIEC CAT). The NCCoE used commercial, standards-based products that are readily available and interoperable with commonly used IT infrastructure and investments. We built an environment that simulates a financial services company's infrastructure. The infrastructure includes the typical network segmentation and IT components (i.e., virtual infrastructure, directories, etc.). Simulated financial systems (banking and loan operations systems) further illustrate the solution.

The NCCoE reference design includes the following capabilities:

- A single system that is capable of interacting with multiple existing access management systems for a complete picture of access rights within the organization
- Secure communications between all components
- Automated logging, reporting, and alerting of identity and access management events across the enterprise
- Ad hoc reporting to answer management, performance, and security questions
- Support for multiple access levels for the ARM system (e.g., administrator, operator, viewer)
- Protection from the introduction of new attack vectors into existing systems
- A complement to, rather than replacement of, existing security infrastructure

While we have used a suite of commercial products to address this challenge, this guide does not endorse these particular products, nor does it guarantee compliance with any regulatory initiatives. Your organization's information security experts should identify the products that will best integrate with your existing tools and IT system infrastructure. Your organization can adopt this solution or one that adheres to these guidelines in whole, or you can use this guide as a starting point for tailoring and implementing parts of a solution.

BENEFITS

The NCCoE's practice guide to address Access Rights Management for the financial services sector can help your organization:

- Reduce damage caused by a successful insider threat attack by limiting the amount of data to which any one person has access
- Limit opportunity for a successful attack by reducing the available attack surface
- Increase the probability that investigations of attacks or anomalous system behavior will reach successful conclusions
- Reduce complexity, which leads to:
    - Faster and more accurate access policy modifications
    - Fewer policy violations due to access inconsistencies
- Simplify compliance by producing automated reports and documentation

SHARE YOUR FEEDBACK

View or download the guide at https://nccoe.nist.gov/projects/use_cases/access_rights_management. Help the NCCoE make this guide better by sharing your thoughts with us as you read the guide. If you adopt this solution for your own organization, please share your experience and advice with us. We recognize that technical solutions alone will not fully enable the benefits of our solution, so we encourage organizations to share lessons learned and best practices for transforming the processes associated with implementing these guidelines.

To provide comments or to learn more by arranging a demonstration of this reference solution, contact the NCCoE at financial_nccoe@nist.gov.

TECHNOLOGY PARTNERS/COLLABORATORS

Technology vendors who participated in this project submitted their capabilities in response to a call in the Federal Register. Companies with relevant products were invited to sign a Cooperative Research and Development Agreement (CRADA) with NIST, allowing them to participate in a consortium to build this example implementation.

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Certain commercial entities, equipment, products, or materials may be identified to adequately describe an experimental procedure or concept. Such identification is not intended to imply recommendation or endorsement by NIST or NCCoE, nor is it intended to imply that the entities, equipment, products, or materials are necessarily the best available for the purpose.

The National Cybersecurity Center of Excellence (NCCoE), a part of the National Institute of Standards and Technology (NIST), is a collaborative hub where industry organizations, government agencies, and academic institutions work together to address businesses' most pressing cybersecurity challenges. Through this collaboration, the NCCoE applies standards and best practices to develop modular, easily adaptable example cybersecurity solutions using commercially available technology.

LEARN MORE

Visit https://nccoe.nist.gov
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NIST SPECIAL PUBLICATION 1800-9B

Access Rights Management for the Financial Services Sector

Volume B:
Approach, Architecture, and Security Characteristics

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DISCLAIMER

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National Institute of Standards and Technology Special Publication 1800-9B Natl. Inst. Stand. Technol. Spec. Publ. 1800-9B, 104 pages, August 2017 CODEN: NSPUE2

FEEDBACK

You can improve this guide by contributing feedback. As you review and adopt this solution for your own organization, we ask you and your colleagues to share your experience and advice with us.

Comments on this publication may be submitted to: financial_nccoe@nist.gov

Public comment period: August 31, 2017 through October 31, 2017

All comments are subject to release under the Freedom of Information Act (FOIA).

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NATIONAL CYBERSECURITY CENTER OF EXCELLENCE

The National Cybersecurity Center of Excellence (NCCoE), a part of the National Institute of Standards and Technology (NIST), is a collaborative hub where industry organizations, government agencies, and academic institutions work together to address businesses' most pressing cybersecurity issues. This public-private partnership enables the creation of practical cybersecurity solutions for specific industries or broad, cross-sector technology challenges. Working with technology partners—from Fortune 50 market leaders to smaller companies specializing in IT security—the NCCoE applies standards and best practices to develop modular, easily adaptable example cybersecurity solutions using commercially available technology. The NCCoE documents these example solutions in the NIST Special Publication 1800 series, which maps capabilities to the NIST Cyber Security Framework and details the steps needed for another entity to recreate the example solution. The NCCoE was established in 2012 by NIST in partnership with the State of Maryland and Montgomery County, Md.

To learn more about the NCCoE, visit https://nccoe.nist.gov. To learn more about NIST, visit https://www.nist.gov.

NIST CYBERSECURITY PRACTICE GUIDES

NIST Cybersecurity Practice Guides (Special Publication Series 1800) target specific cybersecurity challenges in the public and private sectors. They are practical, user-friendly guides that facilitate the adoption of standards-based approaches to cybersecurity. They show members of the information security community how to implement example solutions that help them align more easily with relevant standards and best practices and provide users with the materials lists, configuration files, and other information they need to implement a similar approach.

The documents in this series describe example implementations of cybersecurity practices that businesses and other organizations may voluntarily adopt. These documents do not describe regulations or mandatory practices, nor do they carry statutory authority.

ABSTRACT

Managing access to resources (data) is complicated because internal systems multiply and acquisitions add to the complexity of an organization's IT infrastructure. Identity and access management (IdAM) is the set of technology, policies, and processes that are used to manage access to resources. Access rights management (ARM) is the subset of those technologies, policies, and processes that manage the rights of individuals and systems to access resources (data). In other words, an ARM system enables a company to give the right person the right access to the right resources at the right time. The goal of this project is to demonstrate an ARM solution that is a standards-based technical approach to coordinating and automating updates to and improving the security of the repositories (directories) that maintain the user access information across an organization. The coordination improves cybersecurity by ensuring that user access information is updated accurately (according to access policies), including disabling

accounts or revoking access privileges as user resource access needs change. Cybersecurity is also improved through better monitoring for unauthorized changes (e.g., privilege escalation). The system executes user access changes across the enterprise according to corporate access policies quickly, simultaneously, and consistently. The ARM reference design and example implementation are described in this NIST Cybersecurity "Access Rights Management" practice guide. This project resulted from discussions among NCCoE staff and members of the financial services sector.

This *NIST Cybersecurity Practice Guide* also describes our collaborative efforts with technology providers and financial services stakeholders to address the security challenges of ARM. It provides a modular, open, end-to-end example implementation that can be tailored to financial services companies of varying sizes and sophistication. The use case scenario that provides the underlying impetus for the functionality presented in the guide is based on normal day-to-day business operations. Though the reference solution was demonstrated with a certain suite of products, the guide does not endorse these specific products. Instead, it presents the NIST Cybersecurity Framework (CSF) core functions and subcategories, as well as financial industry guidelines, that a company's security personnel can use to identify similar standards-based products that can be integrated quickly and cost-effectively with a company's existing tools and infrastructure. Planning for deployment of the design gives an organization the opportunity to review and audit the access control information in their directories and get a more global, correlated, disambiguated view of the user access roles and attributes that are currently in effect.

KEYWORDS

Access; authentication; authorization; cybersecurity; directory; provisioning.

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Roger Wigenstam	NextLabs
Don Graham	Radiant Logic
Adam Cohen	Splunk
Clyde Poole	TDi Technologies
Dustin Hayes	Vanguard Integrity Professionals

The technology vendors who participated in this build submitted their capabilities in response to a notice in the Federal Register. Companies with relevant products were invited to sign a Cooperative Research and Development Agreement (CRADA) with NIST, allowing them to participate in a consortium to build this example solution. We worked with:

Product Vendor	Component Name	Function
AlertEnterprise	Enterprise Guardian	Access policy management, administration and account provisioning system
HyTrust	Cloud Control	Privileged user access controller, monitor, and logging system for VSphere
NextLabs	NextLabs	Attribute based access control interface for SharePoint
Radiant Logic	RadiantOne	Virtual directory system
Splunk	Enterprise	Log aggregation and analytics system
TDi Technologies	ConsoleWorks	Application and operating system privileged user access controller, monitor, and logging system
Vanguard Integrity Professionals	Vanguard	Mainframe RACF to LDAP interface system

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1 Summary

The National Cybersecurity Center of Excellence (NCCoE) at the National Institute of Standards and Technology (NIST) addresses the challenge to provide a more secure and efficient way to manage access to data and systems. The NCCoE developed a reference design and an example implementation for this problem using commercially available products. This approach delivers an Access Rights Management (ARM) system that coordinates changes throughout the enterprise, thereby reducing the risk of unauthorized access caused by malicious actors or human error. Throughout this practice guide, access is used as a generic term for privileges and permissions to view, modify, and delete data, applications, and systems.

This example implementation is documented as a NIST Cybersecurity Practice Guide, a how-to handbook that presents instructions to implement an ARM system using standards-based, cybersecurity technologies in the real world. Based on risk analysis and regulatory guidance, this design is intended to help companies gain efficiencies in ARM, while saving money and time during the research and proof-of-concept phases of a project. This guide presents an architecture for implementing an ARM that improves the control of user access information using automation. It also quickly identifies unapproved changes such as privilege escalations by including multiple methods of monitoring the user access information repositories (directories).

1.1 Challenge

Managing user access in a fast-moving industry such as the financial services sector requires frequent changes to user identity and role information and to user access profiles for systems and data. Employees using these various ARM systems may lack methods to coordinate access across the corporation effectively to ensure that ARM changes are executed consistently throughout the enterprise. This inconsistency is inefficient and can result in security risks. See Section 1.3 for the risk factors addressed by the solution.

Many financial services companies use ARM systems that are fragmented and controlled by numerous departments. For example, changes to user identity and role information should be managed by an ARM system within the human resources (HR) department; changes to user access profiles may be managed by IT system administrators; and changes to user access profiles for specific resources or data may be managed by still other systems under the control of various business unit managers.

In collaboration with experts from the financial services sector and collaboration partners that provided the requisite equipment and services, we developed representative use-case scenarios to describe user access security challenges based on normal day-to-day business operations. The use cases include user access changes (e.g., promotion or transfer between departments), new user onboarding, and employees leaving a company.

1.2 Solution

The NCCoE developed an ARM system that executes and coordinates changes across the enterprise ARM systems to change the employee's access for all data and systems quickly, simultaneously, and consistently, according to corporate access policies. The example implementation provides timely management of access changes and reduces the potential for errors. It also enhances the security of the directories. Generally, an ARM system enables a company to give the right person the right access to the right resources at the right time. The ARM reference design and example implementation are described in this NIST Cybersecurity "Access Rights Management" Practice Guide.

Financial sector companies can use some or all of the guide to implement an ARM system. The guide references NIST guidance and industry standards, including the Federal Financial Institutions Examination Council Cybersecurity Assessment Tool (FFIEC CAT). The NCCoE used commercial, standards-based products that are readily available and interoperable with commonly used IT infrastructure. We built an environment that simulates a financial services company's infrastructure. The infrastructure includes the typical network segmentation and IT components (i.e., virtual infrastructure, directories, etc.). Simulated financial systems (banking and loan operations systems) further illustrate the solution.

In the sections that follow, we show how a financial services company can implement an ARM platform using commercially available products to provide a comprehensive management platform for all user access information within the company. As part of the planning process to deploy an ARM system, an organization will have the opportunity to audit the access control information in their directories and get a more global, correlated, disambiguated view of the user access roles and attributes that are currently in effect. User access information includes directory accounts, group membership, and attributes independent of the use of Active Directory or other directory products. We chose the term *user access information* because it is transparent to non-technical readers.

This practice guide:

- Maps security capabilities of the reference design to guidance and best practices from NIST, International Organization for Standardization (ISO) and by the International Electrotechnical Commission (IEC), and the FFIEC CAT
- Delivers:
  - a detailed reference design
  - an example implementation that is modular and can be implemented using different products to achieve the same results
  - instructions for implementers and security engineers, including examples of all the necessary components and installation, configuration, and integration information

- an example implementation that uses products that are readily available and interoperable with existing information technology infrastructure
- solutions that can meet the needs of financial services companies of all sizes

Although the example implementation is built from a suite of commercial products, this practice guide does not endorse these particular products. A company's IT personnel should identify the standards-based products that will best integrate with its existing tools and infrastructure. Companies can adopt this solution or one that adheres to these guidelines in whole, or they can use this guide as a starting point for tailoring and implementing parts of the solution.

The reference design and example implementation support efforts to comply with financial services sector regulations. However, implementation of the reference design or example implementation does not imply or guarantee regulatory compliance.

1.3 Risk Considerations

Members of the financial services sector identified risk factors at both the operational and strategic levels. Operationally, the absence of an ARM platform can increase the risk of compromise of the confidentiality, integrity, and availability of the corporate systems and data.

At the strategic level, an organization might consider the cost of mitigating these risks and the potential return on investment from implementing a product (or multiple products). It may also want to assess if an ARM system can help enhance the productivity of employees, speed delivery of services, or explore the potential to support oversight of resources, including IT, personnel, and data. We review the potential benefits of the reference design in Section 1.4.

We understand that introducing new technology into any environment may introduce new attack vectors. In addition, converging ARM functions concentrates control over the modifications to user access information. We address these key risk areas and provide a comprehensive list of mitigations in Section 6, Security Analysis.

1.4 Benefits

The reference design and example implementation has the following benefits:

- reduces the risk of malicious or untrained people gaining unauthorized access to systems and data
- allows rapid automated provisioning and de-provisioning of user access information, freeing up system administrators to address more critical tasks
- improves management of user access information changes
- rapidly identifies anomalous user account changes

- can be integrated into an organization's existing infrastructure in whole or in part

2 How to Use This Guide

This NIST Cybersecurity Practice Guide demonstrates a standards-based reference design and provides users with the information they need to replicate this approach to ARM. This reference design is modular and can be deployed in whole or in parts.

This guide contains three volumes:

- NIST SP 1800-9A: *Executive Summary*
- NIST SP 1800-9B: *Approach, Architecture, and Security Characteristics*—what we built and why **(you are here)**
- NIST SP 1800-9C: *How-To Guide*—instructions for building the example solution

Depending on their role in an organization, readers might use this guide in different ways:

Business decision makers, including chief security and technology officers will be interested in the *Executive Summary (NIST SP 1800-9A)*, which describes the:

- challenges identified by financial services companies
- operational benefits of adopting the solution
- high-level solution description

Technology or security program managers who are concerned with how to identify, understand, assess, and mitigate risk will be interested in this part of the guide, *NIST SP 1800-9B,* which describes what we did and why. The following sections will be of particular interest:

- Section 3.4, Risk Assessment, provides a description of the risk analysis we performed.
- Section 3.4.2, Security Control Map, maps the security characteristics of this example solution to cybersecurity standards and best practices.

The *Executive Summary, NIST SP 1800-9A,* could be shared with the leadership team members to help them understand the importance of adopting standards-based ways to manage access to data and systems in a secure and efficient manner.

IT professionals who want to implement an approach like this will find the whole practice guide useful. The How-To portion of the guide, *NIST SP 1800-9C*, can be used to replicate all or parts of the build created in our lab. The How-To guide provides specific product installation, configuration, and integration instructions for implementing the example solution. We do not re-create the product manufacturers' documentation, which is generally widely available. Rather, we show how we incorporated the products in our environment to create an example solution.

This guide assumes that IT professionals have experience implementing security products within the enterprise. While we have used a suite of commercial products to address this challenge, this guide does

not endorse these particular products. An organization can adopt this solution or one that adheres to these guidelines in whole, or it can use this guide as a starting point for tailoring and implementing parts of an ARM solution. An organization's security experts should identify the products that will best integrate with its existing tools and IT system infrastructure. We hope organizations will seek products that are congruent with applicable standards and best practices. Section 3.6, Technologies, lists the products we used and maps them to the cybersecurity controls provided by this reference solution.

A *NIST Cybersecurity Practice Guide* does not describe "the" solution, but a possible solution. This is a draft guide. We seek feedback on its contents and welcome input. Comments, suggestions, and success stories will improve subsequent versions of this guide. Please contribute comments using email financial_nccoe@nist.gov or online via the web content tool.

2.1 Typographical Conventions

The following table presents the typographic conventions used in this volume.

Typeface/ Symbol	Meaning	Example
Italics	filenames and pathnames references to documents that are not hyperlinks, new terms, and placeholders	For detailed definitions of terms, see the *NCCoE Glossary.*
Bold	names of menus, options, command buttons and fields	Choose **File > Edit**.
`Monospace`	command-line input, on-screen computer output, sample code examples, status codes	`mkdir`
`Monospace Bold`	command-line user input contrasted with computer output	**`service sshd start`**
blue text	link to other parts of the document, a web URL, or an email address	All publications from NIST's National Cybersecurity Center of Excellence are available at http://nccoe.nist.gov

3 Approach

This project began with a detailed discussion between NCCoE and members of the financial services sector community about their security challenges around implementing least privilege and separation of duty policies. The principle of least privilege, defined as providing the least amount of access (to systems or data) necessary for the user to complete his or her job [1], and the principle of separation of duties, which restricts the amount of responsibilities held by any one individual, are important security tools. The focus of the project became the risk impacts that result from user access information updates not being implemented consistent with corporate access policies. The NCCoE drafted a use case (i.e., project description) that identified the solution security controls with feedback from the financial industry. After an open call in the Federal Register, technology partners volunteered products, services, and resources that provide the desired security controls. The following sections describe the areas of discussion that led to the development of the subject of this practice guide, including the areas of the NIST Cybersecurity Framework (CSF) and FFIEC CAT.

3.1 Audience

This practice guide is intended for individuals or entities interested in understanding the ARM reference design and example solution the NCCoE designed and implemented. The guide describes how financial services companies (or any other sector organization) can add automation to existing identity and access management (IdAM) systems. In addition, the guide describes how to add IdAM monitoring for anomalous identity and access management system changes, such as unauthorized privilege escalations.

3.2 Scope

We determined that the scope should be ARM, including a converged provisioning component. The scope was further refined to include successful execution of the following provisioning functions:

- enabling access for a new employee
- modifying access for an existing employee (including converting an ex-employee to contractor status)
- disabling access for a terminated employee
- identifying anomalous directory changes

The objective of the project is to perform any of these three access change actions from a single management system that can provision user access information changes to all directories (authoritative sources) within a financial services company. The actions can be initiated via an administrative interface by an approved administrator or via a bulk update from a human resource system. In addition, a Monitoring capability was implemented to enhance the security of the directories.

Although the example implementation can provide an approval workflow to ensure that proper management governance is followed, this optional feature was not implemented. Note also that the project does not address access policy decision and enforcement, and identity validation and credential management.

3.3 Assumptions

3.3.1 Security

All network and system changes have the potential to increase the attack surface within an enterprise. Therefore, it is important that the reference design itself be secured to minimize any risks that may otherwise be inherent in its adoption. In the ARM security analysis (Section 6), we identify the security functions and controls that the reference design supports (Section 6.4), and we also discuss the security of the reference design itself (Section 6.5). We assume that all potential adopters of the reference design will implement network security policies. The assessment focuses on how risk factors introduced by the reference design itself are mitigated. We also recommend ways to secure the reference design deployment. However, our evaluation cannot identify all weaknesses, especially those that a specific deployment or specific commercial products may introduce.

3.3.2 Modularity

As noted, this example implementation uses commercially available products. Organizations can swap any of the products we used for ones better suited for their environment. A combination of some or all the components described here, or a single component, can improve the security of identity and access management functions without requiring an organization to remove or replace its existing infrastructure. In addition, organizations may find that we describe new ways to use currently deployed components.

3.3.3 Human Resources Database/Identity Vetting

We assume that a company has a user change process, databases, and other components necessary to establish a valid identity.

3.3.4 Technical Implementation

This practice guide is written from a how-to perspective and aims to provide details on how to design, install, configure, and integrate components. We assume that financial services companies have the technical resources to implement all or parts of the example implementation or have access to companies that can perform the implementation on its behalf. The guide may also provide insights regarding the level of effort and types of resources required to accomplish an ARM implementation.

3.3.5 Limited Scalability Testing

We did not attempt to replicate the user base size that would be found in most companies. We do not identify scalability thresholds in our ARM example implementation because they depend on the type and size of the implementation and are particular to the individual enterprise. We believe the reference design can be applied to any size company because it can be implemented in a modular fashion and is based on standards.

3.3.6 Replication of Enterprise Networks

We were able to replicate the typical information technology or corporate network in a limited manner. The goal was to demonstrate that provisioning functions could be performed from an ARM system regardless of its location in the enterprise. In a real-world environment, the interconnections between enterprise subnetworks depend on the business needs and compliance requirements of the enterprise. We did not attempt to replicate these interconnections. Rather, we acknowledge that implementing our example implementation or its components creates new interfaces across subnetworks.

3.4 Risk Assessment

NIST SP 800-30 Rev. 1, *Risk Management Guide for Information Technology Systems*, defines risk as "a measure of the extent to which an entity is threatened by a potential circumstance or event, and typically a function of: (i) the adverse impacts that would arise if the circumstance or event occurs; and (ii) the likelihood of occurrence." The NCCoE recommends that any discussion of risk management, particularly at the enterprise level, begin with a comprehensive review of NIST 800-37, *Guide for Applying the Risk Management Framework to Federal Information Systems*. The risk management framework (RMF) guidance, as a whole, proved invaluable in giving us a baseline to assess risks, from which we developed the project, the required security controls of the reference design, and this guide.

We performed two types of risk assessment:

- initial analysis of the risk factors discussed with the financial services companies, which led to the creation of the use case and the desired security posture
- analysis of how to secure the capabilities within the solution and minimize any vulnerabilities that they might introduce (see Section 6, ARM Security Analysis)

3.4.1 Assessing Risk Posture

Using the guidance in NIST's series of publications concerning risk, we worked with financial services companies and the Financial Sector Information Sharing and Analysis Center (FS-ISAC) to identify the most compelling risk factors that financial services companies encounter. We participated in conferences and met with members of the financial services sector to define the main security risks to business operations. These discussions resulted in the identification of a primary risk area—the lack of

automated ARM capabilities. We then identified the following threats that an ARM system can help mitigate:

- insiders gaining access through access creep and undocumented accounts
- regular users unintentionally accessing unauthorized data or systems
- external actors gaining access by using malware techniques

These discussions also gave us an understanding of the vulnerabilities that threat actors can exploit due the lack of automated ARM capabilities. We identified the following vulnerabilities:

- undocumented accounts
- accounts with unnecessarily elevated privileges
- dependence on humans to enforce user access policies

These risk factors can also be viewed from a business operations risk perspective:

- impact on service delivery—ensuring that people have access only to the systems they need to perform their job functions reduces the risk of inappropriate or unauthorized use of access that could then affect availability to others
- cost of implementation—implementing ARM once and using it across all systems may reduce both system development costs and operational costs
- compliance with existing industry standards—FFIEC requires deliberate and timely control of logical access to corporate resources
- maintenance of reputation and public image

We subsequently translated the risk factors identified to security functions and subcategories within the NIST CSF and the FFIEC CAT that the design needed to support. We also mapped the categories to NIST's SP 800-53 Rev.4 [2] controls and IEC/ISO controls for additional guidance in Table 3-1.

3.4.2 Security Control Map

As explained in Section 3.4.1, we identified the CSF security functions and subcategories that we wanted the reference design to support through a risk analysis process conducted in collaboration with our financial services sector stakeholders. This was a critical first step in designing the reference design and example implementation to mitigate the risk factors. Table 3-1 lists the addressed CSF functions and subcategories and maps them to relevant NIST standards, industry standards, controls, and best practices, including those published by FFIEC. The items in the FFIEC Examination Handbook column of Table 3-1 are mapped from and reflect the FFIEC Cybersecurity Assessment Tool, dated June 2015, Appendix A – Mapping Baseline Statements to FFIEC IT Examination Handbook. The references provide solution validation points in that they list specific security capabilities that a solution addressing the CSF subcategories would be expected to exhibit.

Organizations can use Table 3-1 to identify the CSF subcategories and NIST 800-53 controls or FFIEC guidance that they are interested in addressing. Note that not all the CSF subcategories or FFIEC guidance can be implemented using technology. The subcategories that describe processes and organizational policies are supported by the reference design, not implemented. Therefore, any organization adopting an ARM solution would need to develop and implement specific processes that address those processes and policies. For example, some of the subcategories within the CSF function "Identify" are processes and policies that should be developed prior to an ARM implementation.

429 **Table 3-1 ARM Reference Design CSF Core Components Map**

CSF Subcategory	NIST 800-53 rev4[a]	IEC/ISO 27001[b]	FFIEC CAT v1[c]	FFIEC IT Exam Handbook Information Security[d]
ID.AM-3: Organizational communication and data flows are mapped.	AC-4, CA-3, CA-9, PL-8	A.13.2.1	D4.C.Co.Int.1: A validated asset inventory is used to create comprehensive diagrams depicting data repositories, data flow, infrastructure, and connectivity.	IS.B.1.3: Identify changes to the technology infrastructure or new products and services that might increase the institution's risk from information security issues. Consider … network topology, including changes to configuration or components. IS.B.9: A risk assessment should include an identification of information and the information systems to be protected, including electronic systems and physical components used to access, store, transmit, protect, and eventually dispose of information. Information and information systems can be both paper-based and electronic.
ID.AM-6: Cybersecurity roles and responsibilities for the entire workforce and third-party stakeholders are established.	CP-2, PS-7, PM-11	A.6.1.1	D1.R.St.B.1: Information security roles and responsibilities have been identified.	IS.B.7: Employees should know, understand, and be held accountable for fulfilling their security responsibilities. Financial institutions should define these responsibilities in their security policy.

CSF Subcategory	NIST 800-53 rev4[a]	IEC/ISO 27001[b]	FFIEC CAT v1[c]	FFIEC IT Exam Handbook Information Security[d]
ID.BE-4: Dependencies and critical functions for delivery of critical services are established.	SA-14, CP-8, PE-9, PE-11, PM-8, SA-14	A.11.2.2, A.11.2.3, A.12.1.3	D1.G.IT.B.2: Organizational assets (e.g., hardware, systems, data, and applications) are prioritized for protection based on the data classification and business value.	IS.WP.I.4.1: Review and evaluate security policies and standards to ensure that they sufficiently address the following areas when considering the risks identified by the institution: software development and acquisition, including processes that evaluate the security features and software trustworthiness of code being developed or acquired, as well as change control and configuration management.

CSF Subcategory	NIST 800-53 rev4[a]	IEC/ISO 27001[b]	FFIEC CAT v1[c]	FFIEC IT Exam Handbook Information Security[d]
PR.AC-1: Identities and credentials are managed for authorized devices and users.	AC-2, IA Family	A.9.2.1, A.9.2.2, A.9.2.4, A.9.3.1, A.9.4.2, A.9.4.3	D3.PC.Im.B.7: Access to make changes to systems configurations (including virtual machines and hypervisor) is controlled and monitored. D3.PC.AM.B.6: Identification and authentication are required and managed for access to systems, applications, and hardware. D3.PC.Am.B.5: Changes to physical and logical user access, including those that result from voluntary and involuntary terminations, are submitted to and approved by appropriate personnel.	IS.B.56: Financial institutions should ensure that systems are developed, acquired, and maintained with appropriate security controls. The steps include maintaining appropriately robust configuration management and change control processes.

PR.AC-3: Remote access is managed.	AC-17, AC-19, AC-20	A.6.2.2, A.13.1.1, A.13.2.1	D3.PC.Am.B.15: Remote access to critical systems by employees, contractors, and third parties uses encrypted connections and multifactor authentication. D3.PC.Im.Int.2: Security controls are used for remote access to all administrative consoles, including restricted virtual systems.	IS.B.45: Financial institutions should secure remote access to and from their systems … securing remote access devices and using strong authentication and encryption to secure communications. IS.WP.II.B.17: Determine whether remote access devices and network access points for remote equipment are appropriately controlled. For example, authentication is of appropriate strength (e.g., two-factor for sensitive components), and remote access devices are appropriately secured and controlled by the institution. IS.B.56: Financial institutions should ensure that systems are developed, acquired, and maintained with appropriate security controls. The steps include maintaining appropriately robust configuration management and change control processes. IS.WP.II.H: Determine whether management explicitly follows a recognized security standard development process or adheres to widely recognized industry standards.

CSF Subcategory	NIST 800-53 rev4[a]	IEC/ISO 27001[b]	FFIEC CAT v1[c]	FFIEC IT Exam Handbook Information Security[d]
PR.AC-4: Access permissions are managed, incorporating the principles of least privilege and separation of duties.	AC-2, AC-3, AC-5, AC-6, AC-16	A.6.1.2, A.9.1.2, A.9.2.3, A.9.4.1, A.9.4.4	D3.PC.Am.B.1: Employee access is granted to systems and confidential data based on job responsibilities and the principles of least privilege. D3.PC.Am.B.2: Employee access to systems and confidential data provides for separation of duties. D3.PC.Am.B.5: Changes to physical and logical user access, including those that result from voluntary and involuntary terminations, are submitted to and approved by appropriate personnel.	IS.B.19: Access rights should be based on the needs of the applicable user to carry out legitimate and approved activities on the financial institution's information systems. IS.WP.I.4.1: Review security policies and standards to ensure that they sufficiently address administration of access rights at enrollment, when duties change, and at employee separation. IS.B.18: Financial institutions should have an effective process to administer access rights, including assigning users and devices only the access required to perform their required functions and updating access rights based on personnel or system changes.

PR.DS-1: Data-at-rest is protected.	SC-28	A.8.2.3	D1.G.IT.B.13: Confidential data is identified on the institution's network. D3.PC.Am.A.1: Encryption of select data-at-rest is determined by the institution's data classification and risk assessment.	IS.B.9: A risk assessment should include an identification of information and the information systems to be protected, including electronic systems and physical components used to access, store, transmit, protect, and eventually dispose of information. Information and information systems can be both paper-based and electronic. IS.WP.I.3.1: Consider whether the institution has identified and ranked information assets (e.g., data, systems, physical locations) according to a rigorous and consistent methodology that considers the risks to customer non-public information as well as the risks to the institution. IS.B.12: Prioritizes the risks present due to threats and vulnerabilities to determine the appropriate level of training, controls, and assurance necessary for effective mitigation. IS.B.51: Encryption is used to secure communications and data storage, particularly authentication credentials and the transmission of sensitive information.

PR.DS-2: Data-in-transit is protected.	AC-4, SC-8, SC-12, SC-13, SC-17, SC-23, SC-8	A.8.2, A.13.1.1, A.13.2.1, A.13.2.3, A.14.1.2, A.14.1.3	D3.PC.Am.B.13: Confidential data is encrypted when transmitted across public or untrusted networks (e.g., Internet). D3.PC.Am.E.5: Controls are in place to prevent unauthorized access to cryptographic keys. D3.PC.Am.Int.7: Confidential data is encrypted in transit across private connections (e.g., frame relay and T1) and within the institution's trusted zones. D3.PC.Im.B.1: Network perimeter defense tools (e.g., border router and firewall) are used. D3.PC.Im.Int.1: The enterprise network is segmented in multiple, separate trust/security zones with defense-in-depth strategies (e.g., logical network segmentation, hard backups, air-gapping) to mitigate attacks.	IS.B.51: Encryption is used to secure communications and data storage, particularly authentication credentials and the transmission of sensitive information. IS.WP.II.B.15: Determine whether appropriate controls exist over the confidentiality and integrity of data transmitted over the network (e.g., encryption, parity checks, message authentication). IS.B.21: Encrypting the transmission and storage of authenticators (e.g., passwords, personal identification numbers (PINs), digital certificates, and biometric templates). IS.B.33: Typical perimeter controls include firewalls that operate at different network layers, malicious code prevention, outbound filtering, intrusion detection and prevention devices, and controls over infrastructure services such as domain name service (DNS). Institutions internally hosting Internet-accessible services should consider implementing additional firewall components that include application-level screening.

CSF Subcategory	NIST 800-53 rev4[a]	IEC/ISO 27001[b]	FFIEC CAT v1[c]	FFIEC IT Exam Handbook Information Security[d]
				IS.WP.I.4.1: Evaluate the appropriateness of technical controls mediating access between security domains.
PR.DS-5: Protections against data leaks are implemented.	AC-4, AC-5, AC-6, SC-8, SC-13, SI-4	A.6.1.2, A.9.1.1, A.9.1.2, A.9.2.3, A.9.4.1, A.9.4.4, A.13.1.3, A.13.2.1, A.13.2.3	D3.PC.Am.Int.1: The institution has implemented tools to prevent unauthorized access to or exfiltration of confidential data.	IS.B.19: Access rights should be based on the needs of the applicable user to carry out legitimate and approved activities on the financial institution's information systems. IS.WP.I.4.1: Review security policies and standards to ensure that they sufficiently address administration of access rights at enrollment, when duties change, and at employee separation.

CSF Subcategory	NIST 800-53 rev4[a]	IEC/ISO 27001[b]	FFIEC CAT v1[c]	FFIEC IT Exam Handbook Information Security[d]
PR.PT-1: Audit/log records are determined, documented, implemented, and reviewed in accordance with policy.	AU Family IR-5, IR-6	A.12.4.1, A.12.4.2, A.12.4.3, A.12.4.4, A.12.7.1	D2.MA.Ma.B.1: Audit log records and other security event logs are reviewed and retained in a secure manner.	IS.B.79: Institutions should strictly control and monitor access to log files whether on the host or in a centralized logging facility. IS.WP.II.B.13: Determine whether logs of security-related events are appropriately secured against unauthorized access, change, and deletion for an adequate time period and that reporting to those logs is adequately protected. IS.B.83: Because the identification of incidents requires monitoring and management, response centers frequently use (security information management (SIM) tools to assist in the data collection, analysis, classification, and reporting of activities related to security incidents.

CSF Subcategory	NIST 800-53 rev4[a]	IEC/ISO 27001[b]	FFIEC CAT v1[c]	FFIEC IT Exam Handbook Information Security[d]
PR.PT-3: Access to systems and assets is controlled, incorporating the principle of least functionality. (p. 29).	AC-3, CM-7	A.9.1.2	D3.PC.Am.B.4: User access reviews are performed periodically for all systems and applications based on the risk to the application or system. D3.PC.Am.B.3: Elevated privileges (e.g., administrator privileges) are limited and tightly controlled (e.g., assigned to individuals, not shared, and require stronger password controls). D4.RM.Om.Int.1: Third-party employee access to the institution's confidential data is tracked actively based on the principles of least privilege.	IS.B.18: Reviewing periodically users' access rights at an appropriate frequency based on the risk to the application or system. IS.WP.I.7.6: Evaluate the process used to monitor and enforce policy compliance (e.g., granting and revocation of user rights). IS.B.19: Authorization for privileged access should be tightly controlled. IS-WP.II.A.1: Determine whether access to system administrator level is adequately controlled and monitored. OT.B.26: Appropriate access controls and monitoring should be in place between service provider's systems and the institution.

PR.PT-4: Communications and control networks are protected.	AC-4, AC-17, AC-18, CP-8, SC-7	A.13.1.1, A.13.2.1	D3.PC.Im.B.1: Network perimeter defense tools (e.g., border router and firewall) are used. D3.PC.Im.Int.1: The enterprise network is segmented in multiple, separate trust/security zones with defense-in-depth strategies (e.g., logical network segmentation, hard backups, air-gapping) to mitigate attacks.	IS.B.33: Typical perimeter controls include firewalls that operate at different network layers, malicious code prevention, outbound filtering, intrusion detection and prevention devices, and controls over infrastructure services such as domain name service (DNS). Institutions internally hosting Internet-accessible services should consider implementing additional firewall components that include application-level screening. IS.WP.I.4.1: Evaluate the appropriateness of technical controls mediating access between security domains. Evaluate the adequacy of security policies and standards relative to physical controls over access to hardware, software, storage media, paper records, and facilities. IS.B.46: Management should establish policies restricting remote access and be aware of all remote-access devices attached to their systems. OPS.B.23: Transmission controls should address both physical and logical risks. In large, complex institutions,

CSF Subcategory	NIST 800-53 rev4[a]	IEC/ISO 27001[b]	FFIEC CAT v1[c]	FFIEC IT Exam Handbook Information Security[d]
				management should consider segregating wide area networks (WAN) and local area networks (LAN) segments with firewalls that restrict access as well as the content of inbound and outbound traffic. IS.WP.I.4: Review security policies and standards to ensure that they sufficiently address the following areas when considering the risks identified by the institution … Network Access - Remote Access Controls (including wireless, virtual private network, modems, and Internet-based). OPS.WP.8.1: Determine whether management has implemented appropriate daily operational controls and processes including … alignment of telecommunication architecture and process with the strategic plan.

CSF Subcategory	NIST 800-53 rev4[a]	IEC/ISO 27001[b]	FFIEC CAT v1[c]	FFIEC IT Exam Handbook Information Security[d]
DE.AE-1: A baseline of network operations and expected data flows for users and systems is established and managed.	AC-4, CM-2, SI-4	A.13.1.1, A.13.2.1	D3.DC.Ev.B.1: A normal network activity baseline is established.	IS.B.77: The behavior-based anomaly detection method creates a statistical profile of normal activity on the host or network. Normal activity generally is measured based on the volume of traffic, protocols in use, and connection patterns between various devices. IS-WP-II-M: Determine whether appropriate detection capabilities exist related to network-related anomalies.
DE.AE-3: Event data are aggregated and correlated from multiple sources and sensors.	CA-7, IR-5, SI-4	A.12.4.1	D3.DC.Ev.E.1: A process is in place to correlate event information from multiple sources (e.g., network, application, or firewall).	IS.B.83: Because the identification of incidents requires monitoring and management, response centers frequently use SIM tools to assist in the data collection, analysis, classification, and reporting of activities related to security incidents. IS.WP.II.G.7: Determine whether appropriate logs are maintained and available to support incident detection and response efforts. IS.B.43: Management has the capability to filter logs for potential security events and provide adequate reporting and alerting capabilities.

CSF Subcategory	NIST 800-53 rev4[a]	IEC/ISO 27001[b]	FFIEC CAT v1[c]	FFIEC IT Exam Handbook Information Security[d]
DE.AE-5: Incident alert thresholds are established.	IR-4, IR-5	A.12.4.1	D5.DR.De.B.1: Alert parameters are set for detecting information security incidents that prompt mitigating actions. D3.DC.An.E.4: Thresholds have been established to determine activity within logs that would warrant management response. D3.DC.An.Int.3: Tools actively monitor security logs for anomalous behavior and alert within established parameters.	IS.B.83: Because the identification of incidents requires monitoring and management, response centers frequently use SIM tools to assist in the data collection, analysis, classification, and reporting of activities related to security incidents. IS.WP.II.G.7: Determine whether appropriate logs are maintained and available to support incident detection and response efforts. IS.B.43: Management has the capability to filter logs for potential security events and provide adequate reporting and alerting capabilities.

CSF Subcategory	NIST 800-53 rev4[a]	IEC/ISO 27001[b]	FFIEC CAT v1[c]	FFIEC IT Exam Handbook Information Security[d]
DE.CM-3: Personnel activity is monitored to detect potential cybersecurity events.	AC-2, AU-12, AU-13, CA-7, CM-10, CM-11	A.12.4.1	D3.DC.An.A.3: A system is in place to monitor and analyze employee behavior (network use patterns, work hours, and known devices) to alert on anomalous activities.	IS.B.73: Financial institutions should gain assurance of the adequacy of their risk mitigation strategy and implementation by monitoring network and host activity to identify policy violations and anomalous behavior. IS.WP.II.M.1: Review security procedures for report monitoring to identify unauthorized or unusual activities. IS.B.77: The behavior-based anomaly detection method creates a statistical profile of normal activity on the host or network. Normal activity generally is measured based on the volume of traffic, protocols in use, and connection patterns between various devices.

a. Mapping taken from "Framework for Improving Critical Infrastructure Cybersecurity," NIST, February 12, 2014
b. Mapping taken from "Framework for Improving Critical Infrastructure Cybersecurity," NIST, February 12, 2014
c. Mapping taken from FFIEC Cybersecurity Assessment Tool Appendix B, FFIEC, June 2015
d. Mapping taken from FFIEC Cybersecurity Assessment Tool Appendix A, FFIEC, June 2015

3.5 Security Functions and Subcategories Related to FFIEC

The example implementation is responsive to the desire to support compliance with the FFIEC CAT guidance as well as the NIST standards and best practices as detailed in Table 3-1.

The Federal Financial Institutions Examination Council (FFIEC) Cybersecurity Assessment Tool (CAT) provides specific guidance that applies to financial institutions and was used as a reference by the development team. The proposed solution is designed to be CAT-informed. This document attempts to capture some of the key areas where CAT guidance is relevant to elements of the solution and its implementation, for reference purposes. Please consult an auditor or examiner for any questions on FFIEC compliance.

The example implementation is informed by FFIEC CAT guidance and may contribute to CAT-aligned implementations by providing mechanisms supporting management, logging, and auditing of all ARM activity efficiently and cost effectively. With this solution in place, information regarding which users have access to which resources is maintained by the existing directories and modified via the central administration and provisioning system. Without the solution, the user access information is provisioned separately to each directory.

Table 3.2 describes how the ARM solution supports compliance with FFIEC CAT guidance.

Table 3-2 FFIEC CAT Guidance

FFIEC CAT Guidance	ARM Solution Characteristics
D4.C.Co.Int.1: A validated asset inventory is used to create comprehensive diagrams depicting data repositories, data flow, infrastructure, and connectivity.	Data flows into and out of the ARM system are documented and enforced because of the asset value to the organization.
D1.G.IT.B.2: Organizational assets (e.g., hardware, systems, data, and applications) are prioritized for protection based on the data classification and business value.	The ARM system is classified as a critical asset that needs to be protected.
D3.PC.AM.B.6: Identification and authentication are required and managed for access to systems, applications, and hardware.	The ARM system manages the updates to the identity and authentication systems (directories) using automation to ensure access policy compliance.
D3.PC.Am.B.5: Changes to physical and logical user access, including those that result from voluntary and involuntary terminations, are submitted to and approved by appropriate personnel.	The ARM workflow receives information from the HR system on terminations and job changes. It can immediately de-provision access for these employees. The

FFIEC CAT Guidance	ARM Solution Characteristics
	workflow can also include an approval process.
D3.PC.Am.B.15: Remote access to critical systems by employees, contractors, and third parties uses encrypted connections and multifactor authentication. **D3.PC.Im.Int.2: Security controls are used for remote access to all administrative consoles, including restricted virtual systems.** **D3.PC.Am.B.1: Employee access is granted to systems and confidential data based on job responsibilities and the principles of least privilege.** **D3.PC.Am.B.2: Employee access to systems and confidential data provides for separation of duties.** **D3.PC.Am.B.5: Changes to physical and logical user access, including those that result from voluntary and involuntary terminations, are submitted to and approved by appropriate personnel.** **D3.PC.Am.Int.1: The institution has implemented tools to prevent unauthorized access to or exfiltration of confidential data.**	A privileged account management (PAM) system is not required as part of an ARM solution. PAM was included to enhance the security of the implementation and addresses this guidance.
D3.PC.Am.B.13: Confidential data is encrypted when transmitted across public or untrusted networks (e.g., Internet). **D3.PC.Am.E.5: Controls are in place to prevent unauthorized access to cryptographic keys.** **D3.PC.Am.Int.7: Confidential data is encrypted in transit across private connections (e.g., frame relay and T1) and within the institution's trusted zones.** **D3.PC.Im.B.1: Network perimeter defense tools (e.g., border router and firewall) are used.** **D3.PC.Im.Int.1: The enterprise network is segmented in multiple, separate trust/security zones with defense-in-depth strategies (e.g., logical network segmentation, hard backups, air-gapping) to mitigate attacks.**	The solution uses Lightweight Directory Access Protocol Secure (LDAPS) to protect data-in-transit between the ARM provisioning system and the directories. The solution is implemented to address this guidance.
D2.MA.Ma.B.1: Audit log records and other security event logs are reviewed and retained in a secure manner.	The ARM solution includes a security management and monitoring system to address this guidance.

FFIEC CAT Guidance	ARM Solution Characteristics
D3.PC.Am.B.4: User access reviews are performed periodically for all systems and applications based on the risk to the application or system. **D3.PC.Am.B.3: Elevated privileges (e.g., administrator privileges) are limited and tightly controlled (e.g., assigned to individuals, not shared, and require stronger password controls).** **D4.RM.Om.Int.1: Third-party employee access to the institution's confidential data is tracked actively based on the principles of least privilege.** **D3.DC.Ev.E.1: A process is in place to correlate event information from multiple sources (e.g., network, application, or firewall).** **D5.DR.De.B.1: Alert parameters are set for detecting information security incidents that prompt mitigating actions.** **D3.DC.An.E.4: Thresholds have been established to determine activity within logs that would warrant management response.** **D3.DC.An.Int.3: Tools actively monitor security logs for anomalous behavior and alert within established parameters.** **D3.DC.An.A.3: A system is in place to monitor and analyze employee behavior (network use patterns, work hours, and known devices) to alert on anomalous activities.**	

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3.6 Technologies

Table 3.3 lists all the technologies used in this project and provides a mapping between the generic application term, the specific product used, and the security control(s) that the product provides. (Recall that Table 3-1 explained the CSF subcategory codes.) This table describes only the product capabilities used in our example solution. Many of the products have additional security capabilities that were not used in our example implementation. The table's Product column contains links to vendor product information that describes the full capabilities.

Table 3-3 Products and Technologies

Security Characteristics	Security Capability	CSF Subcategory	Application	Company	Product	Version	Use
Provision, modify or revoke access throughout all user information repositories (directories)	User access policy management	PR.AC-1: Identities and credentials are managed for authorized devices and users.	Virtual Directory	Radiant Logic	RadiantOne VDS Note: Radiant Logic changed their product name from RadiantOne Virtual Directory Server (VDS) to RadiantOne Federated Identity Service (FID)		Consolidated source for digital identities and authorized access to resources
	User access policy management	PR.AC-1: Identities and credentials are managed for authorized	Policy management	AlertEnterprise	Guardian	4.0 SP04 HF3	Provisions access authorizations from the ARM workflow to Active Directory, OpenLDAP, and Vanguard

Security Characteristics	Security Capability	CSF Subcategory	Application	Company	Product	Version	Use
	User access authoritative information repository	devices and users. PR.AC-4: Access permissions are managed, incorporating the principles of least privilege and separation of duties.	User access information management	AlertEnterprise	Guardian	4.0 SP04 HF3	Provisions access authorizations from the ARM workflow to Active Directory, OpenLDAP, and Vanguard
	Centralized provisioning of access information		Provisioning	AlertEnterprise	Guardian	4.0 SP04 HF3	Provisions access authorizations from the ARM workflow to Active Directory, OpenLDAP, and Vanguard
	User access information repository		Directory	AlertEnterprise	Guardian	4.0 SP04 HF3	Maintains the authoritative source for user access information
				Microsoft	Active Directory		User access information repository
				OpenLDAP	OpenLDAP		User access information repository
			Mainframe RACF interface	Vanguard Integrity Professionals	Vanguard		User access information repository and RACF (mainframe access control interface)

Security Characteristics	Security Capability	CSF Subcategory	Application	Company	Product	Version	Use
	Privileged user access control	PR.PT-3: Access to systems and assets is controlled, incorporating the principle of least functionality.	Privileged User Access Management	TDi Technologies	Console Works	4.9-0u0	Creates an audit trail of access by privileged users of operating systems (OSs) and applications. Limits functions available to privileged users to reduce the potential of out of policy activities.
		PR.AC-3: Remote access is managed.	Privileged User Access Management	HyTrust	CloudControl		Creates an audit trail of access by privileged users of the virtual environment management system
Protect data	Protect stored data	PR.DS-1: Data-at-rest is protected.	Privileged User Access Management	TDi Technologies	Console Works	4.9-0u0	Creates an audit trail of access by privileged users of OSs and applications. Limits functions available to privileged users to reduce the potential of out of policy activities.
	Protect data while in transit	PR.DS-2: Data-in-transit is protected.		Multiple products	-		Data-in-transit is protected using encrypted transmissions such as LDAPS. Protection is also provided via network segmentation.

Security Characteristics	Security Capability	CSF Subcategory	Application	Company	Product	Version	Use
	Limit functions available to privileged users	PR.DS-5: Protections against data leaks are implemented.	Privileged User Access Management	TDi Technologies	Console Works	4.9-0u0	Creates an audit trail of access by privileged users of OSs and applications. Limits functions available to privileged users to reduce the potential of out-of-policy activities.
	Limit access to control network	PR.PT-4: Communications and control networks are protected.		Multiple products	-		Communications are protected through network segmentation.
Track privilege user activity	Monitor privileged user activity	DE.CM-3: Personnel activity is monitored to detect potential cybersecurity events.	Log data aggregation, analysis and correlation	Splunk	Enterprise	6.4	Records logs from all systems to monitor for anomalous personnel activity.
			Privileged User Access Management	TDi Technologies	Console Works	4.9-0u0	Creates an audit trail of access by privileged users of OSs and applications. Limits functions available to privileged users to reduce the potential of out of policy activities.

Security Characteristics	Security Capability	CSF Subcategory	Application	Company	Product	Version	Use
Log aggregation, correlation and analysis	Aggregate log data and analyze for anomalous activity	DE.AE-3: Event data are aggregated and correlated from multiple sources and sensors.	Log data aggregation, analysis and correlation	Splunk	Enterprise	6.4	Records logs from all systems to monitor for anomalous personnel activity.
	Generate alerts based on anomalous activity	DE.AE-5: Incident alert thresholds are established.	Log data aggregation, analysis and correlation	Splunk	Enterprise	6.4	Log analysis and correlation rules are established to alert incidents.
	Log management	PR.PT-1: Audit/log records are determined, documented, implemented, and reviewed in accordance with policy.	Log data timing and security	TDi Technologies	Console Works	4.9-0u0	Controls access to industrial control system (ICS) devices by people (ICS engineers and technicians).
	Log aggregation and analysis		Log data aggregation, analysis and correlation	Splunk	Enterprise	6.4	Records logs for analysis and correlation.

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4 Architecture

ARM involves the organization and control (by organizational policy) of approved access information (directory user account details) used to authenticate and authorize users for access to organizational resources. This guide presents an architecture for implementing an ARM automation and security solution, which improves the control of access information and the cybersecurity monitoring of the information repositories (directories).

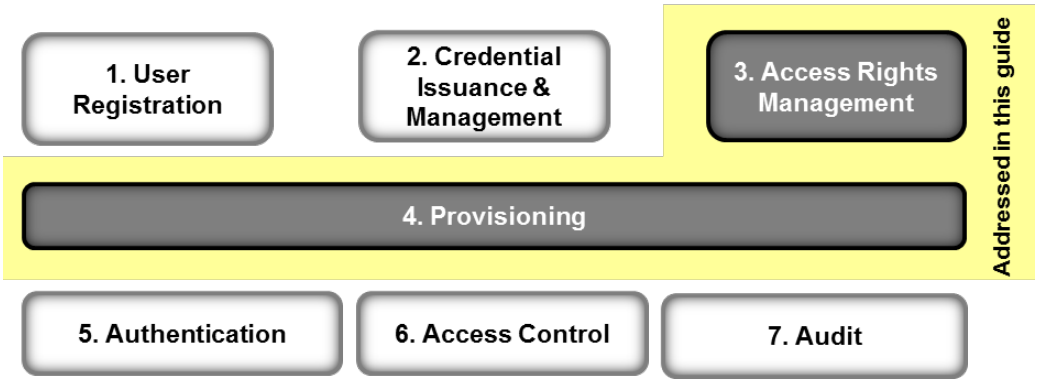
This section describes the high-level architecture and reference design for the ARM system.

4.1 Architecture Description

4.1.1 High-Level Architecture

Figure 4-1 depicts a high-level architecture for identity and access management systems, followed by a description of each of the capabilities. The ARM-solution described in this practice guide is composed of the capabilities illustrated in the yellow portion of Figure 4-1 and is designed to address the security functions and subcategories described in Table 3-1.

Figure 4-1 ARM High-Level Architecture



1. **User registration** determines that there is a reason to give a person access to resources, verifies the person's identity, and creates one or more digital identities for the person.
2. **Credential issuance and management** [3] provides life-cycle management of credentials such as employee badges or digital certificates.
3. **Access rights management** (ARM)determines the resources a digital identity is allowed to use. Arm includes Policy Management and Policy Administration capabilities. (addressed by this guide). In this document, the terms digital identity, account, and user access information are synonymous.

4. **Provisioning** populates repositories (directories) digital identity, credential, and access rights information for use in authentication, access control, and audit. (addressed by this guide).
5. **Authentication** establishes confidence in a person's digital identity.
6. **Access control** [4] allows or denies a digital identity access to a resource.
7. **Audit** maintains a record of resource access attempts by a digital identity as well as changes to digital identities.

The following capabilities included in the high-level architecture are not addressed in this practice guide: User Registration, Credential Issuance and Management, Authentication, Access Control and Audit. These capabilities are not addressed because they are either manual administrative processes invoked when an employee is hired or changes jobs or are automated (run-time) activities that occur every time a person attempts to access a corporate resource (e.g., computer system).

Access rights management and provisioning are addressed in the project. Provisioning connects the administrative activities to the run-time activities by populating and modifying the directories with the user access information. Access rights management (policy management and administration) includes automated functions such as assigning user access rights based organizational policies and determining the proper user access information to be stored in the directories.

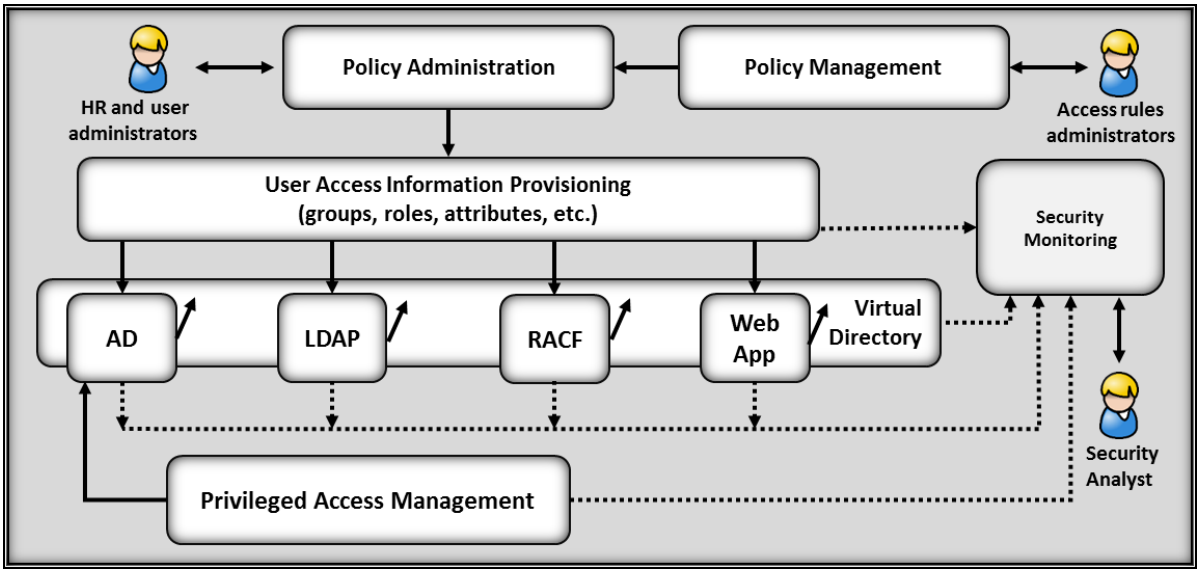
Directories, such as Microsoft Active Directory (AD), Resource Access Control Facility (RACF), and OpenLDAP, are often used in the implementation of run-time functions. Companies typically maintain multiple directories based on application needs and business acquisitions/combinations. These directories are often managed by multiple administrators. Managing access information across directories is complicated because of the coordination effort required among directory administrators. This leads to unwanted situations such as:

- administrators finding it difficult to ensure that employees have access to the resources they need to perform their jobs, and only those resources
- newly hired employees not having access to all the resources they need
- employees who change jobs retaining access to resources they no longer need (access or privilege creep)
- terminated employees retaining access long after they leave

4.1.2 Reference Design

The reference design described here addresses the unwanted situations by implementing ARM and Provisioning capabilities for an enterprise. Figure 4-2 illustrates the reference design of the solution.

Figure 4-2 ARM Reference Design



Note: 1) Solid lines represent policy and user access information transfer/communications, 2) the dotted lines indicate system event and log transfer/communications.

The *Policy Management* capability provides the interface and automation that enable the company to document and store access policy rules for use by the *Policy Administration* capability. The *Policy Management* system includes an interface for business and application owners to record the attributes, groups, or roles that are required to allow access to data and applications.

For example, an individual who serves in the role of bank manager and works in the mid-west division of her company may be given certain access rights that are denied to a bank manager in a different region or division. Implementation of separation of duties and of least privilege access policies enables organizations to reduce the risk of unauthorized access. However, over time, the number and combination of attributes, group memberships, and roles can be quite large. Companies should make efforts to consolidate the attributes, group memberships, and roles used to reduce the number of combinations and complexity **wherever possible**.

The *Policy Administration* capability provides the interface and automation, including approval workflows, to create, modify, and disable user accounts within the directories. It also provides the automation to read files from an HR system that contain user information (new, changed, or terminated employee information). After the *Policy Administration* system reads the user information, it references the user access policies from the *Policy Management* system and initiates any workflows required for access approvals. The workflow may require multiple approvals. In some cases, workflows check for training or other corporate credentials as part of the approval process. The system will then initiate the approved changes (performed by the provisioning capability) needed in all the directories of the

company, virtually simultaneously and within corporate policy. Automation greatly reduces the chances of incorrect account creation or changes.

The *User Access Information Provisioning* capability performs the directory access and change functions to apply the approved changes processed by the *Policy Administration* system. The provisioning capability generates logs for each change action. The *Security Monitor* uses these logs as an input to the anomalous activity monitoring analytics.

The *Virtual Directory* capability performs a directory caching function that is used to monitor the state of the directories. The *Virtual Directory* is configured to mirror the contents of the directories. Directory changes are identified in real time and logged by the *Virtual Directory*. The *Security Monitor* uses this information as an input to the anomalous activity monitoring analytics.

The *Privileged Account Management* (PAM) capability provides the management and control of privileged users of the ARM capabilities and underlying infrastructure. The capability includes logging of user actions (including keystrokes and mouse clicks) and logins, credential management, and user action controls. The *Security Monitor* uses this information as an input to the anomalous activity monitoring analytics. User action controls can include limiting the types of commands users can run.

The *Security Monitor* capability collects and analyzes logs from the provisioning capability, directories, PAM, and the virtual directory. Analytics monitor the incoming logs for indications of anomalous activity. In the example implementation, anomalous activity has been defined as any change to a user account within any directory that the provisioning system did not initiate. Analytics have been created to generate an alert for unexpected changes and logins. Unexpected changes may be an indicator of preparations for or actual malicious activity. The Security Monitoring capability also monitors the PAM capability for all system logins. The monitoring analytics will correlate these logins with directory changes.

The ARM workflow is a pre-defined sequence of steps to process each user access change request. The steps may include approval requests that require an individual or individuals to acknowledge and approve a user access information change before the workflow completes and the change is provisioned. The ARM capability, through provisioning, manages changes to the information in the directories. The combined capabilities can reduce the time to update access information. They also ensure that changes are provisioned consistently across multiple directories and improve the audit trail. The Monitoring Capability is designed to identify directory changes generated by the provisioning system and approved administrators. If an unauthorized change to the user access information in a directory occurs (i.e., a change is made directly rather than being made via the provisioning system), the monitoring system generates an alert for the security analysts. Once an ARM solution is implemented,

administrators do not need to make changes to the directories except for limited situations using the PAM capability.

THE EXAMPLE IMPLEMENTATION WAS DESIGNED TO ADDRESS FOUR BASIC TRANSACTIONS:

1. Creating all required user access information for a new employee in the appropriate directories
2. Updating directories for an existing employee who is changing jobs or requires a temporary access change (or change to contractor status)
3. Disabling all user accounts within ALL the appropriate directories for a terminated employee
4. Improving monitoring of directories for anomalous activity

The reference design does not assume that each person will have a single digital identity. A current employee is likely to have several distinct digital identities because of independent management of the directories. Requiring a single digital identity would create a significant challenge to the adoption and implementation of the reference design. The reference design supports continued use of multiple digital identifiers for employees. A virtual directory has been included in the solution to enhance the security of the directories by monitoring them for changes in real time. The virtual directory can also be used to assist in migrating users to a single digital identity.

Whereas the system to manage access changes is converged, the authority to make access changes remains distributed among appropriate company management. Some access changes will require explicit approval before being authorized. For these situations, the workflow notifies one or more access approvers for each such resource and waits for responses. When the workflow receives approvals, it provisions the authorized access changes in the directories. All information about approved, pending, and provisioned access changes are maintained in the workflow system. Pending access authorizations may be either authorizations that have been approved but not yet provisioned or time-bounded authorizations to be provisioned/de-provisioned at a future time. Explicit approval is used to ensure that managers and system owners retain control over access to critical systems.

When the HR system notifies the workflow that an employee has been terminated, the workflow removes or disables all the employee's accounts from the directories. Integration with HR allows for rapid activation, changes and de-activation of accounts across the organization. These capabilities reduce overhead and administrative downtime. Organizations may benefit significantly from reductions in the time to change access.

5 Example Implementation

This section describes the components of the example implementation of the reference design described in Section 4. A repeatable, demonstrable example of the reference design, it uses the products of participating vendors (collaboration team). The example implementation is not a reference implementation because, we believe, the products used are not the only products (or combination of products) that can provide the capabilities in the reference design.

5.1 Example Implementation Description

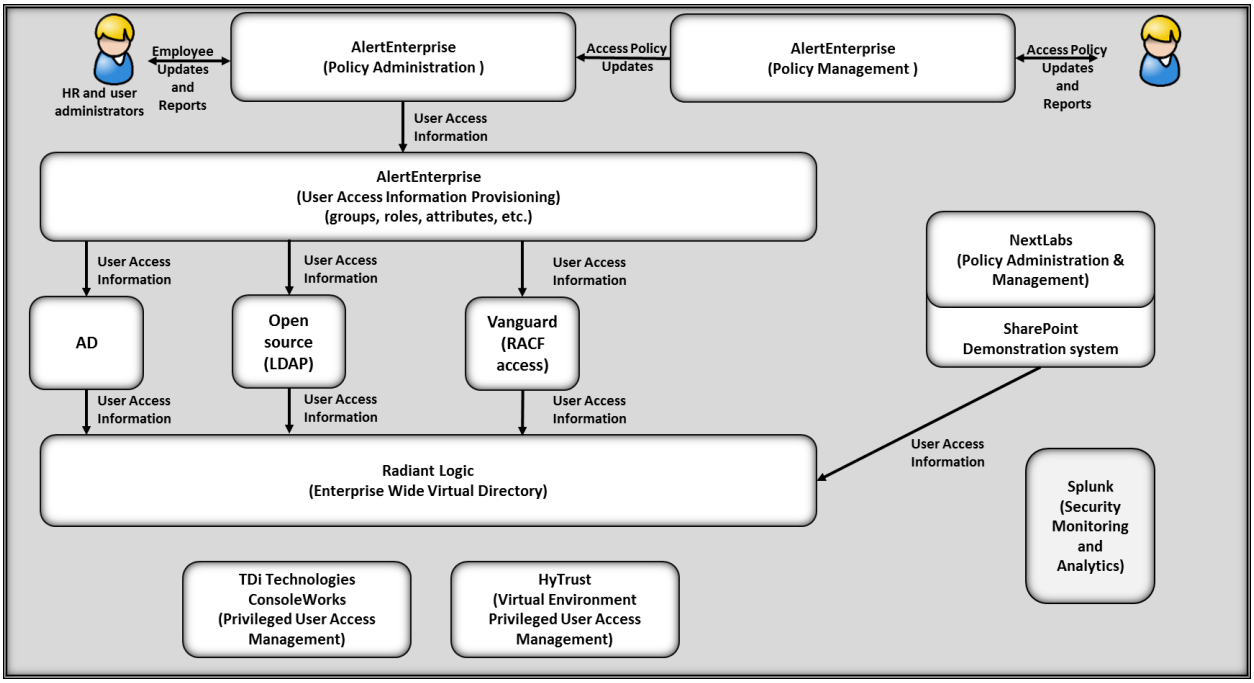
The example implementation is constructed on the NCCoE lab's infrastructure, which consists of a VMware vSphere virtualization operating environment. We used network-attached storage and virtual switches to interconnect the solution components as well as Internet access. The lab network is not connected to the NIST enterprise network. Table 5-1 lists (alphabetically) the software and hardware components we used in the example implementation, as well the specific function each component contributes.

Table 5-1 Example Implementation Component List

Product Vendor	Component Name	Function
AlertEnterprise	Enterprise Guardian	Automation, interface and translation between ARM IdAM servers and the HR system
HyTrust	Cloud Control	Privileged user access controller, monitor, and logging system for VSphere
NextLabs	NextLabs	Attribute-based access control interface for SharePoint
Radiant Logic	RadiantOne	Virtual directory system
Splunk	Enterprise	Log aggregation and analytics system
TDi Technologies	ConsoleWorks	Privileged user access controller, monitor, and logging system
Vanguard Integrity Professionals	Vanguard	Mainframe RACF to LDAP interface system

Figure 5-1 illustrates the example implementation.

Figure 5-1 Example Implementation



Note: The lines indicate the direction of information flow among components of the architecture.

AlertEnterprise (AE) Enterprise Guardian implements the workflow (*Policy Administration*) and the *Policy Management* capabilities. It receives input from an HR system, which we simulated using a manually produced comma-separated value (.csv) file. A .csv file was used to simulate a human resources (HR) system because the NCCoE lab does not have an HR system. A mutually authenticated, integrity-protected connection between an HR system and the Policy Administration capability is the preferred solution. AE Enterprise Guardian also provisions information to the directory instances. No relationship among these directories is assumed. The Policy Management capability provides an interface for management to record access/privilege policies.

Privileged account management is an important to ensure separation of duties and manage administrative accesses. ConsoleWorks uses the Active Directory account information to control privileged user access to OS and application administrative accounts. In addition, we installed HyTrust Cloud Control, to manage privileged user access to the virtual environment management accounts. Cloud Control was installed with manually assigned user access permissions to depict an alternative approach for the implementation of privileged account management.

Radiant Logic RadiantOne Virtual Directory System (VDS) is integrated with the directories in the solution: Active Directory, OpenLDAP, and Vanguard. RadiantOne provides a Virtual Directory capability that is used to integrate the group and attribute information from each directory for each user into a

single view. In the example implementation, the caching capability of this product provides a directory Monitoring capability that identifies user access/account changes in real time and reports those changes to the Security Monitoring capability.

NextLabs is integrated with an instance of SharePoint. NextLabs provides an attribute based access control system used in conjunction with the VDS to demonstrate the ARM example implementation functionality.

Splunk Enterprise is integrated with the directories, VDS, and Enterprise Guardian provisioning systems. It is used for log aggregation and storage as well for log analytics and correlation to identify anomalous conditions for security event alerting purposes.

5.2 Operation of the Example Implementation

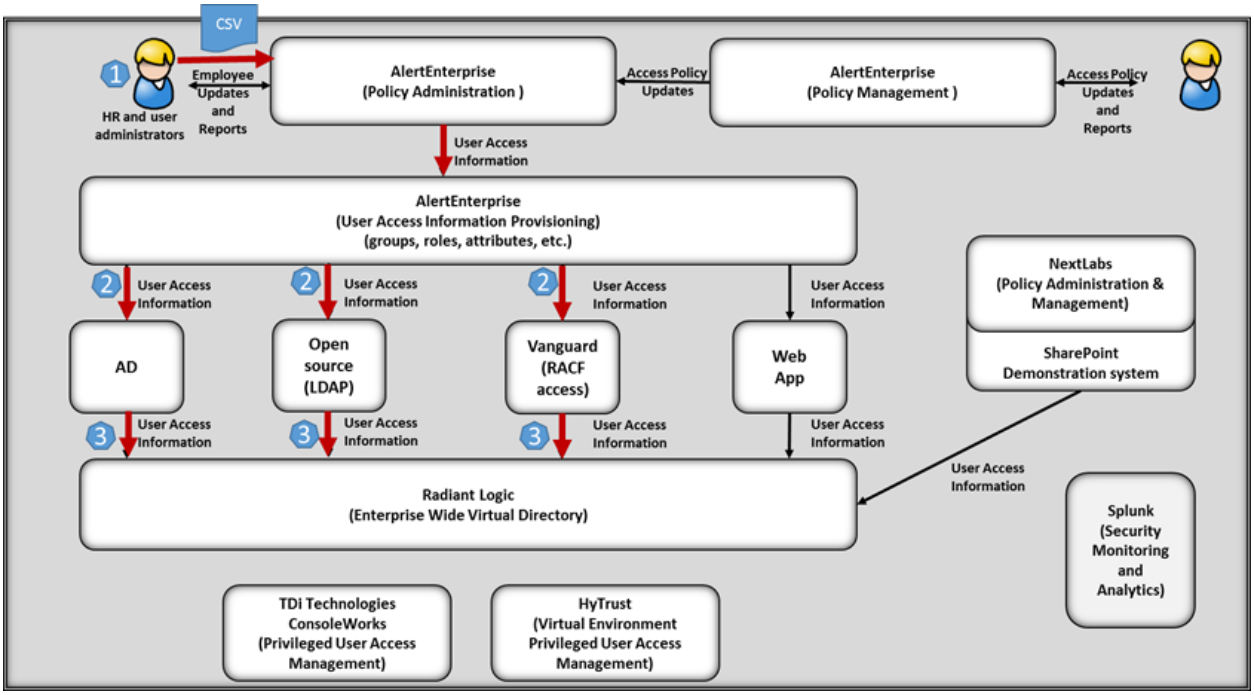
This section explains how the example implementation addresses the risk functions identified in Section 3.4.1. Those factors include inability to centrally manage user accounts and inability to provision, modify, or revoke access throughout the enterprise in a timely manner.

Before operating the solution, the access policies are recorded in the Policy Management capability. The AE Enterprise Guardian (policy management system) capability assists in automated policy compliance by providing an interface to record enterprise access policies. The policy management system feeds the policy administration system with the policy rules required to assign user access information to employees when new employees join the enterprise or change jobs.

The operation of the solution has three primary steps:

1. An update comes from the HR system (see Figure 5-2). The update consists of a .csv file that contains data on new employees and job changes for existing employees (including terminated employees). The AE Enterprise Guardian (policy administration system) reads the data from the HR .csv file. It then initiates the workflow that identifies the user access information to be provisioned to the appropriate directories based on the policies stored in the Policy Management capability. The example implementation does not include management approval in the workflow.
2. The workflow passes the user access information to the provisioning system, which populates the appropriate directories with the user/account access information (e.g., group membership, attributes) for new users and makes changes to the information for existing users as needed, based on the HR user update. If an employee is terminated, all his or her accounts are disabled in this step. Data-in-transit is protected using encryption.
3. once the directories are updated, the updates propagate to the virtual directory. The VDS compares the new version of the directory contents to its cached version at pre-defined intervals. If changes are identified, they are recorded by updating the cache and reported via the logging function. Data-in-transit is protected using encryption.

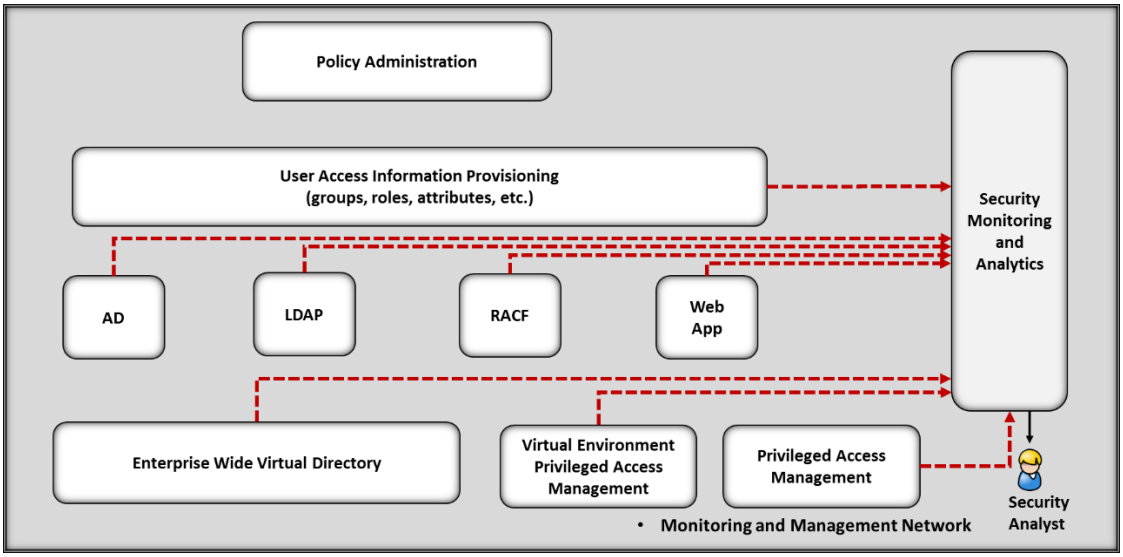
Figure 5-2 Example Implementation Data Flow



Note: The red lines show the data flows; their arrows indicate the flow direction.

The solution includes a monitoring and analytics component to detect anomalous conditions and activity (see Figure 5-3). The analytics correlate logs from the provisioning system with logs from the directories and the virtual directory. The logs from each system report changes to user/account information. Therefore, all changes to an account within a directory must match the changes reported from the provisioning system and virtual directory. If changes occur without matching logs, the security Monitoring Capability generates an alert for an analyst to investigate. The full assessment of the security aspects of the solution are described in Section 6.

Figure 5-3 Monitoring Data Flow



Note: The red dashed lines depict data flows with arrows indicating the flow direction. The data in transit is protected by encryption.

Privileged accounts are accessed via the PAM system. These accounts/users have permission to make changes and maintain the systems within their authority. All use of the PAM system is monitored and logged by the Security Monitoring Capability. Anomalous activity for a privileged account, including multiple failed PAM system login attempts, can be configured to alert.

The NextLabs system is used in conjunction with SharePoint to demonstrate the ARM example implementation operations. NextLabs integrates with SharePoint to manage access to SharePoint pages/sites. In the example implementation, SharePoint represents web applications. The site access is based on an attribute-based access control model implemented in the NextLabs system. NextLabs provides the policy decision point capability for the demonstration. NextLabs uses the VDS for user access information.

5.2.1 Example Implementation Network Components Overview

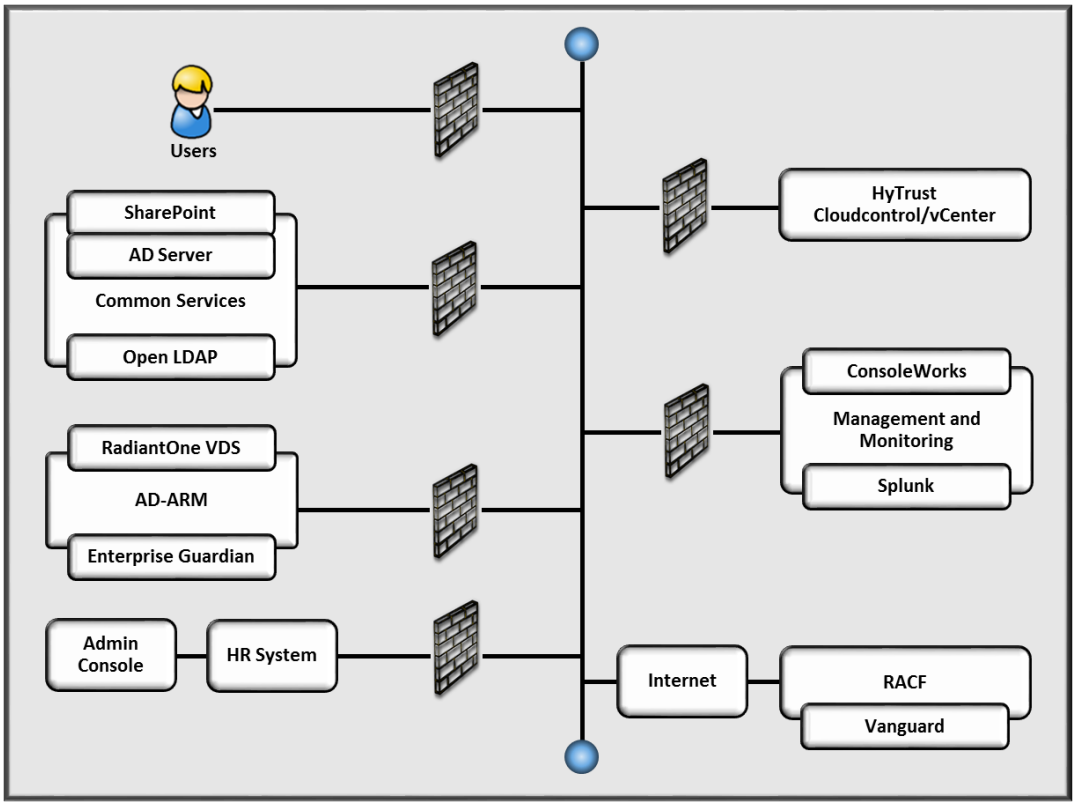
The example implementation architecture consists of multiple networks that partially mirror the infrastructure of a typical financial services company. A management network was implemented to facilitate the management and monitoring of the systems. The example implementation consists of the following subnetworks:

- common services
- access rights management (ID-ARM)
- end-user systems

- virtual environment management
- users
- management and monitoring
- HR
- backbone

These subnetworks were implemented separately in line with best practices for enterprise infrastructure. Firewalls block all traffic except required internetwork communications.

Figure 5-4 ARM Example Implementation Network



The subnetworks shown in Figure 5-4 are described in the following paragraphs.

Internet—The lab environment can access the public Internet to facilitate access to a mainframe (RACF) Vanguard Authenticator demonstration system (provided by Vanguard Integrity Professionals) by the ARM example implementation.

Switching and Routing—Switching in the architecture is executed using a series of physical and virtual switches. Virtual Local Area Networks (VLANs) are implemented to segment the networks shown in

Figure 5-4. VLAN switching functions are handled by physical switches and the virtual environment. Routing was accomplished using routers that also hosted the firewalls.

Backbone—The backbone network provides a protected network space that the other networks can use to route traffic across.

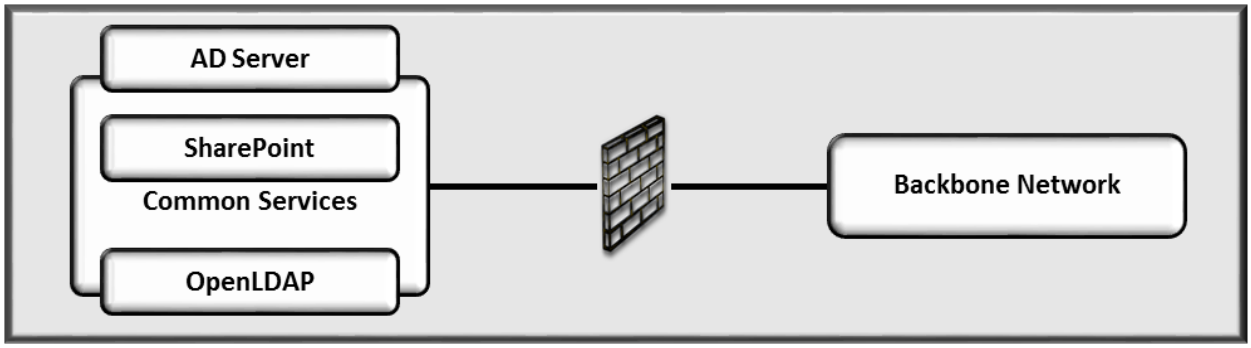
5.2.2 Common Services Network

The example implementation includes the following common services components:

- Active Directory
- OpenLDAP directory
- SharePoint servers

A typical enterprise includes other shared services, such as email servers. We did not include these in the architecture because they are not needed to demonstrate the effectiveness of the ARM example implementation. Table 5-1 and Figure 5-5 identify the specific vendor products we used in this network.

Figure 5-5 Common Services Network



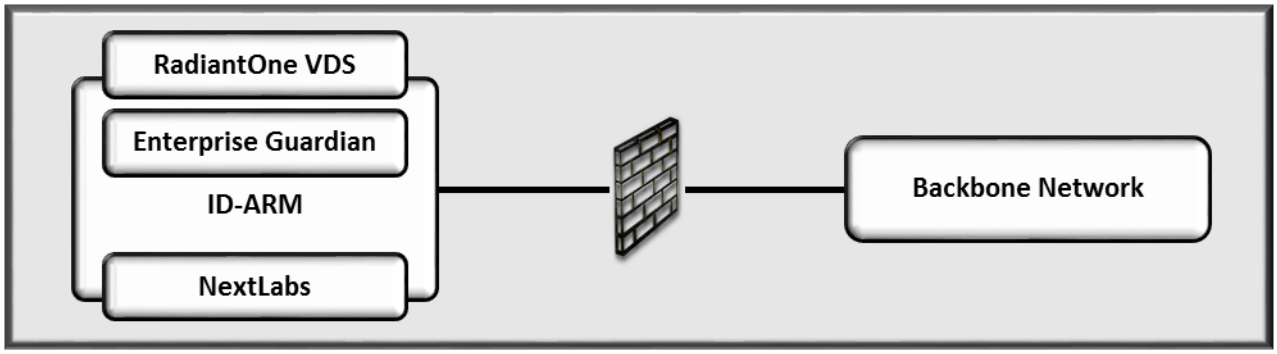
5.2.3 Access Rights Management Network

The following products were installed on the ARM network

- AlertEnterprise Enterprise Guardian ARM system
- Radiant Logic RadiantOne Virtual Directory
- NextLabs Entitlement Management

We separated the ARM systems to highlight the unique ARM components proposed to address the use case. We do not recommend separating ARM functions on their own network. Organizations need to determine the most appropriate implementation of an ARM product within their own infrastructure. Table 5-1 and Figure 5-6 identify the products used in this example implementation.

Figure 5-6 ID-ARM Network



AE Enterprise Guardian provides the workflow management capability. The ARM example implementation takes over control of the directories in the company. An important aspect of the implementation is that the control is implemented by assigning an administrative account credential for each managed directory to the ARM system. When the administrative credential is issued, the company must limit access to the managed directories to administrative users with a PAM system. The security of the solution partially depends on limited access to the managed directories, as discussed in Section 6.

In this example implementation, the central ARM system uses LDAPS to access and update directories. This encrypted data-in-transit version of LDAP prevents network sniffers from recording the provisioned changes. In addition, Radiant Logic's virtual directory product synchronizes with the directories using the same LDAPS protocol.

The Radiant Logic RadiantOne product provides a Virtual Directory capability. In the solution, this product provides two functions: virtual directory for NextLab's use and directory caching for security monitoring. This synchronization is set up to identify and record, at pre-defined intervals, changes within each directory. Radiant Logic reports all changes via logs to the Security Monitoring System.

The NextLabs Entitlement Management product provides the attribute-based access control capability for an instance of SharePoint. The NextLabs product provides the policy decisions for SharePoint when determining access rights for any user attempting to log in to a SharePoint site. This functionality is used in the demonstration of the example implementation.

5.2.4 Network Data Flows

This section describes the data flows within the networks implemented in the example implementation. Figures 5-7 and 5-8 depict data flows using red lines with arrows indicating the flow direction superimposed on network diagrams. The steps are described in Section 5.1. Figure 5-7 depicts the flow of user access information from the HR system to the Policy Administration and Provisioning systems and into the directories. Figure 5-8 depicts the flow of user access information from the directories to

the VDS. Note that all data is routed among the ARM and shared services systems through the backbone network. The data-in-transit is protected using LDAPS.

Figure 5-7 User Access Information Network Data Flow (Steps 1 and 2 in Figure 5-2)

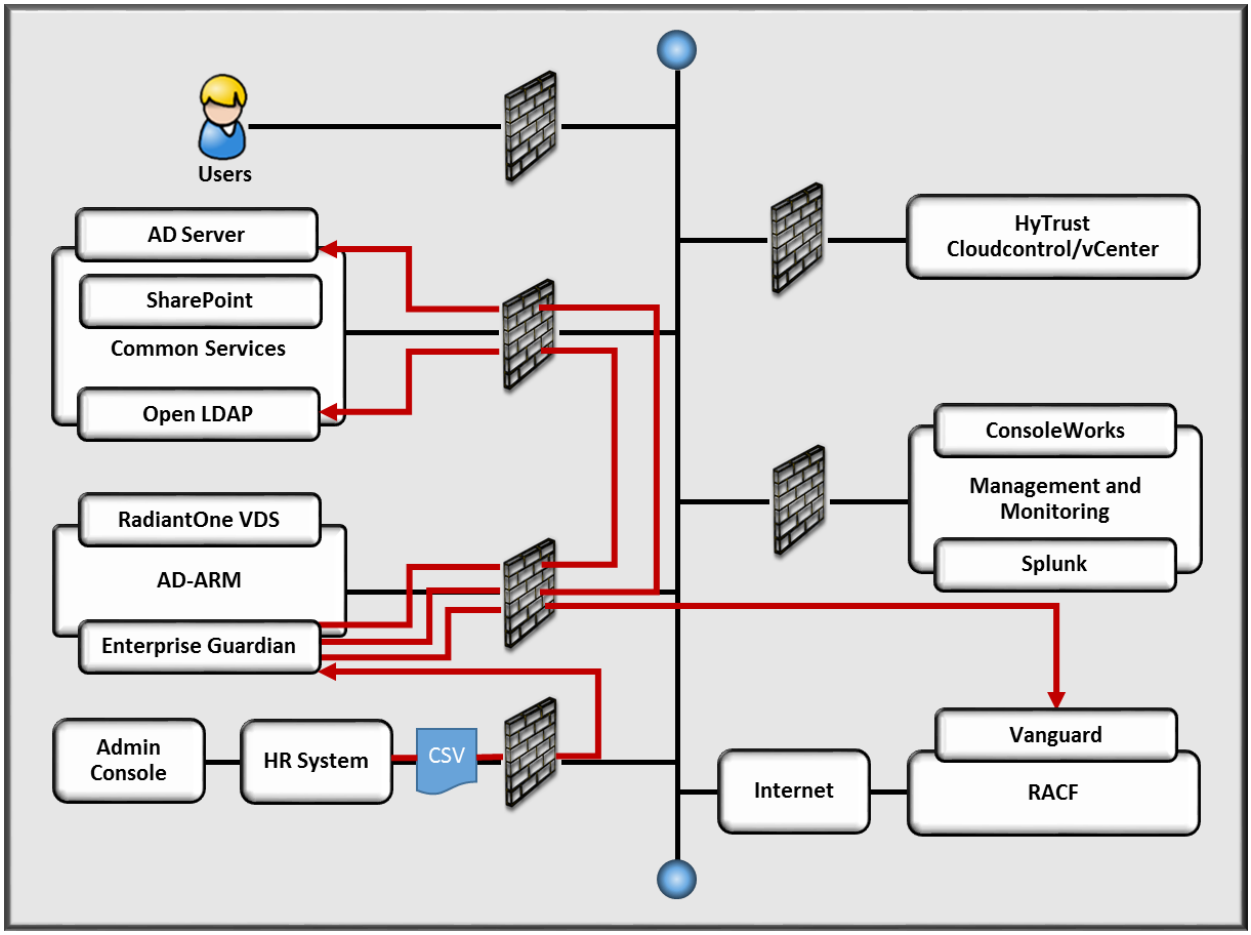
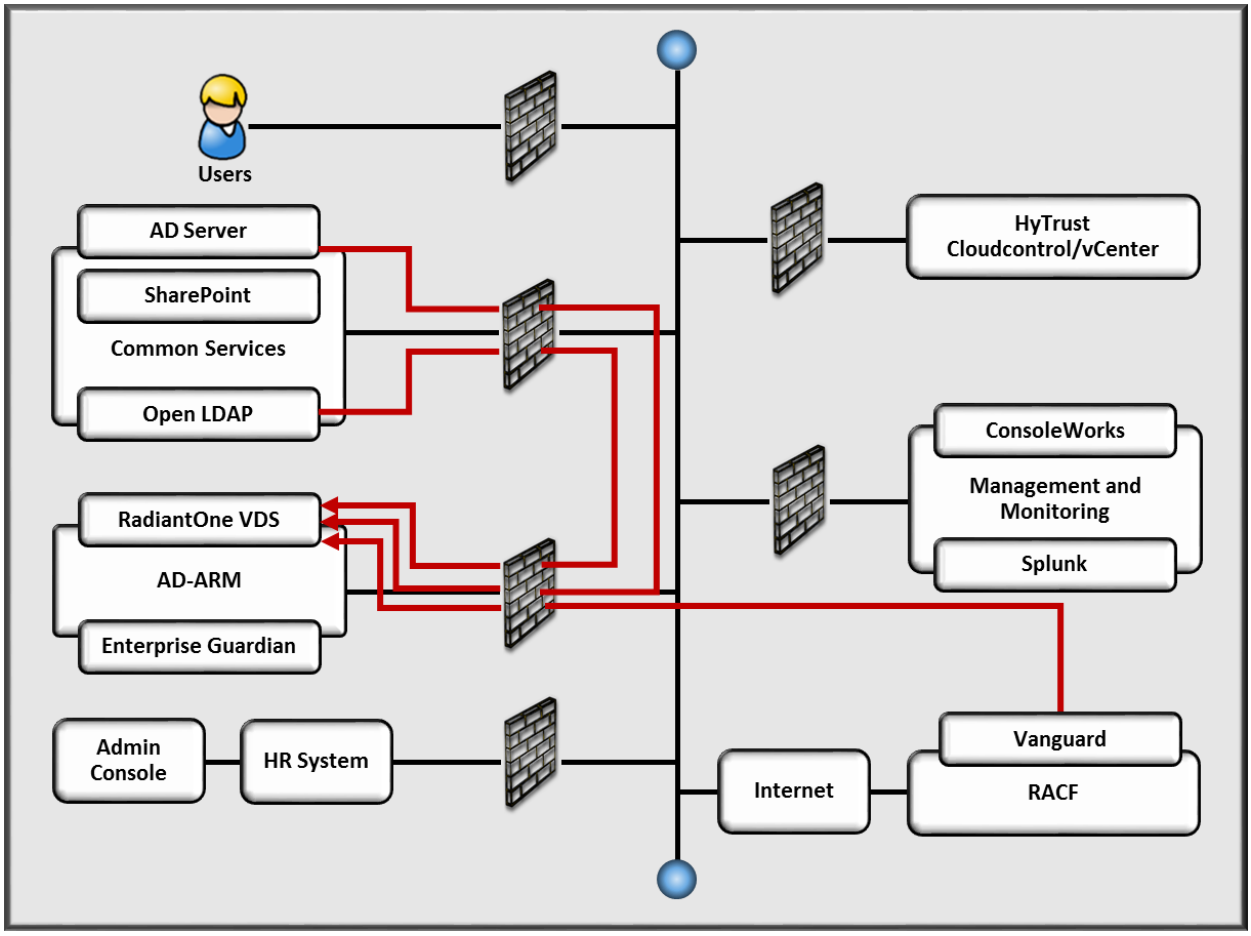
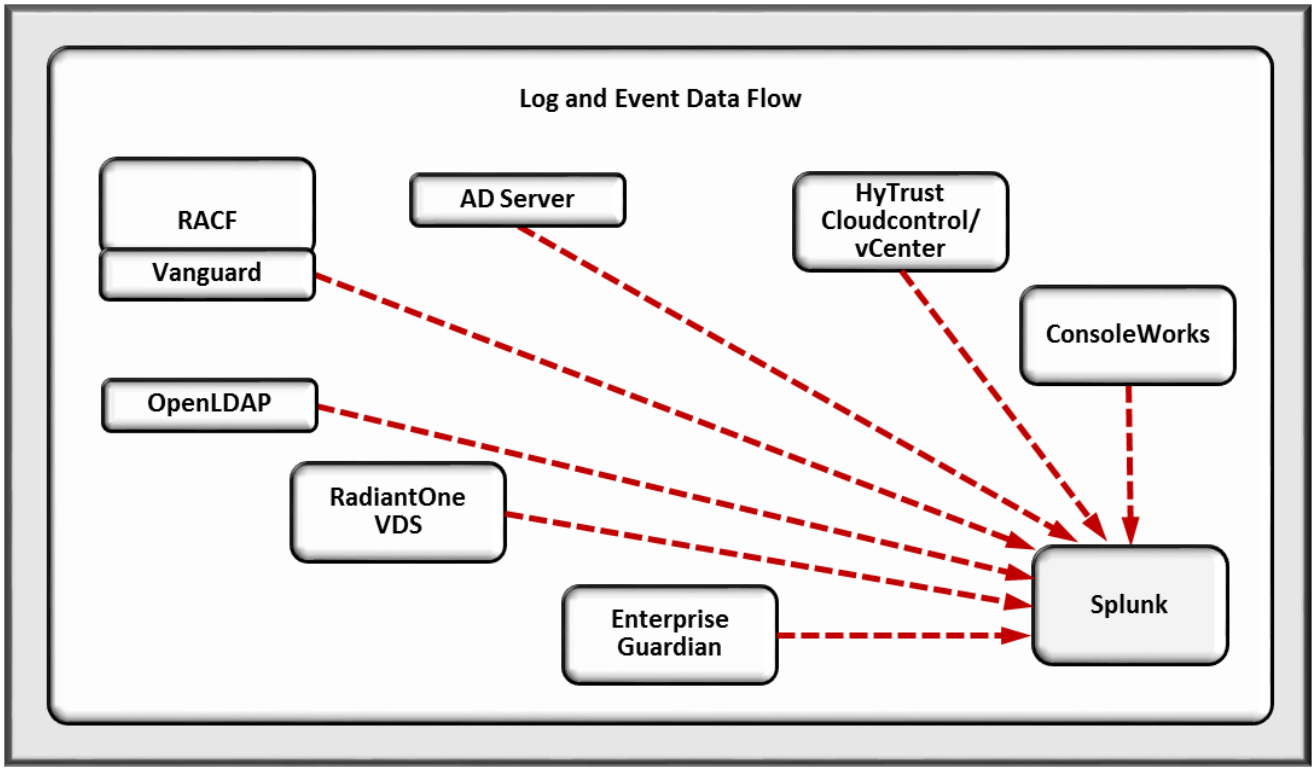


Figure 5-8 User Access Information Network Data Flow (Step 3 in Figure 5-2)



The system monitoring data (log and event data) flow occurs between each system and the security monitoring system. Figure 5-9 depicts the data flows. All monitoring and management data are sent via a separate management network segregated from the Backbone (production) network.

Figure 5-9 Monitoring Network Data Flow



Note: The red dashed lines depict data flows with arrows indicating the flow direction. The data-in-transit is protected by encryption.

5.3 Data

The example implementation requires user dataset files (HR files) in a format similar to that typically provided by human resource systems. Initially, we populated the HR file with user data from a synthetic dataset designed to mirror a typical HR system dataset. We used a .csv file, which is a typical HR system export file type. The data included user names, titles, access assignments, unique identifiers, and other details required to complete valid directory entries. Each directory was pre-configured with the group and attribute fields needed to support the example implementation. The details are included in NIST SP 1800-9C: *How-To Guide.*

6 Security Analysis

We organized the security analysis of the ARM reference design into three parts.

- Section 6.4, Analysis of the Reference Design's Support for CSF Subcategories, analyzes the reference design in terms of the specific subcategories of the CSF that it supports. It identifies the security benefits of each of the reference design capabilities and discusses how the reference design supports specific cybersecurity activities, as specified in terms of CSF subcategories.
- Section 6.5, Analysis of the Security of the Reference Design, reviews vulnerabilities and attack vectors that the reference design might introduce, as well as ways to mitigate them.
- Section 6.6, Security Evaluation Summary, highlights the results of the security assessment and the recommendations from Sections 6.4 and 6.5.

6.1 Assumptions and Limitations

The security evaluation has the following limitations:

- It is not a comprehensive test of all security capabilities, nor is it a red team exercise.
- It cannot identify all weaknesses.
- It does not include the lab infrastructure. It is assumed that devices are hardened. Testing these devices would reveal only weaknesses in implementation that would not be relevant to those adopting this reference architecture.

6.2 Build Testing

The purpose of the security analysis is to understand the extent to which the example solution meets its objective of demonstrating access rights management functionality as defined in Section 3.2. In addition, it seeks to understand the security benefits and drawbacks of the reference design.

6.3 Scenarios and Findings

As we performed our security analysis, we assessed how well the reference design addresses the CSF subcategories it was intended to support. We used the CSF subcategories to structure the security assessment by consulting the specific sections of each standard cited for that subcategory. The cited sections describe the functions and controls the example implementation would be expected to include and perform. Using the CSF subcategories as a basis for organizing our analysis allowed us to systematically consider how well the reference design supports the intended security functions and controls.

6.4 Analysis of the Reference Design's Support for CSF Subcategories

Table 6-1, ARM Reference Design Capabilities and Supported CSF Subcategories, lists reference design capabilities, their functions, and the addressed subcategories, along with the products that we used to instantiate each capability in the example implementation. The security evaluation does not focus on these specific products but on the CSF subcategories because, in theory, any number of commercially available products could be substituted to provide the CSF support represented by a given reference design capability.

The CSF subcategories column of Table 6-1 lists the CSF subcategories that each capability of the reference design supports. The references provide solution validation points in that they list specific security functions and controls that a solution supporting the desired CSF would include. Using the CSF subcategories as a basis for organizing our analysis allowed us to systematically consider how well the reference design supports specific security activities and provides structure to our security analysis. The remainder of this subsection discusses how the reference design supports each of the identified CSF subcategories.

823 **Table 6-1 ARM Reference Design Capabilities and Supported CSF Subcategories**

Capability	Specific Product	Function	CSF Subcategories
Policy Management	AlertEnterprise Enterprise Guardian and NextLabs Entitlement Management	Stores access control policy rules as defined by administrators and delivers these rules to the Policy Administration capability. The access control policy rules define which users, roles, and groups have access to which enterprise resources, while also delivering access policy reports to administrators.	PR.AC-4: Access permissions are managed, incorporating the principles of least privilege and separation of duties.
Policy Administration	AlertEnterprise Enterprise Guardian and NextLabs Entitlement Management	Manages user access-related attributes (e.g., identities, roles, groups) as specified by input from HR administrators. Combines these user access attributes with the access control policy rules that the Policy Management capability delivers to administer enterprise access policy (i.e., to determine which users, roles, and groups have access to which enterprise resources).	PR.AC-4: Access permissions are managed, incorporating the principles of least privilege and separation of duties.
User Access Information Provisioning	AlertEnterprise Enterprise Guardian	Automatically translates the enterprise access policy information that the Policy Administration capability delivers into the corresponding role, attribute, and other parameter values that need to be configured in each individual directory. In this way, the capability automatically provisions to all the directories based on the access information from this single, centralized location. LDAPS is employed to maintain confidentiality and integrity. Also, sends logs of all provisioning activity to the monitoring capability.	PR.AC-4: Access permissions are managed, incorporating the principles of least privilege and separation of duties. PR.DS-2: Data-in-transit is protected.

Capability	Specific Product	Function	CSF Subcategories
User Access Information Repository (also referred to as Directory)	Active Directory OpenLDAP Vanguard	Authoritative source for enterprise user identifiers and their associated roles and attributes. Organizations typically use several different such directories; the reference design integrates with each. These directories support access control to specific enterprise resources based on the user access (account) information stored in them. Each time a user access attempt is made, one or more of these directories is consulted and its contents are used to determine whether the access request will be granted. The directories also send logs of every change that is made to their user access (account) information contents to the monitoring capability. LDAPS is employed to maintain confidentiality and integrity.	PR.AC-4: Access permissions are managed, incorporating the principles of least privilege and separation of duties. PR.DS-2: Data-in-transit is protected. DE.AE-1: A baseline of network operations and expected data flows for users and systems is established and managed.
RACF Interface	Vanguard	Interface capability that translates between the RACF system to/from LDAP or LDAPS. The capability enables RACF to interface with both the User Access Information Provisioning capability and the Enterprise-wide Virtual Directory capability using LDAP or LDAPS.	PR.DS-2: Data-in-transit is protected. PR.AC-4: Access permissions are managed, incorporating the principles of least privilege and separation of duties.

Capability	Specific Product	Function	CSF Subcategories
Enterprise-wide Virtual Directory	RadiantOne VDS	Virtual Directory containing the aggregation of user access information from each of the several different directories in the reference design. It correlates and disambiguates different user accounts that may exist in various directories to create unique user identities and aggregate all the attributes that each user has in each of the directories. It provides a second, global view of the enterprise's access control information, in addition to the authoritative copy of user access information that is stored across the several different physical directories. It also sends logs of every change that is made to any user access information to the monitoring capability. LDAPS is employed to maintain confidentiality and integrity. Logs are reported to the monitoring capability.	PR.AC-4: Access permissions are managed, incorporating the principles of least privilege and separation of duties. PR.DS-2: Data-in-transit is protected.

Capability	Specific Product	Function	CSF Subcategories
Security Monitoring and Analytics (also referred to as Monitoring)	Splunk Enterprise	Receives security monitoring logs documenting all changes made to user access control and policy information at the User Access Information Provisioning capability, each of the directories, the Virtual Directory, the Privileged Access Management Capability, and the Virtual Environment Privileged Access Management capability. Performs analytics on the logs to detect potential inconsistencies and anomalies that might signal security concerns.	PR.DS-1: Data-at-rest is protected. PR.DS-2: Data-in-transit is protected. PR.PT-1: Audit/log records are determined, documented, implemented, and reviewed in accordance with policy. DE.AE-3: Event data are aggregated and correlated from multiple sources and sensors. DE.AE-5: Incident alert thresholds are established.

Note: Table 6-1 describes only the product capabilities and CSF subcategory support that the reference architecture uses. Many of the products have additional security capabilities that are not listed here.

6.4.1 Supported CSF Subcategories

The reference design was created to identify a set of capabilities and their relationship to provide an ARM solution. The CSF includes functions, categories, and subcategories that define the capabilities and processes needed to implement a cybersecurity program. Within this practice guide, the NCCoE has identified the CSF subcategory capabilities and processes in Table 3-1 that are desirable to implement an ARM solution. Each of the following sections describes how the ARM reference design addresses the CSF subcategories, included in Table 3-1, with technical capabilities. Also included are the CSF subcategory processes from Table 3-1 that are beyond the scope of the ARM solution but are important for organizations to address. Some CSF subcategories are supported by individual capabilities of the reference design; others, by the reference design as a whole. Yet other CSF subcategories are relevant because the reference design is predicated on their being addressed by the enterprise-wide architecture.

6.4.1.1 ID.AM-3: Organizational communication and data flows are mapped

The reference design:

- Defines and identifies all ARM-related organizational communication and data flows.
- Defines each of the directories, as well as the flow of data and connectivity between these directories and other capabilities in the reference design.
- Supports CSF subcategory ID.AM-3 with respect to access control management information.
- Does *not* address organizational communication and data flows for any other types of information because they are unique to each organization.

By adopting the reference design, an organization thereby fulfills its support for CSF subcategory ID.AM-3 with respect to organizational communication and data flows that are related to access control management.

6.4.1.2 ID.AM-6: Cybersecurity roles and responsibilities for the entire workforce and third-party stakeholders are established

The reference design is predicated on there being a clearly defined set of roles and responsibilities for each user that determines that user's access control information (i.e., the roles, groups, and attributes that apply to that user and that thereby determine what resources he or she is authorized to access and at what level of privilege). The organizational access policy administrators define the roles and responsibilities of the entire workforce and describe these roles and responsibilities in terms of which employees have access to what resources (and at what level). They then populate this information into the Policy Management and Policy Administration capabilities of the reference design so it can automatically provision the user access information directories based on the roles and responsibilities that any given company will have defined for the workforce. Once these roles and responsibilities have

been established and provided to the reference design, the design then serves as the mechanism for enforcing the access control-related aspects of these roles and responsibilities.

The design does not include a capability that audits the user access information within the directories. The NCCoE determined that auditing of directory content was out of scope because the capability is well understood and widely adopted.

6.4.1.3 ID.BE-4: Dependencies and critical functions for delivery of critical services are established

With respect to the delivery of the critical service of access control, the reference design establishes the User Access Information Provisioning capability as a centralized source for managing and provisioning all user access control information, and it recognizes this capability as a new critical asset. It also recognizes the importance of each individual directory for storing authoritative user access information and supporting access control, identifying these directories as part of the critical infrastructure. The VDS and the Monitoring Capability are essential for ensuring the integrity of the information the directories store.

6.4.1.4 PR.AC-1: Identities and credentials are managed for authorized devices and users

Managing identities and credentials for authorized devices and users is inherent in and fundamental to the reference design. The objective of the design is to automate administering and provisioning user access changes throughout the enterprise for access control purposes.

6.4.1.5 PR.AC-3: Remote access is managed

To provide security to the reference design capabilities, the reference design does not permit any users, even privileged ones, to log in to the consoles of any reference design capabilities directly. It forces all console access to be performed via PAM systems for physical and virtual machines. In the reference design, PAM enables remote access to the capabilities, managing and logging privileged access to the consoles of physical reference design capabilities. Privileged access to virtual machines is managed by the Virtual Environment (VE) PAM capability. Section 6.5.3 discusses privileged access further.

6.4.1.6 PR.AC-4: Access permissions are managed, incorporating the principles of least privilege and separation of duties

The main objective of the reference design is to manage access permissions for all enterprise resources and servers in a converged and automated fashion capable of supporting the principles of least privilege and separation of duties. Once corporate access policies have been defined and integrated with the reference design in the form of access policy updates, access information updates, and enterprise business rules/workflows, the reference design automatically and consistently provisions all the enterprise directories with the access information necessary to ensure that the directories enforce corporate access policies.

Access Rules administrators should base corporate access policies on the principles of least privilege and separation of duties. The principle of least privilege, defined as providing the least amount of access (to systems or data) necessary for the user to complete his or her job, and the principle of separation of duties, which restricts the amount of responsibilities held by any one individual, are important security tools. These tools help prevent fraud and abuse by limiting the amount of privilege that individual users have and requiring multiple individuals to collude to accomplish certain goals. The reference design, through its Policy Management, Policy Administration, and User Access Information Provisioning capabilities, ensures that the directories are provisioned based on these enterprise access policies. So, assuming access policies are designed to incorporate the principles of least privilege and separation of duties, the reference design will manage and enforce access permissions according to these principles.

In addition, to ensure the security of the reference design itself, typical enterprise users must not be authorized to create or modify user accounts on any enterprise machines. Nor should they be able to log in to any reference design capabilities. Only privileged users should be permitted to access reference design capabilities and the machines on which reference design capabilities run. Various levels of administrator privileges should be established and managed to administer the reference design capabilities themselves and the physical and virtual infrastructure on which the reference capabilities run. All privileged administrative activity must be performed through the PAM and VE PAM capabilities to ensure that all such activity is logged, with the logs being sent from the PAM and VE PAM to the Monitoring Capability for scrutiny. Still higher levels of administrator privileges must be established to administer the PAM and VE PAM capabilities themselves because PAM and VE PAM administrators have the authority to turn off logging and modify the privileges that administrators of other reference design capabilities have. Section 6.5.3 discusses privileged access management and the hierarchy of privileged users in more detail.

6.4.1.7 PR.DS-1: Data-at-rest is protected

User access information is not encrypted while stored at rest. However, this data is spread across the directories, and these directories are in their own security enclave. The security enclave consists of the physical directories only, without any other reference design capabilities, situated on their own subnetwork that is separated from the rest of the reference design by a firewall. The firewall is configured to permit communications using only the specific ports and protocols that are required.

Furthermore, although this information is not integrity protected while at rest, its integrity is monitored by the Monitoring capability. The Monitoring capability receives logs of user access information changes from the User Access Information Provisioning and VDS capabilities as well as each of the directories. The Monitoring capability correlates and compares the log information it receives from each of the above capabilities to ensure that the information is consistent across all sources. In this way, it is possible to verify that each change made to the directories is the result of a legitimate, corresponding event at the User Access Information Provisioning capability that resulted from input from the Policy Administration capability. If a change is detected to a directory that cannot be correlated with logs

signaling related events at these other capabilities, the Monitoring system generates an alert to signal that this change to the data-at-rest in the directory might be unauthorized. File integrity tools are available to monitor for loss-of-integrity events within systems like directories. These tools are not addressed in the reference design.

6.4.1.8 PR.DS-2: Data-in-transit is protected

LDAPS is used to encrypt user access information while it is in transit between reference design capabilities. In the example implementation, a single application is used to implement the Policy Management, Policy Administration, and User Access Information Provisioning capabilities so that all information flows between these capabilities remain inside the same application and are not transmitted over a network where they would be vulnerable to eavesdropping or tampering. If the reference design were to be built using separate physical components to instantiate the Policy Management, Policy Administration, and User Access Information Provisioning capabilities, messages exchanged among these capabilities would need to be provided with at least data integrity and preferably confidentiality protections. The User Access Information Provisioning capabilities encrypt all logs that they send to the Monitoring Capability. It would thus be very difficult to fake a log from one of these capabilities to the Monitoring capability with the aim of trying to trick the Monitoring capability into thinking that an unauthorized user is permitted to have access. Spoofing such a log would require that an adversary possess the keys used to encrypt the logs.

In the current example implementation (RFC 2830), LDAPS is used to perform read-and-write access to the directories and to the VDS capability, ensuring that user access information sent across a network to these remote capabilities is encrypted.

Also, when log information is sent to the Monitoring capability, it is encrypted using the Splunk connector application, resulting in protection from disclosure as well as unauthorized modification.

6.4.1.9 PR.DS-5: Protections against data leaks are implemented

The reference design itself, through its focus on management of access permissions, protects the enterprise in general against data leaks that might occur were someone to gain unauthorized access to resources on the production network. By preventing unauthorized access to information, the reference design protects against leaks of that information. The reference design, however, is not intended to protect against exfiltration of information by an authorized user; addressing such an insider threat is not within the scope of the guide. The reference design does, however, include some mechanisms to deter data leaks perpetrated by insiders. The fact that data flows within the reference design are encrypted serves to ensure that even if data-in-transit within the reference design were to be exfiltrated, this information would not be in plaintext form. Also, the PAM capability serves to limit which data privileged users can access, thereby limiting what privileged insiders can exfiltrate and copy. For example, administrators may be given access to administration and configuration directories and not to directories that contain sensitive data files. The PAM capability also logs all privileged user access,

ensuring that if a privileged user misuses his or her authority and leaks data, this activity would be recorded in log files.

6.4.1.10 PR.PT-1: Audit/log records are determined, documented, implemented, and reviewed in accordance with policy

Although it does not include an audit solution, the reference design supports auditing by aggregating all access-related log information in one location (the Security Monitoring capability), thereby enabling centralized accountability and tracking of access change activity. Locally, various events are monitored and logged at each reference design capability (see NIST SP 1800-9C: *How-To Guides* for a list of events logged). These logs are sent to the Security Monitoring capability. Security Analysts will typically be authorized to have read-only access to these logs to review and respond to potential security events. Monitoring and analytics tools will also have access to these logs for anomaly and potential security event detection. All system administrators or other privileged users are required to use the PAM system. Therefore, any actions they take, including abuse of their privileged access, will be monitored and logged. These logs will be sent to the Security Monitoring capability. Given that access to the logs in the Security Monitoring capability would enable an adversary to delete or modify logs that document adversarial activity, the ability to delete or modify such logs should, by policy, require the cooperation of multiple individuals.

6.4.1.11 PR.PT-3: Access to systems and assets is controlled, incorporating the principle of least functionality

The reference design itself, through its focus on managing access permissions, inherently supports the control of access to all enterprise systems and assets. User access information, combined with access policies, can be configured to enforce the principle of least functionality.

6.4.1.12 PR.PT-4: Communications and control networks are protected

Network perimeter defense tools, including border routers and firewalls, are used in the reference design; the directories are isolated on their own subnetwork, separated from the rest of the reference design by a firewall that is configured to permit only ports and protocols required to store and retrieve user access information.

Similarly, other capabilities of the reference design are isolated on their own subnetworks, as shown in Section 5. For example, the Security Monitoring capability and PAM are isolated on their own subnetwork, the Policy Administration, Policy Management, User Access Information Provisioning, and VDS capabilities are isolated on their own subnetwork, and the VE PAM is isolated on its own subnetwork. Such separation ensures that if an intruder can gain access to one of these subnetworks, the resulting access does not provide the opportunity to eavesdrop on traffic that is being exchanged between reference design capabilities on other networks. Nor can the intruder use a capability on which he or she has gained a foothold in one subnetwork as a platform from which to launch an attack on

capabilities in another subnetwork if such an attack would require the use of ports or protocols that the subnetwork's firewall is configured to block.

A management subnetwork is implemented to segment log and administrator access to capabilities. This segmentation further isolates administrative and log data to reduce the potential of eavesdropping and rogue user access to administration interfaces.

6.4.1.13 DE.AE-1: A baseline of network operations and expected data flows for users and systems is established and managed

Within the reference design, the directories constitute the authoritative repositories of user access information (accounts). The contents of these directories can be considered the baseline with respect to user access information. If user access (account) is changed in any of the following ways and is therefore inconsistent with the contents of the authoritative baseline (i.e., the contents of all the directories), the Monitoring capability detects this inconsistency and generates an alert:

- via direct manipulation of directory information such as an account change, addition, or deletion/deactivation by an insider or malware
- temporary removal of a directory from its network for offline manipulation
- administrative change mistake by a privileged user via the PAM system

The Security Monitoring capability can detect this inconsistency because every user access information update and every provisioning operation generates a log message that is sent to the Security Monitoring capability. For every valid account update, a consistent set of logs is expected to flow from each capability to the Security Monitoring capability, and the log messages received from all capabilities are checked for consistency.

In addition, when user access updates are made to each directory, these changes are also propagated to the VDS, which also sends logs of these updates to the Monitoring capability. Hence, the Security Monitoring capability also checks to ensure that for each update that is logged at a directory, a corresponding update is logged by the VDS. The VDS functionality increases the effectiveness of a directory monitoring program through synchronization and change reporting. This increase will enable anomalous directory changes to be reported within seconds to minutes, depending on the VDS capability configuration.

This established set of log data flowing from reference design capabilities to the Security Monitoring capability is event-based, meaning that the data flow is initiated by specific activities that, once detected, generate logs (see NIST SP 1800-9C: *How-To Guides* for a list of events logged). The activity at the affected reference design capability must be identified and then reported to the Security Monitoring Capability. If the process that is supposed to detect the activity or generate or transmit the log to the Security Monitoring capability stops working temporarily and then resumes operation, whatever updates have occurred in the interim will not have generated any logs. In particular, if a change is made

to a directory while it is not connected to the network, no log event is generated at the time of the change. If the update was the result of a legitimate provisioning operation, the Monitoring capability detects an inconsistency in the logs received from various capabilities and it generates a false alarm. However, if the update was performed by an adversary who intentionally modified a directory while it was offline, this change to the directory could not generate a log, even though the directory contents would now be inconsistent with the contents of the Provisioning capability and of the VDS. This type of activity would be detected, and an alert noting that the directory connection was lost by the VDS would be sent to the Security Monitoring capability.

Monitoring directory update events is not the same as looking at the actual data in the directories. Log collection and transmission is typically performed as a best-effort process. Log collection agents sometimes go down, and they can be fragile, so there would be some risk inherent in relying solely on reference design capabilities to self-report activities and updates. If a directory update event were to somehow fail to reach the Security Monitoring capability, there would be no way to know that the change was made without looking at the information in the directory.

To mitigate the possibility that the best-effort nature of event-based reporting could be exploited to populate a directory with unauthorized information in this way, the VDS is configured to monitor the connections that it has with each of the directories, thereby ensuring that these connections are up. If any of the directories go offline or if its connection with the VDS goes down for any reason, this event would be signaled to the Security Monitoring capability. In addition, the VDS is configured to cache the directory information that it has stored. Once the cache has been initialized and caching has been turned on, the VDS monitors the user access information for any changes. When it detects a change or a connection being re-established to a directory that had been offline, the VDS compares the access information it has cached with the values present in the directories. If there are any discrepancies, it creates a log of these and sends the log to the Security Monitoring capability, enabling the Security Monitoring capability to detect unauthorized changes to the directories. If the reference design incurs too much of a performance hit because of the VDS cache information volume, a separate server can be set up to store the VDS's view of user access information for comparison with the actual contents of the directories. The reference design should not rely solely on the monitoring and flow of event-based logs to ensure that no unauthorized changes have been made to the directories; regular auditing of actual directory contents is also important to reduce risk and bring additional value.

In many cases, an organization's ARM system could have started out simply using a single directory, but, as a consequence of mergers and acquisitions, other applications, resources, and directories were added. As a result, an organization might not have complete awareness of the extent of any given user's access control authorizations across all appliances. Practically, an organization that deploys the reference design will want to ensure that it converts from the policies that it is enforcing at the time of adoption to the policies that it seeks to enforce. Simply adopting the reference design does not cause an organization to automatically begin enforcing its desired access control policy. The objective of reference design is to ensure the integrity of access changes as updates are applied. How well an

organization enforces the access control policies overall depends on the initial baseline contents of those directories. Certifying that these initial baseline contents are correct is not addressed in the design. Planning for deployment of the design gives an organization the opportunity to go back and audit the access control information in their directories and get a more global, correlated, disambiguated view of the user access roles and attributes that are currently in effect.

Ideally, in an operational deployment of the reference design, a separate system would also be deployed to periodically examine the directory contents to verify that they enforce enterprise policies as intended. Having such a system enables a security analyst to determine when an access control mistake is the result of a breakdown in business process as opposed to being the result of a security breach or technology failure.

6.4.1.14 DE.AE-3: Event data are aggregated and correlated from multiple sources and sensors

The Security Monitoring capability aggregates and correlates user access information change event logs from three types of sources:

- User Access Information Provisioning capability
- each of the directories (which, in aggregate, constitute the authoritative/baseline source)
- Virtual Directory capability

If any inconsistencies in the user access data changes across these sources are detected, an alert is generated. The Security Monitoring capability also receives log information from the PAM and the Virtual Environment PAM capabilities and generates an alert if it detects privileged user access attempts that are not consistent with the user access information that it has received from other reference design capabilities.

6.4.1.15 DE.AE-5: Incident alert thresholds are established

The alert thresholds are binary: if the user access information logs that the Security Monitoring capability receives from each of its sources are not consistent with each other, an alert is generated. If the user access information logs received from the various capabilities are consistent with each other, no alert is generated.

6.4.1.16 DE.CM-3: Personnel activity is monitored to detect potential cybersecurity events

All activity of privileged users on physical reference design capabilities is monitored and logged by the PAM capability for OSs and applications. Similarly, all activity that virtual machine (VM) Administrators perform on VMs (but not the activity that they perform on the OSs installed on those VMs) is logged by the VE PAM. The administrators of the OSs and applications running on VMs make use of the PAM capability for access. These capabilities log each administrator's activity on either the physical console or the VM and send the logs to the Monitoring capability. They also generate alerts when operations that

are not authorized are attempted. The Security Monitoring capability monitors the alerts generated by these physical and virtual PAM capabilities to detect potential cybersecurity events.

6.5 Security of the Reference Design

The list of reference design capabilities in Table 6-1 focuses on the access control capabilities of the reference design that are needed to enable it to meet its objective of automating the management of user access information (accounts). Table 6-1 does not focus on capabilities needed to manage and secure the reference design. However, the reference design itself must be managed and secured. To this end, this second part of the security evaluation focuses on the security of the reference design.

Measures implemented to protect the reference design from outside attack include:

- isolating certain capabilities on separate subnetworks protected by firewalls
- implementing a management network to isolate log and management traffic from the production (business operations) networks
- securing critical user access information and logs to protect them from unauthorized insertion, modification, or deletion
- logging of all privileged user access activities
- encryption and integrity protection of user access information and logs while this information is in transit between capabilities

Table 6-2, Capabilities for Managing and Securing the ARM Reference Design, describes the security protections each capability provides and lists the corresponding products that were used to instantiate each capability. The security evaluation focuses on the capabilities rather than the products. The NCCoE is not assessing or certifying the security of the products included in the example implementation. We assume that the enterprise already deploys network security capabilities such as firewalls and intrusion detection devices that are configured according to best practices. The focus here is on securing capabilities introduced by the reference design and minimizing their exposure to threats.

Table 6-2 Capabilities for Managing and Securing the ARM Reference Design

This table describes only the product capabilities and CSF subcategory support used in the reference architecture. Many of the products have significant additional security capabilities that are not listed here.)

Capability	Specific Product	Function	CSF Subcategories
Subnetting	N/A	Technique of segmenting the network on which the reference design is deployed so that capabilities on one subnetwork are isolated from capabilities on other subnetworks. If an intruder can gain access to one segment of the network, this technique limits his or her ability to monitor traffic on other segments of the network. For example, the enterprise's production network, on which user access information and decisions are conveyed, is separate from the reference design's monitoring and management subnetwork.	PR.DS-1: Data-at-rest is protected. PR.PT-4: Communications and control networks are protected.
User Access Information Repository Firewall	PFSense	Sits between one or more directories and the rest of the reference design, with one interface connecting to the subnetwork that is dedicated to the directories and a second interface connecting to the rest of the reference design. Monitors all traffic that flows to and from the directories. This firewall is configured to permit only the required ports and protocols (e.g., LDAPS) to be exchanged between the User Access Information Provisioning capability and the directory and between the VDS capability and the directory. Privileged user access to this firewall (i.e., access of all users authorized to change firewall rules) must be managed through the Privileged Access Management capability.	PR.PT-4: Communications and control networks are protected.

Capability	Specific Product	Function	CSF Subcategories
Privileged Access Management	TDi Technologies ConsoleWorks	Manages privileged access to the OSs of all physical reference design capabilities. This is the single portal into which all users with administrator privileges must log in; it defines what systems these administrators are authorized to access based on their role and attributes. It also logs every keystroke that is performed by users with administrator privileges, creating an audit trail of privileged user access to the OSs of the physical systems that are hosting reference design capabilities. Allowed commands can also be identified to further control administrator actions.	PR.AC-3: Remote access is managed. PR.AC-4: Access permissions are managed, incorporating the principles of least privilege and separation of duties. PR.PT-3: Access to systems and assets is controlled, incorporating the principle of least functionality. DE.CM-3: Personnel activity is monitored to detect potential cybersecurity events.
Virtual Environment Privileged Access Management	HyTrust Cloud Control	Manages privileged access to the virtual environment (including machines, switches, and host hardware) that host reference design capabilities. Cloud Control is the single portal into which all users with administrator privileges to virtual environment systems must log in; it defines what VMs these administrators are authorized to access based on the user's role and attributes. It logs activity that administrators perform on VMs, but it does not log operations that are performed on the OSs that are installed on those VMs. These logs create an audit trail of privileged user access in the virtual environment that is hosting the reference design capabilities.	PR.AC-3: Remote access is managed. PR.AC-4: Access permissions are managed, incorporating the principles of least privilege and separation of duties. PR.PT-3: Access to systems and assets is controlled, incorporating the principle of least functionality. DE.CM-3: Personnel activity is monitored to detect potential cybersecurity events.

Capability	Specific Product	Function	CSF Subcategories
Log Integrity	Splunk Forwarder	Forwards log information from each reference design capability to the Monitoring capability. This capability encrypts log files before sending them, thereby providing them with both integrity and confidentiality while in transit. If an alternative product were used to instantiate this capability, it could add a time stamp and hash/integrity seal to each log file instead, thereby providing the file with integrity, but not confidentiality, protections. However, if the hash/integrity seal were to continue to be stored with the log file at the Monitoring capability, it would provide a mechanism to detect unauthorized modifications made to the log file while stored there.	PR.DS-6: Integrity checking mechanisms are used to verify software, firmware, and information integrity. PR.DS-6: Integrity checking mechanisms are used to verify software, firmware, and information integrity. PR.PT-1: Audit/log records are determined, documented, implemented, and reviewed in accordance with policy. DE.AE-3: Event data are aggregated and correlated from multiple sources and sensors. PR.DS-2: Data-in-transit is protected.

6.5.1 Securing New Attack Surfaces

The reference design introduces new capabilities into the enterprise, and with any new capability comes the potential for new attack surfaces. Implementation of this reference architecture necessitates securing potential attack surfaces. To safeguard the internal systems covered under the proposed ARM system, the following steps can be taken:

1. ***Points of entry.*** The reference design enables employee access to be enabled, modified, and disabled from a single management system that provisions user access information changes to all directories within the enterprise. To prevent the reference design's converged provisioning capability from being transformed into an advantage for the adversary, the organization must secure logical and physical access to the Policy Management, Policy Administration, and User Access Information Provisioning capabilities, in addition to controlling access to the individual directories themselves.
2. ***Disabling monitoring.*** Consistency between the contents of this virtual directory and each of the individual physical directories is used to determine if any changes were made to the contents of the directories (and therefore unable to send log messages documenting these changes to the Security Monitoring capability). To ensure the reference design's Security Monitoring capability receives the proper log messages from the VDS, prevent unauthorized access to the VDS.
3. ***Sabotaging detection.*** Aggregation of user access information and logs in the Security Monitoring capability provides enormous potential in terms of anomaly detection. To prevent malicious changes to the security logs within the Security Monitoring capability, ensure unauthorized access to its contents is blocked.

6.5.1.1 Securing Access to the Policy Administration Capability

User access information changes are not typically made from within any user accounts on the Policy Administration capability, which could be misused to cause the unauthorized modification of user access information or workflows. Typically, user access information changes are initiated via a bulk update from a human resource system. User access information updates are input via .csv files that the Policy Administration capability receives from the HR system. HR administrators who are authorized to do so create .csv files and feed them into the Policy Administration capability. By policy, workflows, which are essentially business process rules that can be defined to enforce access (and other) policy, should be established to ensure that no single HR administrator can perform updates in isolation. Workflows based on the principles of least privilege and separation of duties should be defined that ensure that before updates are performed, multiple HR administrators and or multiple administrative approvals must be received. It should not be possible to submit a fake, unauthorized .csv file to the Provisioning capability; the Provisioning capability should only accept .csv files from the HR system with appropriate approvals in the context of a defined workflow.

6.5.1.2 Securing Access to the Policy Management Capability

The ability to create and modify user access policies within the Policy Management capability must also be carefully controlled. By policy, workflows should be established to ensure that no single administrator can create or modify policies in isolation. Workflows based on the principles of least privilege and separation of duties should be defined to ensure that before updates are performed, multiple administrators and or multiple administrative approvals must be received. It should not be possible to submit policies that have not been properly vetted and approved in the context of a defined workflow.

6.5.1.3 Securing Access to the User Access Information Provisioning Capability

The User Access Information Provisioning capability initiates provisioning activity on the various directories based on input that is received at the Policy Administration and Policy Management capabilities and that propagates to the User Access Information Provisioning capability. The provisioning capability should not accept direct input from any source other than the Policy Administration capability.

6.5.1.4 Securing Access to the Security Monitoring and Analytics Capability

If an adversary could modify the contents of the Monitoring capability without detection, it is essentially "game over" with respect to the ability of the reference design to monitor all access rights changes. By policy, only security analysts, whose role is to be notified of alerts and examine the logs pertinent to those alerts to determine if there is a genuine security event, should be able to view logs, and the logs should be only accessible via read-only access. Workflows based on the principles of least privilege and separation of duties should be defined to ensure that before any changes to the monitoring analytics are performed, multiple administrators and or multiple administrative approvals are received. It should not be possible to create or modify analytics that have not been properly vetted and approved.

As with other reference design capabilities, both policy and the fact that the Monitoring capability's console password is secured across multiple vaults should help ensure that the only way privileged users can access the Monitoring capability for administration is via the PAM capability. The PAM capability, as has been stated, logs all privileged activity that is performed on the Monitoring capability. However, it sends these logs to the Monitoring capability. If an inside adversary can misuse his or her privileges on the Monitoring capability to compromise that capability, it is likely that he or she can also configure the Monitoring capability to ignore, delete, or modify the logs that it receives from the PAM documenting this nefarious activity. To truly protect the Monitoring capability, it would be necessary to ensure that all PAM logs of activity performed on the Monitoring capability are sent to a separate "monitor of monitors" capability, rather than to the Monitoring capability. Such protection against privileged access management abuse is important, but it is not addressed in the reference design.

6.5.2 Ensuring Information Integrity

As mentioned earlier, access to each reference design capability must be secured to prevent unauthorized modification or deletion of access policies, user access information, and analytics information that is stored in these capabilities. In addition to preventing access to this information while it is stored in these capabilities, the information must be protected from modification while it is in transit between reference design capabilities. If user access or policy information were to be deleted, modified, or falsified while in transit between capabilities, the result would be a loss of confidence in the access authorization and authentication of users. It is essential that the user access and policy information have at least its integrity and ideally its confidentiality protected when in transit between capabilities. Securing communications among all capabilities is essential to securing the reference design. To provide this protection, all information sent to and from directories and the VDS is encrypted using the transport layer security (TLS) protocol.

All logs sent within the reference design are encrypted in transit to ensure the confidentiality and integrity of the log information while it is in transit from the reference design capability that is the source of the log to the Monitoring capability. Once the log file is transmitted to the Monitoring capability, it is stored in the clear (i.e., in plaintext form), where it would be vulnerable to modification or deletion if an adversary were somehow able to gain unauthorized access to the Monitoring capability.

6.5.3 Privileged Access Management

Ideally, as a basic security principle, the privileged user access information that is consulted to manage access to the reference design (i.e., to manage privileged access to reference design capabilities and the information they contain) should not be provisioned, stored, or managed by the reference design itself. Access information for privileged users should be managed by a system separate from the reference design, and all privileged access should be monitored and logged for auditing and accountability purposes. The responsibilities of controlling access to reference design capabilities and monitoring and logging privileged actions performed on these capabilities fall under the discipline of PAM.

6.5.3.1 Privileged Users

The access rules defined within the reference design should incorporate the principles of least privilege and separation of duties. Users should be given the authority to access only those resources that they need to access to fulfill their duties, and nothing more. As a result, unprivileged users can log in to their desktops and access specific resources on the production network that they need to do their jobs, but they are not authorized to log in to any of the capabilities in the reference design.

We would expect any organization that adopts the reference design to have several classes of privileged users who are authorized to access reference design capabilities or the machines on which they are running for the purposes of administering those capabilities and machines.

6.5.3.2 Insider Threat

The reference design securely provisions and stores user access information for unprivileged users, thereby ensuring that if an adversary gains insider access to the organization as an unprivileged user, the damage that he will be able to do will be restricted to only those resources to which his role gives him access and limited by what he is authorized to do with those resources. As an unprivileged employee, he will not have access to reference design capabilities or to the information stored on them, so the reference design itself should be secure from an unprivileged insider threat. The extent to which the reference design is protected against a privileged insider threat, however, depends on the privileged access management solution with which the reference design is integrated. Although comprehensive mitigation of the privileged insider threat is important, privileged access management is not addressed in this document.

6.5.3.3 Privileged User Access Information Storage

As mentioned earlier, the reference design includes PAM mechanisms for demonstration purposes, but these mechanisms are not intended to provide a comprehensive PAM solution. In particular, as one shortcut, the reference design stores the user access information that is consulted to determine who has privileged access to the PAM in the reference design itself (i.e., in the AD directory), rather than in a separate system for privileged user access information. This means that when a user logs in to the PAM capability, for example, the AD directory is consulted to determine if that user should be granted access and what privileges he or she should have. So, it is the contents of the AD that determine whether a user should have access to the PAM capability, but it is the PAM capability that determines whether a user should have the privilege to modify the content of the AD. As a result of this cyclical dependency, the Console Administrator for the AD directory could, in theory, log in to the console of the machine hosting the AD directory and add the necessary account and attribute information required to give himself PAM privileges that would enable him to access to all reference design machines via the PAM. It should be noted that the reference solution would detect these particular attacks because the Monitoring capability would generate an alert when it receives logs indicating that AD directory modifications occurred, when it does not receive corresponding logs from other reference design capabilities. In addition, policy and workflow precautions, such as requiring multiple parties to agree to changes to privileged accounts, could be implemented to try to mitigate the threat of such privilege escalation attacks. Solving these types of insider threats in general is beyond the scope of the reference design. However, they demonstrate the importance of integrating the reference design with a comprehensive PAM solution.

6.5.4 Isolating Reference Design Capabilities from Each Other

As mentioned earlier, each of the following sets of reference design capabilities is situated on its own separate subnetwork to isolate these capabilities from each other:

- Policy Administration, Policy Management, User Access Information Provisioning, and Virtual Directory capabilities
- Security Monitoring and Analytics capability and Privileged Access Management capability
- Virtual Environment Privileged Access Management capability
- Directories

Each of the reference design subnetworks is also isolated, via subnetting, from the enterprise's production network (backbone network).

Each subnetwork is separated from the rest of the reference design by a firewall that is configured to restrict the type of data that flow into and out of the subnetwork to the minimum set of necessary protocols. The ports and protocols to which each firewall restricts access are documented in NIST SP 1800-9C: *How-To Guides*.

6.5.4.1 Addressing Attacks

We used the Adversarial Tactics, Techniques, and Common Knowledge (ATT&CK™) model and framework developed by The MITRE Corporation to identify the following adversary tactics and techniques that the reference design protects against:

- Privilege escalation results when an adversary obtains a higher level of permissions on a system or network than he is authorized to have.
  - An adversary employing the tactic of privilege escalation might use the technique of trying to modify his user access information attributes that are stored in the enterprise directories so that these attributes permit him to have more access authority than he is entitled.

    The reference design protects against privilege escalation through its use of logging and monitoring, which enables it to detect unauthorized changes in user attribute information.
  - Alternatively, an adversary attempting to achieve privilege escalation could use the technique of creating an account for a new (nonexistent) user in one of the enterprise's directories and giving that new user the desired higher level of privileges.

    If such an account is created in a directory directly rather than being provisioned via the Policy Administration and Provisioning capabilities, the Security Monitoring capability is designed to detect that the account was not created using the converged provisioning system and generate an alert.
- Credential access results when an adversary obtains access to enterprise resources that he is not authorized to access. An adversary employing the tactic of credential access could use the technique of trying to obtain legitimate user credentials that belong to another user by eavesdropping on these credentials as they are sent to and from directories in the network.

The reference design protects against credential access through its use of LDAPS (secure socket layer-based encrypted traffic between LDAP servers and clients), which prevents the network from sniffing another user's credentials.

6.5.5 Deployment Recommendations

When deploying the reference design in an operational environment, organizations should follow security best practices to address potential vulnerabilities and ensure that all assumptions on which the solution relies are valid to minimize any risk to the production network. Organizations leveraging the reference design should adhere to the following list of recommended best practices that are designed to reduce risk. Note that the laboratory instantiation of the reference design did not implement every security recommendation. They should not, however, consider this list to be comprehensive; merely following this list will not guarantee a secure environment. Planning for deployment of the design gives an organization the opportunity to go back and audit the access control information in their directories and get a more global, correlated, disambiguated, view of the user access roles and attributes that are currently in effect.

6.5.5.1 Patch, Harden, Scan, and Test [5]

- Keep OSs up to date by patching, version control, and monitoring indicators of compromise (e.g., performing virus and malware detection as well as keeping anti-virus signatures up to date).
- Harden all capabilities: all capabilities should be deployed on securely configured OSs that use long and complex passwords and are configured according to best practices.
- Scan OSs for vulnerabilities.
- Test individual capabilities to ensure that they provide the expected CSF subcategory support and that they do not introduce unintended vulnerabilities.
- Evaluate reference design implementations before going operational with them.

6.5.5.2 Other Security Best Practices [6]

- Install, configure, and use each capability of the reference design according to the capability vendor's security guidance.
- Change the default password when installing software.
- Identify and understand which pre-defined administrative and other accounts each capability comes with by default to eliminate any inadvertent back doors into these capabilities. Disable all unnecessary pre-defined accounts and, even though they are disabled, change their default passwords (just in case some future patch to the capability enables these accounts).

- Segregate reference design capabilities onto their own subnetwork, separate from the production network, either physically or by using virtual private networks and port-based authentication or similar mechanisms.
- Protect the various reference design subnetworks from each other and from the production network using security capabilities such as firewalls and intrusion detection devices that are configured according to best practices.
- Configure firewalls to limit connections between the reference design network and the production network, except for connections needed to support required internetwork communications to specific IP address and port combinations in certain directions.
- Configure and verify firewall configurations to ensure that data transmission to and from reference design capabilities is limited to only those interactions that are needed. All communications that are permitted should be restricted to specific protocols and IP address and port combinations in specific directions.
- Monitor the firewalls that separate the various reference design subnetworks from one another.
- NIST SP 1800-9C: *How-To Guides* contain the firewall configurations that show the rules that were implemented in each of the firewalls for the example implementation. These configurations are provided to enable the reader to reproduce the traffic filtering/blocking that was achieved in the implementation.
- Apply encryption or integrity-checking mechanisms to all information exchanged between reference design capabilities (i.e., to all user access, policy, and log information exchanged) so that tampering can be detected. Use only encryption and integrity mechanisms that conform to most recent industry best practices. Note that in the case of directory reads and writes, protected mode is defined as the use of LDAPS (RFC 2830).
- Strictly control physical access to both the reference design and the production network.
- Deploy a separate, complete system for PAM.
- Deploy a configuration management system to serve as a “monitor of monitors” to ensure that if any changes are made to the list of information logged and reported to the Monitoring Capability or to the analytics in the Monitoring Capability, notifications will be generated. Such a system could also serve to monitor whether reference design Monitoring capabilities such as log integrity capabilities or the Monitoring Capability itself go offline or stop functioning and generate alerts when these capabilities become unresponsive.
- Deploy a system that audits and analyzes directory contents to create a description of who has access to what resources and validate that these access permissions correctly implement the enterprise’s intended business process and access policies.

6.5.5.3 Policy Recommendations

- Define the access policies to enforce the principles of least privilege and separation of duties.

- Equip the Monitoring capability with as complete a set of rules as possible to take full advantage of the ability to identify anomalous situations that can signal a cyber event. Define enterprise-level workflows that include business and security rules to determine each user's access control authorizations and ensure that enterprise access control policy is enforced as completely and accurately as possible.
- Develop an attack model to help determine the types of things that should generate alerts.
- Grant only a very few users (e.g., human resource administrators) the authority to modify (initiate, change, or delete) employee access information. Require the approval of more than one individual to be received to initiate employee access information updates. Log all employee access information modifications that are made. Define workflows to enforce these requirements.
- Grant only a very few users (e.g., access rules administrators) the authority to modify (initiate, change, or delete) access rules. Require the approval of more than one individual to be received to initiate access rule updates. Log all access rule modifications that are made. Define workflows to enforce these requirements.
- Grant only a very few users (e.g., security analyst) the authority to modify (initiate, change, or delete) the analytics that are applied to log information by the Monitoring capability to determine what constitutes an anomaly and generates an alert. Any changes made to the analytics should, by policy, require the approval of more than one individual, and these changes should themselves be logged, with the logs sent to a monitor-of-monitors system other than the Monitoring Capability and to all security analysts and other designated individuals. Define workflows to enforce these requirements.

6.5.5.4 Privileged Access Recommendations [7]

- Deploy a separate, complete system for privileged access management.
- Limit the number of privileged accounts on reference design capabilities to one or two specific console administrators (if the capability is on a physical machine) or virtual administrators (if the capability is virtual) and a backup administrator account. Limit the number of persons who serve as console administrator for more than one capability.
- Require all users logging in to any reference design capability to do so via the PAM (to ensure that all privileged user activity is logged and that these logs will be sent to the Monitoring capability). Forbid all reference design capabilities from having their consoles accessed directly in a way that bypasses the PAM.
- Ensure that any administrative changes to the PAM (i.e., the creation of any new privileged user accounts, the modification of privileges in privileged user accounts, or a change to the list of PAM activity that is logged) require, by policy, the approval of more than two individuals. Also, ensure that all administrative changes to the PAM are logged and will generate notifications.

- Require the PAM and VE PAM consoles to be accessed in person rather than permitting them to be accessed remotely.
- Configure the PAM to have an always-on connection to all devices in the reference design so that it can monitor each device's console port. This configuration ensures that all activity performed over the console port will be logged for monitoring and audit purposes. Configure the PAM such that if it's always-on connection to any device is disconnected, an alert is generated. This configuration ensures that security auditors can be aware of any times during which the console port of a device might have been accessed without the activity being logged or monitored.

6.6 Security Evaluation Summary

The security benefits of the reference design include:

- converged management of user access information and policy
- user access information provisioning that is governed by documented and repeatable business processes (workflows)
- rapid provisioning and de-provisioning using consistent, efficient, and automated processes
- centralized log storage to support the ability to apply monitoring and analytics across capabilities to detect potential security events, as well as to easily track and audit all user access information and policy changes, provisioning requests, and directory modifications.

These convergence, automation, and monitoring capabilities increase the security of organizations that adopt the reference design.

Automation of the administration and provisioning of user access information enables efficient, quick, and consistent enforcement of the principles of least privilege and separation of duties with respect to the access authority granted to each enterprise user. By performing administration and provisioning automatically, the reference design eliminates the need for individuals or groups of system administrators to manually modify, monitor, or audit the content of each of the enterprise's directories. Such automation improves security by reducing the possibility of human error being introduced during these processes. It ensures that when users are added or removed, or their responsibilities and the things they are authorized to do change, the modifications that need to be made to the user access information that determines what systems they have access to, when they have access to them, and what they can do on those systems can be provisioned from a single, converged location that automatically propagates these changes to all directories throughout the enterprise. These access information changes can be provisioned accurately and consistently throughout the enterprise instantaneously, ensuring that each employee's access permissions are synchronized across all enterprise directories. These capabilities help to reduce the so-called privilege creep that sometimes occurs as a user's role changes, and he or she is given access to additional systems without necessarily having his or her previous access privileges reduced or modified accordingly. Privilege creep can create

opportunities for insider threat attacks. These capabilities also help to reduce the possibility that a user's access permissions become inconsistent across directories.

The reference design also automatically monitors changes to the content of each directory and supports an audit system by sending logs from all reference design capability to a single location (the Monitoring capability). Consolidation of logs from all reference design capabilities at the Monitoring capability enables the reference design to correlate the logs of updates made to each enterprise directory with logs from the policy administration and provisioning capabilities and from the VDS in a way that is not possible when the logs generated by these capabilities are not consolidated at a single location. This consolidation enables the reference design to ensure that access information updates that are made to the enterprise's directories are in fact the result of personnel status information modifications input by HR, defined and approved according to business workflow rules and access policy, and provisioned via the reference design.

Use of the Monitoring capability has the potential to help eliminate access policy inconsistencies that could result from human error, as well as to detect security incidents that may be the result of a deliberate attack. Log consolidation, combined with the ability to monitor and apply analytics to the logs generated by all reference design capabilities, makes it possible for the reference design to automatically detect anomalous situations that can indicate a security breach that would be more difficult, if not impossible, to detect at any single user access information directory being considered in isolation. In addition, although it does not include an audit solution, the reference design enables access-related audits to be performed easily and efficiently by aggregating all log information in the Monitoring capability.

As with any solution, the reference design introduces new capabilities to the enterprise, and with any new capabilities come new threat surfaces. However, these threats can be mitigated using mechanisms designed to secure access to the new capabilities and to the user access information and logs that they exchange and store. In addition, the reference design's security monitoring and analytics capability also helps mitigate threats by systematically subjecting the logs from all reference design capabilities to anomaly detection analytics that ensure the authenticity of all directory entries and updates.

7 Functional Evaluation

We conducted a functional evaluation of the ARM example implementation, as implemented in our laboratory, to verify that it worked as expected. The evaluation verified that the example implementation could perform the following functions:

- Assign and provision access information to directories based on a set of organizational access policy rules.
- Create, modify, and deactivate/delete users in directories.
- Detect changes to user access information within directories.
- Generate a security alert when it detected anomalous activity—specifically, when it detected changes to any directory without also receiving logs corresponding to these changes from all other expected ARM capabilities.

Section 7.1 describes the format and components of the functional test cases. Each functional test case is designed to assess the capability of the example implementation to perform the functions listed above and detailed in the ARM use case requirements in Section 7.2. SharePoint is used for demonstration and testing purposes to simulate application and data resources for which access is managed. Access is controlled via attributes and group membership information stored in the directories.

7.1 ARM Functional Test Plan

This test plan includes the test cases necessary to conduct the functional evaluation of the ARM example implementation. The ARM example implementation is currently deployed in a lab at the NCCoE. The implementation tested is described in Section 5.

Each test case consists of multiple fields that collectively identify the goal of the test, the specifics required to implement the test, and how to assess the results of the test. Table 7-1 provides a template of a test case, including a description of each field in the test case

Table 7-1 Test Case Fields

Test Case Field	Description
Parent requirement	Identifies the top-level requirement or the series of top-level requirements leading to the testable requirement.
Testable requirement	Drives the definition of the remainder of the test case fields. Specifies the capability to be evaluated.
Associated Security Controls	The NIST SP 800-53 Rev. 4 controls addressed by the test case.
Description	Describes the objective of the test case.
Associated test cases	In some instances, a test case may be based on the outcome of another test case(s). For example, analysis-based test cases produce a result that is verifiable through various means (e.g., log entries, reports, and alerts).
Preconditions	The starting state of the test case. Preconditions indicate various starting state items, such as a specific capability configuration required or specific protocol and content.
Procedure	The step-by-step actions required to implement the test case. A procedure may consist of a single sequence of steps or multiple sequences of steps (with delineation) to indicate variations in the test procedure.
Expected results	The expected results for each variation in the test procedure.
Actual results	The observed results.
Overall result	The overall result of the test as pass/fail. In some test case instances, the determination of the overall result may be more involved, such as determining pass/fail based on a percentage of errors identified.

7.2 ARM Use Case Requirements

Table 7.2 identifies the ARM functional evaluation requirements that are addressed in this test plan and their associated test cases. The teller application access attribute is held in the OpenLDAP directory and the loan application access attribute is held in Active Directory. These applications will be referenced throughout the test plans to verify directory modifications. The NCCoE does not have a mainframe application that can be used for testing. Therefore, verification of RACF changes will be done manually through inspection of the directory contents.

1509 **Table 7-2 ARM Functional Requirements**

Capability Requirement (CR) ID	Parent Requirement	Sub-requirement 1	Sub-requirement 2	Test Case
CR 1	The ARM example implementation shall include an ARM workflow capability that can create users with policy-driven attributes and group memberships in the following directories:			
CR 1.a		Active Directory		ARM-1
CR 1.b		OpenLDAP		ARM-1
CR 1.c		RACF (via Vanguard)		ARM-1
CR 2	The ARM example implementation shall include an ARM workflow capability that can deactivate users in the following directories:			
CR 2.a		Active Directory		ARM-2
CR 2.b		OpenLDAP		ARM-2
CR 2.c		RACF (via Vanguard)		ARM-2
CR 3	The ARM example implementation shall include a workflow capability that can change an existing user's attributes and group memberships in the following directories:			
CR 3.a		Active Directory		ARM-3
CR 3.b		OpenLDAP		ARM-3
CR 3.c		RACF (via Vanguard)		ARM-3

Capability Requirement (CR) ID	Parent Requirement	Sub-requirement 1	Sub-requirement 2	Test Case
CR 4	The ARM example implementation shall include a security Monitoring capability that can detect changes to user attributes and group memberships in the following:			
CR 4.a		Active Directory (AD) via logs from:		
CR-4.a.1			AD	ARM-4
CR-4.a.2			Radiant Logic	ARM-4
CR-4.a.3			AlertEnterprise	ARM-4
CR 4.b		OpenLDAP via logs from:		
CR-4.b.1			OpenLDAP	ARM-4
CR-4.b.2			Radiant Logic	ARM-4
CR-4.b.3			AlertEnterprise	ARM-4
CR 4.c		RACF via logs from:		
CR-4.c.1			Vanguard	ARM-4
CR-4.c.2			Radiant Logic	ARM-4
CR-4.c.3			AlertEnterprise	ARM-4
CR 5	The ARM example implementation shall include a security Monitoring capability that will generate			

Capability Requirement (CR) ID	Parent Requirement	Sub-requirement 1	Sub-requirement 2	Test Case
	an alert based on pre-defined anomalous (logged) activity for the following use cases:			
CR 5.a		Active Directory user changes with no correlated log received from:		ARM-5
CR-5.a.1			AD	ARM-5
CR-5.a.2			Radiant Logic	ARM-5
CR-5.a.3			AlertEnterprise	ARM-5
CR 5.b		OpenLDAP user changes with no correlated log received from:		
CR-5.b.1			OpenLDAP	ARM-5
CR-5.b.2			Radiant Logic	ARM-5
CR-5.b.3			AlertEnterprise	ARM-5
CR 5.c		RACF (Vanguard) user changes with no correlated log received from:		
CR-5.c.1			RACF (Vanguard)	ARM-5

Capability Requirement (CR) ID	Parent Requirement	Sub-requirement 1	Sub-requirement 2	Test Case
CR-5.c.2			Radiant Logic	ARM-5
CR-5.c.3			AlertEnterprise	ARM-5

7.3 Test Case: ARM-1

Table 7-3 Test Case ID: ARM-1

Parent requirement	(CR 1) The ARM example implementation shall include an ARM workflow capability that can create users with policy-driven attributes and group memberships in the following directories.
Testable requirement	(CR 1.a) Active Directory, (CR 1.b) OpenLDAP, (CR 1.c) RACF
Description	Show that the ARM example implementation can create users in the various directories with the appropriate access and permissions.
Associated test cases	N/A
Associated CSF Subcategories	PR.AC-1, PR.AC-4
Preconditions	HR representative .csv file is available. ARM example implementation is implemented and operational in the lab environment. Standard and privileged user sets are known to the testers. Privileged users are provisioned directly within the ConsoleWorks and HyTrust applications. A set of directories: AD, OpenLDAP and RACF (Vanguard) are operational.
Procedure	Activate ARM workflow engine and run command to read the HR .csv file. Verify that the AlertEnterprise system successfully processes the data. Query the directories to determine if the users are provisioned to the directories with the correct group memberships and attributes as specified by the .csv file. Query the Vanguard RACF system to verify that users are correctly provisioned as expected from the information included in the HR .csv file. At a workstation on the user network, attempt to log in to the teller application as a user known to have access to the teller application. The teller application control attribute is contained in the OpenLDAP directory. At a workstation on the user network, attempt to log in to the loan application as a user known to have access to the loan application. The loan application control attribute is contained in the AD directory.

	At a workstation on the user network, attempt to log in to the teller application as a user known to not have access to the teller application. At a workstation on the user network, attempt to log in to the loan application as a user known to not have access to the loan application.
Expected Results (pass)	Access Allowed (CR 1.a-c) Users with allowed access can log in to loan and teller demo applications. Access Denied (CR 1.a-c) Users without allowed access are unable to log in to loan and teller demo applications.
Actual Results	(example text) This system functioned appropriately and provided the expected results. Users that are known to not have access were unable to log in to the applications. Users that are known to have access to each application were allowed access.
Overall Result	Pass/Fail (with comments)

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7.4 Test Case ARM-2

Table 7-4 Test Case ID: ARM-2

Parent requirement	(CR 2) The ARM example implementation shall include an ARM workflow capability that can deactivate users in the following directories:
Testable requirement	(CR 2.a) Active Directory, (CR 2.b) OpenLDAP, (CR 2.c) RACF
Description	Show that the ARM solution can deactivate users in the appropriate directories.
Associated test cases	n/a
Associated CSF Subcategories	PR.AC-1, PR.AC-4
Preconditions	Successful completion of Test Case ARM-1. Create a new HR dataset that deactivates several users in each directory.
Procedure	Perform Test Case ARM-1 to ensure that user accounts have been created in the directories Read the new HR dataset (described in the pre-conditions) by AlertEnterprise. Verify that the AlertEnterprise system successfully processes the data. Query the directories to determine if the user changes are correctly provisioned to the directories. (deactivated) At a workstation on the user network, attempt to log in to the teller application as a user known to previously have had access to the teller application. (successful attempt in ARM-1). At a workstation on the user network, attempt to log in to the loan application as a user known to previously have had access to the loan application. (successful attempt in ARM-1). Query the Vanguard RACF system to verify the users are correctly deactivated as expected from the information included in the HR .csv file.
Expected Results (pass)	User accounts within the directories are deactivated preventing users from gaining access to resources. (CR 2.a-c)
Actual Results	(CR-2) The ARM example implementation shall include an ARM workflow capability that can deactivate users in the following directories: (CR 2.a) Active Directory: Users that previously had an active account are now in a deactivated account status.

	(CR 2.b) OpenLDAP: Users that previously had an active account are now in a deactivated account status. (CR 2.c) RACF: Users that previously had an active account are now in a deactivated account status.
Overall Result	Pass/Fail (with comments)

7.5 Test Case ARM-3

Table 7-5 Test Case ID: ARM-3

Parent requirement	(CR 3) The ARM example implementation shall include a workflow capability that can change an existing user's attributes and group memberships within the following directories.
Testable requirement	(CR 3.a) Active Directory, (CR 3.b) OpenLDAP, (CR 3.c) RACF
Description	Show that the ARM solution can change user attributes and group memberships within directories.
Associated test cases	CR 1
Associated CSF Subcategories	PR.AC-1, PR.AC-4
Preconditions	Reuse ARM example implementation in the state after ARM-1 is completed. Create a new HR dataset that makes changes to the access permissions to the users in the original dataset. Change allowed to denied and denied to allow for all the users in the dataset.
Procedure	Operate the example implementation to read the new HR file. Choose a set of users with known access and a set of users without access for each of the loan, teller systems, and Vanguard RACF attribute. Use the ARM workflow to deny access for the set of users with known access chosen in 1 above. Use the ARM workflow to allow access for the set of users known to not have access chosen in 1 above. Process the HR dataset with the AlertEnterprise system. Verify that the AlertEnterprise successfully processes the dataset. At a workstation on the user network, attempt to log in to the teller application as a user known (from ARM-1) to have access to the teller application. At a workstation on the user network, attempt to log in to the loan application as a user known (from ARM-1) to have access to the loan application. At a workstation on the user network, attempt to log in to the teller application as a user known (from ARM-1) to not have access to the teller application. At a workstation on the user network, attempt to log in to the loan application as a user known (from ARM-1) to not have access to the loan application.

	Query the Vanguard RACF system to verify the user accesses are correctly changed as expected from the information included in the HR .csv file.
Expected Results (pass)	(CR 3) The ARM example implementation shall include an ARM workflow capability that can change user attributes and group memberships in the following directories: (CR 3.a) Active Directory: Users that had previously had access to the loan application (from ARM-1) no longer have access. Users that had previous not had access to the teller application (from ARM-1) now do have access. (CR 3.b) OpenLDAP: Users that had previously had access to the teller application (from ARM-1) no longer have access. Users that had previous not had access to the loan application (from ARM-1) now do have access. (CR 3.c) RACF: User accesses are changed as expected.
Actual Results	This system functioned appropriately and provided the expected results. (CR 3) The ARM example implementation can change user attributes and group memberships in the following directories: (CR 3.a) Active Directory: Users that had previously had access to the loan application (from ARM-1) no longer have access. Users that had previous not had access to the teller application (from ARM-1) now do have access. (CR 3.b) OpenLDAP: Users that had previously had access to the teller application (from ARM-1) no longer have access. Users that had previous not had access to the loan application (from ARM-1) now have access. (CR 3.c) RACF: User accesses changed as expected.
Overall Result	Pass/Fail (with comments)

7.6 Test Case ARM-4

Table 7-6 Test Case ID: ARM-4

Parent requirement	(CR 4) The ARM example implementation shall include a security monitoring capability that can detect changes to user attributes and group memberships in the following:
Testable requirement	(CR 4.a) Active Directory (CR-4.a.1) AD, (CR-4.a.2) Radiant Logic, (CR-4.a.3) AlertEnterprise (CR 4.b) OpenLDAP (CR-4.b.1) AD, (CR-4.b.2) Radiant Logic, (CR-4.b.3) AlertEnterprise (CR 4.c) RACF (CR-4.c.1) AD, (CR-4.c.2) Radiant Logic, (CR-4.c.3) AlertEnterprise
Description	Show that the ARM solution can detect when user changes occur within the directories.
Associated test cases	CR 1
Associated CSF Subcategories	DE.AE-1, DE.AE-3, DE.AE-5
Preconditions	Reuse ARM example implementation in the state after ARM-1 is completed.
Procedure	Process the HR dataset from Test Case 3 (the one that changes user access information in each of the directories). Check the security monitoring system to verify that the changes made are reported via logs from each of these systems for a change that occurs to a user in AD: AD, Radiant Logic, and AlertEnterprise. Check the security monitoring system to verify that the changes made are reported via logs from each of these systems for a change that occurs to a user in OpenLDAP: OpenLDAP, Radiant Logic, and AlertEnterprise. Check the security monitoring system to verify that the changes made are reported via logs from each of these systems for a change that occurs to a user in RACF (Vanguard): RACF (Vanguard), Radiant Logic, and AlertEnterprise.
Expected Results (pass)	(CR 4) The ARM security monitoring system receives and stores the logs indicating changes to the following directories: (CR 4.a) Active Directory from (CR-4.a.1) AD, (CR-4.a.2) Radiant Logic, (CR-4.a.3) AlertEnterprise (CR 4.b) OpenLDAP from (CR-4.b.1) OpenLDAP, (CR-4.b.2) Radiant Logic, (CR-4.b.3) AlertEnterprise

	(CR 4.c) RACF (Vanguard) from (CR-4.c.1) Vanguard, (CR-4.c.2) Radiant Logic, (CR-4.c.3) AlertEnterprise
Actual Results	This system functioned appropriately and provided the expected results. (CR 4) The ARM security monitoring system receives and stores the logs indicating changes to the following directories: (CR 4.a) Active Directory from (CR-4.a.1) AD, (CR-4.a.2) Radiant Logic, (CR-4.a.3) AlertEnterprise (CR 4.b) OpenLDAP from (CR-4.b.1) OpenLDAP, (CR-4.b.2) Radiant Logic, (CR-4.b.3) AlertEnterprise (CR 4.c) RACF (Vanguard) from (CR-4.c.1) Vanguard, (CR-4.c.2) Radiant Logic, (CR-4.c.3) AlertEnterprise
Overall Result	Pass/Fail (with comments)

7.7 Test Case ARM-5

Table 7-7 Test Case ID: ARM-5

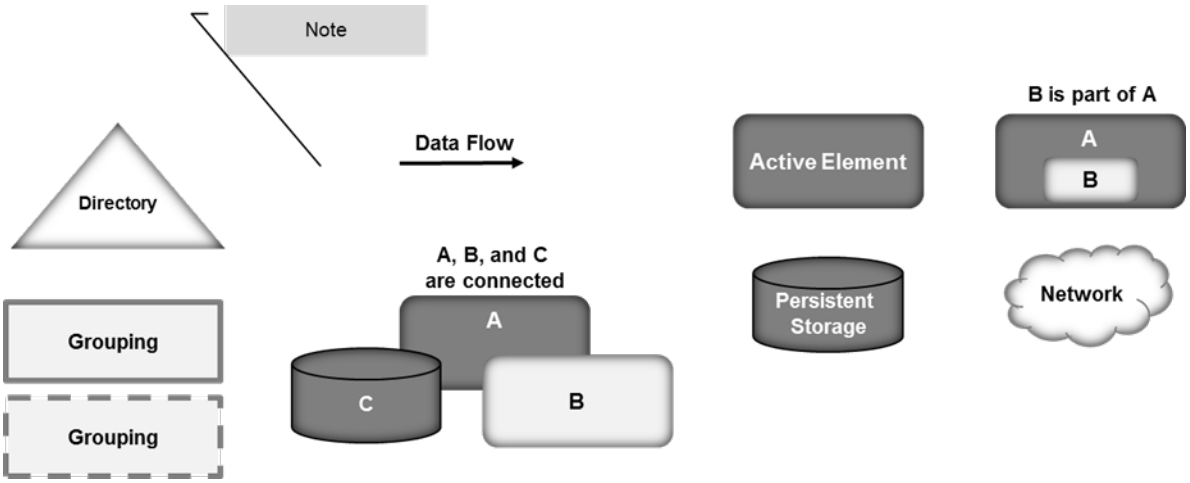
Parent requirement	(CR 5) The ARM example implementation shall include a security monitoring capability that will generate an alert based on pre-defined anomalous (logged) activity for the following use cases:
Testable requirement	(CR 5.a) Active Directory user changes with no correlated log received from: (CR-5.a.1) AD, (CR-5.a.2) Radiant Logic, (CR-5.a.3) AlertEnterprise (CR 5.b) OpenLDAP user changes with no correlated log received from: (CR-5.b.1) OpenLDAP, (CR-5.b.2) Radiant Logic, (CR-5.b.3) AlertEnterprise (CR 5.c) RACF (Vanguard) user changes with no correlated log received from: (CR-5.c.1) RACF (Vanguard), (CR-5.c.2) Radiant Logic, (CR-5.c.3) AlertEnterprise
Description	Show that the ARM example implementation can detect when anomalous user changes occur within the directories.
Associated test cases	CR 1
Associated CSF Subcategories	DE.AE-3, DE.AE-5
Preconditions	Reuse ARM example implementation in the state after ARM-1 is completed.
Procedure	Make a change to each of the directories without the AlertEnterprise provisioning system (anomalous activity) or the privileged account management system. This requires a privileged account on each directory system.
Expected Results (pass)	(CR 5) The ARM example implementation shall include a security monitoring capability that will generate an alert based on pre-defined anomalous (logged) activity for the following use cases: Alert generated for each of the following instances: (CR 5.a) Active Directory user changes with no correlated log received from: (CR-5.a.1) AD, (CR-5.a.2) Radiant Logic, (CR-5.a.3) AlertEnterprise (CR 5.b) OpenLDAP user changes with no correlated log received from: (CR-5.b.1) OpenLDAP, (CR-5.b.2) Radiant Logic, (CR-5.b.3) AlertEnterprise (CR 5.c) RACF (Vanguard) user changes with no correlated log received from: (CR-5.c.1) Vanguard, (CR-5.c.2) Radiant Logic, (CR-5.c.3) AlertEnterprise

Actual Results	This system functioned appropriately and provided the expected results. (CR 5) The ARM example implementation generates an alert based on pre-defined anomalous (logged) activity for the following use cases: Alert were generated for each of the following instances: (CR 5.a) Active Directory user changes with no correlated log received from: (CR-5.a.1) AD, (CR-5.a.2) Radiant Logic, (CR-5.a.3) AlertEnterprise (CR 5.b) OpenLDAP user changes with no correlated log received from: (CR-5.b.1) OpenLDAP, (CR-5.b.2) Radiant Logic, (CR-5.b.3) AlertEnterprise (CR 5.c) RACF (Vanguard) user changes with no correlated log received from: (CR-5.c.1) Vanguard, (CR-5.c.2) Radiant Logic, (CR-5.c.3) AlertEnterprise
Overall Result	Pass/Fail (with comments)

Appendix A List of Acronyms

AD	Active Directory
ARM	Access Rights Management
CAT	Cybersecurity Assessment Tool
CR	Capability Requirement
CSF	Cybersecurity Framework
.csv	Comma-Separated Value
DNS	Domain Name Service
FFIEC	Federal Financial Institutions Examination Council
FS-ISAC	Financial Sector Information Sharing and Analysis Center
HR	Human Resources
ID	Identity
IP	Internet Protocol
LDAPS	Lightweight Directory Access Protocol Secure
NCCoE	National Cybersecurity Center of Excellence
NIST	National Institute of Standards and Technology
OS	Operating System
PAM	Privileged Account Management
RACF	Resource Access Control Facility
RMF	Risk Management Framework
SIM	Security Information Management
TLS	Transport Layer Security
VE	Virtual Environment
VDS	Virtual Directory System
VLAN	Virtual Local Area Network
VM	Virtual Machine

Appendix B Legend for Diagrams



Appendix C References

[1] J. Saltzer, "Protection and the Control of Information Sharing in Multics," *Communications of the ACM*, 17 (7), 388-402 (1974).

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NIST SPECIAL PUBLICATION 1800-9C

Access Rights Management for the Financial Services Sector

Volume C:
How-to Guides

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DRAFT

This publication is available free of charge from:
https://nccoe.nist.gov/projects/use-cases/access-rights-management

National Institute of Standards and Technology
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Certain commercial entities, equipment, products, or materials may be identified in this document in order to describe an experimental procedure or concept adequately. Such identification is not intended to imply recommendation or endorsement by NIST or NCCoE, nor is it intended to imply that the entities, equipment, products, or materials are necessarily the best available for the purpose.

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FEEDBACK

You can improve this guide by contributing feedback. As you review and adopt this solution for your own organization, we ask you and your colleagues to share your experience and advice with us.

Comments on this publication may be submitted to: financial_nccoe@nist.gov

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All comments are subject to release under the Freedom of Information Act (FOIA).

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The National Cybersecurity Center of Excellence (NCCoE), a part of the National Institute of Standards and Technology (NIST), is a collaborative hub where industry organizations, government agencies, and academic institutions work together to address businesses' most pressing cybersecurity issues. This public-private partnership enables the creation of practical cybersecurity solutions for specific industries or broad, cross-sector technology challenges. Working with technology partners—from Fortune 50 market leaders to smaller companies specializing in IT security—the NCCoE applies standards and best practices to develop modular, easily adaptable example cybersecurity solutions using commercially available technology. The NCCoE documents these example solutions in the NIST Special Publication 1800 series, which maps capabilities to the NIST Cyber Security Framework and details the steps needed for another entity to recreate the example solution. The NCCoE was established in 2012 by NIST in partnership with the State of Maryland and Montgomery County, Md.

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NIST CYBERSECURITY PRACTICE GUIDES

NIST Cybersecurity Practice Guides (Special Publication Series 1800) target specific cybersecurity challenges in the public and private sectors. They are practical, user-friendly guides that facilitate the adoption of standards-based approaches to cybersecurity. They show members of the information security community how to implement example solutions that help them align more easily with relevant standards and best practices and provide users with the materials lists, configuration files, and other information they need to implement a similar approach.

The documents in this series describe example implementations of cybersecurity practices that businesses and other organizations may voluntarily adopt. These documents do not describe regulations or mandatory practices, nor do they carry statutory authority.

ABSTRACT

Managing access to resources (data) is complicated because internal systems multiply and acquisitions add to the complexity of an organization's IT infrastructure. Identity and access management (IdAM) is the set of technology, policies, and processes that are used to manage access to resources. Access rights management (ARM) is the subset of those technologies, policies, and processes that manage the rights of individuals and systems to access resources (data). In other words, an ARM system enables a company to give the right person the right access to the right resources at the right time. The goal of this project is to demonstrate an ARM solution that is a standards-based technical approach to coordinating and automating updates to and improving the security of the repositories (directories) that maintain the user access information across an organization. The coordination improves cybersecurity by ensuring that user access information is updated accurately (according to access policies), including disabling accounts or revoking access privileges as user resource access needs change. Cybersecurity is also improved through better monitoring for unauthorized changes (e.g., privilege escalation). The system executes user access changes across the enterprise according to corporate access policies quickly, simultaneously, and consistently. The ARM reference design and example implementation are described in this NIST Cybersecurity "Access Rights Management" practice guide. This project resulted from discussions among NCCoE staff and members of the financial services sector.

This *NIST Cybersecurity Practice Guide* also describes our collaborative efforts with technology providers and financial services stakeholders to address the security challenges of ARM. It provides a modular, open, end-to-end example implementation that can be tailored to financial services companies of varying sizes and sophistication. The use case scenario that provides the underlying impetus for the functionality presented in the guide is based on normal day-to-day business operations. Though the reference solution was demonstrated with a certain suite of products, the guide does not endorse these specific products. Instead, it presents the NIST Cybersecurity Framework (CSF) core functions and subcategories, as well as financial industry guidelines, that a company's security personnel can use to identify similar standards-based products that can be integrated quickly and cost-effectively with a company's existing tools and infrastructure. Planning for deployment of the design gives an organization the opportunity to review and audit the access control information in their directories and get a more global, correlated, disambiguated view of the user access roles and attributes that are currently in effect.

KEYWORDS

Access; authentication; authorization; cybersecurity; directory; provisioning.

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Hemma Prafullchandra	HyTrust
Roger Wigenstam	NextLabs
Don Graham	Radiant Logic
Adam Cohen	Splunk
Clyde Poole	TDi Technologies
Dustin Hayes	Vanguard Integrity Professionals

The technology vendors who participated in this build submitted their capabilities in response to a notice in the Federal Register. Companies with relevant products were invited to sign a Cooperative Research and Development Agreement (CRADA) with NIST, allowing them to participate in a consortium to build this example solution. We worked with:

Product Vendor	Component Name	Function
AlertEnterprise	Enterprise Guardian	Access policy management, administration and account provisioning system

Product Vendor	Component Name	Function
HyTrust	Cloud Control	Privileged user access controller, monitor, and logging system for VSphere
NextLabs	NextLabs	Attribute based access control interface for SharePoint
Radiant Logic	RadiantOne	Virtual directory system
Splunk	Enterprise	Log aggregation and analytics system
TDi Technologies	ConsoleWorks	Application and operating system privileged user access controller, monitor, and logging system
Vanguard Integrity Professionals	Vanguard	Mainframe RACF to LDAP interface system

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1 Introduction

The NIST Cybersecurity Practice Guide shows IT professionals and security engineers how we implemented this example solution. In Volume C we cover all the products employed in the reference design. We do not re-create the product manufacturers' documentation, which is presumed to be widely available. Rather, these guides show how we incorporated the products together in our environment.

Note: These are not comprehensive tutorials. There are many possible service and security configurations for these products that are out of scope for this example implementation.

1.1 Practice Guide Structure

This NIST Cybersecurity Practice Guide demonstrates a standards-based reference design and provides users with the information they need to replicate this access rights management (ARM) approach. The reference design is modular and can be deployed in whole or in parts.

The guide contains three volumes:

- NIST SP 1800-9a: *Executive Summary* — High-level overview
- NIST SP 1800-9b: Approach, Architecture, and Security Characteristics—What we built and why
- NIST SP 1800-9c: *How-To Guides*—Instructions for building the example implementation **(you are here)**

Depending on your role in your organization, you might use this guide in different ways:

Business decision makers, including chief security and technology officers will be interested in the *Executive Summary (NIST SP 1800-9a)*, which describes the:

- challenges identified by financial services companies
- operational benefits of adopting the solution
- high-level solution description

Technology or security program managers who are concerned with how to identify, understand, assess, and mitigate risk will be interested in the *Approach, Architecture, and Security Characteristics (NIST SP 1800-9b)* part of the guide, which describes what we did and why. The following sections will be of interest:

- Section 3.4.1, Assessing Risk Posture, describes the risk analysis we performed.
- Section 3.4.2, Security Control Map, maps the security functions and control of this example implementation to cybersecurity standards and best practices.

IT professionals who want to implement an approach like this will find the whole Practice Guide useful. The guide's information will provide insight into the resources and skills needed to implement an ARM solution. You can use the How-To portion of the guide, NIST SP 1800-9c (which is this document), to replicate all or parts of the example implementation created in our lab. *NIST SP 1800-9c* provides specific product installation, configuration, and integration instructions for implementing the example implementation. We do not re-create the product manufacturers' documentation, which is generally widely available. Rather, we show how we incorporated the products in our environment to create an example implementation.

The guide assumes that IT professionals have experience implementing security products within the enterprise. Though we have used a suite of commercial products to address the challenge, this guide does not endorse these particular products. Your organization can adopt this solution or one that adheres to these guidelines in whole, or you can use this guide as a starting point for tailoring and implementing parts of the solution. Your organization's security experts should identify the products that will best integrate with your existing tools and IT system infrastructure. We hope you will seek products that are congruent with applicable standards and best practices.

A *NIST Cybersecurity Practice Guide* does not describe "the" solution, but a possible solution. This is a draft guide. We seek feedback on its contents and welcome your input. Comments, suggestions, and success stories will improve subsequent versions of this guide. Please contribute your thoughts to financial_nccoe@nist.gov.

1.2 Build Overview

The build is an example implementation of an access rights management system. The main components of the system include policy management, policy administration, access information provisioning, and security monitoring. In addition to these components, we have included privileged access management to secure the administration of the main components.

Security of the implementation is provided through logging changes to account/access information within the directories, a virtual directory, the policy administration system, and the privileged access management systems. The virtual directory is used to cache (mirror) the contents of the directories by checking for changes every 60 sec. All changes are reported to the security monitoring system immediately. Analytics within the security monitoring system (log collection and monitoring) correlates incoming logs. Security analysts are alerted when the analytics identify potential security events caused by inconsistent logs. Furthermore, the security analysts can drill down and investigate the cause of any alert. The available information within the security monitoring system enables them fully analyze the logs causing the alert and determine a course of action to effectively mitigate the cybersecurity incident. In addition, the directory monitoring provides another tool to monitor for malicious insider activity.

1.3 Typographical Conventions

The following table presents typographic conventions used in this volume.

Typeface/ Symbol	Meaning	Example
Italics	filenames and pathnames references to documents that are not hyperlinks, new terms, and placeholders	For detailed definitions of terms, see the *NCCoE Glossary.*
Bold	names of menus, options, command buttons and fields	Choose **File > Edit**.
`Monospace`	command-line input, on-screen computer output,	`mkdir`

Typeface/ Symbol	Meaning	Example
	sample code examples, status codes	
`Monospace Bold`	command-line user input contrasted with computer output	**`service sshd start`**
blue text	link to other parts of the document, a web URL, or an email address	All publications from NIST's National Cybersecurity Center of Excellence are available at http://nccoe.nist.gov

1.4 Logical Architecture Summary

NIST Special Publication 1800-9b (SP1800-9b) describes an example implementation consisting of user access management (including provisioning) and security monitoring / data collection. SP1800-9b includes a much more detailed description of the architecture for building an instance of the example implementation using commercial products. That architecture is depicted in Figure 1-1 and Figure 1-2.

Figure 1-1 Logical Access Rights Management Lab Build Architecture

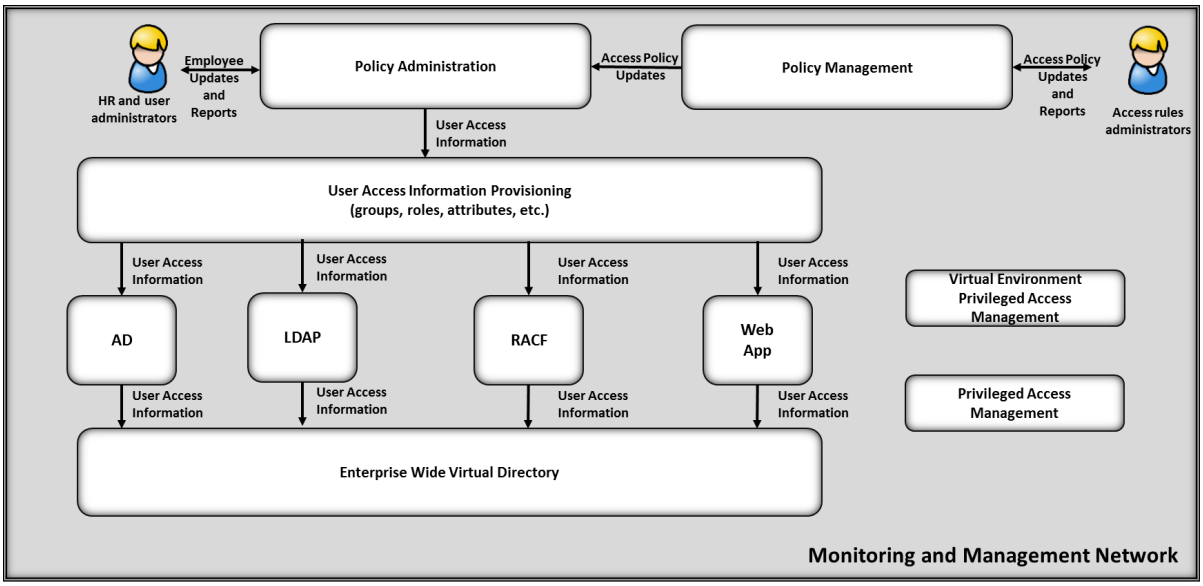
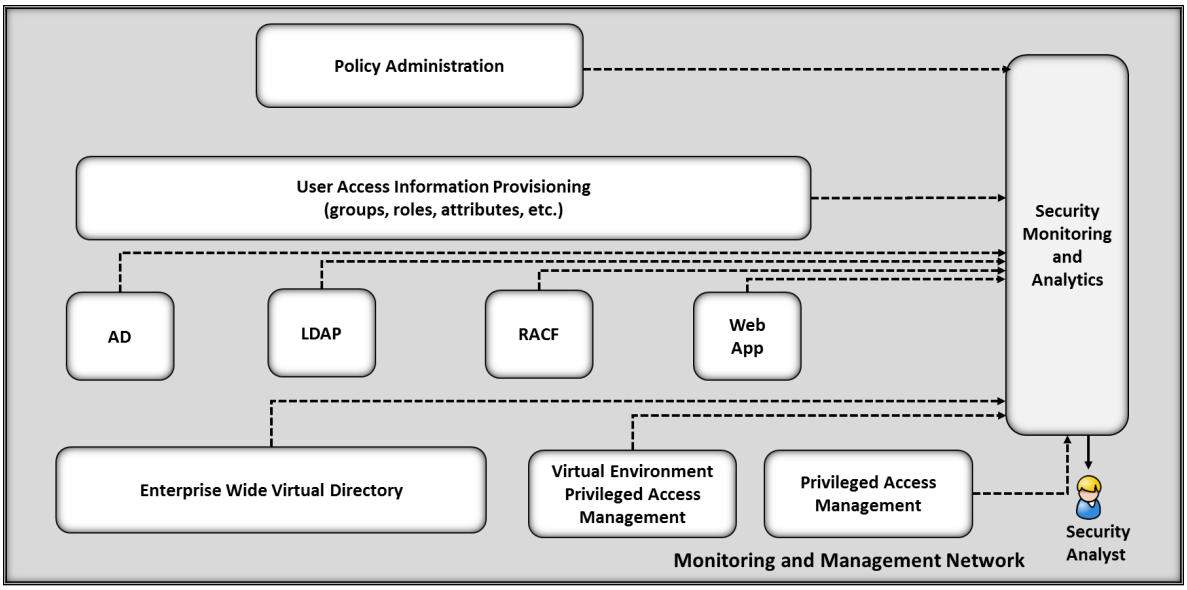


Figure 1-2 Logical Security Log Collection and Monitoring Lab Build Architecture



This volume of the practice guide provides detailed instructions on installing, configuring, and integrating the products used to build an instance of the example solution. The role of each product in the example implementation is described in SP1800-9b, Section 4, Architecture.

1.5 Network Diagrams

The architecture diagrams in the previous section present the logical connections needed among the products used to build an instance of the example implementation. This section describes the virtual environment lab implementation depicting the connectivity among the products.

1.6 NCCoE Lab

Figures 1-3 and Figure 1-4 show the network configurations used in the example implementation.

Figure 1-3 NCCoE Lab Networking Diagram

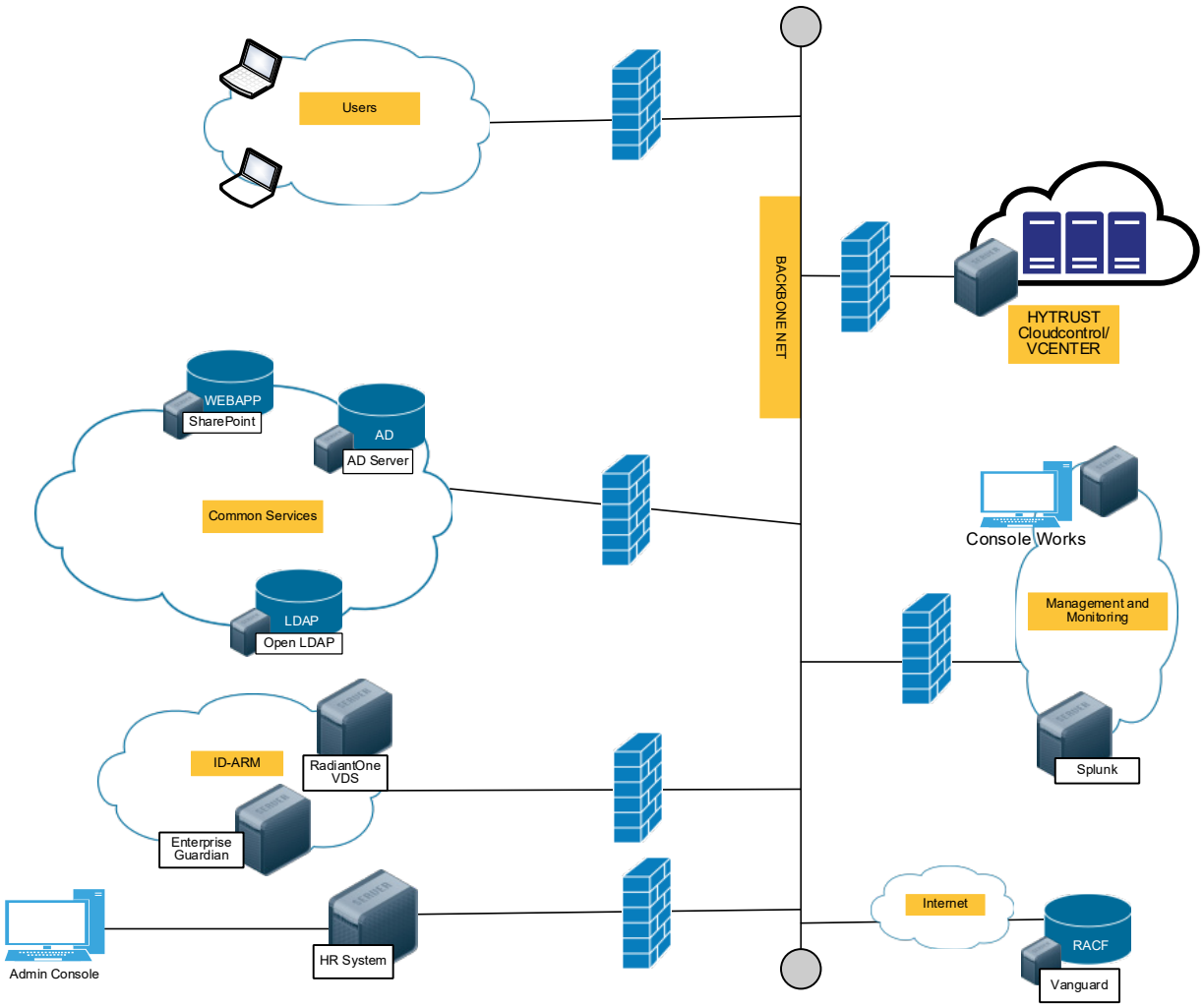
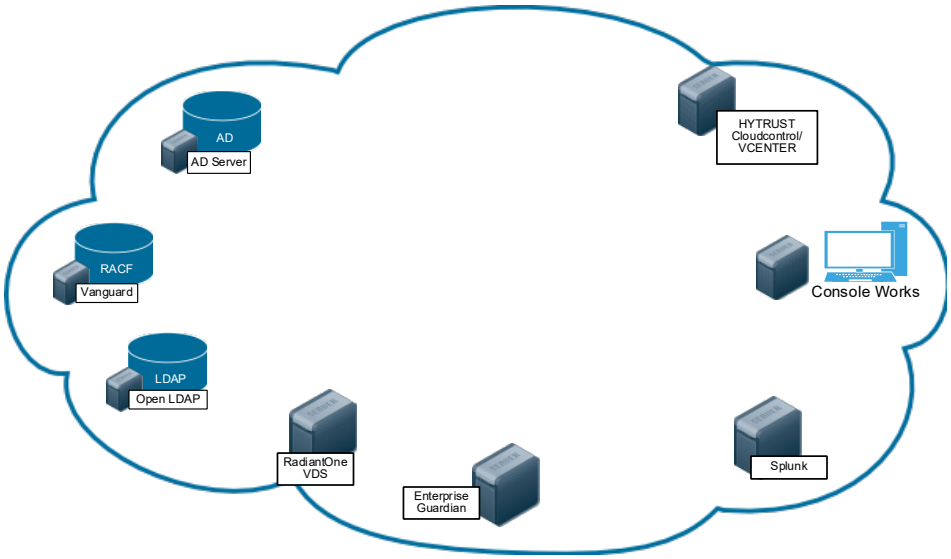


Figure 1-4 NCCoE Lab Networking Diagram



The following table includes the IP addresses for each of the networks depicted in Figure 1-3 and Figure 1-4.

Table 1-1 NCCoE Lab Network and System IP Addresses

Network	System	IP Address
Logging Network: 192.168.17.0/24	Splunk	192.168.17.10
Vendor Network: 10.33.50.0/16	ConsoleWorks	10.33.50.164
Common Services Network : 192.168.19.0/24	ActiveDirectory	192.168.19.10
	OpenLDAP	192.168.19.11
ID-ARM: 192.168.14.0/24	AlertEnterprise	192.168.14.113
	RadiantOne VDS	192.168.14.111
Vanguard: 172.17.212.0/24	VanguardMainframe	172.17.212.10
HyTrust: 192.168.20.0/24	CloudControl	192.168.20.11
	ESXiServer	192.168.20.12
Users: 192.168.15.0/24	User 1	192.168.15.110
	User 2	192.168.15.111
	HR1	192.168.15.112

2 Product Installation Guides

This section of the practice guide contains detailed instructions for installing and configuring all the products used to build an instance of the example implementation Product installation information is organized alphabetically by vendor, with one section for each instance of the product.

2.1 AlertEnterprise

AlertEnterprise Enterprise Guardian is an identity and access management system that provides end to end automated account provisioning, account change management, policy enforcement, and account administration across multiple diverse account directory systems.

2.1.1 How It's Used

AlertEnterprise Enterprise Guardian is used in the example implementation to provide access policy management, account change logging/reporting, account administration and account provisioning. Provisioining accounts includes creating new accounts and changes to existing accounts, including disabling accounts within multiple directories simultaneously.

2.1.2 Virtual Machine Configuration

The AlertEnterprise virtual machine consists of a Windows Server 2012 R2 configured as follows:

- Windows Server 2012 R2
- 1 CPU
- 2 NICs
- 32GB Mem
- 190GB Storage

Network Configuration (Interface 1)
IPv4 Manual
IPv6 Disabled
IP Address: 192.168.14.113
Netmask: 255.255.255.0
Gateway: 192.168.14.1
DNS Name Servers: 192.168.19.10
DNS-Search Domains: acmefinancial.com

Network Configuration (Interface 2)
IPv4 Manual
IPv6 Disabled
IP Address: 192.168.17.114
Netmask: 255.255.255.0
Gateway: 192.168.17.1
DNS Name Servers 192.168.19.10
DNS-Search Domains: acmefinancial.com

2.1.3 Prerequisites

Before starting the installation of the Enterprise Guardian Application, you must install the prerequisite software, which consist of a compatible version of JRE, Apache Activemq, and a SQL database. You will also need a supported internet browser and zip extracting software. See the *AlertEnterprise System Requirement Specifications Guide* for a full list of supported prerequisite software.

Prerequisite software used in this build:

- JRE 1.6 Update 22
- Apache Tomcat 6.0.26
- Oracle SQL Database 12c
- Google Chrome 55.0.2883.87
- 7-zip 16.04

2.1.4 Java

1. Download and install Java from the Oracle web site.
2. Make sure that JAVA_HOME variable is set to the folder where Java is installed and `%JAVA_HOME%/bin` is in the system's path.
3. Open the Command Prompt in Administrator Mode (right-click > Run as Administrator) and issue:

   ```
   Set JAVA_HOME=<PATH OF JDK/JRE>
   ```

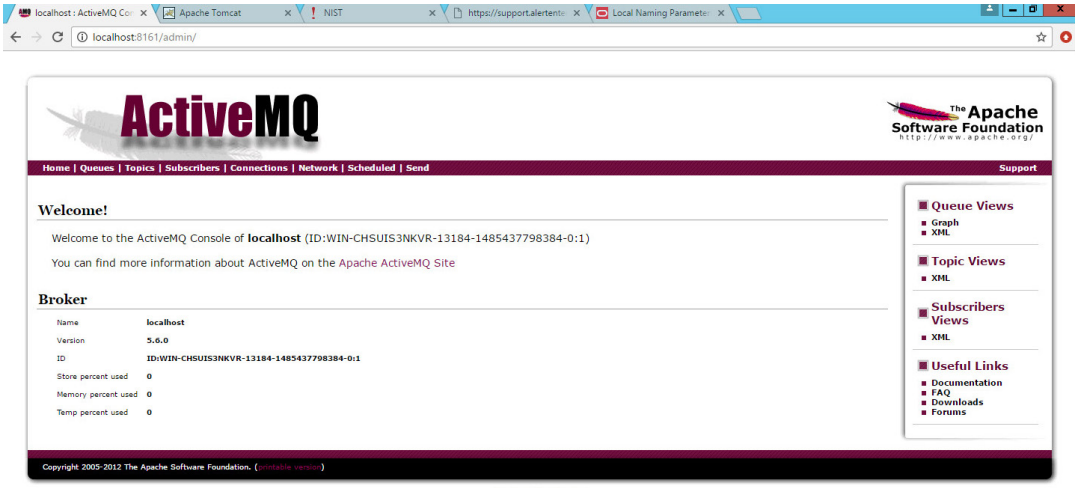
   Where <> is the path where Java is installed, for example, `C:\Program Files\Java\JRE6`
4. Setting Path:
   `PATH= C:\Program Files\Java\JDK1.6.0-21\bin;%PATH%`
5. Checking JAVA_HOME and PATH:

   ```
   Echo %JAVA_HOME%
   Echo %PATH%
   ```

2.1.5 Apache Activemq

1. Install the Activemq server according to documentation found on the Apache website.
2. Run ActiveMQ as a Windows service.
3. Ensure the server is installed correctly and running by connecting to the admin console on port 8161. For example: `URL: <IP address of the server where Active MQ is 2130`

installed>:8161/admin



2.1.6 Oracle DB

1. Install the Oracle SQL database according to documentation found on the Oracle website.
2. Ensure the pdborcl pluggable database service name is added correctly in the tnsnames.ora file per the Oracle documentation.

```
# tnsnames.ora Network Configuration File: C:\app\OracleHomeUser1\product\12.1.0\dbhome_1\network\admin\tnsnames.ora
# Generated by Oracle configuration tools.

LISTENER_ORCL1 =
  (ADDRESS = (PROTOCOL = TCP)(HOST = localhost)(PORT = 1521))


ORACLR_CONNECTION_DATA =
  (DESCRIPTION =
    (ADDRESS_LIST =
      (ADDRESS = (PROTOCOL = IPC)(KEY = EXTPROC1521))
    )
    (CONNECT_DATA =
      (SID = CLRExtProc)
      (PRESENTATION = RO)
    )
  )

ORCL1 =
  (DESCRIPTION =
    (ADDRESS = (PROTOCOL = TCP)(HOST = localhost)(PORT = 1521))
    (CONNECT_DATA =
      (SERVER = DEDICATED)
      (SERVICE_NAME = orcl1)
    )
  )

PDBORCL =
  (DESCRIPTION =
    (ADDRESS = (PROTOCOL = TCP)(HOST = localhost)(PORT = 1521))
    (CONNECT_DATA =
      (SERVER = DEDICATED)
      (SERVICE_NAME = pdborcl)
    )
  )
```

3. Open a command prompt and test by connecting with this command: **`sqlplus sys/<password>@pborcl as sysdba`**.

2.1.7 7-Zip

1. Download and install 7-Zip from www.7-zip.org.

2.1.8 Installation

You can install the AlertEnterprise Enterprise Guardian Application in three steps. This information is also found within the *AlertEnterprise Installation Guide*.

1. Install and Configure the Apache Tomcat Server.
2. Configure the database server.

3. Deploy the application.

2.1.9 Install and Configure Tomcat

1. Install the Apache Tomcat Server per the documentation found on the Apache website. Details can also be found within the *AlertEnterprise Enterprise Guardian Install Guide*.
    a. During the installation, specify the destination folder as **C:\AlertEnterprise\Tomcat.**
2. When installation is complete, navigate to **Start>Programs>Configure Tomcat** and select the **Java** tab.
3. Add the following lines to the end of Java Options, ensuring there are no spaces:

```
-XX:PermSize=1024
-Xms2048m
-Xmx2048m
-Dcom.alnt.fabric.loadInitData=force
"                                                    "--Dalert.db.update=update
```

4. Click **Apply** and **OK** to close the dialog box.

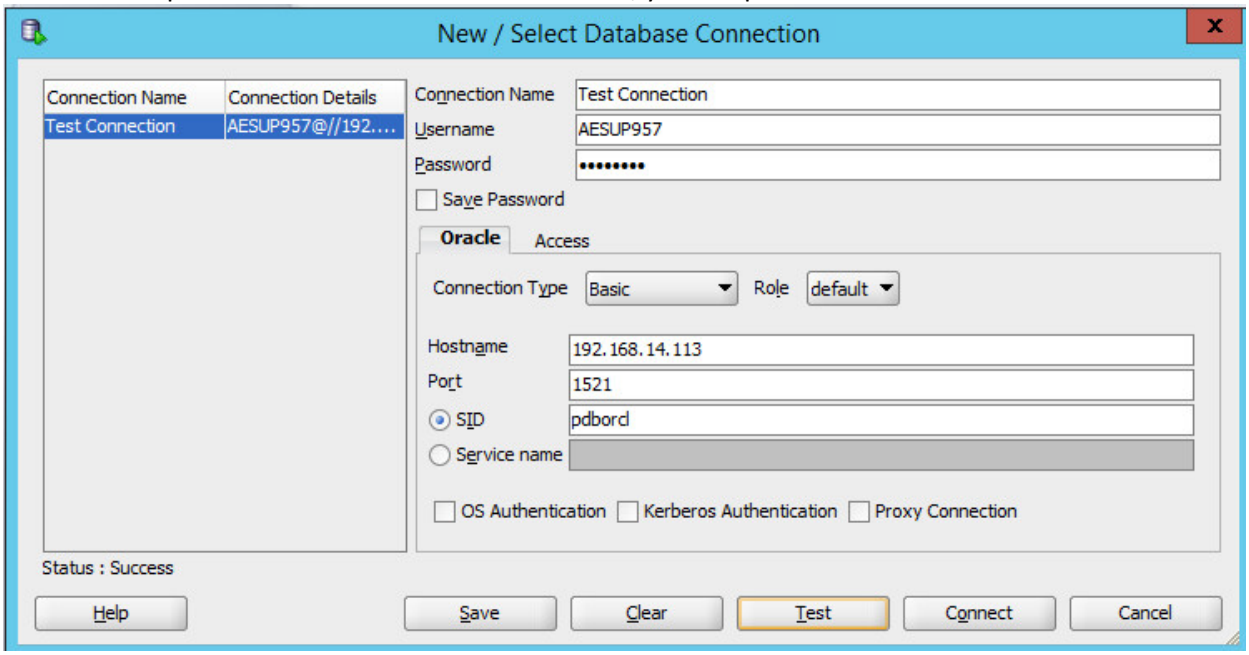
2.1.10 Configure the Database Server

The NCCoE build supports Oracle SQL Database 12c. See the administrator's guide for the full installation and configuration guide. Open a command prompt with administrator privileges and connect: **`sqlplus sys/<password>@pborcl as sysdba`**

1. Create a new schema/SID per your naming convention: **`create user <user/schema name> identified by <password>`**, you may have to unlock the schema: **`alter user <user/schema name> identified by <password> unlock`**
2. Use **`grant <attribute> to <user/schema name>;`** to grant the new user all of the following attributes:

   connect; resource; create synonym; create session; create sequence; create view; unlimited tablespace; create procedure; create trigger; create table

3. You can use Oracle SQL Developer to test the connection using the username and password created in Step 2. When this connection is successful, you can proceed.



2.1.11 Deploying the Application

After you have successfully configured the database, proceed to deploy the AlertEnterprise product on your web application server. The following deployment steps are required for the Tomcat 6.0 version:

Note: For steps required to use the SAP system connector or MySQL database, see the vendor documentation.

1. Stop the Tomcat server from the Windows services if it is already running. Click **Start > Run** and type `services.msc` then click **OK**. Select the Apache Tomcat and click the **Stop Service** icon to stop the service.
2. Copy the `AlertEnterprise.war, AccessMap.war` (if you possess AlertInsight license), `AlertEnterpriseHelp.war`, and `jasperserver-pro.war` files to the `<Tomcat installation folder>\webapps\` path.
3. If you have a license for the Password Management application, you need to copy the password management war file (`AIPM.war`) to `<Tomcat installation folder>/webapps`.
4. Create new folders `AlertCommonLib` and `AlertExternalLib` under the `<Tomcat Installation Folder>`.
5. Extract `AlertCommonLib.zip` under the `AlertCommonLib` folder. You will see many new files in this folder.
6. Edit `<Tomcat Installation Folder>\conf\catalina.properties` using any editor and add `common.loader` as described below:
   `common.loader=${catalina.base}/lib,${catalina.base}/lib/*.jar,${catalina.home}/lib,${catalina.home}/lib/*.jar,${catalina.home}/AlertCommonLib/*.jar,${catalina.home}/AlertExternalLib/*.jar` . Save the file and close the editor.
7. Add Database Connection. Add a new resource entry as below with name `jdbc/alntdb` in `<Tomcat installation folder>\conf\context.xml`. Replace the code in <> with relevant information.

For ORACLE:

```
<Resource description="DB Connection"
name="jdbc/alntdb" auth="Container"
type="com.mchange.v2.c3p0.ComboPooledDataSource"
factory="org.apache.naming.factory.BeanFactory"
user=<"Schema User">
password=<"Schema User Password">
jdbcUrl="jdbc:oracle:thin:@<db host name>:<db port>:<schema name>/SID"
driverClass="oracle.jdbc.driver.OracleDriver"   maxPoolSize="100"
                                minPoolSize="5"
             acquireIncrement="5"
numHelperThreads="20"
maxIdleTime="600"
maxIdleTimeExcessConnections="300"
debugUnreturnedConnectionStackTraces="true"
unreturnedConnectionTimeout="900" />
```

8. To add more <resource> entries, see the *AlertEnterprise Enterprise Guardian Installation Guide*.

2.1.12 Start the Server

1. Make sure that Active MQ is up and running and then start the Tomcat server.
2. Start the AlertEnterprise application using the address of the form http://<Server IP Address>:8080/AlertEnterprise.

   Note: 8080 is the default port on local host. If you want to change it, change it in the server.xml.

3. Log on to the application using username *admin* and password: *System@123*. You should be able to view the Home screen of the application.

2.1.13 Provisioning Configuration

For this build, the AlertEnterprise support team pre-configured AlertEnterprise Enterprise Guardian for provisioning. Configuring the provisioning functionality involves several steps to ensure that each connector is properly provisioning attributes. All steps for configuring provisioning are documented and delivered with the application in the **Help** tab. The parameters used during the configuration of different components are found here.

2.1.14 Creating System Connectors

1. Navigate to **Setup > Manual Configuration > Systems > System**.
2. Click **New** to create a new system.
3. Enter the following Definition:
   a. System Type – `Active Directory`
   b. Connector Name – `AD`
   c. Connector Description – `AD`
   d. Connector Long Description – `AD`
   e. Connector Type – `LDAP` (default)
4. Click **Next**.
5. Enter the following Parameters:
   a. HostName – `192.168.19.10`
   b. Port Number – `636` (use `389` if SSL is not configured yet)
   c. Service user Dn – `CN=AlertServiceAccount,CN=Users,DC=Acmefinancial,DC=com`
   d. Password – `Fsarm@nccoe1`
   e. Use SSL – `true` (use `false` if SSL is not configured yet)

f. User Base DN – `OU=Operations,DC=Acmefinancial,DC=com`
g. Group Base DN – `DC=Acmefinancial,DC=com`
h. Object Class – `user`
i. Is Primary – `Yes`
j. LastModified Column role – `whenChanged`
k. Last Modified User Column – `whenChanged`

6. Click **Next**.
7. Enter the following parameters:
   a. Application – `AlertAccess`
   b. Check the following boxes – `Provisioning, Role Management, Offline System, Allow Modify Role`
   c. Category – `production`
   d. Time Zone – `Eastern Standard Time`
8. Click **Next.**
9. Click **Save.**
10. Repeat Steps 1–9 to add the OpenLDAP and RACF connectors with the following parameters:

OpenLDAP:

a. System Type – `OpenLDAP Server`
b. Connector Name – `OPENLDAP`
c. Connector Description – `OpenLDAP`
d. Connector Type – `OpenLDAP`
e. HostName – `192.168.19.11`
f. Port Number – `636` (use 389 if SSL is not configured yet)
g. Service user Dn – `CN=Admin,DC=Acmefinancial,DC=com`
h. Password – `Fsarm@nccoe1`
i. Use SSL – `true` (use false if SSL is not configured yet)
j. User Base DN – `OU=Operations,DC=Acmefinancial,DC=com`
k. Group Base DN – `OU=Operations,DC=Acmefinancial,DC=com`
l. Object Class – `inetOrgPerson`
m. Group Object Class Name – `groupOfUniqueNames`
n. Primay Connection – `Yes`
o. LastModified Column role – `whenChanged`
p. Last Modified User Column – `whenChanged`
q. Member Attribute Name for Group – `uniqueMember`
r. LDAP DnName – `cn`
s. LDAP Account Control Column Name – `cn`
t. User Password attributed – default
u. Encode Password Required? – default
v. LDAP Group Search Attributed – `cn`
w. userIdColumnName (Optional Parameter) - `cn`
x. Application – `AlertAccess`
y. Check the following boxes – `Provisioning, Role Management, Offline System, Allow Modify Role`
z. Category – `production`
aa. Time Zone – `Eastern Standard Time`

RACF:

a. System Type – `OpenLDAP Server`
b. Connector Name – `RACF_OPENLDAP`

c. Connector Description – `RACF_OpenLDAP`
d. Connector Type – `OpenLDAP`
e. HostName – `172.17.212.10`
f. Port Number – `636` (use 389 if SSL is not configured yet)
g. Service user Dn – `racfid=TSNI00,profiletype=user,sysplex=sysplex1`
h. Password – `Fsarm@nccoe1`
i. Use SSL – `true` (use false if SSL is not configured yet)
j. User Base DN – `profiletype=user,sysplex=sysplex1`
k. Group Base DN – `profiletype=user,sysplex=sysplex1`
l. Object Class – `racfUser`
m. Primay Connection – `Yes`
n. LDAP DnName – `racfId`
o. LDAP UserID Column Name – `racfId`
p. User Password attributed – default
q. Encode Password Required? – default
r. Ignore user check – `Yes`
s. isObjectClassExist – `No`
t. userIdColumnName (Optional Parameter) – `racfid`
u. isCnAttrExists (Optional Parameter) – `No`
v. Application – `AlertAccess`
w. Check the following boxes – `Provisioning, Role Management, Offline System, Allow Modify Role`
x. Time Zone – `Eastern Standard Time`

File Connector

a. System Type – `File Connector`
b. Connector Name – `FILE CONNECTOR`
c. Connector Type – `FileConnector`
d. User Folder Path – `C:\Program Files\User`
e. Role Folder Path – `C:\Program Files\Role`
f. User role Folder Path – `C:\Program Files\UserRole`
g. Column Header for User ID – `UserId`
h. Skip Provisioning – `Yes`
i. Application – `AlertAccess`
j. Check the following boxes – `Provisioning, Role Management`
k. Category – `Production`
l. Time Zone – `Eastern Standard Time`

Identity Store

a. System Type – `Database (JDBC J2EE)`
b. Connector Name – `IDENTITYSTORE`
c. Connector Type – `Database (JDBC J2EE)`
d. User Name – `admin`
e. Password – `System@123`
f. JNDI Name – `java:comp/env/jdbc/alntdb`
g. Application – `Alert Access`
h. Check the following boxes – `Provisioning, Role Manangement, Offline System, Identity Provider`
i. Category – `Production`
j. Time Zone – `Eastern Standard Time`

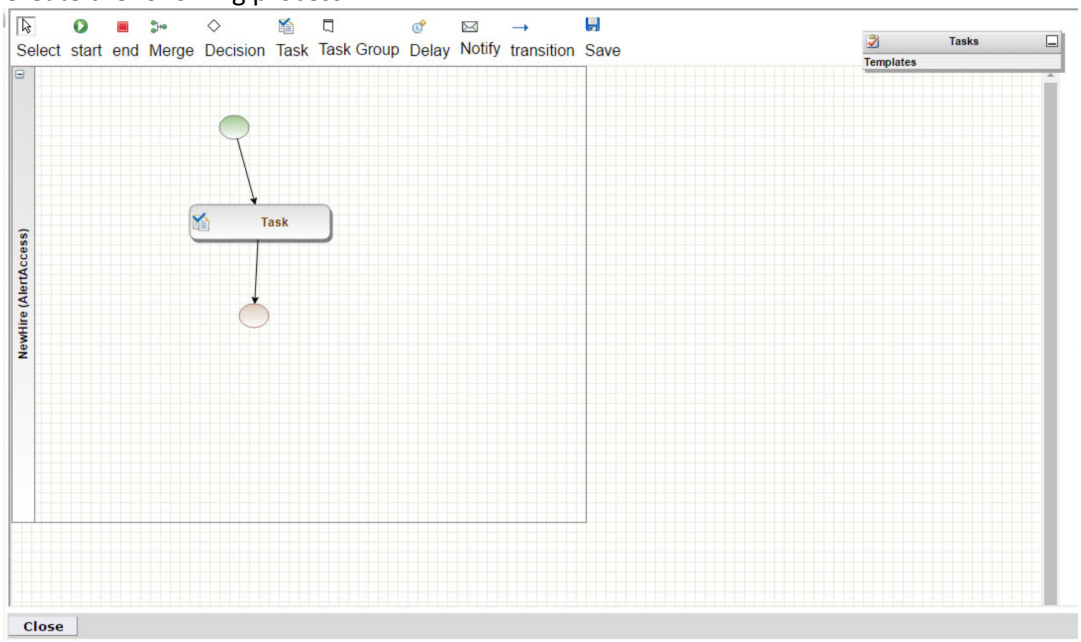
2.1.15 User Data Source

1. Navigate to **Setup>Manual Configuration>User Data>User Data Source.**
2. Click **New.** Create the following User Data Source:

System Type	Connector	Unique Key	Sequence	Mapping
Database (JDBC J2EE)	IDENTITYSTORE	UserId	1	1) UserId – IDENTITYSTORE – UserId 2) FirstName – IDENTITYSTORE – FirstName 3) LastName – IDENTITYSTORE – LastName 4) ValidFrom – IDENTITYSTORE – ValidFrom 5) ValidTo – IDENTITYSTORE – ValidTo

2.1.16 Process Designer

1. Navigate to **Setup>Manual Configuration>Process Engine>Process Designer.**
2. Click **New.**
3. Enter `New Hire` as Process Name and `Alert Access` as Rule Type. Click **Next.**
4. Create the following process:



2.1.17 Policies

1. Navigate to **Setup>Manual Configuration>Policy Engine>Policies.**
2. Click **New.** Create the following policies:

Policy Name	Rule Name	Priority	Active	Attribute Name	Value
OpenLDAP prov Action	OpenLDAP prov Action	0	Yes	System ProvAction	Change_Roles
Termination-shell update	Termination-shell update	0	Yes	loginShell	disable

2.1.18 Rules

1. Navigate to **Setup>Manual Configuration>Policy Engine>Rules.**
2. Click **New.** Create the following rules:

Rule Name	Entity Type	Rule Type	Description	Applicable To	Attributes	Condition
Survey Rule	Workflow	Survey	Survey Rule	Initiator	AND	
NewHire	Workflow	AlertAccess	NewHire	Initiator	AND Request Category	= Change Access
NewHireSuggestDefault	Workflow	AlertAccess	NewHireDefault	Suggest/Default	AND Request Category	1) =NewHire 2) =Change-Acces 3) =Rehire
Role Assignement	Workflow	AlertAccess	Role Assign	Policy	AND Role:Alias	Any Value
OpenLDAP prov Action	Workflow	AlertAccess	OpenLDAP provisioning action	Policy	AND Request Category; System Multi Select	1) =Termination and =OpenLDAP 2) =Rehire and =OpenLDAP
Termination-shell update	Workflow	AlertAccess	Terminate shell update	Policy	AND Request Category	=Termination

2.1.18.1 Suggest/Default Access

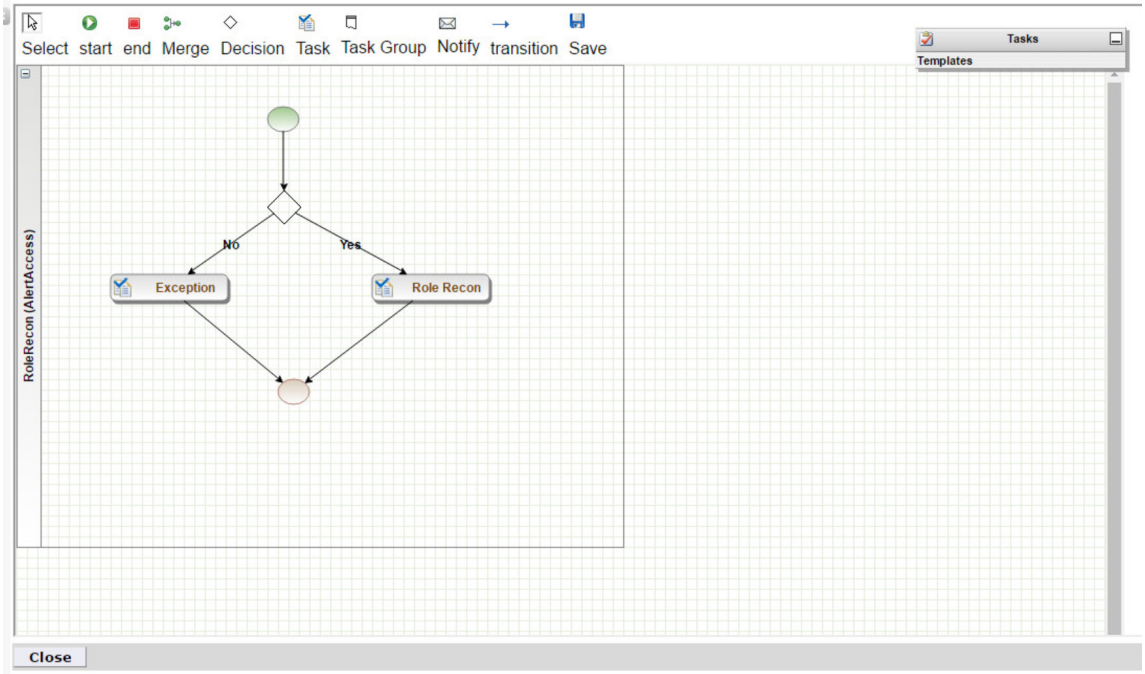
1. Navigate to **Setup>Manual Configuration>Policy Engine>Suggest/Default Access.**
2. Click **New.** Create the following criteria:

Name	Type	Condition	Search By	Resources	Attributes
NewHire	Default	NewHireSuggestDefault	Systems	OpenLDAP, AD, RACF_OPENLDAP	
DefaultRole-Assignment	Default	NewHireSuggestDefault	Role Attributes		Alias
123	Defaul	NewHireSuggestDefault	Role Attributes		RoleDescription

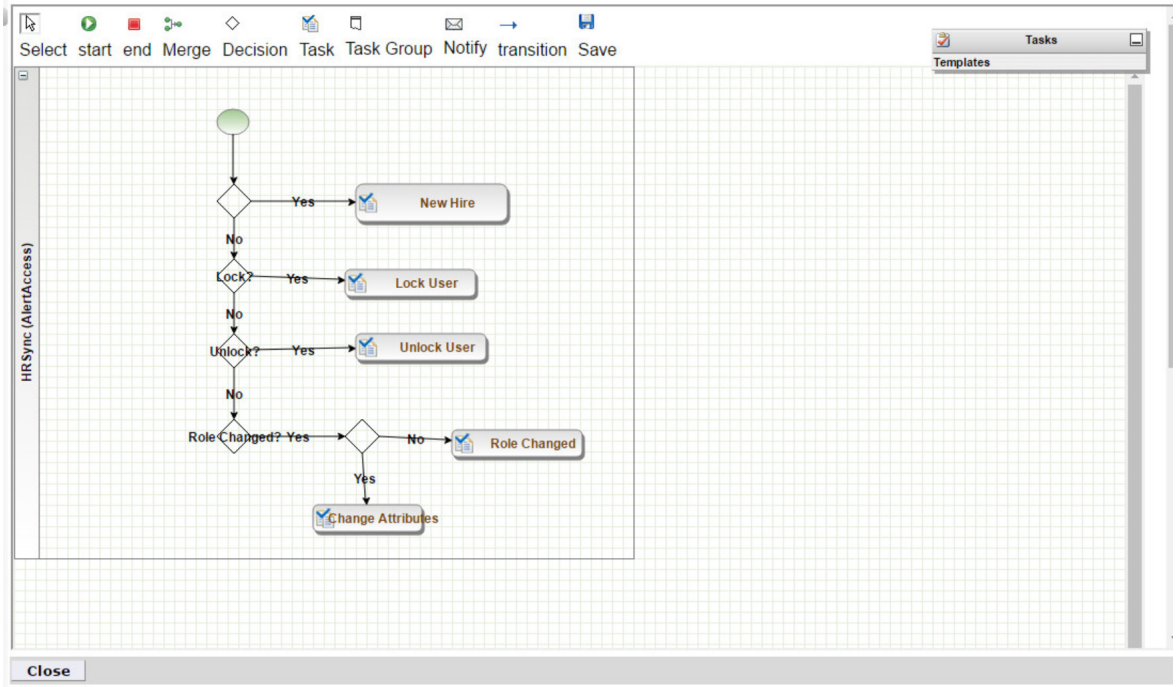
2.1.19 Policy Designer

1. Navigate to **Setup>Manual Configuration>Policy Engine>Policy Designer.**
2. Click **New.**
3. Enter `RoleRecon` as the **Name** and `Alert Access` as the **Rule Type**.

4. Create the following policy:



5. Repeat Steps 1-4 for with HRSync as the **Name** and the following policy:



2.1.19.1 Rule Action Handlers

1. Navigate to **Setup>Manual Configuration>Policy Engine>Rule Action Handler.**
2. Click **Create.** Create the following action handlers:

Action Handler Name	Workflow	Task Type	Value	Priority	Update Identity Info	Evaluate Enter-prises Role
Termination	AlertAccess	Recon Create Request	Termination	0	Yes	No
Recon Excep-tion	AlertRecon	Recon Exception Record		0		
NewHire	AlertAccess	Recon Create Request	NewHire	0	Yes	No
Rehire	AlertAccess	Recon Create Request	Rehire	0	Yes	No
UpdateRepo	AlertAccess	Update Identity Info	Yes	0	Yes	No
Role recon	AlertRecon	Recon Create role in Repo		0		
ChangeAc-cess	AlertAccess	Recon Create Request	ChangeAccess	0	Yes	No
ChangeUser	AlertAccess	Recon Create Request	ChangeUser	0	Yes	No
Attribute Change	AlertAccess	Recon Create Request	Attribute Change	0	Yes	No

2.1.19.2 Job Triggers

1. Navigate to **Setup>Manual Configuration>Job Scheduler>Triggers.**
2. Click **Create.** Create the following trigger:

Name	HRSync
Description	HRSync
Type	Reconciliation
Batch Size	100
Number of Attempts	3
Policy Designer for Users	HRSync
Policy Designer for roles	RoleRecon
System:Reconciliation From	FILE CONNECTOR
Reconciliation System:	FILE CONNECTOR
Field Mapping Group	HR Sync
Process Deleted Option for Full Reconciliation	User Role
Process Deleted Option for Incremental Reconciliation	User Role

2.1.20 Triggers Field Map

1. Navigate to **Setup>Manual Configuration>Job Scheduler>Triggers Field Map.**
2. Click **Create.** Create the following field map group:

Group Name	Type
HR Sync	Reconciliation

2.1.21 Form Customization

1. Navigate to **Setup>Manual Configuration>Form Customization>Attributes.**
2. Click **Create.** Create the following attributes:

Name/Label	Attribute Type	Visible	Mandatory	Data Type	Field Type	Check Boxes
ADUserId	Custom	No	No	String	Textbox	Provisioning
LDAPUserId	Custom	No	No	String	Textbox	Provisioning
ADuserName	Custom	No	No	String	Textbox	Provisioning
LDAPuserName	Custom	No	No	String	Textbox	Provisioning
FirstName	Standard	Yes	Yes	String	Textbox	Provisioning
EmployeeNo	Custom	No	No	String	Textbox	Provisioning
BaseDN	Custom	No	No	String	Textbox	Provisioning
L	Custom	No	No	String	Textbox	Provisioning
Pager	Standard	Yes	Yes	String	Textbox	Provisioning
Initials	Standard	Yes	No	String	Textbox	Provisioning
Racfid	Custom	No	No	String	Textbox	Provisioning
Racfprogrammername	Custom	No	No	String	Textbox	Provisioning
Racfworkattrusername	Custom	No	No	String	Textbox	Provisioning
Racfaddressline1	Custom	No	No	String	Textbox	Provisioning
Racfaddressline4	Custom	No	No	String	Texbox	Provisioning

Note: This list is not exhaustive. The application is deployed with several attributes preconfigured.

2.1.22 User Field Mapping

1. Navigate to **Setup>Manual Configuration>Identity & Access>User Field Mapping.**
2. Select **Identity** from the drop-down menu. Click **Go**.
3. Click **Create New**.
4. Create the following field mappings:

Custom Field	Visible in List	isSearchable	Column Location
UserId	Yes	Yes	1
ValidFrom	No	No	2
ValidTo	No	No	3
FirstName	Yes	Yes	4
LastName	Yes	Yes	5

Alias	No	No	6
Email	No	No	7
ManagerId	No	No	8
Department	No	No	9
JobTitle	No	No	10
CompanyName	No	No	11
ManagerName	No	No	12
FullName	No	No	13
Mobile	No	No	14
User Base Dn	No	No	15
ADUserId	No	No	16
LDAPUserId	No	No	17
ADuserName	No	No	18
LDAPuserName	No	No	19
EmployeeNo	No	No	20
Initials	No	No	21
Pager	No	No	22
L	No	No	23
Racfid	No	No	24
Racfprogrammername	No	No	25
Racfworkattrusername	No	No	26
Racfaddressline1	No	No	27
Racfaddressline4	No	No	28

2.1.23 Provisioning Mapping

1. Navigate to **Setup>Manual Configuration>Identity & Access>Provisioning>Provisioning Mapping.**
2. Select the connector and click **Configure** for the following connectors:

IDENTITYSTORE

Database Attribute Name	Mandatory	AlertEnterprise Attribute Name	Default Value	Editable	Visible	Validation Flag	isUser-Id attribute
FullName	No	FullName	$<FirstName> $<LastName>	No	No	No	No

OPENLDAP

Database Attribute Name	Mandatory	AlertEnterprise Attribute Name	Default Value	Editable	Visible	Validation Flag	isUser-Id attribute
Cn	No	LDAPUserId		Yes	Yes	No	Yes
Sn	No	LastName		Yes	Yes	No	No

givenName	No	FirstName		Yes	Yes	No	No
UserBaseDn	No	BaseDn		Yes	Yes	No	No
uidNumber	No	uidNumber	1	Yes	Yes	No	No
gidNumber	No	gidNumber	1	Yes	Yes	No	No
homeDirectory	No	Homedirectory		Yes	Yes	No	No
objectClass	No	UserObjectClass	inetOrgPerson| organizationalPerson| Person|Top| PosixAccount			No	No
Mail	No	Email		Yes	Yes	No	No
userPassword	No	Password		Yes	Yes	No	No
employeeNumber	No	EmployeeNo		Yes	Yes	No	No
Mobile	No	Mobile		No	No	No	No
DepartmentNumber	No	Department		No	No	No	No
Title	No	JobTitle		No	No	No	No
O	No	CompanyName		No	No	No	No
loginShell	No	loginShell		No	No	No	No
Uid	No	LDAPUserId		Yes	Yes	No	Yes
L	No	L		No	No	No	no

617 **AD**

Directory Attribute Name	Mandatory	AlertEnterprise Attribute Name	Default Value	Editable	Visible	Validation Flag	isUser-Id attribute
sAMAccountName	No	ADUserId		Yes	Yes	No	Yes
Sn	No	LastName		Yes	Yes	No	No
givenName	No	FirstName		Yes	Yes	No	No
accountExpires	No	ValidTo		Yes	Yes	No	No
UserBaseDn	No	User Base Dn		Yes	Yes	No	No
unicodePwd	No	Password	System@123	Yes	Yes	No	No
displayName	No	DispalyName	$<LastName>, $<FirstName>	Yes	Yes	No	No
Mail	No	Email		Yes	Yes	No	No
employeeNumber	No	EmployeeNo		No	No	No	No
Mobile	No	Mobile		No	No	No	No
Department	No	Department		No	No	No	No
userPrincipalName	No	NISTEmptyDN	$<UserID>@AcmeFinancial.com	No	No	No	No
Title	No	JobTitle		No	No	No	No
Company	No	CompanyName		No	No	No	No
userAccountControl	No	UserAccountControl	512	No	No	No	No
Pager	No	Pager		No	No	No	No
Initials	No	Initials		No	No	No	no

618 **RACF_OPENLDAP**

Directory Attribute Name	Mandatory	AlertEnterprise Attribute Name	Default Value	Editable	Visible	Validation Flag	isUser-Id attribute
Racfid	Yes	Racfid		No	No	No	Yes
Racfworkattrusername	No	Racfworkattrusername		No	No	No	No
UserBaseDn	Yes	homeDirectory	profiletype=user,	No	No	No	No

			sysplex=sysplex1				
objectClass	No	UserObjectClass	racfUser	No	No	No	No
Racfprogrammername	No	Racfprogrammername		No	No	No	No
Racfaddressline1	No	Racfaddressline1		No	No	No	No
Racfaddressline4	No	Racfaddressline4		No	No	No	No

2.1.24 External Provisioning Attributes

1. Navigate to **Setup>Manual Configuration>Identity & Access>Provisioning>External Provisioning Attributes.**
2. Select the connector and click **Configure** for the following connectors:

OPENLDAP

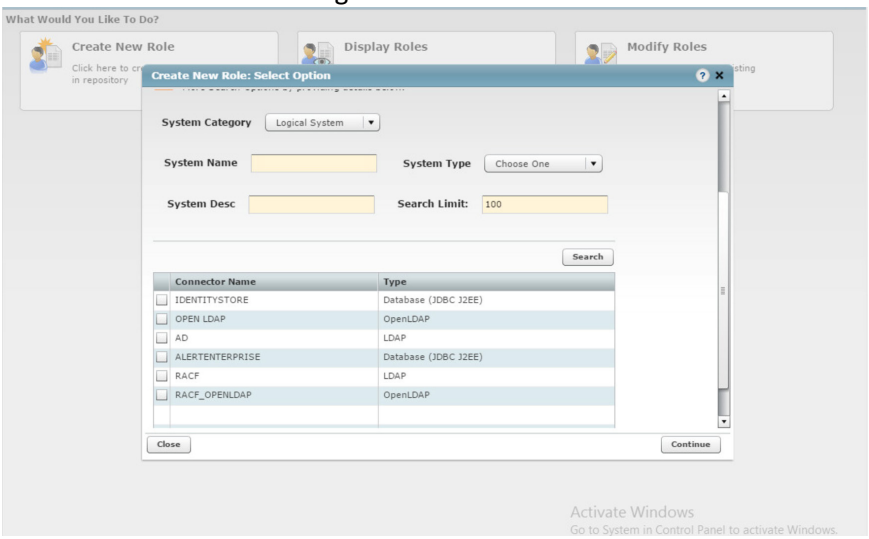
Name	Description
loginShell	loginShell

RACF_OPENLDAP

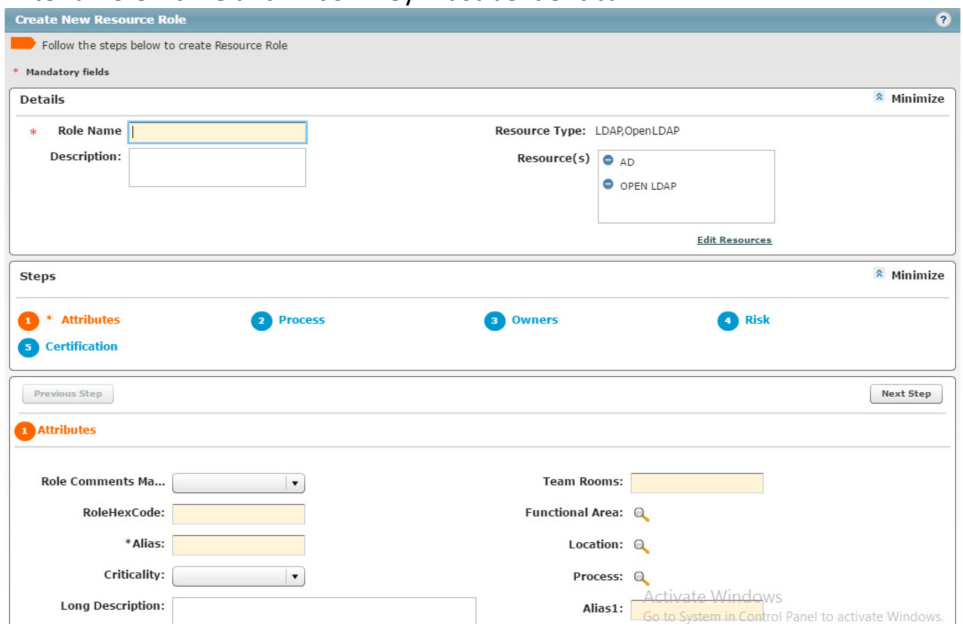
Name	Description
Racfid	Racfid
Racfworkattrusername	Racfworkattrusername
UserBaseDn	UserBaseDn
objectClass	objectClass
Racfprogrammername	Racfprogrammername
Racfaddressline1	Racfaddressline1
Racfaddressline4	Racfaddressline4

2.1.25 Role Repository

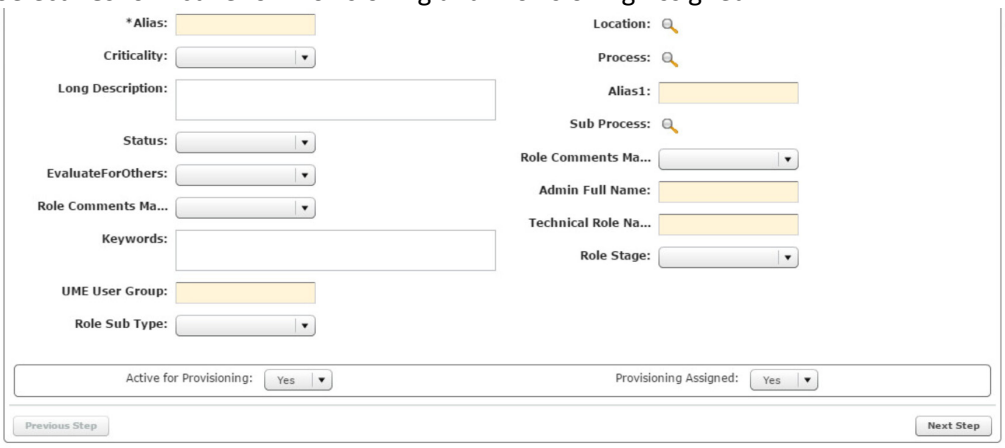
1. Navigate to **Setup>Manual Configuration>Role Repository**.
2. Click **Create New Role** to begin.



3. Select **Create New Role** from Start.
4. Click **Search** to load the connector names. Select the **OpenLDAP** and **AD** connectors.
5. Click **Continue.**
6. Enter a **Role Name** and **Alias**. They must be identical.



7. Select **Yes** for Active for Provisioning and Provisioning Assigned.



8. Create the following roles in the repository:

Role Name	Resource(s)
Accounting Manager	AD, OpenLDAP
Branch Manager	AD, OpenLDAP
Financial Analyst	AD, OpenLDAP
Financial Manager	AD, OpenLDAP
Loan Officer	AD, OpenLDAP
Operations Manager	AD, OpenLDAP
Security Analyst	AD, OpenLDAP
Systems Admin	AD, OpenLDAP

Teller	AD, OpenLDAP
VM Admin	AD, OpenLDAP

2.1.26 Enabling SSL

To better secure LDAP communications between AlertEnterprise Enterprise Guardian and the directory servers, we have configured such communications to use SSL encryption. Specifically, the LDAPS protocol has been configured. The steps to configure LDAPS for each connection to a directory server are as follows:

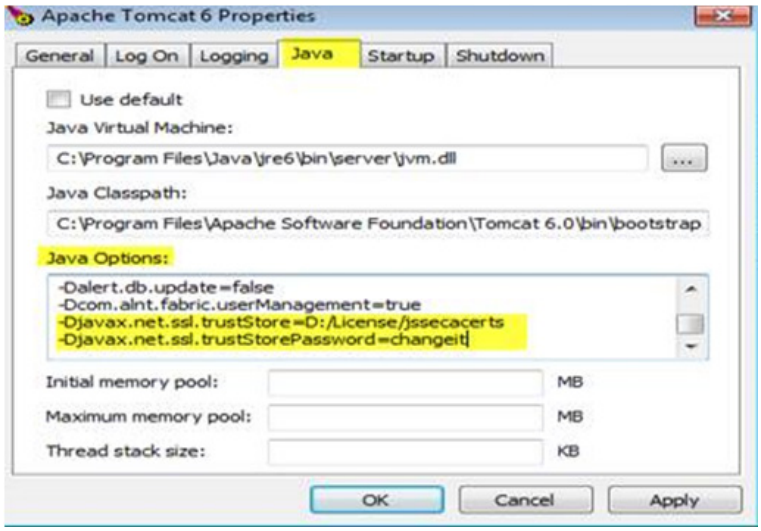
1. Create a *D:\cert\folder* on your system.
2. Place certificate jar file inside that folder.
3. Open the command prompt in administrator mode and perform the command:
   `cd D:\cert\`
4. Download certificate from directory server using the following command:

   ```
   java -cp ALNTADCertUtil.jar com.alnt.ADCertInstaller
   <IP_Address_Of_Directory_Server>:636
   ```

   This creates the jssecacerts file in **`D:\cert\`** folder.
5. Add the following D parameters in `<Tomcat Installation Folder>/bin/Tomact6w`

   `-Djavax.net.ssl.trustStore=D:/License/jssecacerts`

   `-Djavax.net.ssl.trustStorePassword=changeit`



6. Copy jssecacerts to D:/License (create this folder if it does not exist) and restart Tomcat.
7. Switch connection back to 636 port and set SSL as true from false.

2.2 HyTrust Cloud Control

HyTrust CloudControl provides a variety of security and policy enhancements to the virtual infrastructure without impacting the GUI tha vSphere, NSX and ESXi admins already know and use. HyTrust CloudControl mediates the actions taken by virtual infrastructure administrators using familiar interfaces. Approved actions are allowed, disapproved actions are blocked and additional approval workflow is enabled.

2.2.1 How Its Used

HyTrust CloudControl (HTCC) is used as a centralized point of control for access management within the virtual infrastructure of this example implementation.

2.2.2 Virtual Machine Configuration

HTCC uses one ESXi host and two virtual machines for its infrastructure. One virtual machine is the HTCC appliance. This virtual machine is delivered as an .OVF file from the HyTrust support site. The other virtual machine is a VCenter server, which is installed as a virtual machine within the ESXi host.

Note: The ESX host and HTCC Virtual Machine requirements depend on the specific load of a protected virtual environment. See the HTCC installation guide for a complete list of system requirements.

VCenter Server:

- Windows Server 2012 R2
- 2 CPU core
- 16GB of RAM (memory)
- 1 NIC
- 60GB of storage

HTCC:

- CentOS 4/5/6/7 (64-bit)
- 4 CPU core
- 16GB of RAM (memory)
- 1 NIC
- 70GB of storage

Network Configuration (VCenter Server)
IPv4 Manual
IPv6 Disabled
IP Address: 192.168.20.6
Netmask: 255.255.255.0
Gateway: 192.168.20.1
DNS Name Servers: 192.168.19.10
DNS-Search Domains: acmefinancial.com

Network Configuration (HTCC)
IPv4 Manual
IPv6 Disabled
IP Address: 192.168.20.11
Netmask: 255.255.255.0
Gateway: 192.168.20.1
DNS Name Servers 192.168.19.10
DNS-Search Domains: acmefinancial.com

2.2.3 Installing Vcenter Server

Install Vcenter Sever 6.0 according to the VMware documentation found here.

2.2.4 Configuring Vcenter Server

Vcenter server is configured with 1 host and 1 data center.

ESXi Host:

1. VMware ESXi, 6.0.0
2. Dell PowerEdge R620
3. 20 CPUs x 2.8 GHz
4. 23,478 mb / 262,098 mb
5. 8 Physical Adapters

2.2.5 Deploying HTCC

Before installing the HTCC appliance, the following conditions should be in place:

- Virtual infrastructure, consisting of installed vCenter Servers and, optionally, ESX hosts.
- Network connectivity and access to the HTCC host machine.
- The HTCC installation requires an ESX host with at least one dedicated network interface (using VLANs).
- For Directory Service mode authentication, setup of Microsoft Active Directory (AD) with an AD Service Account and the recommended HyTrust security groups, as described in the *HyTrust CloudControl Administration Guide*.
- Services used by virtual infrastructure clients should be routable from the appropriate interface.

See the HTCC installation guide for a step-by-step guide on deploying the HTCC appliance. The installation guide is available on request.

2.2.6 Configuring HTCC

The HTCC Management network interface (eth0) must be manually configured before you can access the HTCC Management Console.

Configure the HTCC Management network interface:

1. At the vSphere Client console window, log in as the user *ascadminuser* with the password Pa$$w0rd123!.
2. You are prompted to assign a new password to the local HTCC administrator account (*ascadminuser*). Be sure to keep your new password in a safe and secure place.
3. Start the setup procedure. At the prompt, type: `setup`
4. Manually assign a static IP address to the management network interface (eth0) and set the subnet mask, gateway, and DNS server addresses.
5. Save by typing: `y`

6. Log out after network settings have been saved. This build is configured with the following settings:

```
Last login: Wed Apr  5 15:13:50 on ttys001
MM229136-PC:~ dwynne$ ssh ascadminuser@10.33.50.38
ascadminuser@10.33.50.38's password:
Last login: Wed Apr  5 19:20:39 2017 from 10.97.67.143
[hytrust:standalone ~]$ setup

CloudControl Setup - HyTrust CloudControl - 4.6.2.46611

Please specify network settings for the Connection 1 (eth0) interface

The appliance is configured with the following settings:

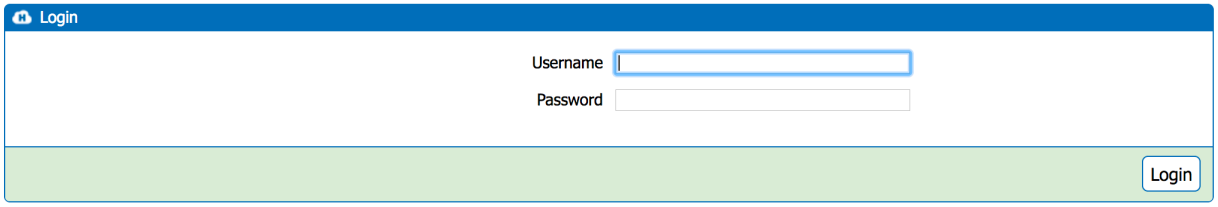
         IP: 192.168.20.11
    Netmask: 255.255.255.0
    Gateway: 192.168.20.1
 DNS Server: 192.168.19.10
```

The HTCC web-based management console is used to customize the HTCC settings. When accessing HTCC for the first time, you must use the IP address in the URL. For example:

`https://<ipaddress>/asc`

1. Enter the IP address of the HTCC Management network interface.
2. Manually allow the security exception.

The login screen appears.

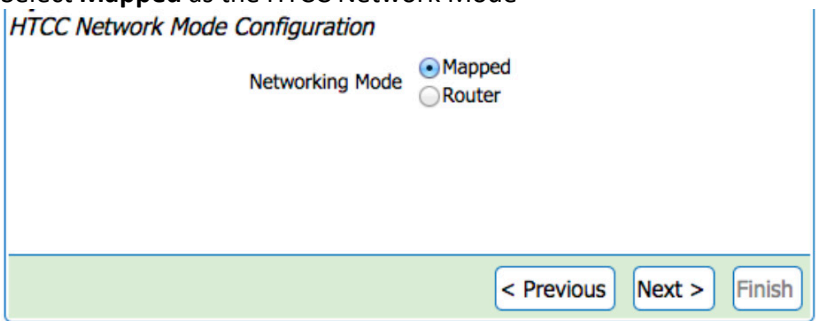


Once logged in, you can complete the initial setup and configuration. Here is an overview of the initial setup and configuration steps. The detailed steps can be found in the HTCC installation guide, which is available on request.

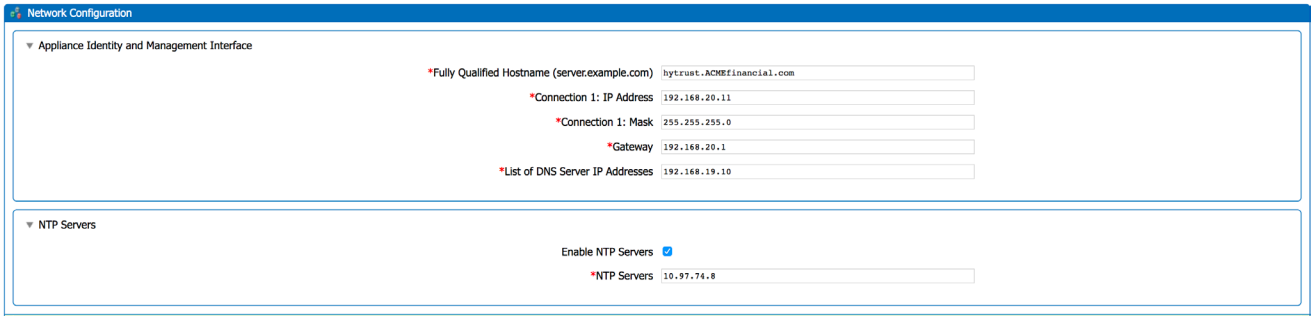
1. Accept the end-user license agreement.
2. If applicable, install a license.
3. Complete the **HTCC Installation Wizard** based on your selected networking mode.
4. Perform post-installation setup.

HTCC Installation Wizard:

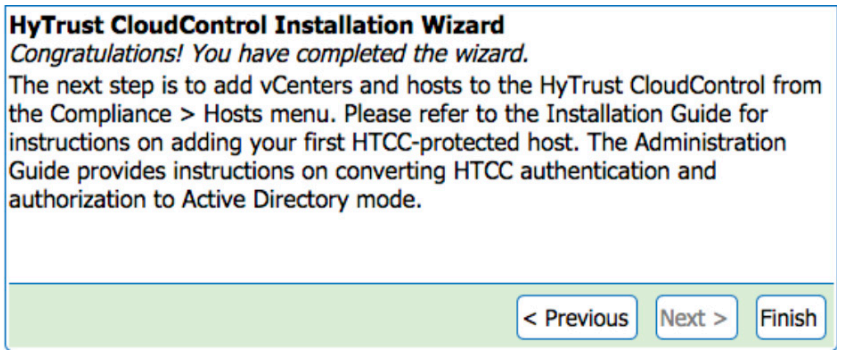
1. Select **Mapped** as the HTCC Network Mode



2. Specify the network information on the Network Configuration page. This build is configured as follows:

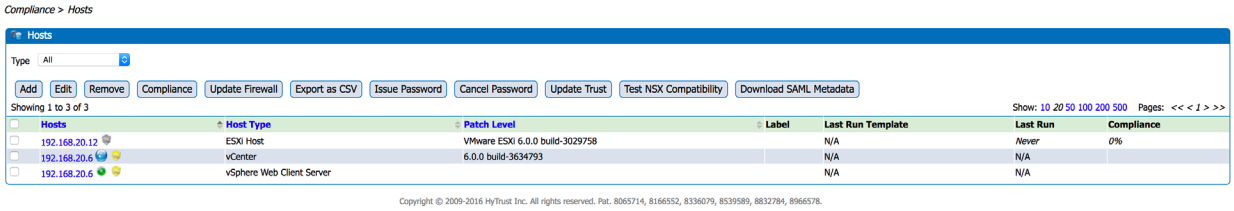


3. Click **Next** and select **Finish.**

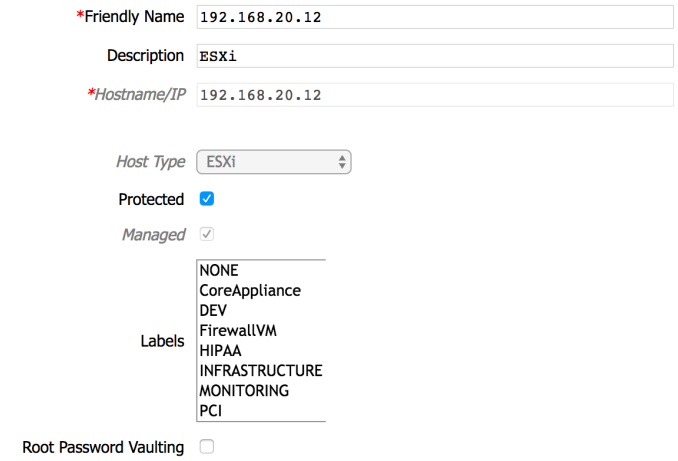


Add VCenter and Hosts to the HTCC:

In this build, three managed hosts are added. The three hosts are ESXi, Vcenter, and Vcenter Web Client Server. For the full list of options for the host and detailed steps of adding a host, see the HTCC installation guide. The configurations of each added host are as follows:



ESXi:



*SSH Port 22

Use VI SDK Secure Port ☑

*VI SDK Secure Port 443

Logging Aggregation ◉ Local ○ Explicit Syslog Server

Syslog Server

Note: Ensure that each host is protected.

Published Hostname/IP

Published IP Mask

vCenter:

*Friendly Name 192.168.20.6

Description

**Hostname/IP* 192.168.20.6

User ID htaserviceaccount@acmefinancial.com

Password ••••

Host Type vCenter

Protected ☑

*HTTPS Secure Port 443

Use HTTPS Secure Port ☑

*HTTP Port 80

Use VI SDK Secure Port ☑

*VI SDK Port 80

*VI SDK Secure Port 443

Logging Aggregation ◉ Local ○ Explicit Syslog Server

Syslog Server

Authentication Mode ◉ Use HTCC Service Account (default)

Use of a Service Account is the only authentication mode currently supported with vSphere 6.

*Published Hostname/IP	192.168.20.7
*Published IP Mask	255.255.255.0

Note: The htaserviceaccount must be created in Active Directory first. See Integrating with Active Directory.

vSphere Web Client Server:

*Friendly Name	192.168.20.6
Description	
*Hostname/IP	192.168.20.6
User ID	htaserviceaccount@acmefinancial.com
Password	••••
Host Type	Web Client Server
Protected	☑
Managed	☐

Logging Aggregation	◉ Local ○ Explicit Syslog Server
Syslog Server	

	Authentication Mode settings will be applied to all vCenters when connecting through this Web Client Server.
Authentication Mode	◉ Use HTCC Service Account (default)
	Use of a Service Account is the only authentication mode currently supported with vSphere 6.

*Published Hostname/IP	192.168.20.7
*Published IP Mask	255.255.255.0

2.2.7 Integrating With Active Directory

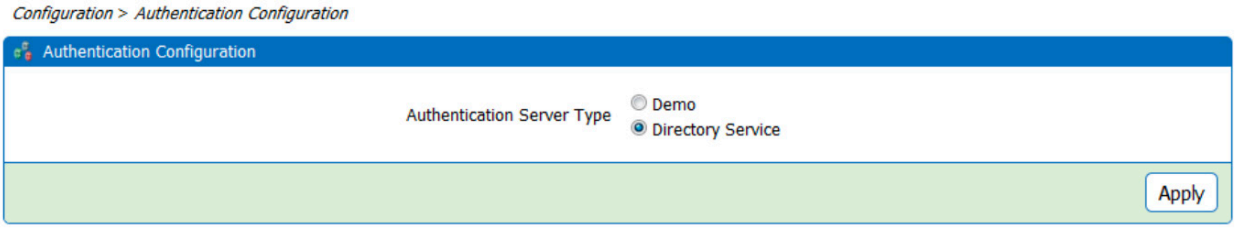
In this build, HTCC is integrated with Active Directory. Users who have access to the virtual environment have accounts in AD and are a part of the *'hytrust users'* group.

First, you must create a service account in Active Directory with the following permissions. In this build, the *htaserviceaccount* is created.

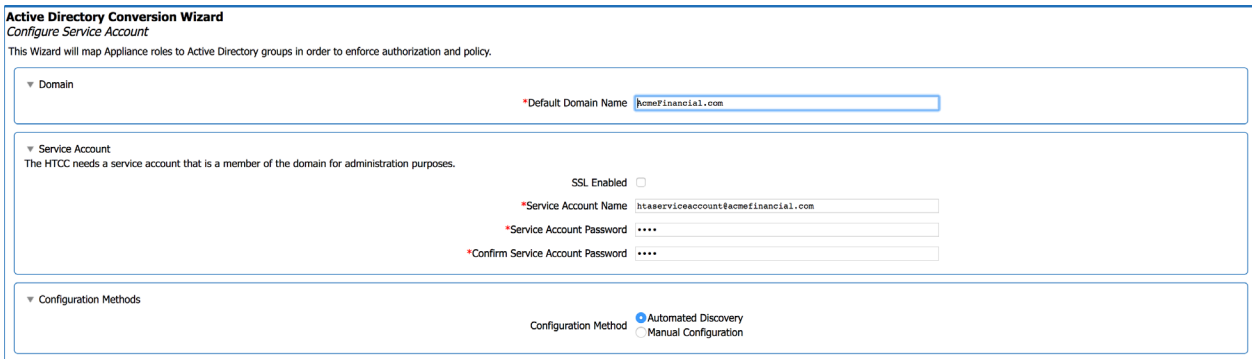
- Domain object: *Read memberOf*
- User object: attributes *memberOf* and *distinguishedName*
- Group object: attributes *member*, *memberOf*, and *distinguishedName*

To convert HTCC to Directory Service mode:

1. Open the Authentication Configuration page (**Configuration > Authentication**).
2. Select the **Directory Service** radio button and click **Apply**.

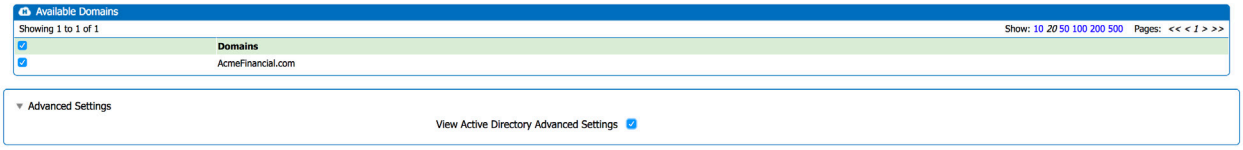


The Active Directory Conversion Wizard opens, which guides you through the steps to connect HTCC to your directory service. The first page is the Configure Service Account page.

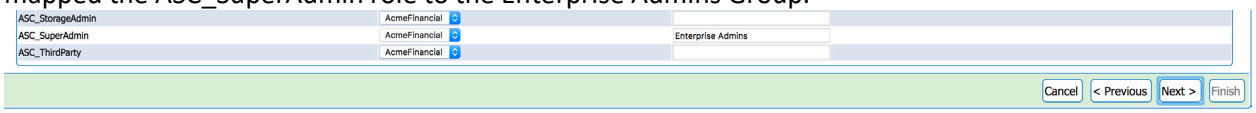


3. Use the Service Account panel to specify the AD HTCC service account information. Select **Automated Discovery**. Click **Next.**

Check **View Active Directory Advanced Settings** to view advanced settings. Otherwise, select **Next.**



The Rule Conversion page appears where you can map HTCC roles to AD groups. For this build, we mapped the ASC_SuperAdmin role to the Enterprise Admins Group.



Note: At a minimum, one Active Directory security group (e.g., SuperAdmin) must be mapped to HTCC ASC_SuperAdmin role for AD conversion to be successful.

4. Click **Next**.

A summary page appears confirming the AD settings. Review the information to make sure the **Domain Controllers**, **Rule Conversion**, and **Service Account** settings are accurate.

5. Click **Finish** to convert HTCC to Directory Service mode.

Perform the following steps to create the HTCC security groups in AD:

1. Create a security group for each HTCC you choose. For this build, two groups called '*Hytrust Users'* and '*Hytrust Users 2'* are created.
2. For each group, assign the Group scope to *Global* and the Group type to *Security*.

For additional configuration options for integrating with Active Directory. see the HTCC Administration Guide, which is available on request.

2.2.8 Creating and Deploying Access Policies

Before creating and deploying access policies on a virtual infrastructure, confirm that HTCC is protecting the vCenter Server and all the imported hosts. See the *HyTrust CloudControl Installation Guide* for assistance in importing a vCenter Server, adding a host, or protecting these resources.

After importing a vCenter Server protected host, HTCC adds the vCenter Server object structure to a new draft policy and deploys it automatically.

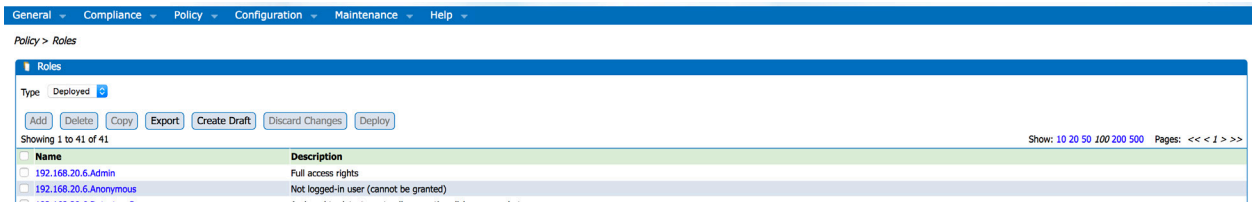
Any time a new virtual machine is created or a new host is added, the new object is automatically added to the HTCC policy and the deployed policy is enforced on the new object. To view the current policy, navigate to **Policy>Resources.** The *Deployed* policy is the policy that is currently in effect.

To make a change in the deployed policy, such as adding a new rule to a protected host, follow these steps:

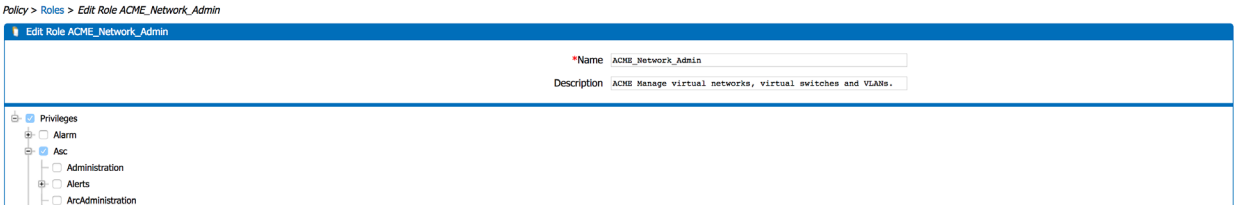
1. Open any **Policy** page.
2. Click the **Create Draft** button. This copies the "Deployed" policy to a "Draft" policy.
3. Make your desired changes to the Draft policy using the various policy pages.
4. Click the **Deploy** button to replace the current Deployed policy with the Draft policy.

For this build, two roles are created called **ACME_Network_Admin** and **ACME_Systems_Admin**. To create the rules and roles used to demonstrate the access rights management capability, follow these steps:

1. Navigate to **Policy>Roles.**
2. Select **Create Draft.**



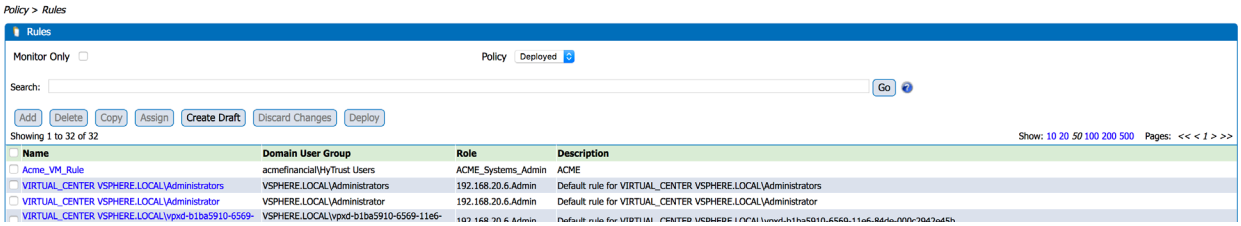
3. Select **Add.** First, create the network admin role. Then, name the role and provide a description.



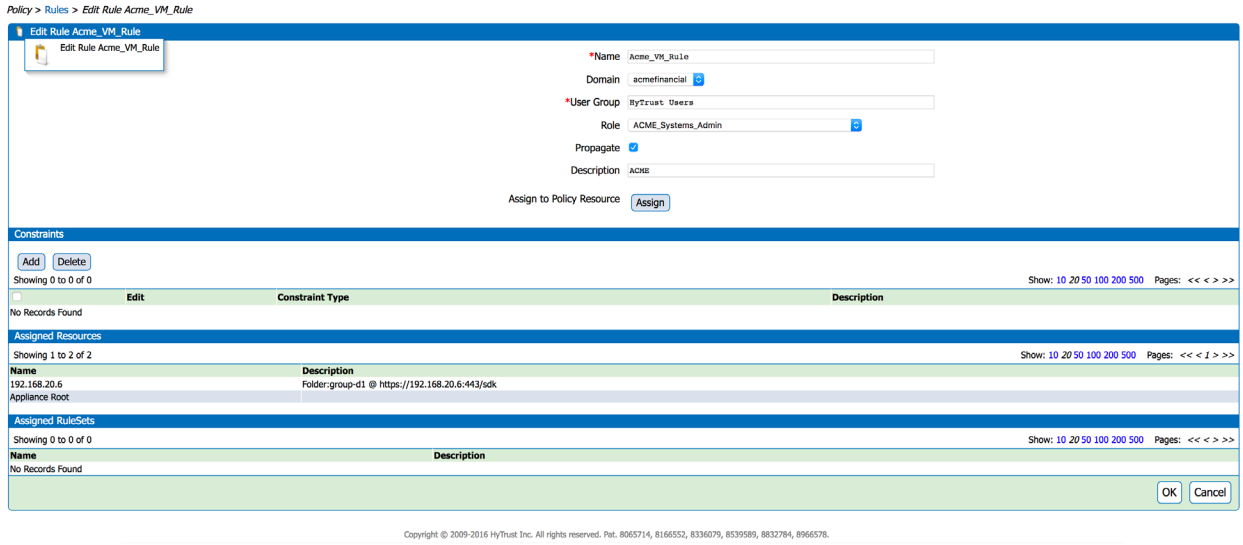
4. Select all of the following permissions:
    a. **Asc>NxOsConfig, NxOsShow, NxOsXmlApi,ssh,storage**
    b. **DVPortgroup>Entire List** (*Note:* This configuration item is deprecated in versions 5.1 and above of the product.)
    c. **DVSwitch>Entire List**
    d. **DataCenter>IpPoolConfig,IpPoolQueryAllocations,IpPoolReleaseIp**
    e. **Global>CancelTask,LogEvent**
    f. **Host>Config>AdvancedConfig,NetService,Network,PciPassthru**
    g. **Network>Assign,Delete,Router**
    h. **Resource>Delete**
    i. **System>Entire List**
    j. **Task>Entire List**
    k. **VirtualMachine>Config>ManagedBy,MultiActions**
5. Press **OK.**
6. Press **Deploy.**
7. Repeat Steps 2–6 to create the system admin role, but with the following permissions selected:
    a. **Global>CancelTask,LogEvent**
    b. **System>Entire List**
    c. **Task>Entire List**
    d. **VApp>Entire List**
    e. **VirtualMachine>Entire List**

Next, you must create the rules that will apply the roles to the host. First, create the rule for the system admins role, assigning it to the '*HyTrust Users*' AD group.

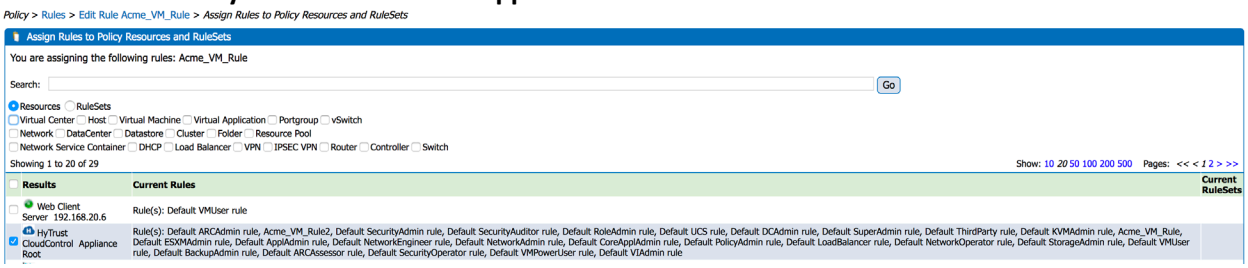
8. Navigate to **Policy>Rules.**
9. Select **Create Draft.**



10. Select **Add.** Name the rule and type in the user group created in Active Directory.



11. Select **Assign.**
12. Check the **HyTrust CloudControl Appliance Root** radio button.

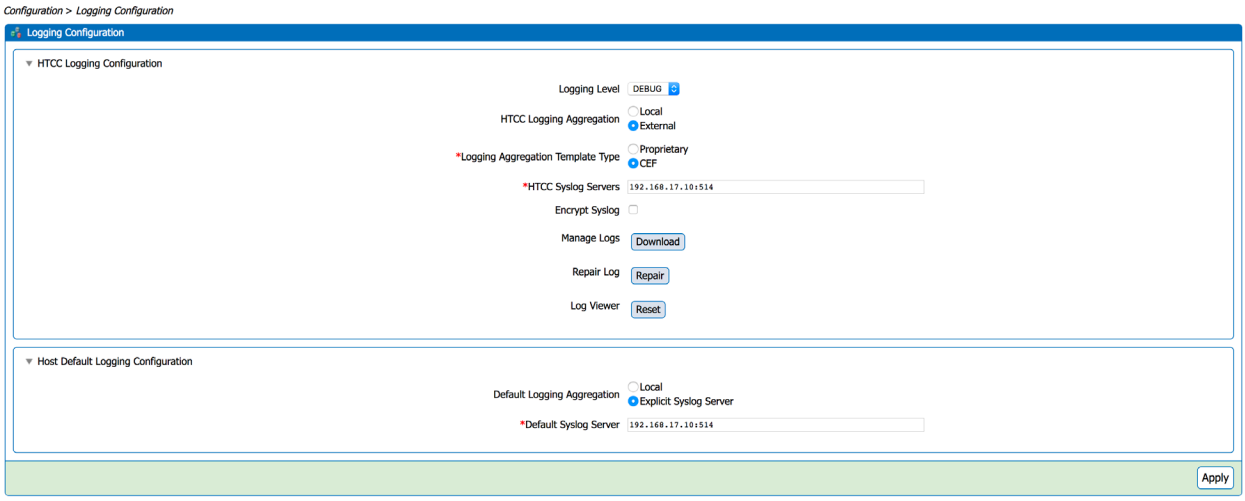


13. Select **OK.**
14. Select **OK.**
15. Select **Deploy.**
16. Repeat Steps 1–9 to create a rule for the network admins role, assigning it to the *'Hytrust Users 2'* active directory group.

2.2.9 Configure Logging

1. Select **Configuration > Logging.**
2. Select the **DEBUG** logging level.
3. Select **External.**
4. Select **CEF.**

5. Enter the IP address of the Splunk server, specify port 514.



6. Select **Explicit Syslog Server.**
7. Enter the IP address of the Splunk server, specify port 514.
8. Select **Apply.**

2.3 Microsoft Active Directory

An LDAP directory service that stores user account and attribute information.

2.3.1 How It's Used

Microsoft AD acts as one of the user identity management repositories in the example solution. AD can provision and de-provision user identities; the creation, modification, and deletion of subject attributes; and the provisioning and de-provisioning of subject attributes to specific user identities. Administration of user identity and attribute provisioning is controlled by AlertEnterprise Enterprise Guardian. AD is also used for its logging and auditing of user identity and attribute provisioning administration.

2.3.2 Virtual Machine Configuration

The AD virtual machine is configured as follows:

- 1 CPU Core
- 4GB RAM
- 84GB HDD
- 2 Network Adapters

Network Configuration (Interface 1)
IPv4 Manual
IPv6 Disabled
IP Address: 192.168.19.10
Netmask: 255.255.255.0
Gateway: 192.168.19.1
DNS Name Servers: 192.168.19.10
DNS-Search Domains: AcmeFinancial.com

2.3.3 Installing AD

Install a new Windows server 2012 R2 Active Directory Forest:

https://technet.microsoft.com/en-us/windows-server-docs/identity/ad-ds/deploy/install-a-new-windows-server-2012-active-directory-forest--level-200-

The name of the domain used for this build is AcmeFinancial.com.

2.3.4 DNS Configuration

1. Create the following host records in the AcmeFinancial.com forward lookup zone:

Name	FQDN	IP address
Activedirectory	Activedirectory.acmefinancial.com	192.168.19.10
ADBackup	ADBackup.acmefinancial.com	192.168.19.12
ConsoleWorks	Consoleworks.acmefinancial.com	192.168.17.11
Openldap	Openldap.acmefinancial.com	192.168.19.11
Racf	Racf.acmefinancial.com	172.17.212.10
RadiantOne VDS	RadiantOne VDS.acmefinancial.com	192.168.14.111
RadiantOne VDS	RadiantOne VDS.acmefinancial.com	192.168.17.100
Sharepoint2	Sharepoint2.acmefinancial.com	192.168.17.113
Splunk	Splunk.acmefinancial.com	192.168.17.10
VcenterServer	Vcenterserver.acmefinancial.com	192.168.20.6

2. Create the following IPv4 reverse lookup zones:

Name
14.168.192.in-addr.arpa
17.168.192.in-addr.arpa
19.168.192.in-addr.arpa
20.168.192.in-addr.arpa
212.17.212.in-addr.arpa

2.3.5 Installing Splunk Universal Forwarder

Note: You will need a Splunk account to download the Splunk Universal Forwarder. It is free and can be set up at: https://www.splunk.com/page/sign_up

Download the Splunk Universal Forwarder from: http://www.splunk.com/en_us/download/universal-forwarder.html

You want the latest version for OS version Windows (64-bit). Because this is installing on Windows, select the file that ends in .msi. An example is: spunkforwarder-6.4.2-00f5bb3fa822-x64-release.msi

2.3.6 Install Security Compliance Manager

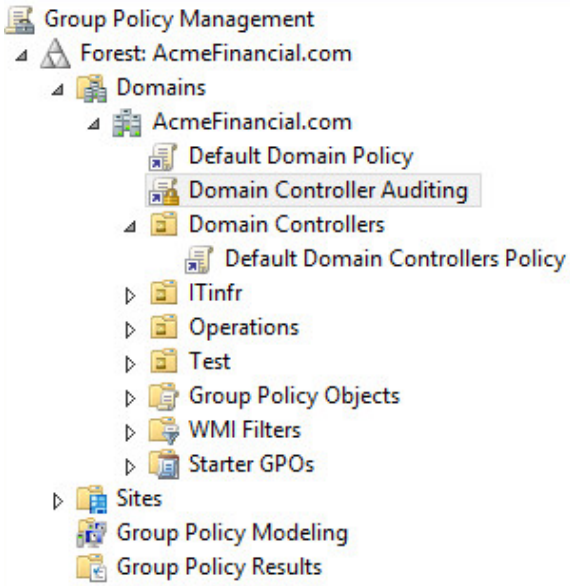
Install Microsoft Security Compliance Manager: https://www.microsoft.com/en-us/download/details.aspx?id=53353

2.3.7 Group Policy Object (GPO) Configuration

Auditing is enforced using the Microsoft Group Policy feature. Group policy auditing is administered with Microsoft Security Compliance Manager (SCM). Details for downloading and installing SCM can be found here.

SCM consist of baseline configurations based on Microsoft security guide recommendations and industry best practices. In this build, the Domain Controller Security Policy is deployed using SCM to established a benchmark. The .CAB file is included in the SCM. In our build, we deployed this benchmark named as "Domain Controller Auditing." For directions for deploying a benchmark, see the Microsoft documentation found here.

Group policy automatically applies the Default Domain Policy and Default Domain Controllers Policy when AD is installed, as shown here:

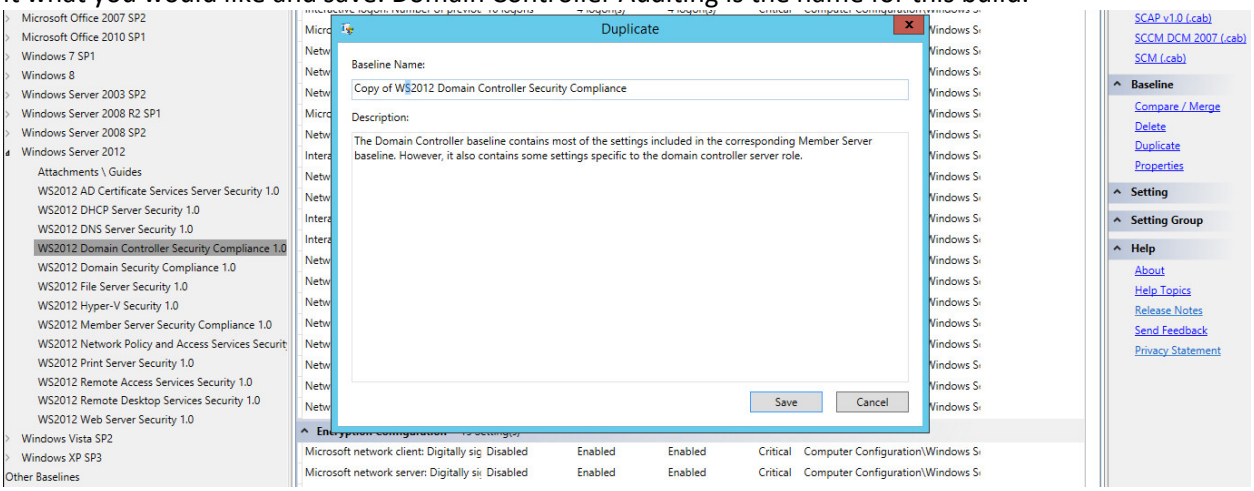


For this build, no changes are made to the Default Domain or Default Domain Controllers Policy. Both policies are *"enabled"* and *"link enabled."*

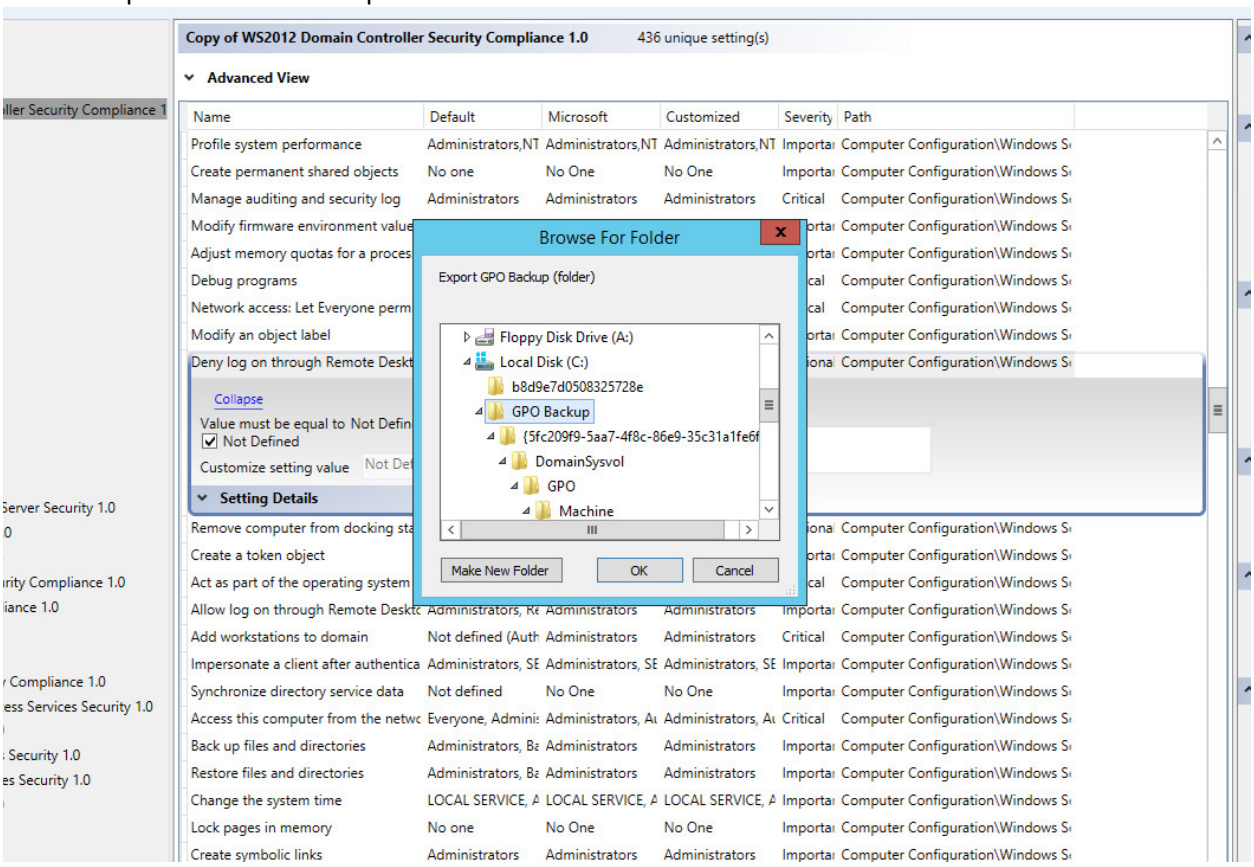
Minor changes are made to the Domain Controller Auditing Policy to enable the ability to audit user account changes, attribute changes, and policy changes for this build.

Note: This example is built in a lab environment. Some security measures were dialed back or turned off for testing purposes.

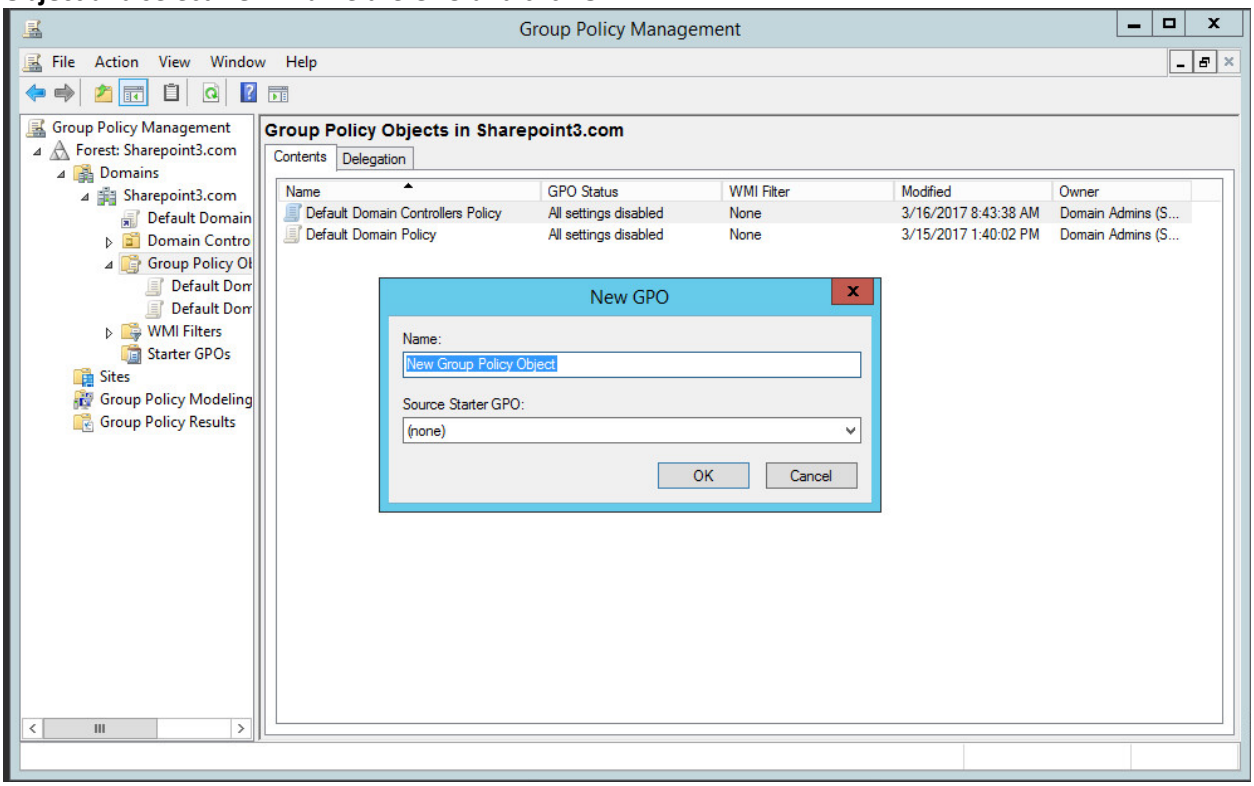
1. Create a duplicate of the “WS2012 Domain Controller Security Compliance 1.0” baseline. Name it what you would like and save. Domain Controller Auditing is the name for this build.



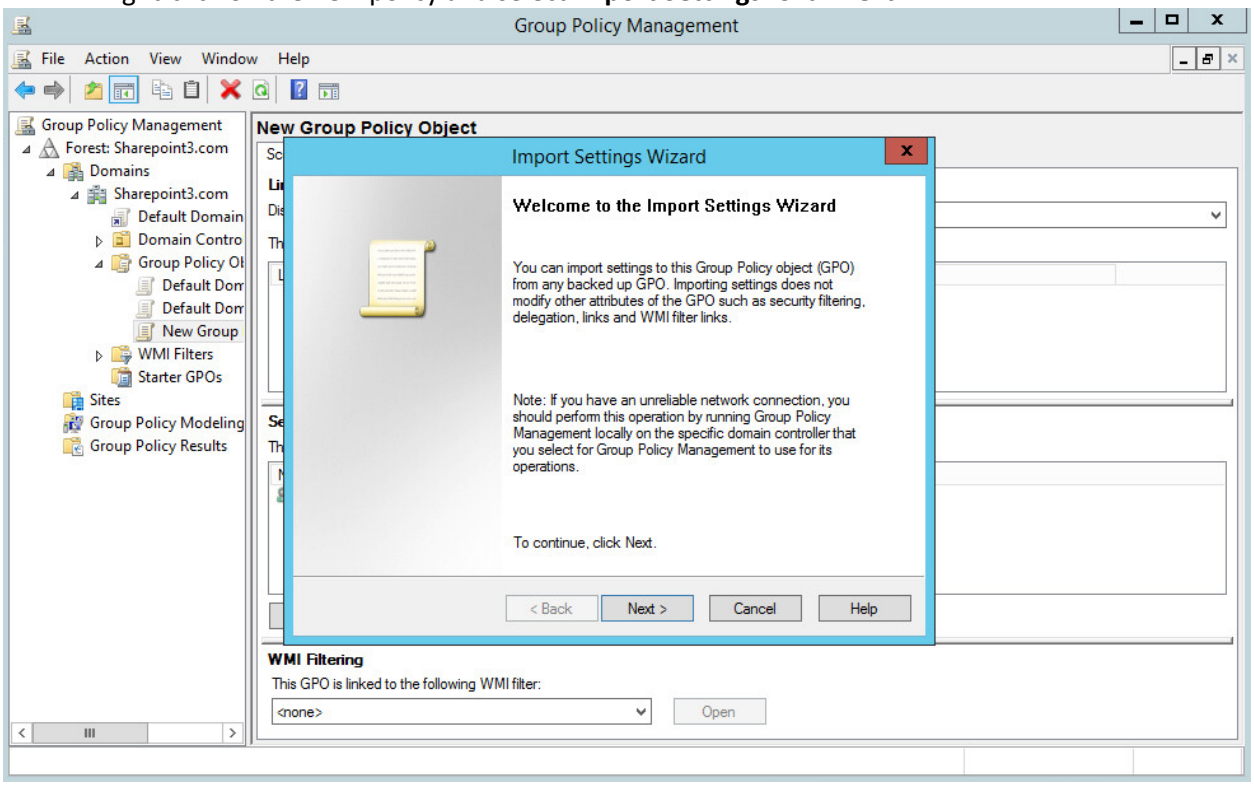
2. Export to a GPO backup folder.



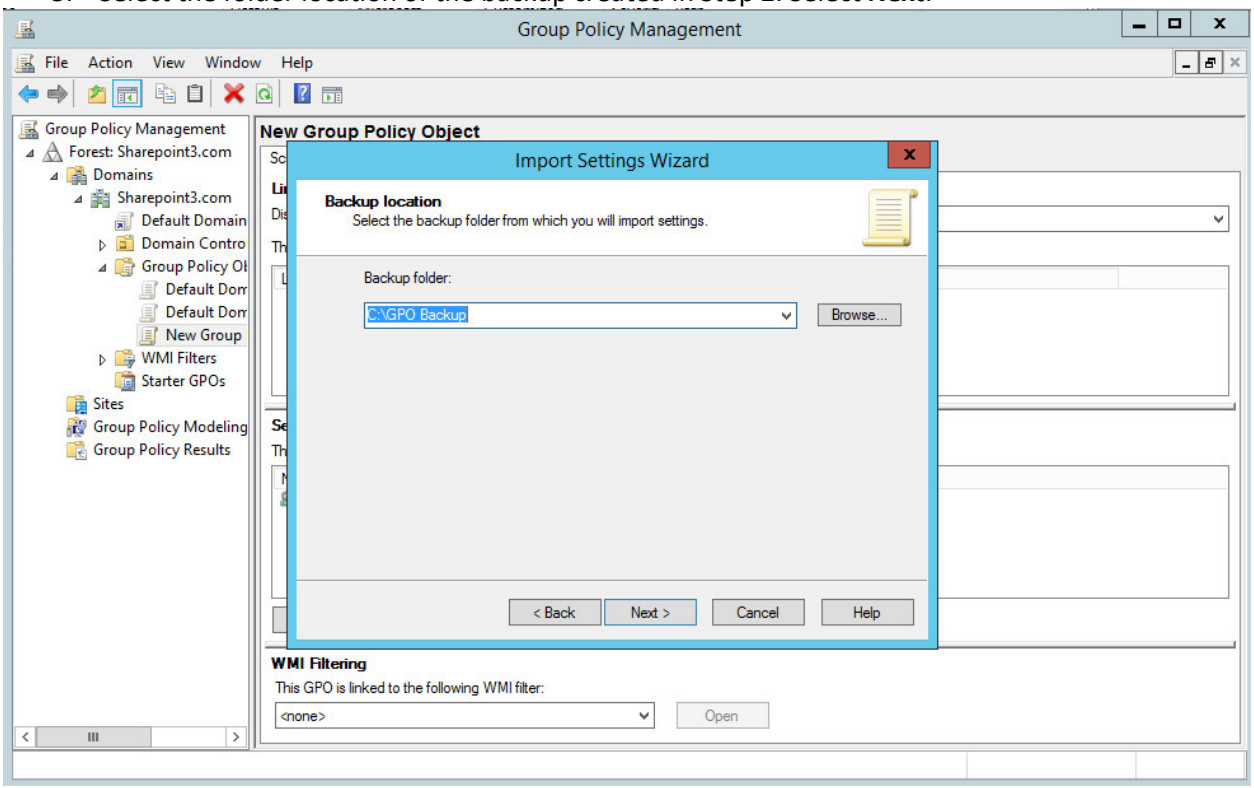
3. Open group policy management. Under the top level of the domain, right-click on **Group Policy Object** and select **New**. Name the GPO and click **OK.**



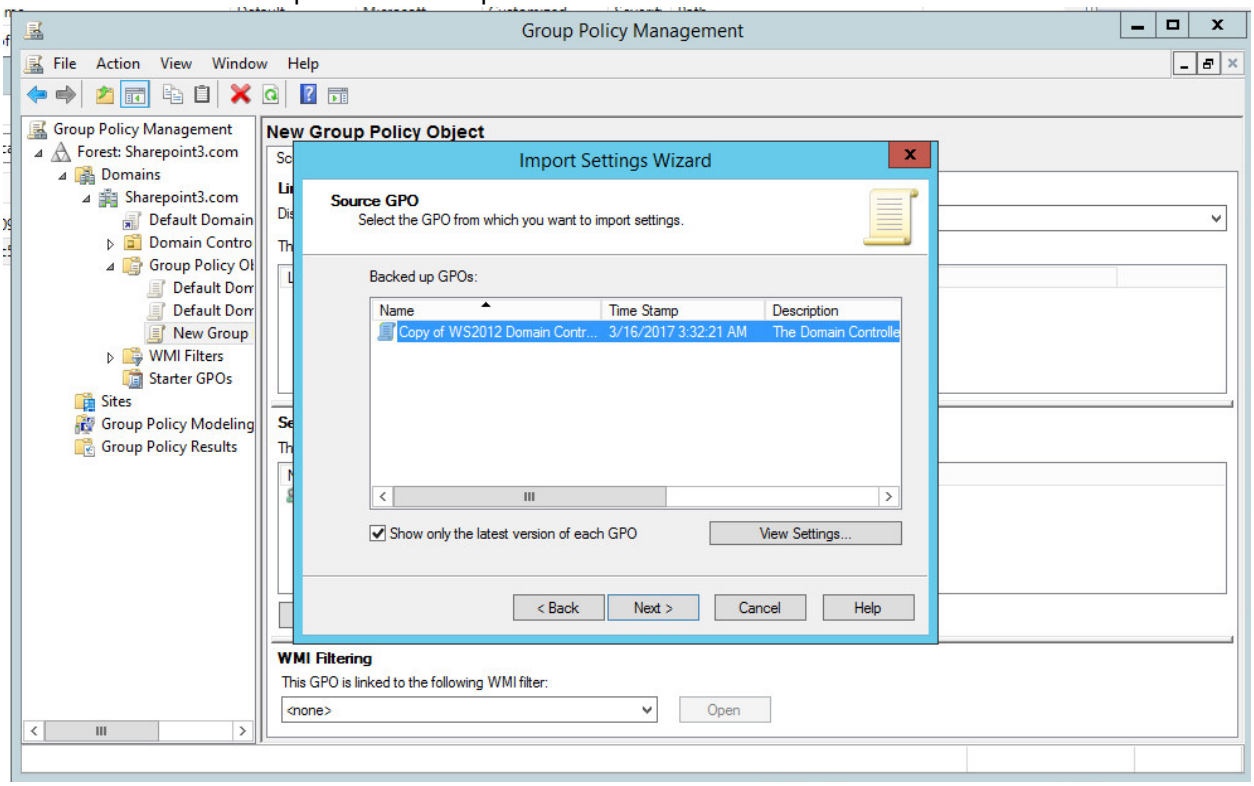
4. Right-click on the new policy and select **Import Settings**. Click **Next**.



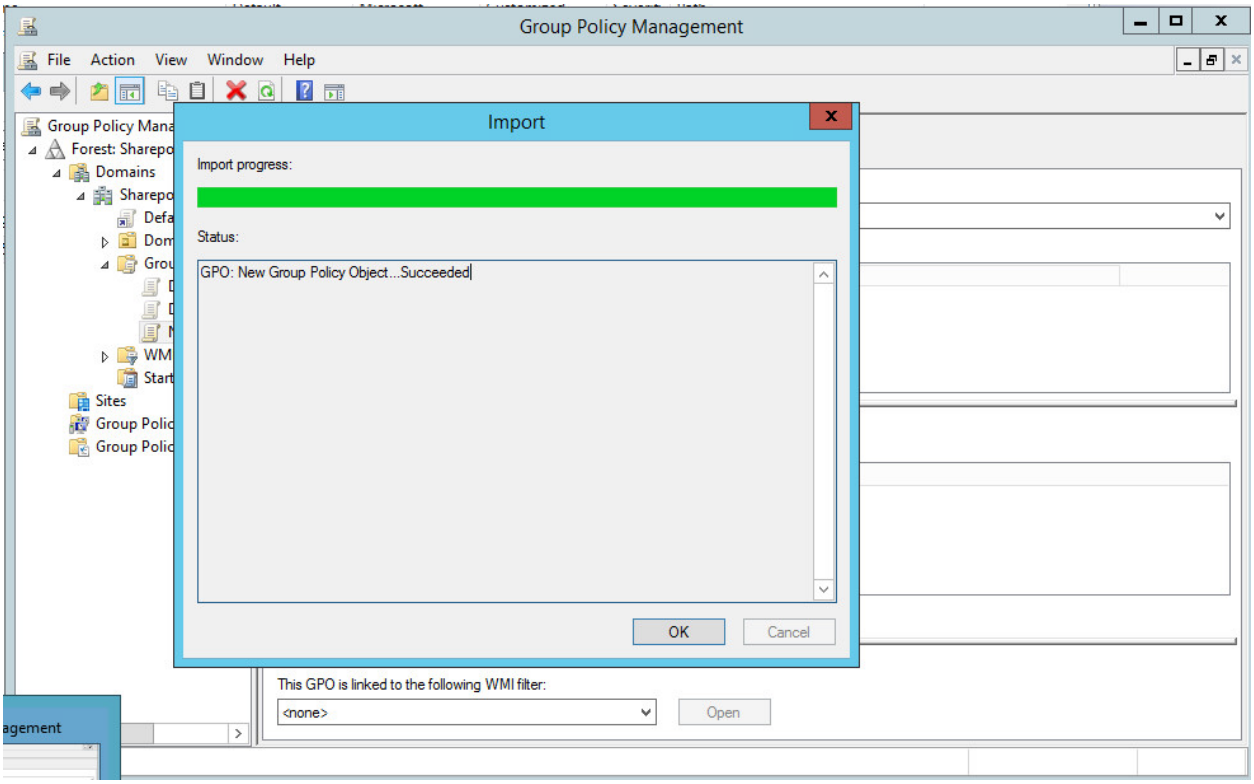
5. Select the folder location of the backup created in Step 2. Select **Next**.



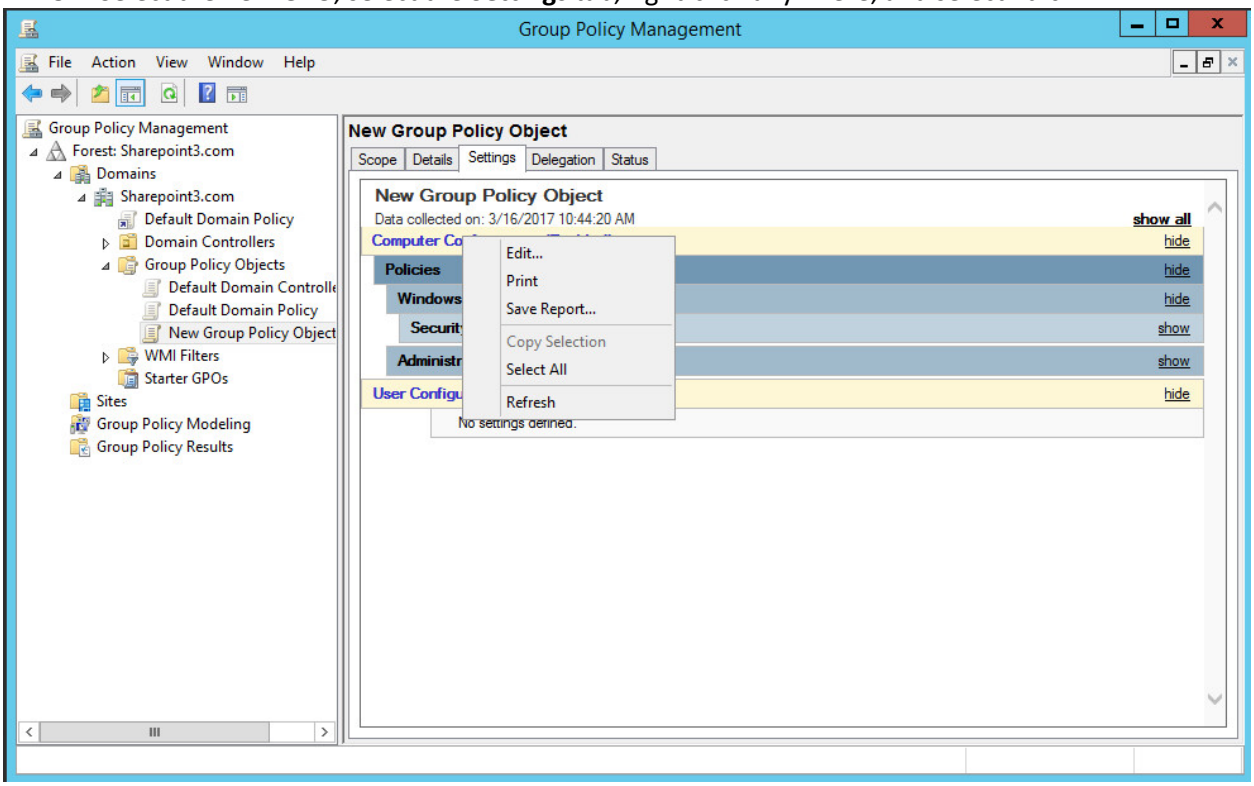
6. Select the backup created in Step 2.



7. Click **Next** at the end of the wizard and **Finish**.

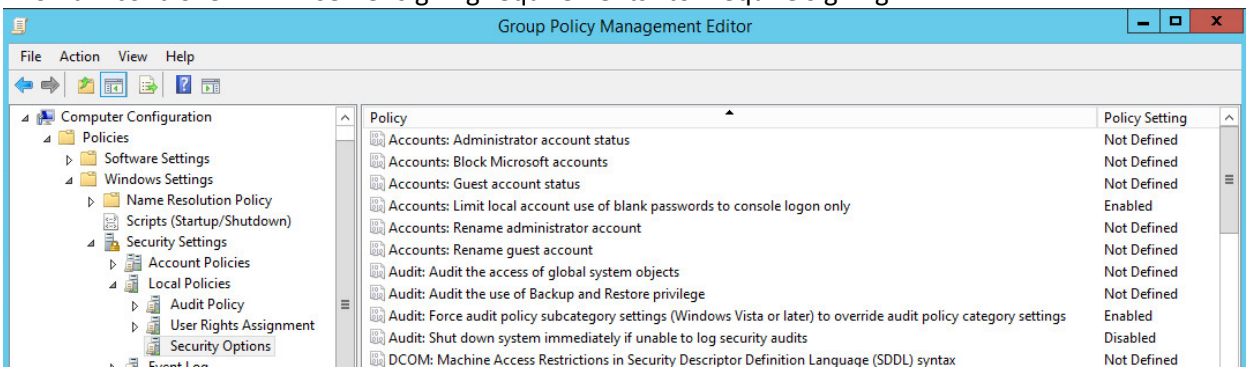


8. Select the new GPO, select the **Settings** tab, right-click anywhere, and select **Edit**.



9. Navigate to **Computer Configuration>Policies>Windows Settings>Security Settings>Local Policies>Security Options**. Change the value for "Audit: Force audit policy subcategory settings

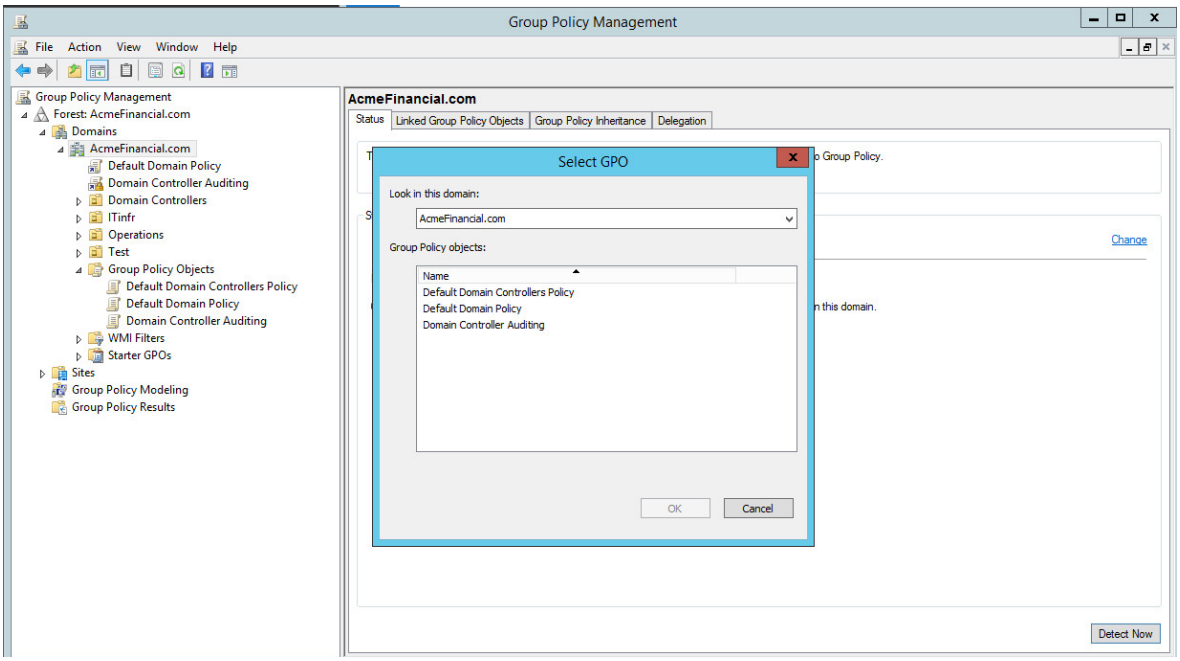
(Windows Vista or later) to override audit policy category settings" to "Enabled." Change the value for "Domain controller: LDAP server signing requirements" to "require signing."



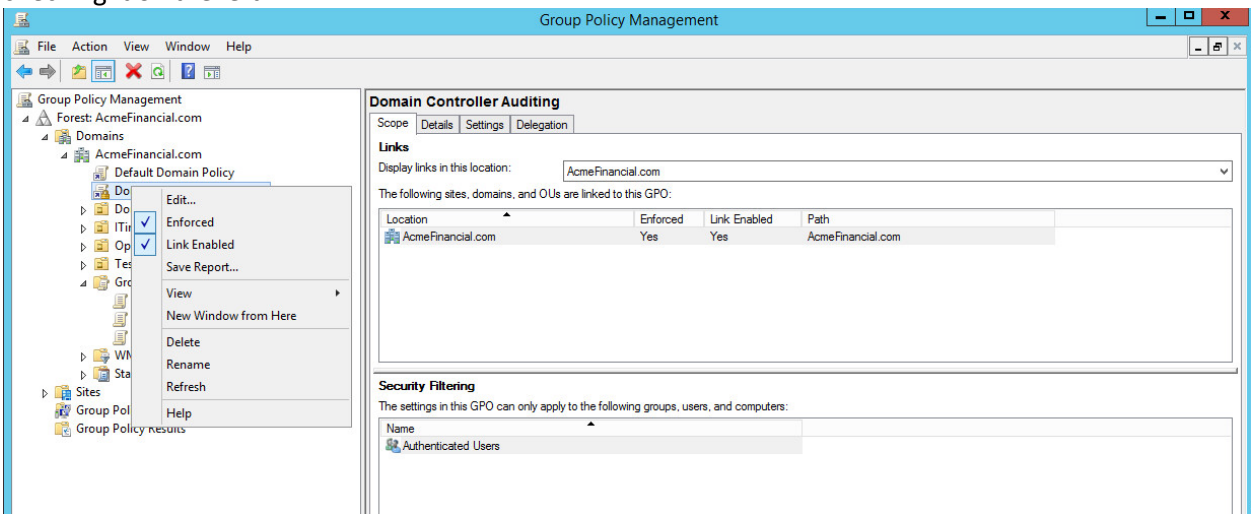
10. Navigate to **Computer Configuration>Policies>Windows Settings>Security Settings>Advanced Audit Policy Configuration>Audit Policies**. Make the following changes and save:

Account Logon	
Audit Credential Validation	***Success, Failure***
Account Management	
Audit Application Group Management	***Success, Failure***
Audit Distribution Group Management	***Success, Failure***
DS Access	
Audit Directory Service Access	***No Auditing***
Audit Directory Service Changes	***Success, Failure***
Object Access	
Audit Files Share	***Success***
Audit File System	***Success***
Policy Change	
Audit Audit Policy Change	***Success, Failure***
Audit Authentication Policy Change	***Success***
Audit Authorization Policy Change	***Success***
Audit MPSSVC Rule-Level Policy Change	***Success***

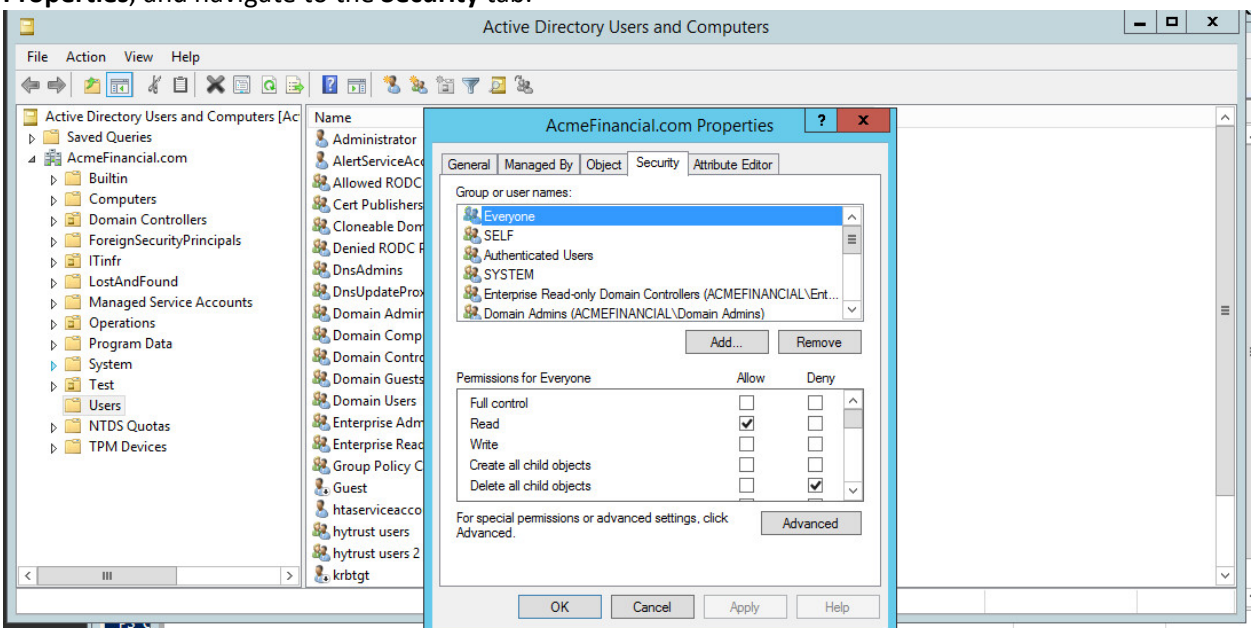
11. Right-click on the top level of the domain again, select **Link an Existing GPO**, and choose the created GPO.



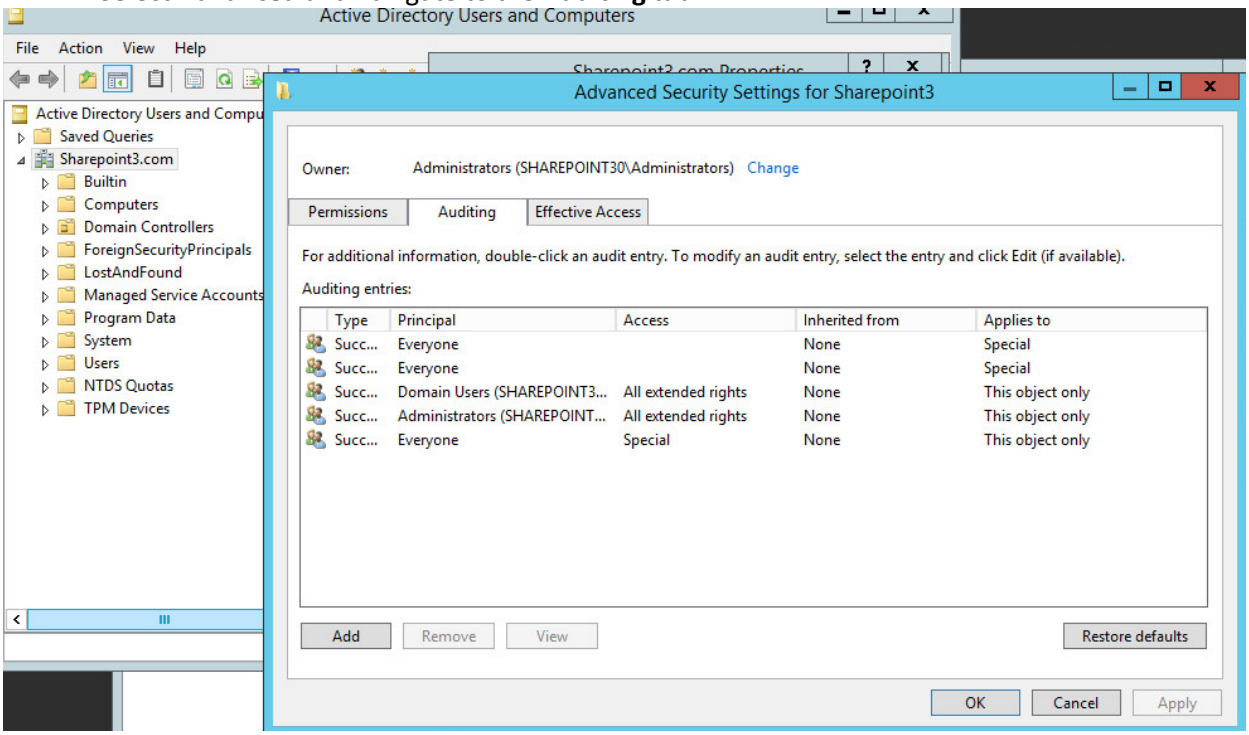
12. Right-click on the new GPO linked directly under the top-level domain and select **Enforced** by checking it on the left.



13. Open **Active Directory Users and Computers**, right-click on the top level of the domain, select **Properties**, and navigate to the **Security** tab.

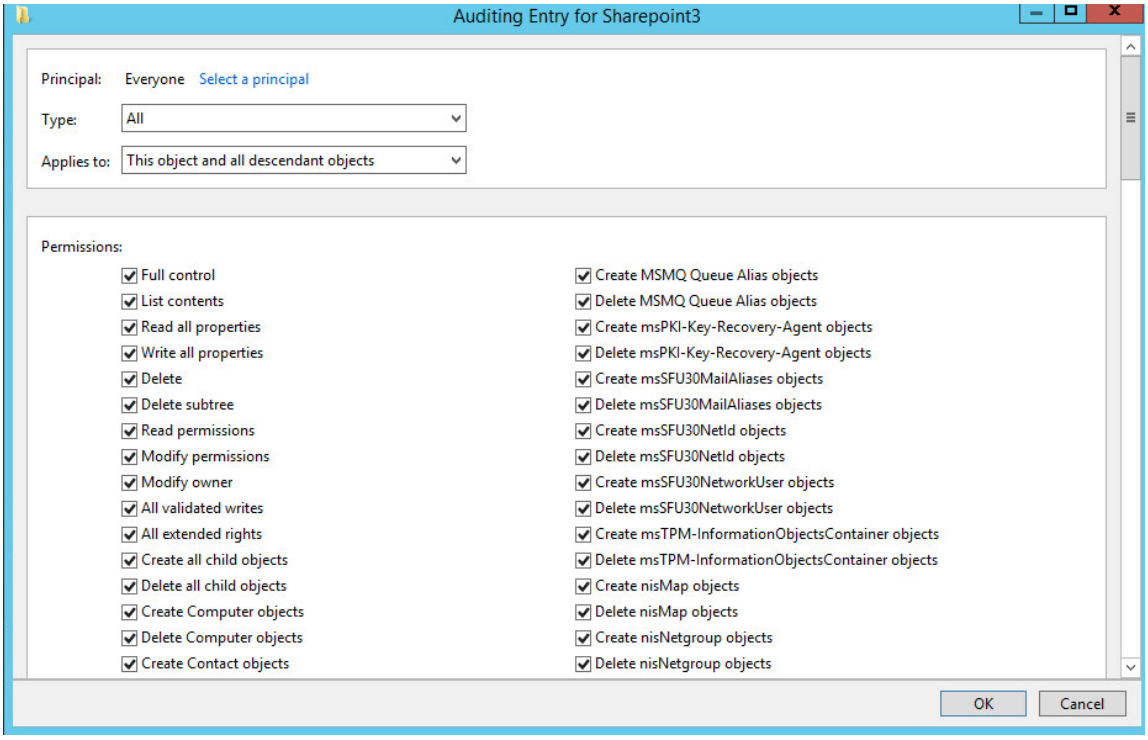


14. Select **Advanced** and navigate to the **Auditing** tab.



15. **Add** a new entry with the following parameters:

Type: *All*, Principal: *Everyone*, Applies to*: This object and all descendant objects*. Select every checkbox under "Permissions" and "Properties" to audit for each action. Click **OK** and apply the changes.



2.3.8 Script: AdDOnlineStatus.ps1

A powershell script is scheduled to run regularly on the active directory server that determines whether it is online or not and writes messages to a local file that Splunk consumes.

```
#This script determines if this server is online or offline
#If a gateway route exists, the script will
#output the current time, hostname, status and previous time (last
#time it wrote to output file)
#Check if gateway route exists
if (Get-Netroute 0.0.0.0/0)
   {
   #Store date in PrevTime variable
   $PrevTime = Get-Date -format "ddd MMM dd HH:mm:ss \EST yyyy"
   #Check if prevtime-file.txt exists
   if (ls C:\scripts\prevtime-file.txt)
      {
         #Place the contents of prevtime-file.txt in the PrevTime variable
      $PrevTime=Get-Content C:\scripts\prevtime-file.txt
      }
   #Place the current date in CurrentTime
```

```
   $CurrentTime = Get-Date -format "ddd MMM dd HH:mm:ss \EST yyy"
   #Overwrite the contents of prevtime-file.txt with the current date
   Get-Date -format "ddd MMM dd HH:mm:ss \EST yyy" > C:\scripts\prevtime-file.txt
   $HostVar = hostname
   $Status = 'online'
   #Add the contents of the variables CurrentTime, HostVar, Status, PrevTime to
Radiant-Status-Output.csv
   Add-Content C:\scripts\AD-Status-Output.csv
$CurrentTime','$HostVar','$Status','$PrevTime
   }
else
   {
   $PrevTime = Get-Date -format "ddd MMM dd HH:mm:ss \EST yyyy"
   if (ls C:\scripts\prevtime-file.txt)
      {
      $PrevTime=Get-Content C:\scripts\prevtime-file.txt
      }
      $CurrentTime = Get-Date -format "ddd MMM dd HH:mm:ss \EST yyy"
      Get-Date -format "ddd MMM dd HH:mm:ss \EST yyy" > C:\scripts\prevtime-file.txt
      $HostVar = hostname
      $Status = 'offline'
      Add-Content C:\scripts\AD-Status-Output.csv
$CurrentTime','$HostVar','$Status','$PrevTime
   }
```

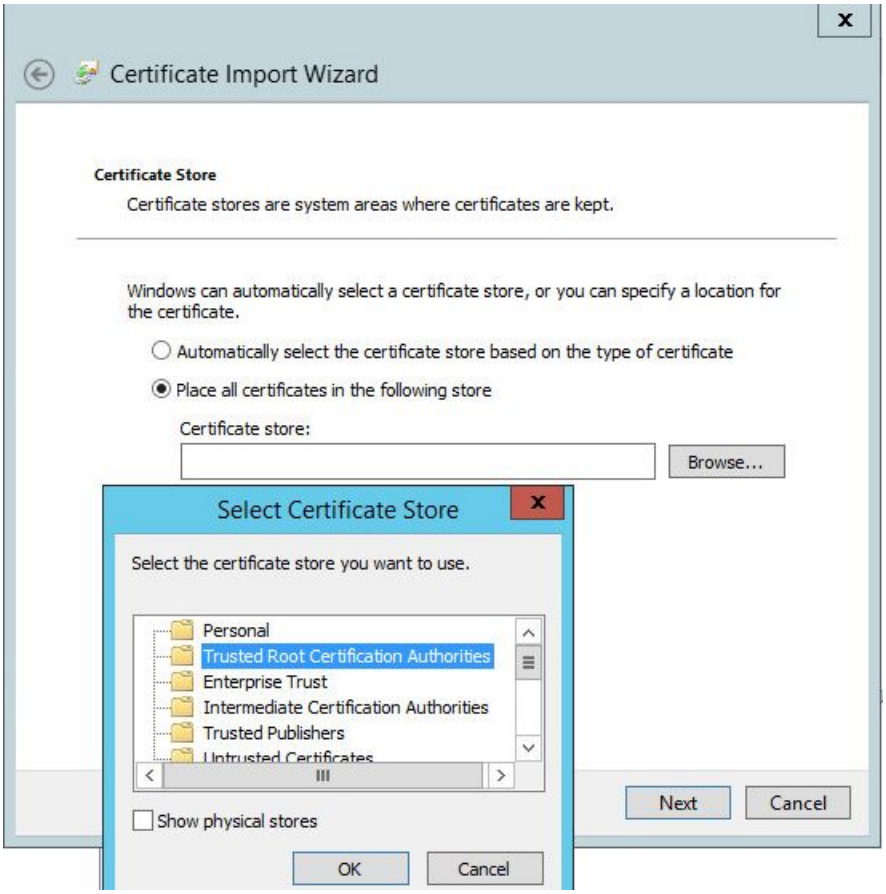
2.3.9 LDAPS Configuration

Once installed, the Active Directory service listens for both LDAP and LDAPS connections. To make LDAPS active, you will need to make sure that the certificates for the Active Directory domain controller and the certificate authority (CA) that signed the certificate are properly installed. Once these certificates are imported, LDAP clients will be able to use the LDAPS service.

1. Copy the CA and domain controller certificates over to the Active Directory domain controller.
2. Right-click on each certificate and choose **Install Certificate.**
3. Choose **Local Machine**.

4. Click **Next**
5. Choose the placement of the certificate:
    a. Choose to place the certificate in the **Personal Store** if it is the domain controller's certificate.
    b. Choose to place the certificate in the **Trusted Store** if it is the CA certificate.
6. Click **OK** and then click **Next.**

LDAPS requests can be processed at this point.



2.4 NextLabs Entitlement Manager

NextLabs Entitlement Manager is a dynamic authorization system based on Attribute Based Access Control.

2.4.1 How It's Used

NextLabs Entitlement Manager is used to authorize access to the web application, which is SharePoint in this build. Entitlement Manager requires three components for functionality: NextLabs Control Center, Policy Studio, and Entitlement Management for Microsoft SharePoint Server.

NextLabs Control Center is installed on its own server along with Policy Studio. Entitlement Management is installed on an instance of Microsoft SharePoint Server.

2.4.2 Virtual Machine Configuration

The NextLabs virtual machine is configured with:

- Windows Server 2012 R2
- 8 CPU cores
- 16GB of RAM
- 1 NIC
- 100GB of Storage

Network Configuration (Interface 1)
IPv4 Manual
IPv6 Disabled
IP Address: 192.168.14.117
Netmask: 255.255.255.0
Gateway: 192.168.14.1
DNS Name Servers: 192.168.14.1
DNS-Search Domains: n/a

2.4.3 Prerequisites

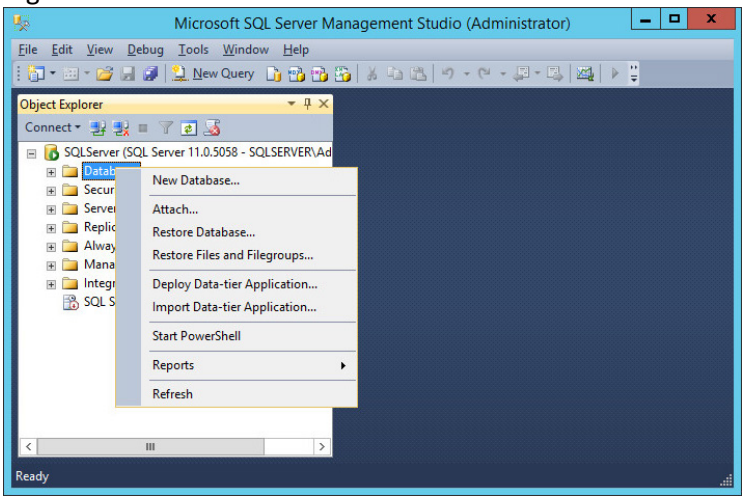
NextLabs Control Center requires an Oracle or MS SQL Server. It is recommended that the database be given 500GB of free storage space. In this build, only 100GB of storage is used for development purposes.

Additionally, multiple deployment configurations are supported. The development deployment configuration is used in this build. For this deployment, the Control Center server is deployed on the same instance as the SQL Server. For a full list of supported software and deployment configurations, see the *NextLabs Control Center Installation Guide* found at the customer portal.

2.4.4 Installing NextLabs

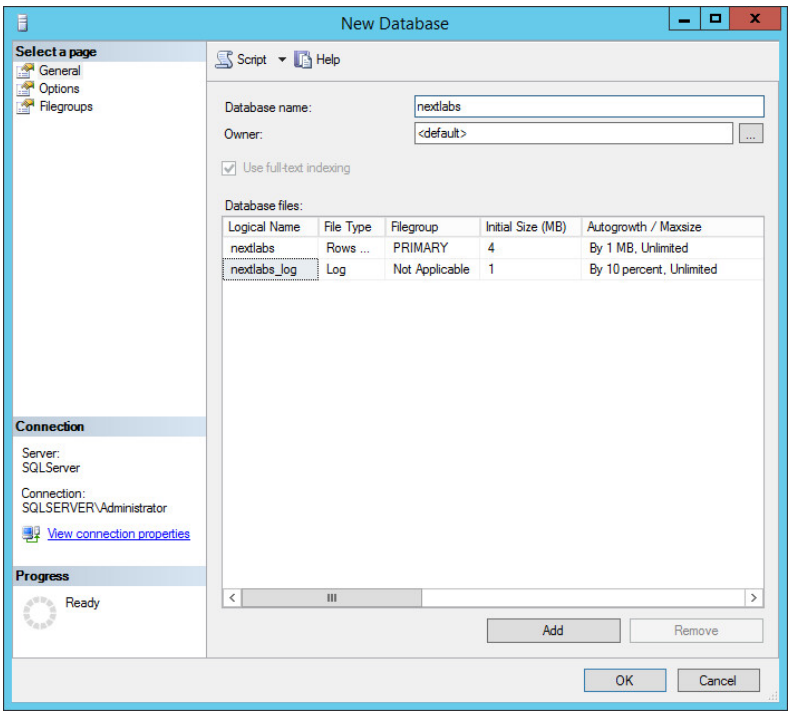
Control Center 7.7

1. Install the Microsoft SQL Server 2012 according to instructions available online.
2. Open Microsoft SQL Server Management Studio and log in to the Microsoft SQL Server.
3. Right-click on **Databases** and left-click on **New Database**.

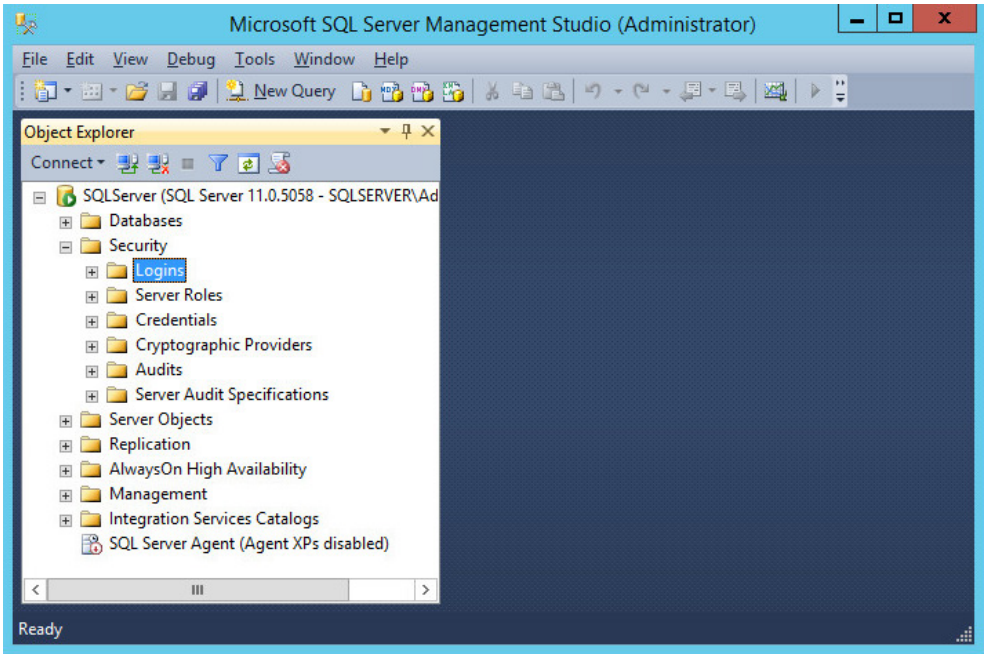


4. In the New Database window, specify a **Database name** that works for you. The application automatically copies this into the **Logical Names** of the **Database files**. Click **OK**. Example name

from this build: **nextlabs.**

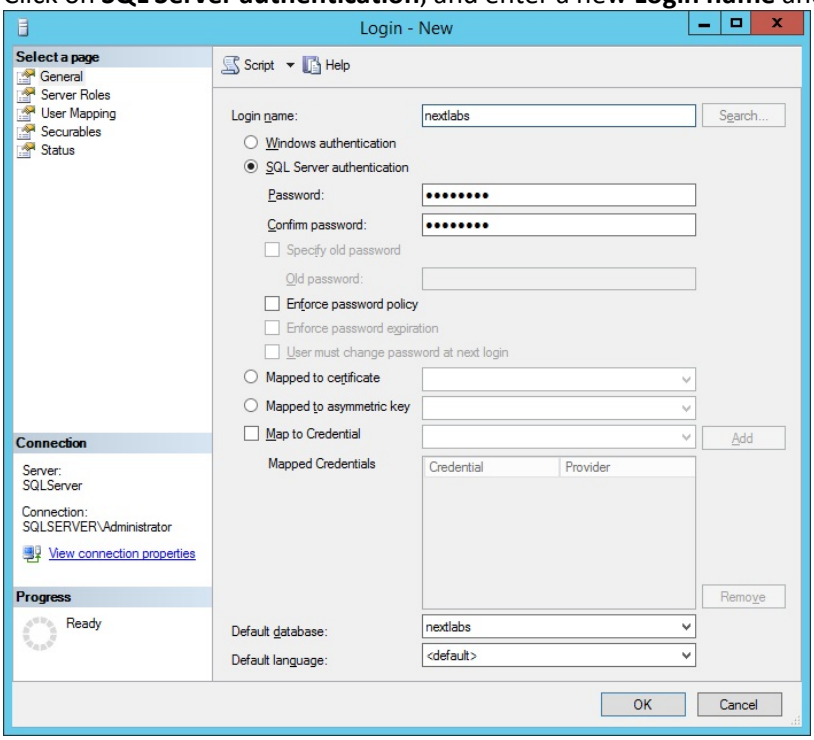


5. Click on the menu box next to **Security** to begin the process for creating a new login for the new NextLabs database's administrator.

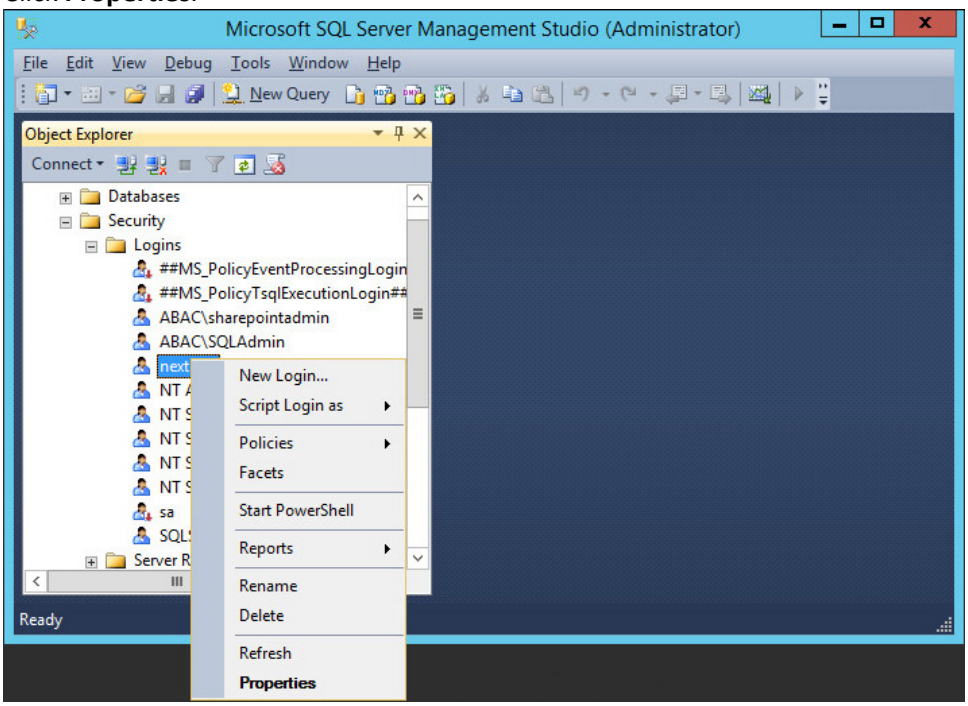


6. Right-click **Logins**. Left-click **New Login**.

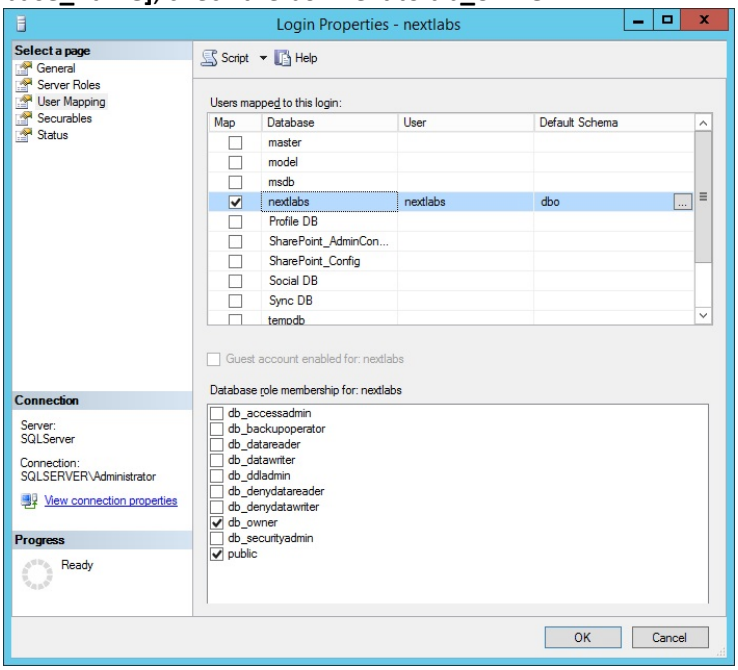
7. Click on **SQL Server authentication**, and enter a new **Login name** and **Password**.



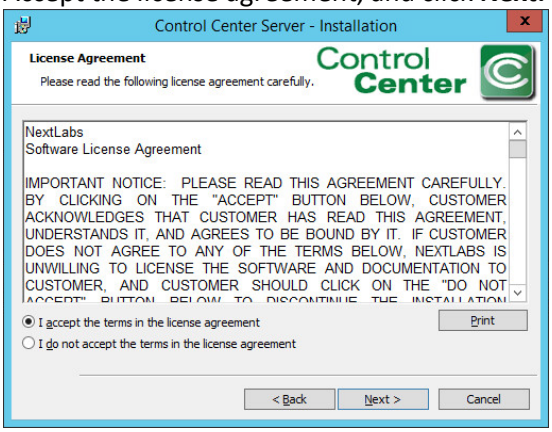
8. Click the menu box next to **Logins**. Right-click on the new user created in the previous step. Click **Properties**.



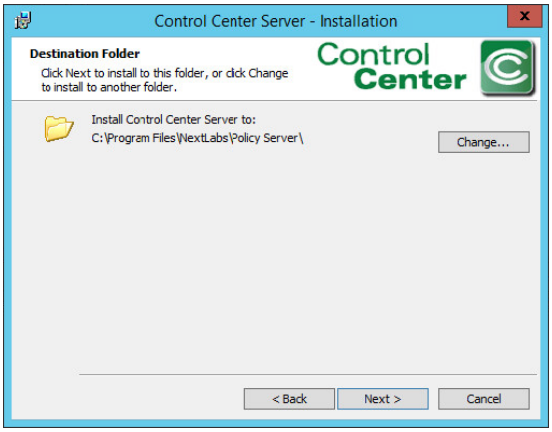
9. Click on **User Mapping**, then **New Database**. Under **Database role membership for: [database_name]**, check the box next to **db_owner**.



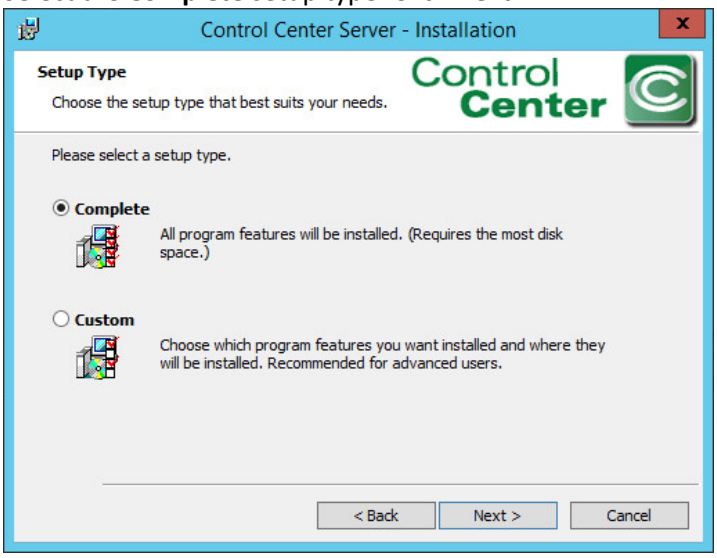
10. Locate the installation zip file, provided by NextLabs support, and extract it.
11. Run the installer as follows:
    a. On a Windows server, launch Command Prompt as Administrator.
    b. In the command prompt, navigate to the folder that contains `install.bat`. The following is an example of the cd command to type if the installation zip file is extracted in `c:\build. cd build\ControlCenter-Windows-chef-- main\PolicyServer`
12. From this directory, run the command: `install.bat`
13. Click **Next**.
14. Accept the license agreement, and click **Next.**



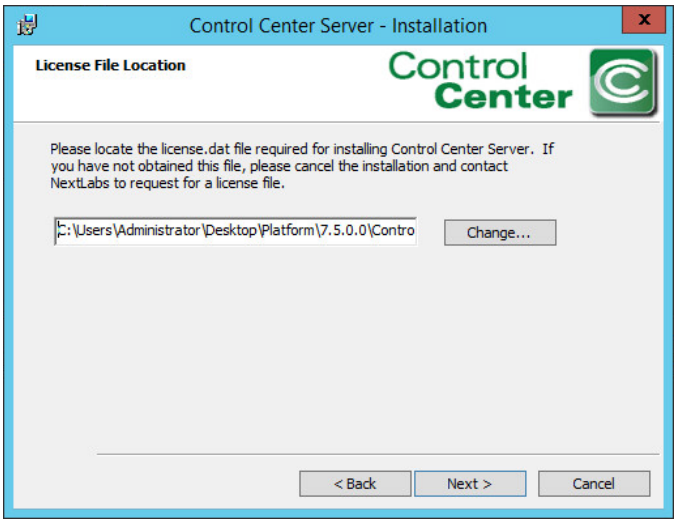
15. Click **Next.**



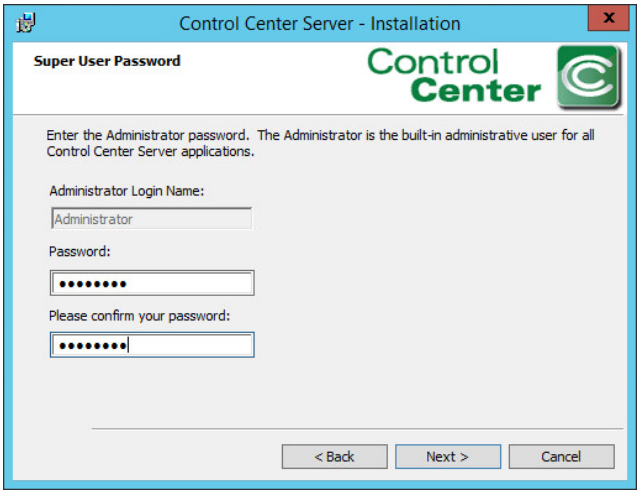
16. Select the **Complete** setup type. Click **Next.**



17. Enter the location of the license file. Click **Next.**

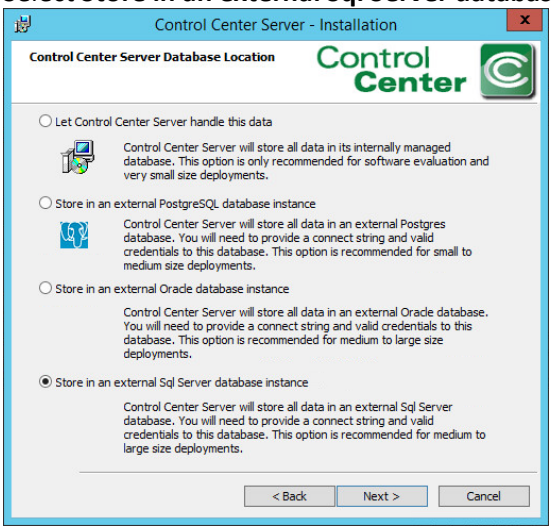


18. Enter a Password for the built-in administrative user for all Control Center Server applications. Click **Next.**

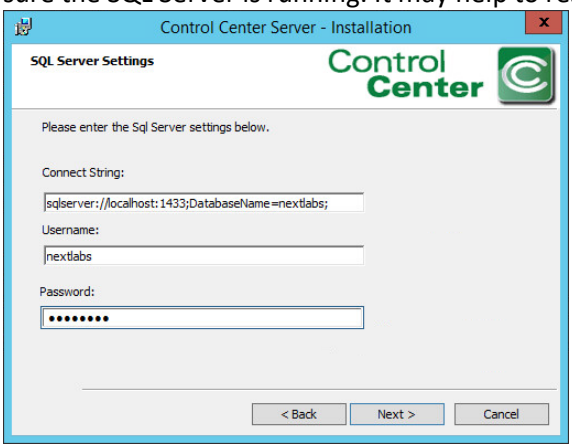


19. Enter a Password to access the SSL certificates for the Control Center Server. Click **Next.**
20. Enter a Password to access the Encryption Key Store for the Control Center Server. Click **Next.**
21. At the Application User Authentication screen, click **Skip.**

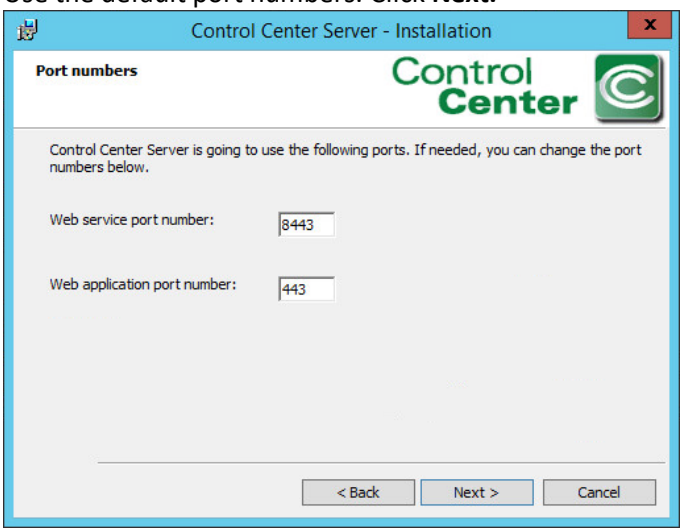
22. Select **Store in an external Sql Server database instance.** Click **Next.**



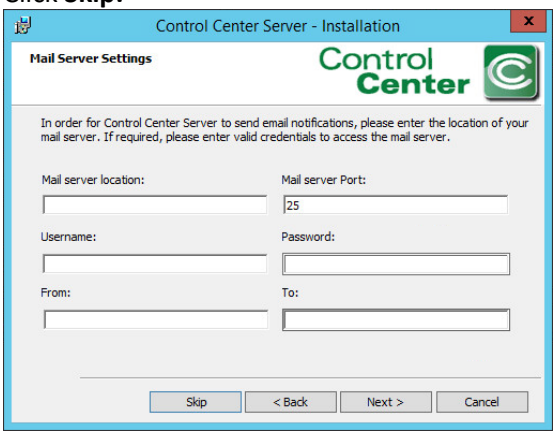
23. At the SQL Server settings screen, specify the **Connect String**, **Username**, and **Password**. Make sure the SQL Server is running. It may help to restart the SQL Server.



24. Use the default port numbers. Click **Next.**



25. Click **Skip.**



26. Click **Install.**
27. Once completed, click **Finish.**
28. Open an Internet browser, navigate to https://localhost/administrator, and log in to the Control Center Administrator web application.

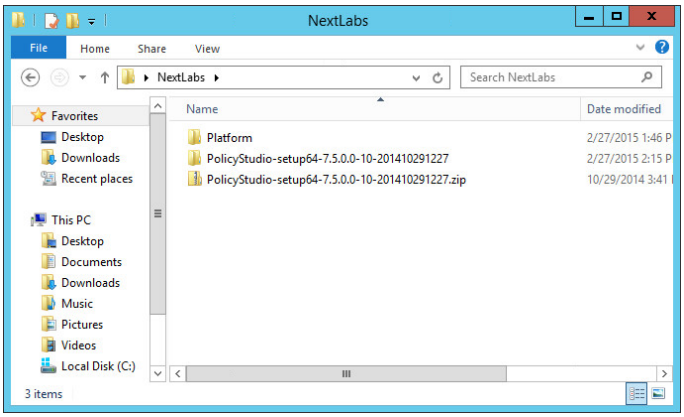
a. Enter the Administrator Username and Password to log in.

29. Once logged in to the Control Center Administrator web application in your browser, you can verify that the NextLabs Control Center is installed and configured correctly on the SQL Server.

Policy Studio 7.7

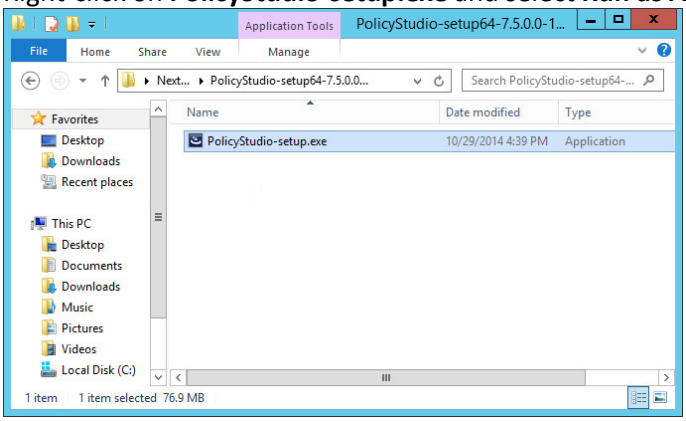
Complete the standard Policy Studio installation per NextLabs documentation available to customers using the following steps:

1. On the same server, go to your desktop or other known location where the required NextLabs Policy Studio installation files are stored.
2. Right-click on **PolicyStudio-setup64-7.5.0.0-10-201410291227.zip** and select **Extract All**. Wait for files to be extracted.

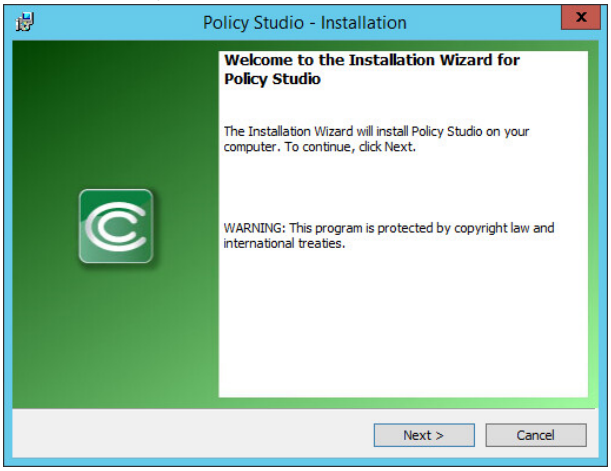


3. Double-click to open the **PolicyStudio-setup64-7.5.0.0-10-201410291227** folder.

4. Right-click on **PolicyStudio-setup.exe** and select **Run as Administrator**.

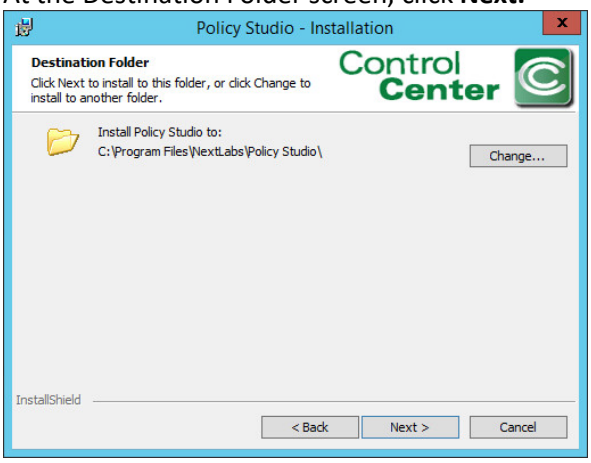


5. At the Welcome to the Installation Wizard for Policy Studio screen of the Policy Studio Installation Window, click **Next**.

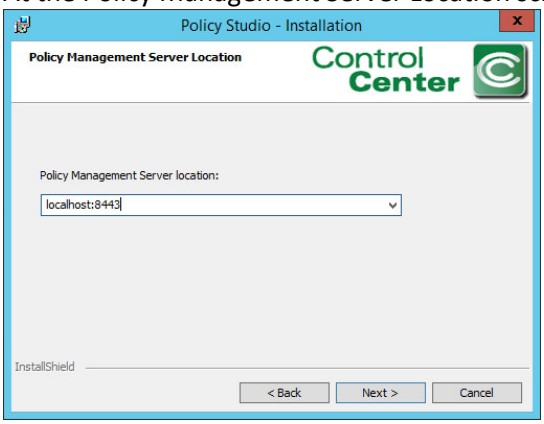


6. At the License Agreement screen, select **I accept the terms in the license agreement**, and click **Next**.

7. At the Destination Folder screen, click **Next.**

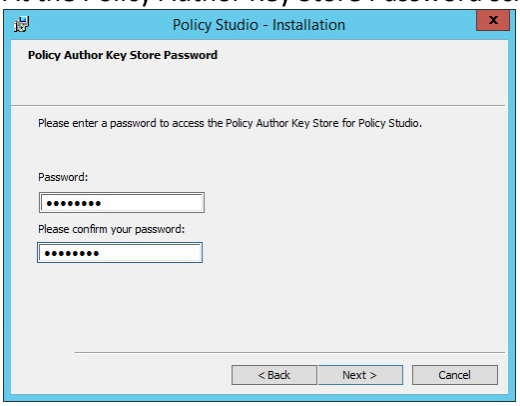


8. At the Policy Management Server Location screen, enter the default location **localhost:8443**.

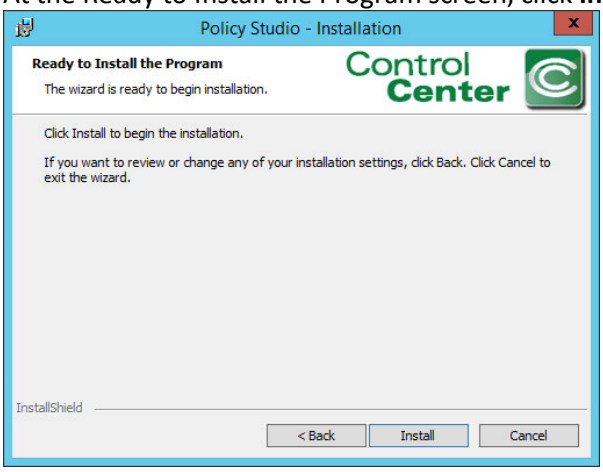


Click **Next**.

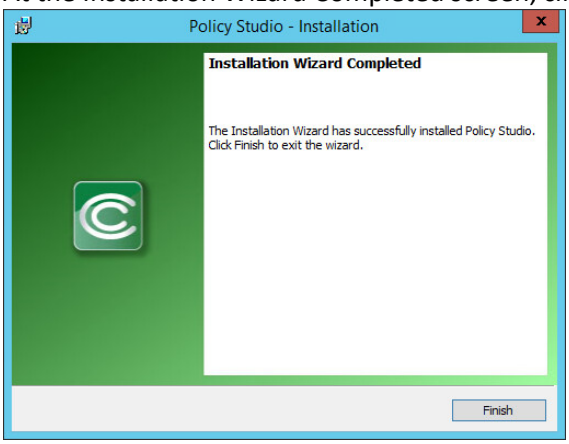
9. At the Policy Author Key Store Password screen, enter a **Password** and click **Next**.



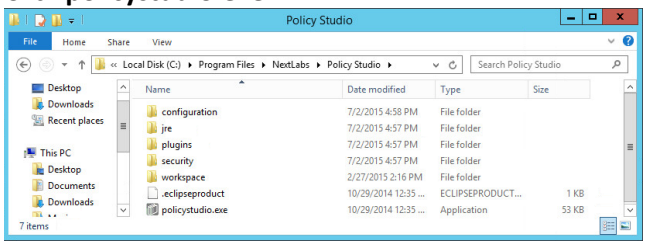
10. At the Ready to Install the Program screen, click **Install**.



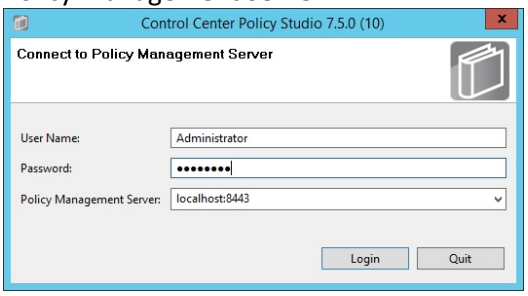
11. At the Installation Wizard Completed screen, click **Finish**.



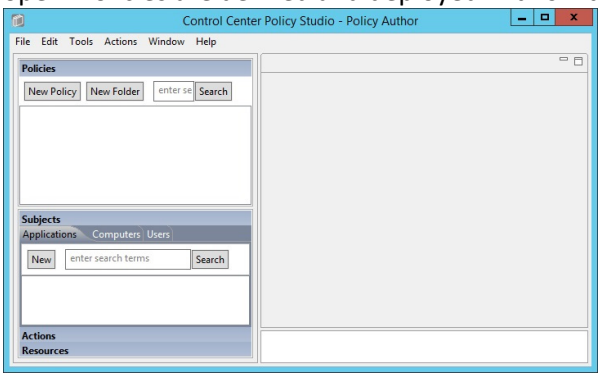
12. In Windows Explorer, find and open the **policystudio.exe** application file.
    a. Navigate to the **C:/ drive>Program Files>NextLabs>Policy Studio**.
    b. Click **policystudio.exe**.



13. In the Control Center Policy Studio window, enter a **User Name** and **Password** to connect to the Policy Management Server.



14. If the connection is successful, the Control Center Policy Studio - Policy Author window will open. Policies are defined and deployed in this interface.

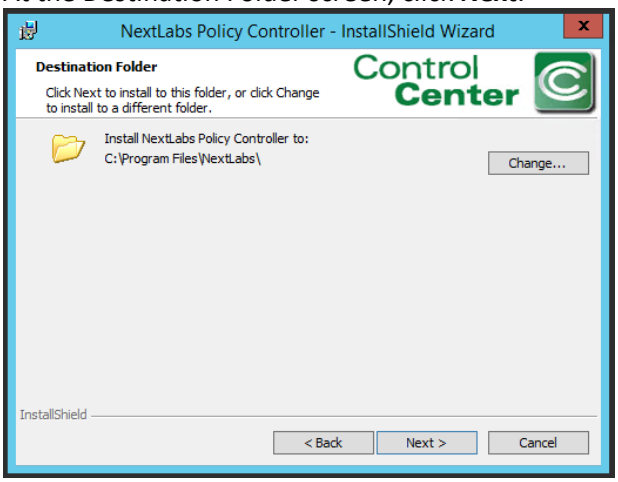


Policy Controller 7.7

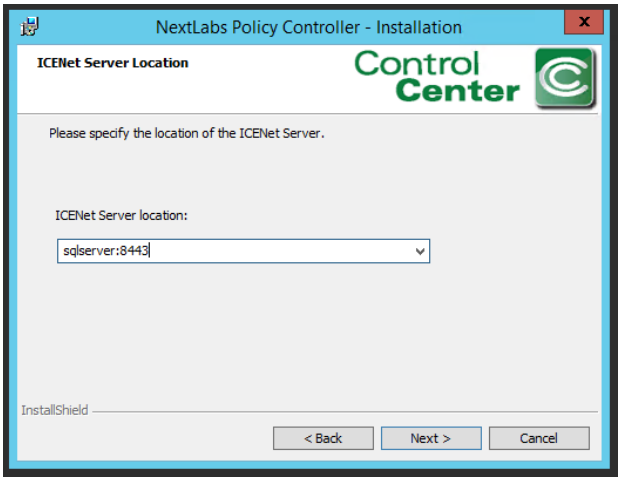
The Policy Controller is installed on the SharePoint Server. To complete standard Policy Controller installation per NextLabs documentation available to customers, use the following steps:

1. On the SharePoint Server, go to your desktop or other known location where the required NextLabs Policy Controller installation files are stored.
2. Extract the files from the **PolicyController-CE-64-<version>.zip** file.
3. Open the **PolicyController-CE-64-<version>** folder.
4. Click **CE-PolicyController-setup64.msi** to begin installation.
5. At the Welcome to the InstallShield Wizard for NextLabs Policy Controller Installation screen, click **Next**.
6. At the License Agreement screen, select **I accept the terms in the license agreement** and click **Next**.

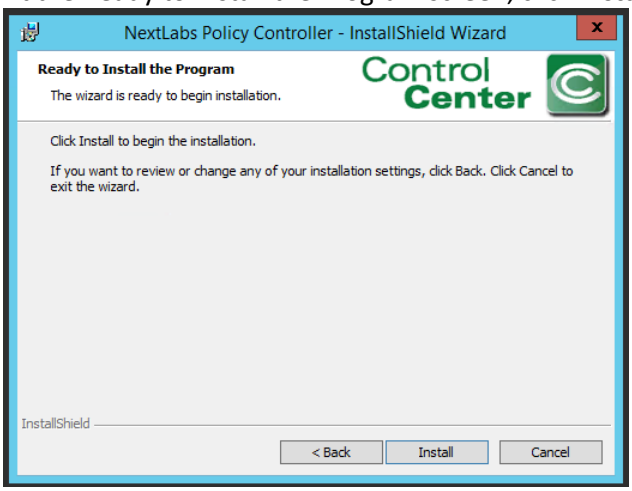
7. At the Destination Folder screen, click **Next**.



8. At the ICENet Server Location screen, enter the default ICENet Server Location: sqlserver:8443. Click **Next**.



9. At the Ready to Install the Program screen, click **Install**.



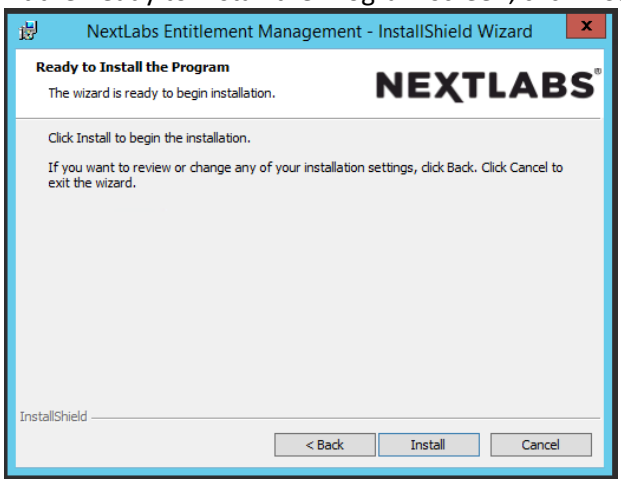
10. At the InstallShield Wizard Completed screen, click **Finish**.

11. In the window that immediately opens, click **Yes** to restart the computer, or click **No** to wait and restart after installing Entitlement Manager.

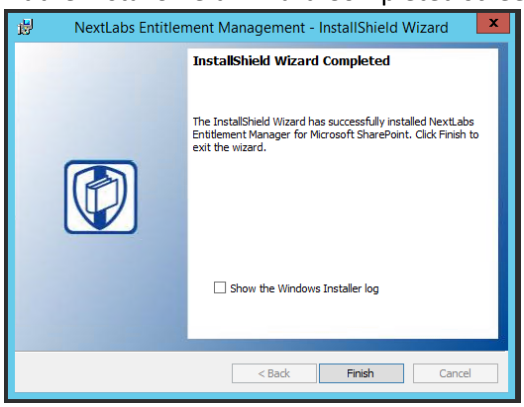
Entitlement Manager for Microsoft SharePoint 7.6

Entitlement Manager is installed once SharePoint and the Policy Controller have been installed. The web application site and site collection must already exist in SharePoint. See Section 2.7 for installing SharePoint and creating site collections. Complete the standard Entitlement Manager for SharePoint Server installation per NextLabs documentation available to customers using the following steps.

1. On the SharePoint Server, go to your desktop or other known location where the required NextLabs Policy Controller installation files are stored.
2. Extract the files from the **SharePointEnforcer-2013-64-<version>.zip** folder.
3. Open the **SharePointEnforcer-2013-64-<version>** folder.
4. Click on the **SharePointEnforcer-2013-64-<version>.msi** to begin the installation.
5. At the Welcome to the InstallShield Wizard for NextLabs Entitlement Manager for MicroSoft Share-Point screen, click **Next**.
6. At the License Agreement screen, select **I accept the terms in the license agreement** and click **Next**.
7. At the Ready to Install the Program screen, click **Install**.

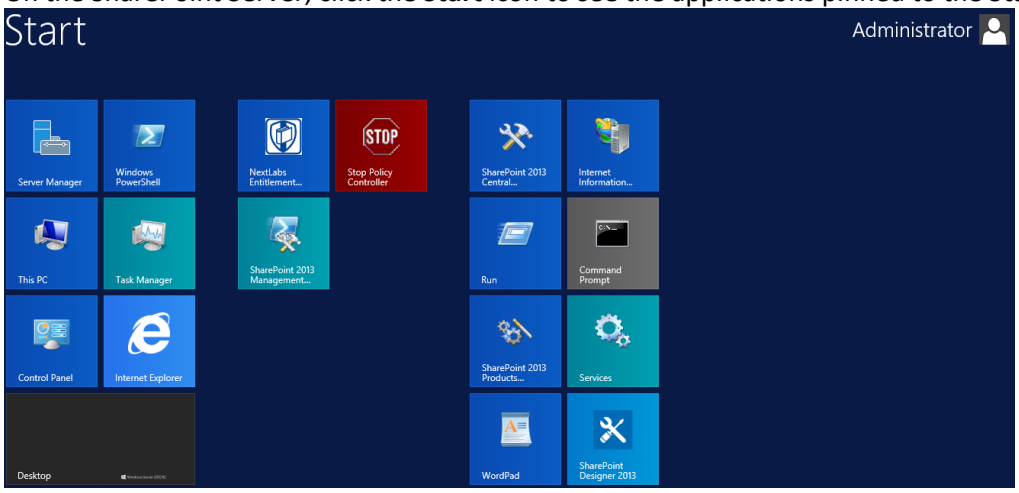


8. At the InstallShield Wizard Completed screen, click **Finish**.



9. After installing, the IIS server must be reset:
    a. Click the Windows icon and begin typing the word **PowerShell** and open the windows PowerShell application.
    b. From within the Windows PowerShell window, type in this command and press **Enter** to reset Internet Information Services: **iisreset.**

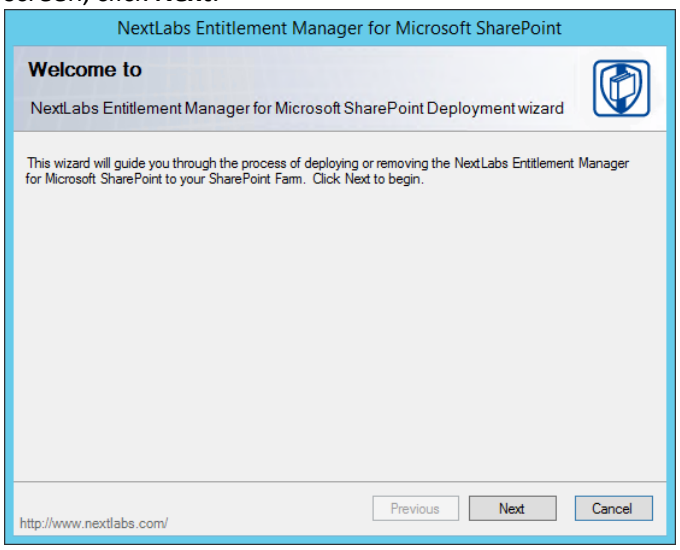
10. On the SharePoint Server, click the **Start** icon to see the applications pinned to the **Start** menu.



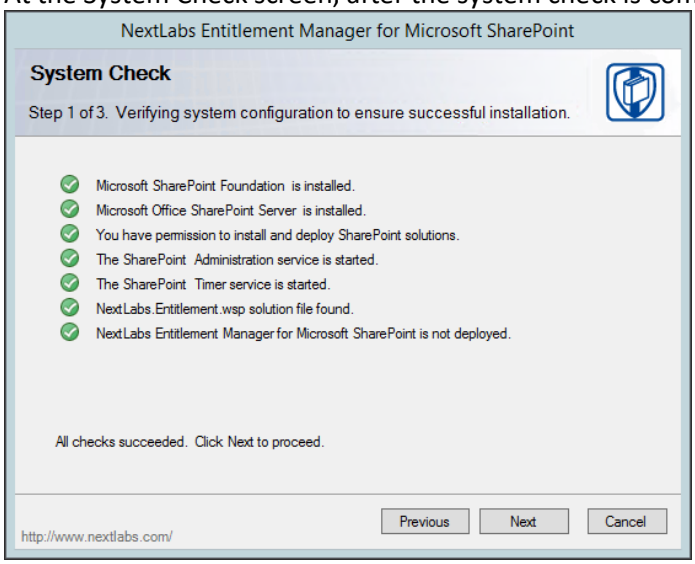
11. Click the NextLabs Entitlement Manager for SharePoint Server Deployment icon.

This shortcut is automatically pinned during the initial installation. In case the shortcut is not created automatically, the application can be opened from File Explorer at the **location: C:\Program Files\NextLabs\SharePoint Enforcer\bin\NextLabs.Entitlement.Wizard.exe**

12. At the Welcome to NextLabs Entitlement Manager for Microsoft SharePoint Deployment wizard screen, click **Next**.



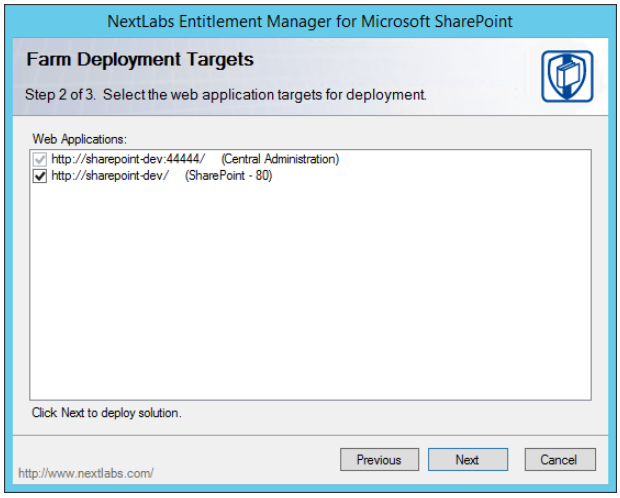
13. At the System Check screen, after the system check is complete, click **Next**.



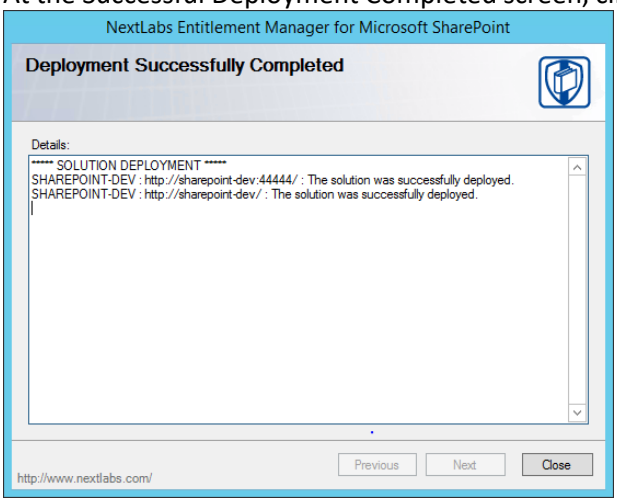
14. At the Farm Deployment Targets screen, select the applicable web application on which to deploy.

    Note: If only one entry is listed, i.e., **http://sharepoint:44444/Central Administration**, no web applications have been created.

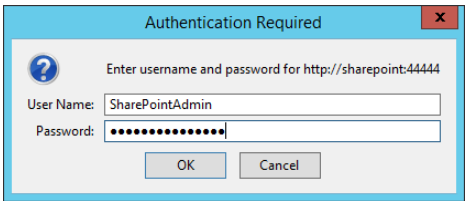
15. At the Deploying Step 3 of 3 screen, click Next.



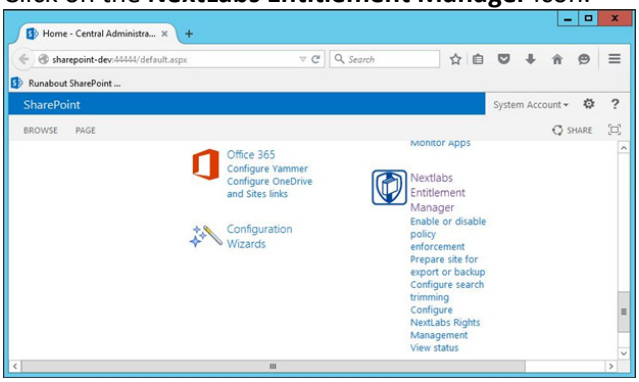
16. At the Successful Deployment Completed screen, click **Close**.



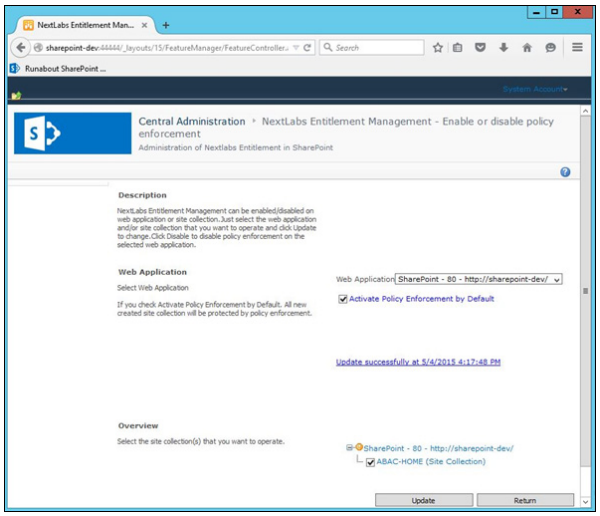
17. Open a browser and navigate to the SharePoint Central Administration Portal. Log in with the SharePoint Administrator account.



18. Click on the **NextLabs Entitlement Manager** icon.



19. In the page that opens, scroll down to verify that the correct **Web Application** is chosen and the service is **Enabled**.



2.5 OpenLDAP

OpenLDAP is an open source implementation of the Lightweight Directory Access Protocol. It stores user identity information along with various other attributes that are indicative of access rights, and it is able to provide the necessary information that requesting services need to make authorization decisions.

2.5.1 How It's Used

OpenLDAP stores user information and associated attributes for users who need access to Unix/Linux based applications. Examples of such attributes are a user's userid, group, organizational unit, job title and various other custom attributes. The OpenLDAP service listens and responds to requests from the virtual directory service that acts as the enterprise policy information point and has the responsibility for retrieving, organizing, and aggregating each user's attribute set under a single view.

2.5.2 Virtual Machine Configuration

The OpenLDAP virtual machine is configured aas follows:

- Ubuntu Linux 16.04 LTS
- 1 CPU core
- 2GB of RAM
- 2 NICs
- 60GB of storage
- OpenLDAP server software

Network Configuration (Interface 1)
IPv4 Manual
IPv6 Disabled
IP Address: 192.168.19.11
Netmask: 255.255.255.0
Gateway: 192.168.19.1
DNS Name Servers 192.168.19.10
DNS-Search Domains: acmefinancial.com

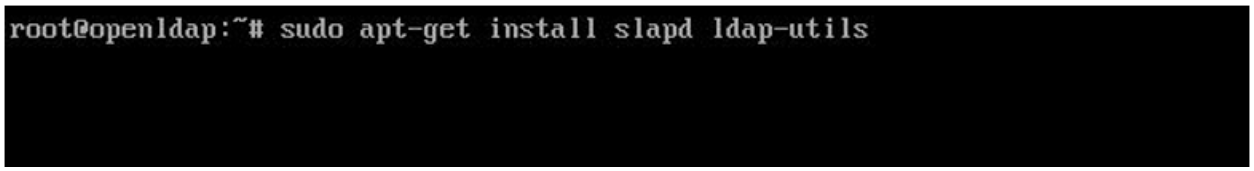
Network Configuration (Interface 2)
IPv4 Manual
IPv6 Disabled
IP Address: 192.168.19.11
Netmask: 255.255.255.0
Gateway: 192.168.19.1
DNS Name Servers 192.168.19.10
DNS-Search Domains: acmefinancial.com

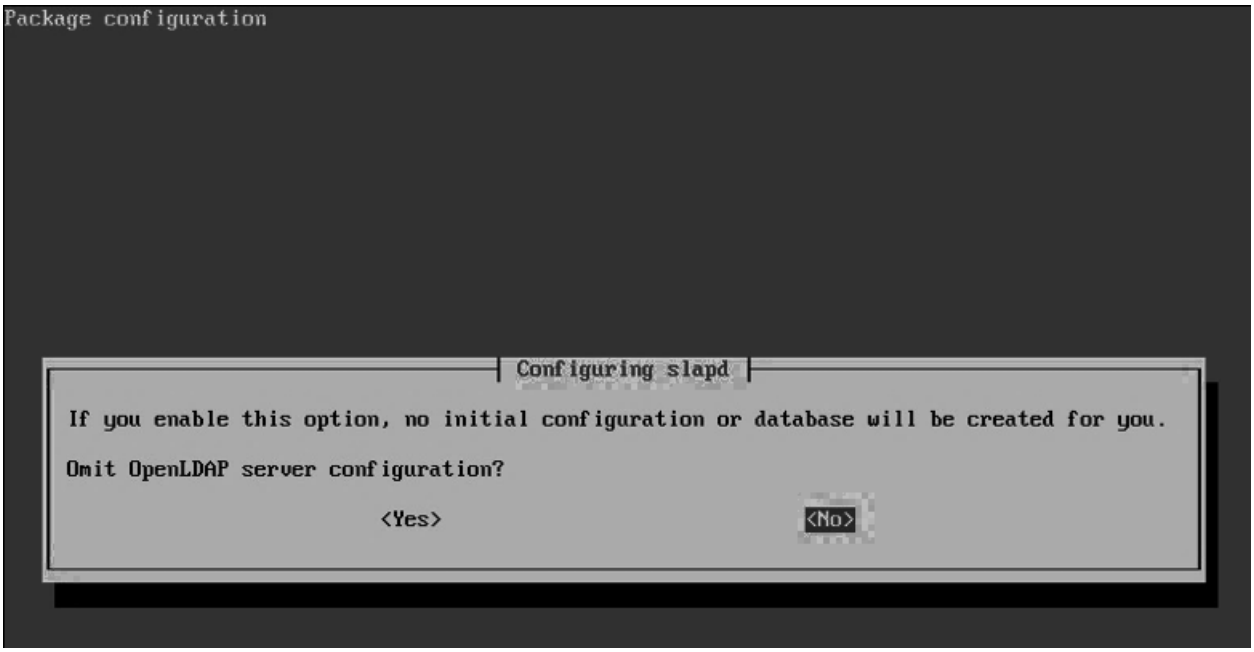
2.5.3 Firewall Configuration

Enter the following commands in sequence to allow traffic to LDAPS and SSH ports only.

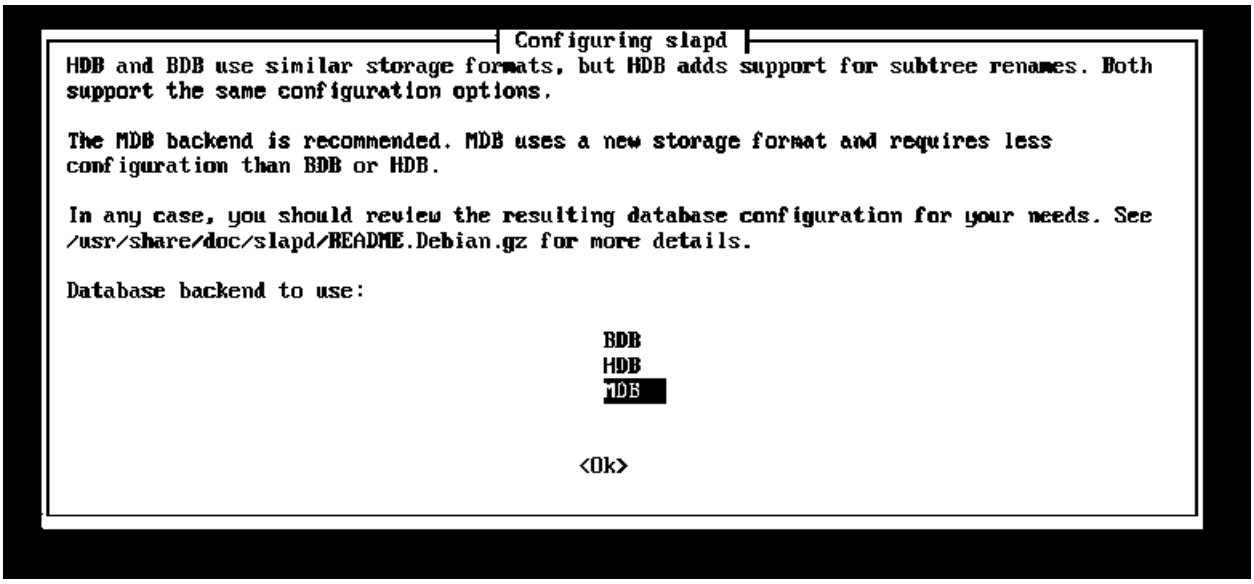
```
ufw allow 636/tcp to allow
ufw allow 22/tcp to allow
ufw default deny incoming
```

2.5.4 Installation





1. Select **No** and press **Enter.**
2. Enter the organizational Name on the following screen (for example, acmefinancial.com).
3. Enter the administrator password for the BaseDN (BaseDN: acmefinancial.com).



4. Select **MDB** as the Backend database for OpenLDAP and press **Enter**.

5. Select **No** and press **Enter**.

6. **Select No** to disable LDAPv2.

2.5.5 Audit Configuration

1. Enter `mkdir /etc/ldap/logs` at a shell prompt to create a directory that is writable by the OpenLDAP service.

2. Enter **`chown openldap.openldap /etc/ldap/logs`** to make the logs subdirectory owned by the openldap service.
3. Enter **`touch create-cn-module.ldif`** to create a file that will be used to load a cn module. This will allow the AuditLogConfig object class to be added. The file contents should be as follows:

```
dn: cn=module,cn=config
objectClass: olcModuleList
cn: module
olcModulepath: /usr/lib/ldap
olcModuleLoad: auditlog.la
```

4. Enter **`ldapadd -Q -Y -EXTERNAL -H ldapi:/// -f create-cn-module.ldif`** to add the cn module.
5. Enter **`touch logging.ldif`**. The file contents should be as follows:

```
dn: olcOverlay=auditlog,olcDatabase={1}hdb,cn=config
changetype: add
objectClass: olcOverlayConfig
objectClass: olcAuditLogConfig
olcOverlay: auditlog
olcAuditlogFile:/etc/ldap/logs/auditlog.log
```

6. Enter **`chmod 775 /etc/ldap/logs`**.
7. Enter **`chmod 664 /etc/ldap/logs/auditlog.log`**.
8. Enter **`ldapadd -Q -Y -EXTERNAL -H ldapi:/// -f logging.ldif`**.
9. Changes to user records should now appear in /etc/ldap/logs/auditlog.log.

2.5.6 STARTTLS and LDAPS Configuration

1. On the OpenLDAP server, create an ssl directory /etc/ldap/ssl. Enter **`mkdir /etc/ldap/ssl`**.
2. Move the certificates created for the OpenLDAP server from the Certificate of Authority to the ssl subdirectory:
   a. **`scp openldap_cert.pem user1@openldap.acmefinancial.com:\ldap\ssl`**
   b. **`scp openldap_privatekey.pem user1@openldap.acmefinancial.com:\ldap\ssl`**
   c. **`scp acmefinancial.com-CA.pem user1@openldap.acmefinancial.com:\ldap\ssl`**
3. Install the CA certificate so that local applications can use the certificate when necessary:
   a. **`cp acmefinancial.com-CA.pem /usr/share/ca-certificates/acmefinancial.com-CA.crt`**
   b. Add *acmefinancial.com-CA.crt* to the end of the /etc/ca-certificates.conf file.
   c. Enter **`sudo update-ca-certificates`**.
4. Create a certificate information file called certinfo.ldif in /etc/ldap/ssl with the following contents:

```
dn: cn=config
add: olcTLSCACertificateFile
olcTLSCACertificateFile: /etc/ldap/ssl/acmefinancial.com-CA.pem
-
add: olcTLSCertificateFile
olcTLSCertificateFile: /etc/ldap/ssl/openldap_cert.pem
-
add: olcTLSCertificateKeyFile
olcTLSCertificateKeyFile: /etc/ldap/ssl/openldap_privatekey.pem
```

5. Set permissions and ownership on the certificate files so that the openLDAP user can read the key file:
    a. `sudo adduser openldap ssl-cert`
    b. `chgrp ssl-cert /etc/ldap/ssl/openldap_privatekey.pem`
    c. `chmod g+r /etc/ldap/ssl/openldap_privatekey.pem`
    d. `chmod o-r /etc/ssl/ldap/openldap_privatekey.pem`
    e. **chown root.ssl-cert /etc/ldap/ssl/openldap_privatekey.pem**
    f. **chown root.ssl-cert /etc/ldap/ssl/openldap_cert.pem**
    g. **chmod root.ssl-cert /etc/ldap/ssl**
6. Reconfigure slapd by running the following command
    a. **ldapmodify -Y EXTERNAL -H ldapi:/// -f /etc/ldap/ssl/certinfo.ldif**
    b. Restart slapd **by running service slapd restart**

StartTLS should now be enabled.

7. Enable LDAPS by adding `ldaps:/// to the SLAPD_SERVICES` line in the */etc/default/slapd* file:

```
# slapd normally serves ldap only on all TCP-ports 389. slapd can al
so
# service requests on TCP-port 636 (ldaps) and requests via unix
# sockets.
# Example usage:
# SLAPD_SERVICES="ldap://127.0.0.1:389/ ldaps:/// ldapi:///"
SLAPD_SERVICES="ldap:/// ldapi:/// ldaps:///"
```

    a. Go to the SLAPD_SERVICES line and add ldaps:/// as shown above.
    b. Enter **service slapd restart** to restart the OpenLDAP service.
8. Prepare the slapd client to use StartTLS:
    a. Create the /etc/ldap/ssl directory.
    b. Copy acmefinancial.com-CA.pem to /etc/ldap/ssl/ directory.
    c. Go to the client computer and edit /etc/ldap/ldap.conf.
    d. Comment out the previous TLS_CACERT entry and add a new one pointing to the location of your CA certificate.

```
# TLS certificates (needed for GnuTLS)
#TLS_CACERT      /etc/ssl/certs/ca-certificates.crt
TLS_CACERT       /etc/ldap/ssl/acmefinancial.com-CA.pem
```

2.5.7 Formatting Audit Logs

The file */etc/ldap/logs/auditlog.log* stores log entries destined for the Splunk indexer. Using the following scripts, the logs were formatted in such a way that enables the Splunk indexer to easily determine the start and end of each log event.

2.5.8 Script: /etc/ldap/logs/auditlogscript

```
#!/bin/bash
# Remove newlines, make file a single string and dump to auditlog.string
tr -s  '\n' ' ' < /etc/ldap/logs/auditlog.log > /etc/ldap/logs/auditlog.string
# Change every occurrence of #0 to just 0
sed -i -e 's/#0/0/g' /etc/ldap/logs/auditlog.string
# Remove spaces between attributes and their values
sed -i -e 's/: /:/g' /etc/ldap/logs/auditlog.string
#Additional formatting helpful in showing field separation
sed -i -e 's/ /;;/g' /etc/ldap/logs/auditlog.string
# Change # to newline making each line a unique openldap event and dump
# to auditlog.lines
tr -s '#' '\n' </etc/ldap/logs/auditlog.string> /etc/ldap/logs/auditlog.lines
#Additional formatting in removing unneeded lines
sed -i '/;;end;;/d' /etc/ldap/logs/auditlog.lines
# Empty previous contents of outlog.log
# outlog.log is effectively overwritten when script runs
cp /dev/null /etc/ldap/logs/outlog.log
# Call add-timestamp.py to add readable timestamps and dump to outlog.log
/etc/ldap/logs/add-timestamp.py
```

2.5.9 Script: /etc/ldap/logs/add-timestamp.py

```
#!/usr/bin/python3
import datetime
start_index = 0
end_index = 0
timestamp = 123456789  #var to store datetime object; values are placeholders
localtime = "12345"   #string var to store local time; values are placeholders
filename = "/etc/ldap/logs/auditlog.lines" #Each event in file is a line
#Open the file, parse each each line,identified char set in IF
#statement exposing the epoch_time without leading or trailing  chars
with open(filename, 'r') as file_object:
   for string in file_object:
      if ";;dc" in string:
         end_index = string.find(";;dc")
         string = string.strip()
```

```
        newstring = string[start_index:end_index]
        newstring = newstring.lstrip(';')
        newstring = newstring.lstrip('add')
        newstring = newstring.lstrip('modify')
        newstring = newstring.lstrip('delete')
        newstring = newstring.lstrip('rdn')
        newstring = newstring.lstrip(';')
        epoch_time = int(newstring)     #Store epoch_time as integer
        #Convert epoch_time to  datetime object and store in  timestamp
        timestamp = datetime.datetime.fromtimestamp(epoch_time)
        #Convert value in timestamp to string and store in localtime
        localtime = str(timestamp)
      #If line is blank, do nothing, else prepend localtime to line
      if string.isspace():
        pass
      else:
        with open('/etc/ldap/logs/outlog.log','a') as outfile_object:
          outfile_object.write(localtime + string + '\n')
```

2.5.10 Script: /etc/cron.daily/openldap-status

```
#!/bin/bash
#This script sends online status updates to splunk with enough information
#such that anlytics on Splunk can determine whether or not this host has
#failed to send updates in a given period.

if ls /var/log/oldstatustime # check if file exists
then
  prevtime=$(cat /var/log/oldstatustime) #store date in file in variable prevtime
else
  date >/var/log/oldstatustime  #else write current date to file path
fi
#write time hostname previous run time and online keyword to file path
#in a single line separated by commas
((date && hostname && echo $prevtime && echo online)|tr -s '\n' ','|sed
s'/online,/online/';echo "") >> /var/log/openldap-status-file.csv
date > /var/log/oldstatustime
```

2.6 Radiant Logic

Radiant Logic RadiantOne Virtual Directory Server (VDS) is a virtual directory that performs a federated identity service. (Note: Radiant Logic changed their product name from RadiantOne Virtual Directory Server (VDS) to RadiantOne Federated Identity Service (FID)).

2.6.1 How Its Used

The RadiantOne VDS (VD) is used in two capacities in this example implementation. First, the VD acts as a federated identity service, correlating users from each directory into a single view. Second, the VD acts as a monitoring service, where the created view is cached, and changes made to the cache are logged and sent to Splunk.

2.6.2 Virtual Machine Configuration

The Radiant Logic virtual machine is configured as follows:

- Ubuntu Linux 16.04 LTS
- 4 CPU cores
- 24GB of RAM
- 2 NICs
- 100GB of storage

Network Configuration (Interface 1)
IPv4 Manual
IPv6 Disabled
IP Address: 192.168.17.100
Netmask: 255.255.255.0
Gateway: 192.168.17.1
DNS Name Servers: 192.168.17.1
DNS-Search Domains: n/a

Network Configuration (Interface 2)
IPv4 Manual
IPv6 Disabled
IP Address: 192.168.14.111
Netmask: 255.255.255.0
Gateway: 192.168.14.1
DNS Name Servers 192.168.14.1
DNS-Search Domains: n/a

2.6.3 Installing the Virtual Directory

To install the VD, see the documentation provided with the software. The VD installation guide can also be found on the Radiant Logic support website here.

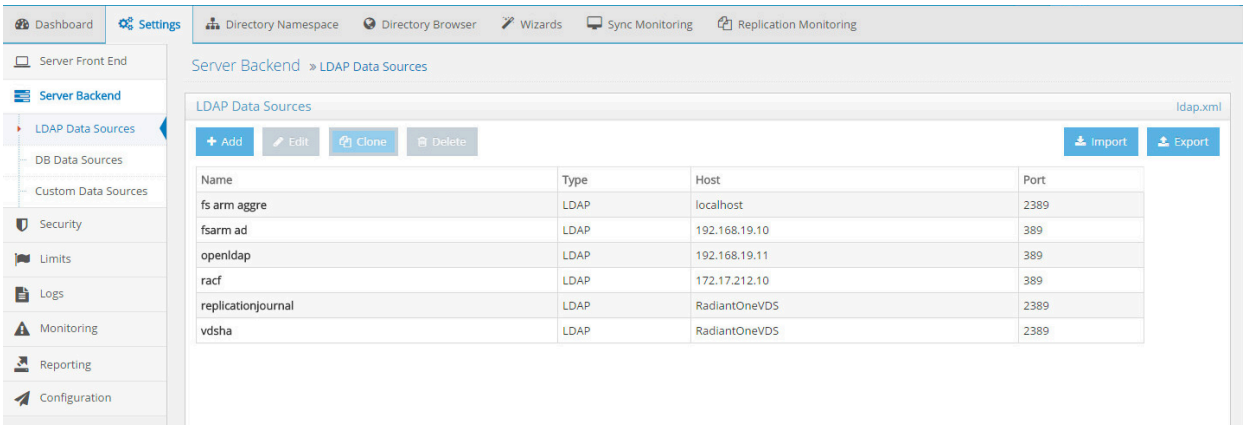
2.6.4 Configuring VD

Steps for configuring the VD are as follows:

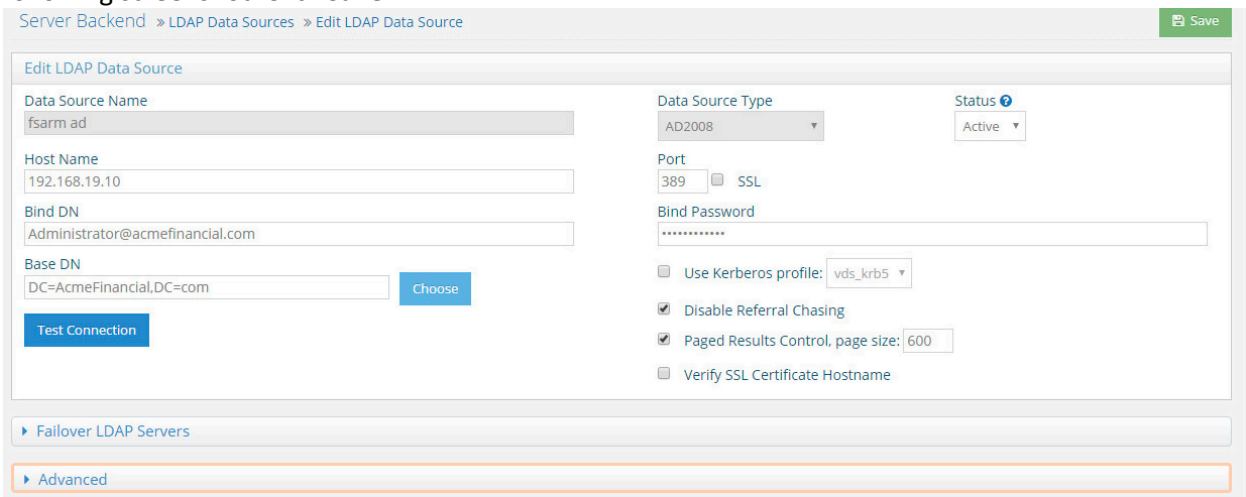
- Add server backends.
- Create proxy backend.
- Configure caching and system connectors.
- Create SharePoint view.
- Log Settings.

To add the server backends in the VD, complete the following steps:

1. While logged in as the Directory Manager, navigate to **Settings>Server Backend>LDAP Data Sources,**
2. Click **Add.**

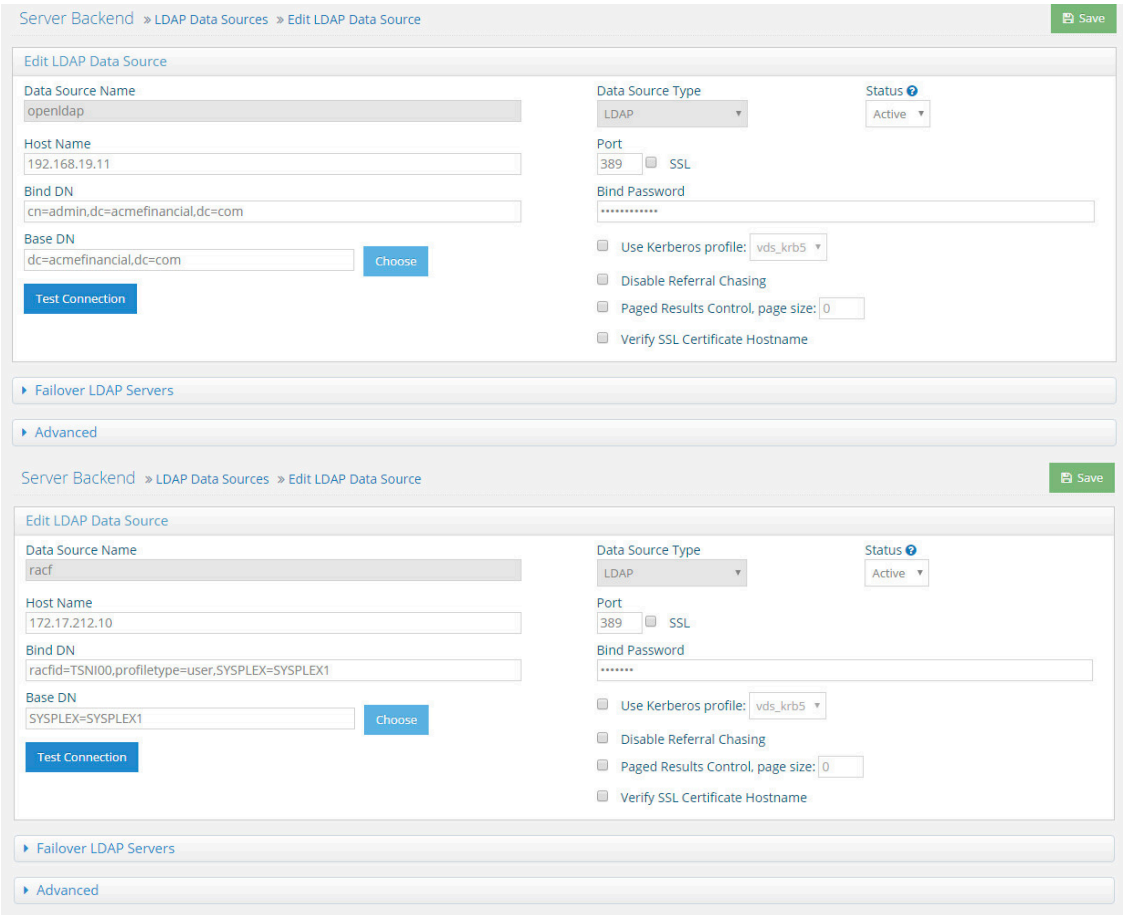


3. Name the data source and enter the parameters. For AD, the parameters used are shown in the following screenshot. Click **Save.**



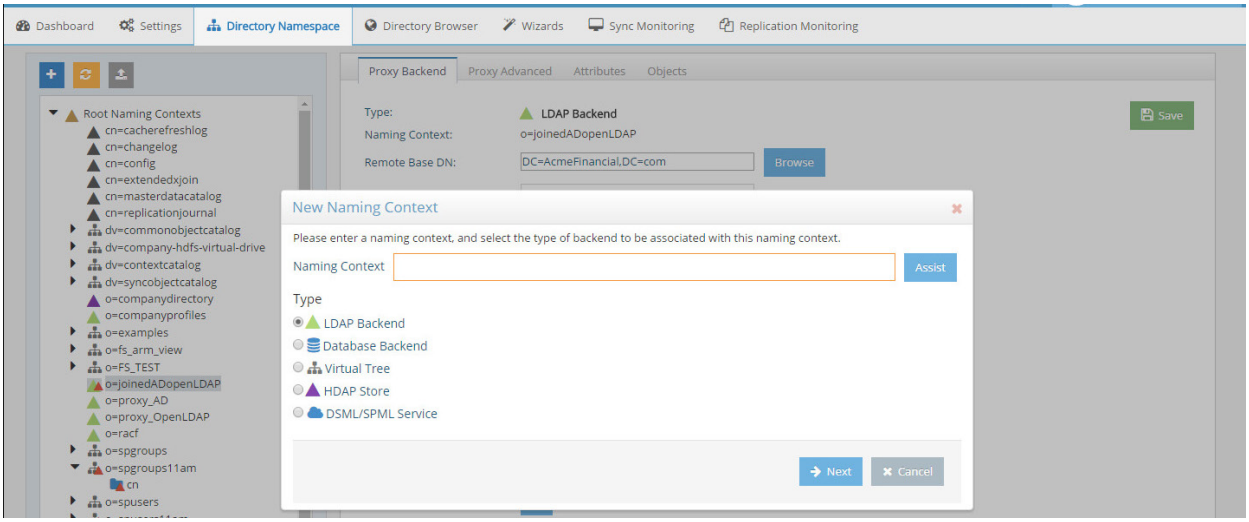
Note: Be sure to select **Disable Referral Chasing** for AD.

4. Repeat Steps 2 and 3 for the OpenLDAP and RACF directories. Use LDAP as the data source type. Details for each are shown in the following screenshots:

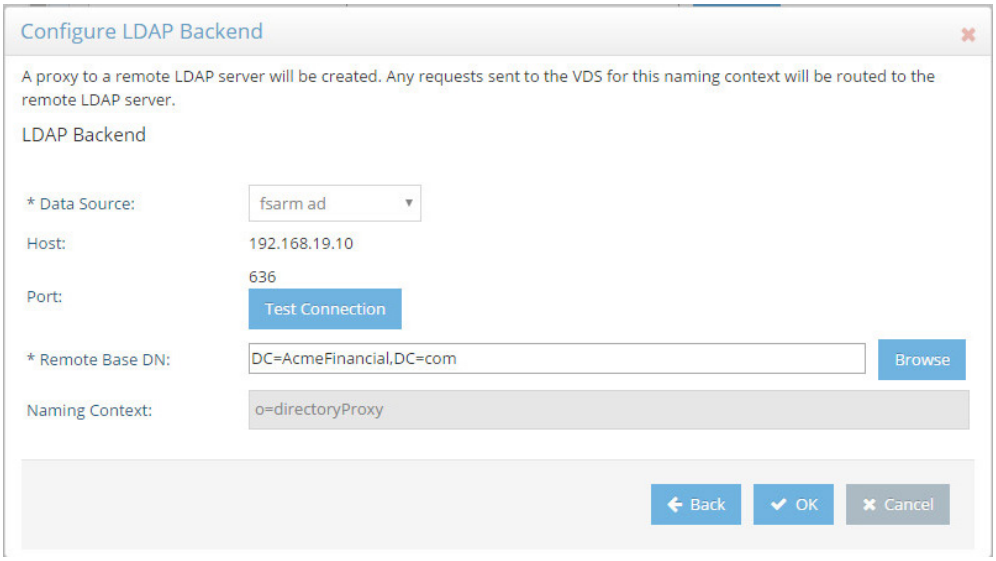


To create a proxy view to the backend directories, complete the following steps:

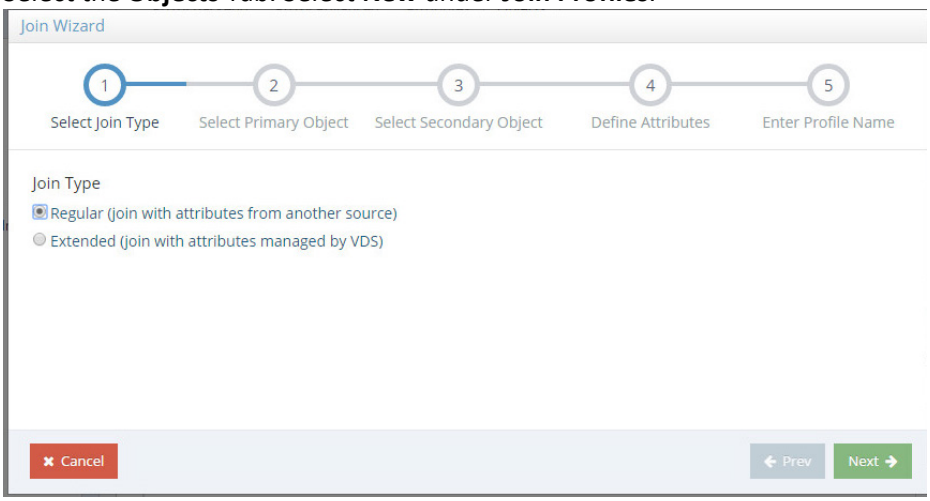
1. On the Directory Namespace tab, select **New Naming Context** (the plus sign) at the top left of the screen.
2. Select **the LDAP Backend** radio button and enter a naming context such as o=directoryProxy. Select **Next**.



3. Select the name of the AD backend created earlier as the **Data Source**. Select the **Remote Base DN** of the domain. Select **OK.**

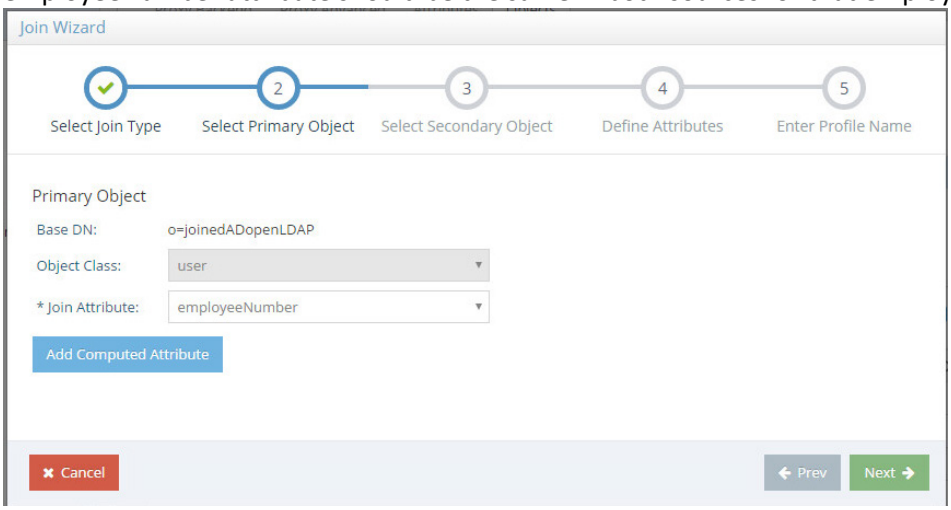


4. When the LDAP proxy is created, select the root naming context created in the left window pane.
5. Select the **Objects** Tab. Select **New** under **Join Profiles**.

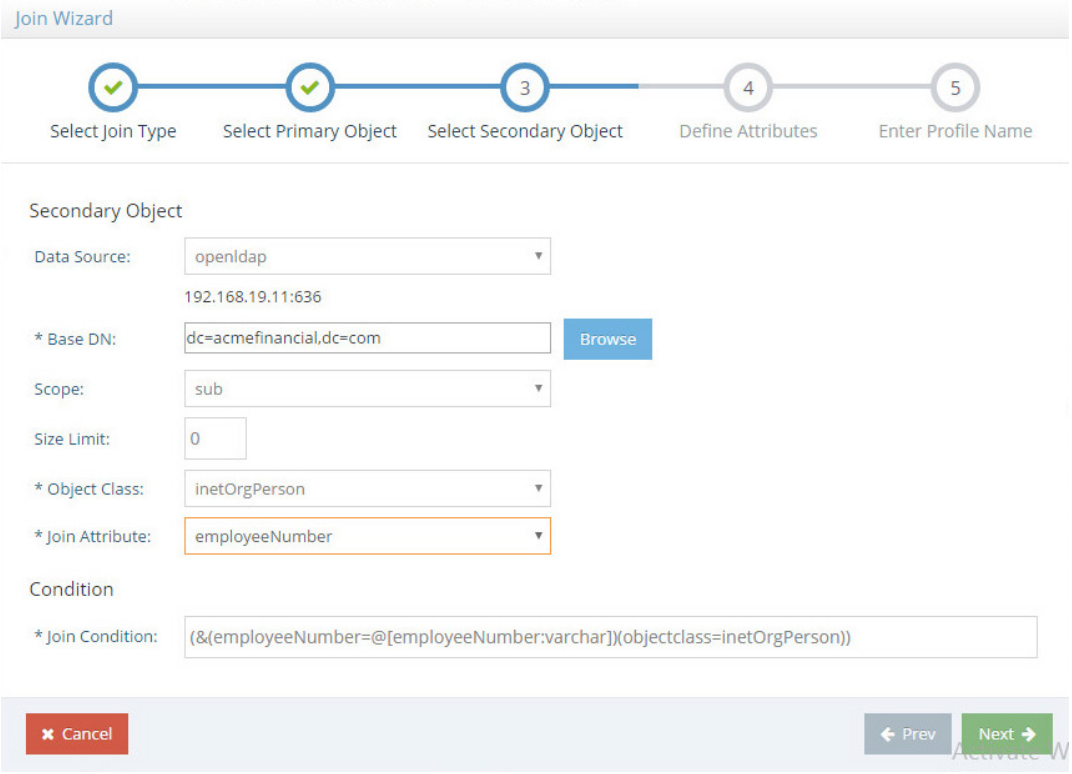


6. Choose **Regular.** Click **Next.**

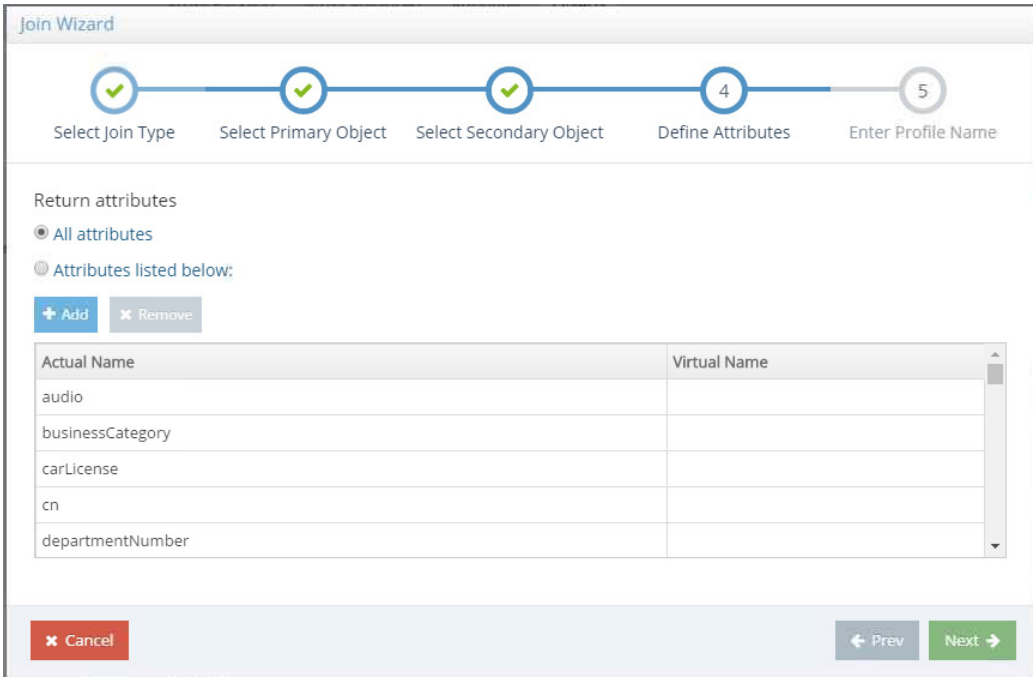
7. Select employeeNumber as the Join Attribute. Click **Next**. *Note:* The employee number must be unique for each user. For example, if an employee has an account in AD and OpenLDAP, the employeeNumber attribute should be the same in both sources for that employee.



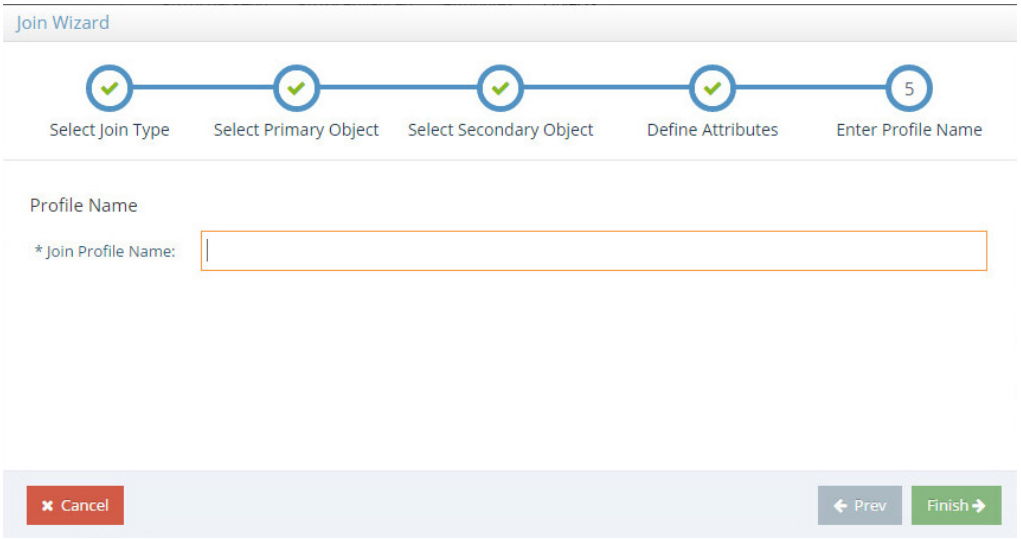
8. Select **openLDAP** as the **Data Source** and enter **dc=acmefinancial,dc=com** as the **Base DN**. Specify **sub** as the **Scope**, **inetOrgPerson** as the **Object Class**, and **employeeNumber** as the **Join Attribute**. Leave **Size Limit** as default. Click **Next**.



9. Select **All Attributes**. Click **Next.**



10. Name the Join Profile. Click **Finish.**

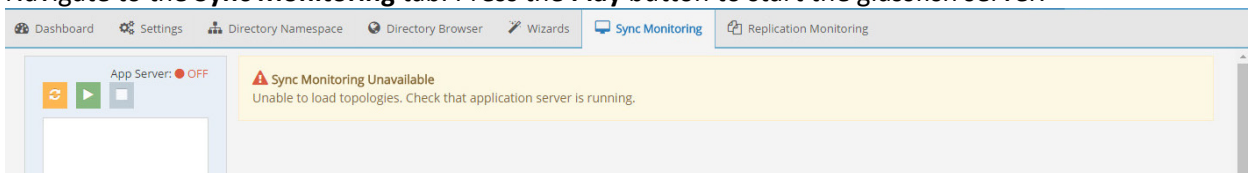


11. Repeat Steps 5–10 to join the RACF directory using the appropriate RACF objectClass and Base DN.

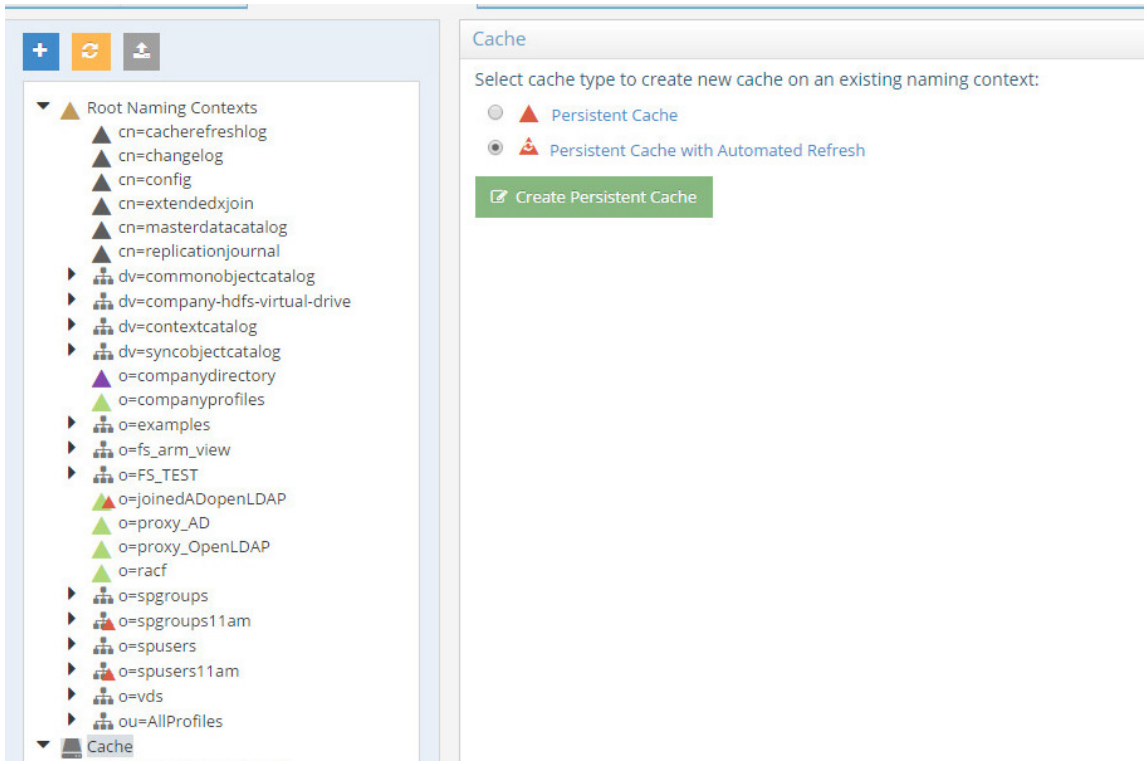
2.6.5 Configure Logging

To log changes to each directory object, you must create a cache for the proxy view created in the previous section. To create the cache and log changes made to the backend directories, complete the following steps:

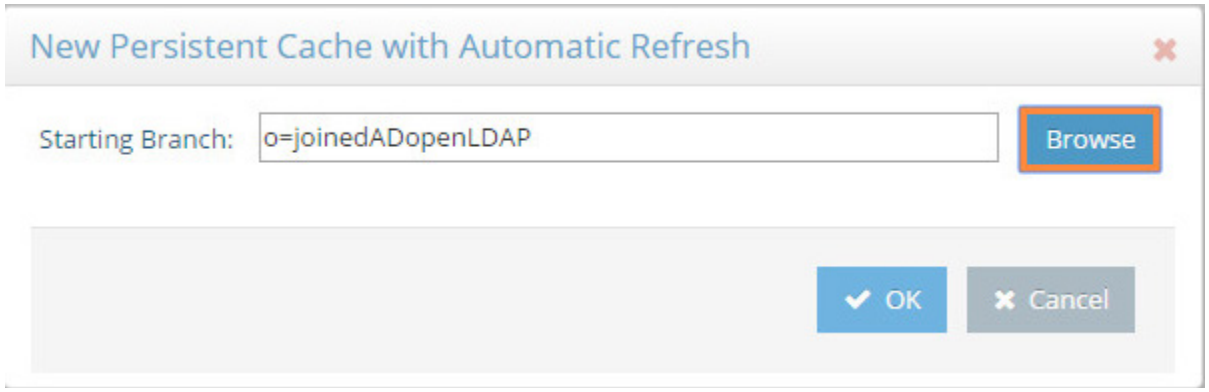
1. Navigate to the **Sync Monitoring** tab. Press the **Play** button to start the glassfish server.



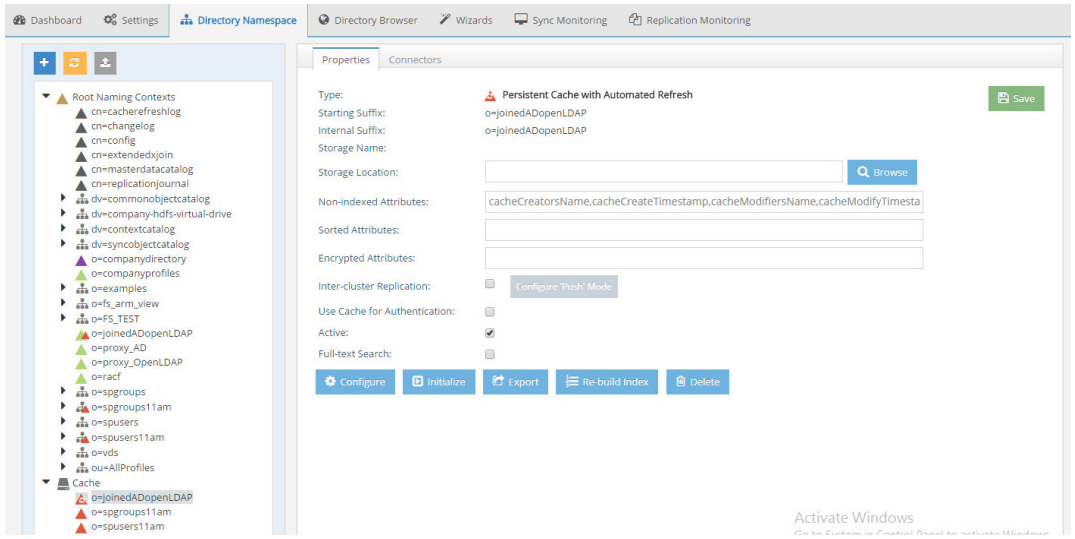
2. In the **Directory Namespace** tab, highlight **Cache** in the left window pane. Select **Persistent Cache with Automated Refresh**. Click **Create Persistent Cache.**



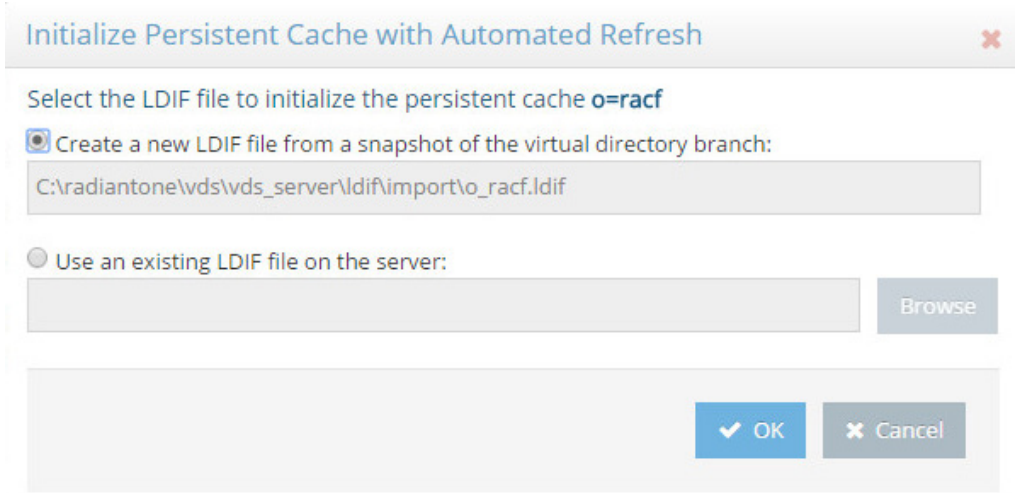
3. Browse and select the LDAP proxy created in the previous section. Select **OK.** The VD creates the cache.



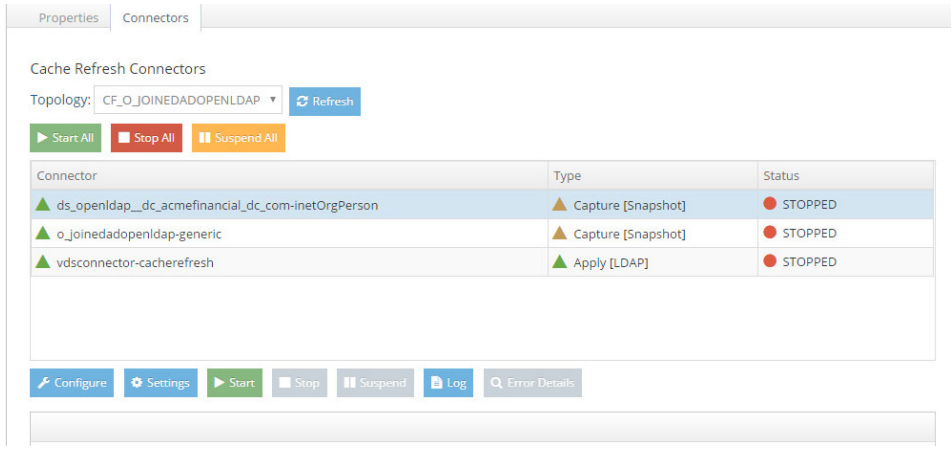
4. Select the created cache from the lower left window. Click **Initialize** to make the cache active.



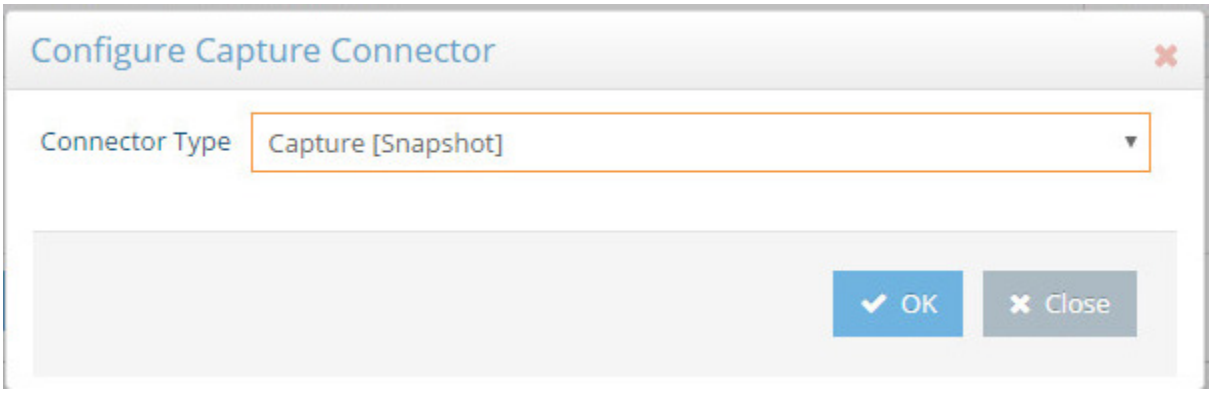
5. Select **Create a new LDIF file from a snapshot of the virtual directory branch**. Click **OK**. This step may take a while depending on the number of accounts in the backend directories.



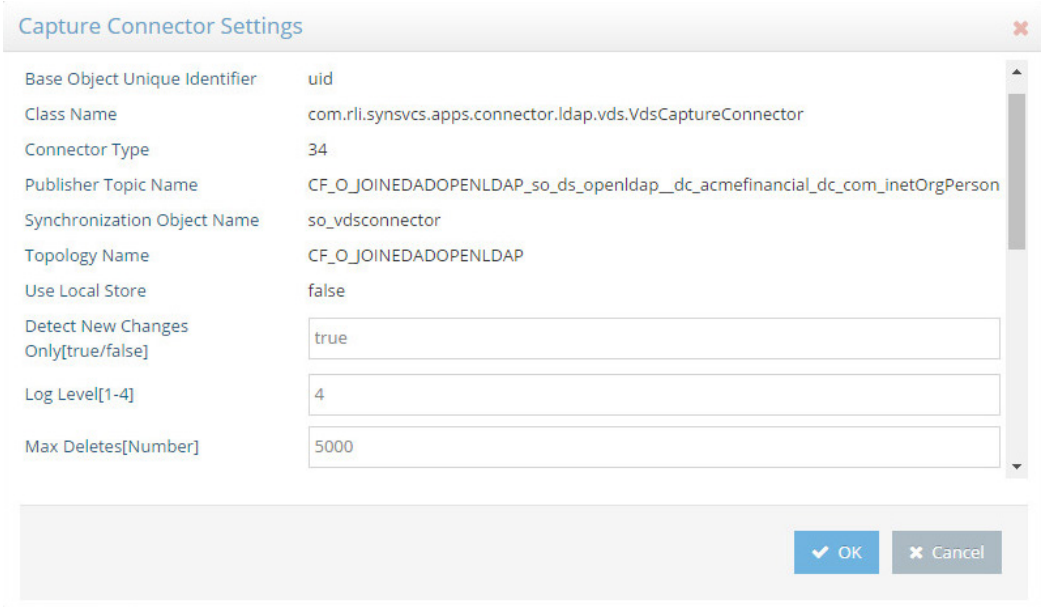
6. Once complete, **Save** the settings.
7. Select the **Connectors** tab.



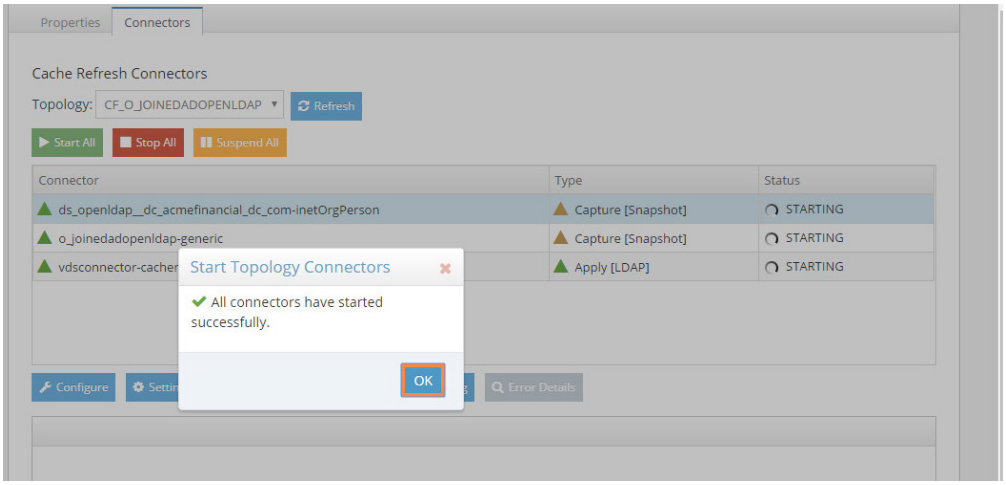
8. There should be a connector for each backend directory and one for the connector itself. Highlight the first connector. Select **Configure.** Change the connector type to "Capture [Snapshot]." Click **OK**. Repeat this step for each connector except the "vdsconnector-cacherefresh."



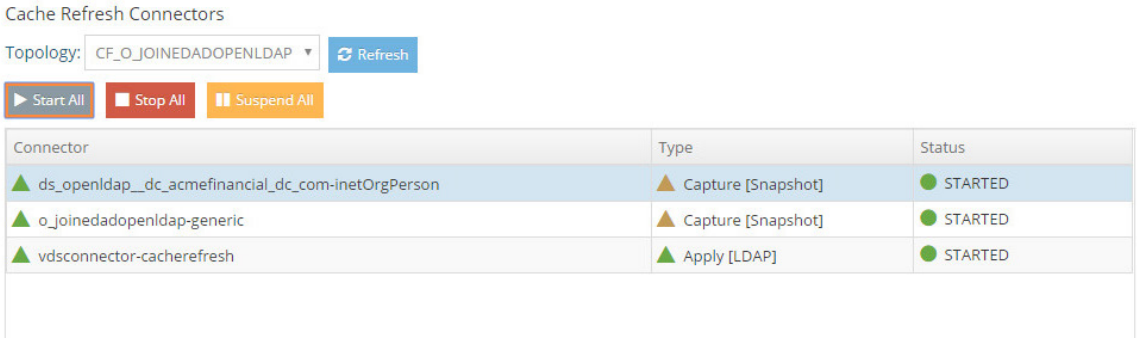
9. Back at the **Connectors** tab, highlight the first connector. Select **Settings**. Change the log level to the number 4. Click **OK**. Repeat this step for each connector except the "vdsconnector-cacherefresh."



10. Select **Start All** to start all the connectors. Click **OK**.



11. If the **Status** from each connector reads STARTED, you are done with this step. If not, review the logs and check the connections to the backend databases.

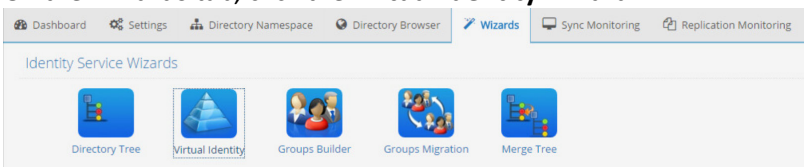


2.6.6 Configure Views for SharePoint

For applications to perform a global search (identify a user and locate groups) in the virtual namespace and be able to locate entries from many different types of underlying sources, the schemas must be mapped to a common naming context. There are many possible ways to configure virtual views for identities. We will leverage the Virtual Identity Wizard and the Groups Builder Wizard. For more details on each wizard, refer to the *RadiantOne System Admin Guide*. This guide is available on request.

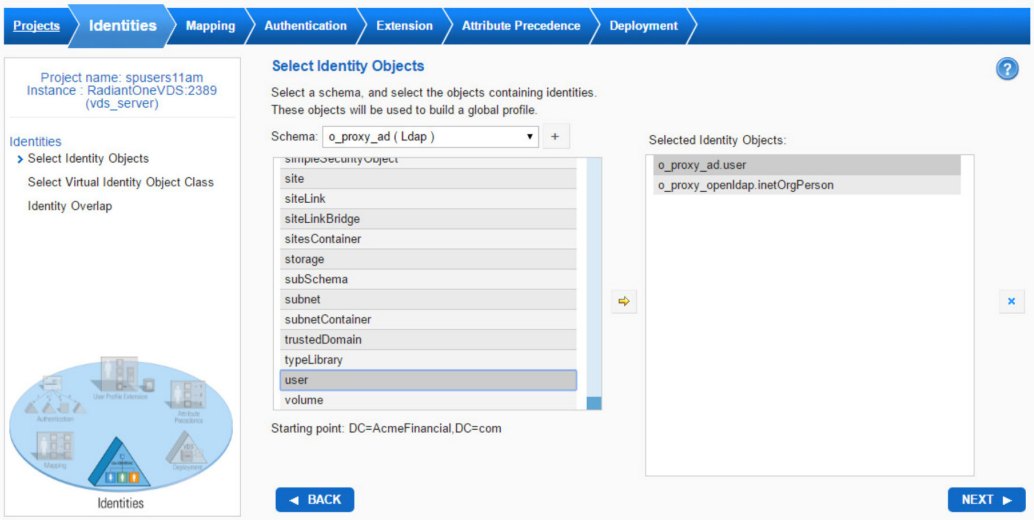
To configure the Virtual Identities for SharePoint, follow these steps:

1. On the **Wizards** tab, click the **Virtual Identity Wizard**.

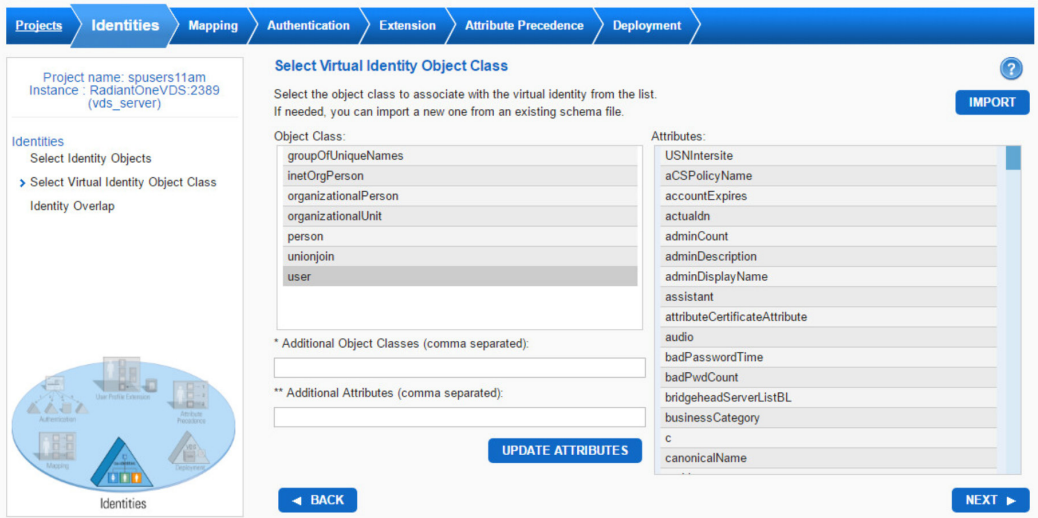


2. Click **Next**.
3. Click **New** and enter a project name (e.g., spusers) and click **Next**.
4. If you do not already have the schemas extracted from the data sources (or even data sources defined), use the + button to do so. The schema objects selected must be the ones associated with the user entries in the backends (e.g., InetOrgPerson for the LDAP, and user for AD). For more information, including exact steps on this process, see the *RadiantOne System Admin Guide*.

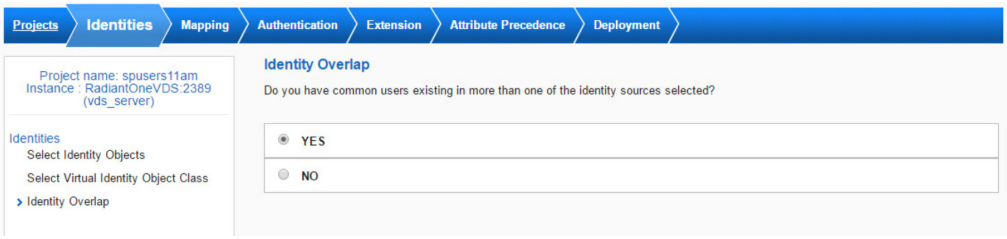
5. After connections to the backends are established and the schemas have been extracted, the drop-down list will be be populated with these objects. Select the object (e.g., objectclass) for each of the data sources and use the button to define it as a "Selected Identity Object."
6. Create the Selected identity objects shown below with the user schema from the AD backend and the inetOrgPerson from the openLDAP backend.



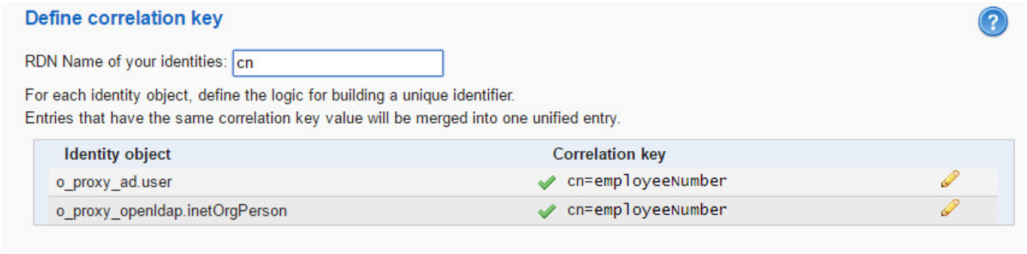
7. Click **Next**.
8. Select the objectclass to associate the virtual entries with. To support forms-based authentication in SharePoint via the LDAP Membership Provider, you should make sure that the objectclass you select here later matches the one used to configure the SharePoint web application's web.config file. The user object class is used here.



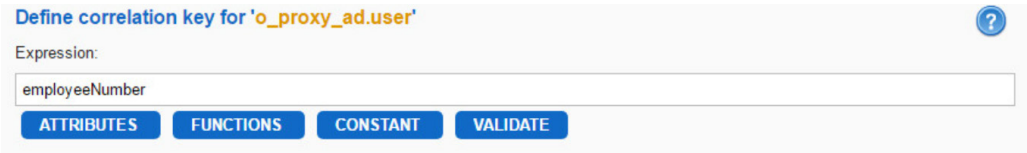
9. Click **Next**.
10. Select **Yes**. Click **Next**.



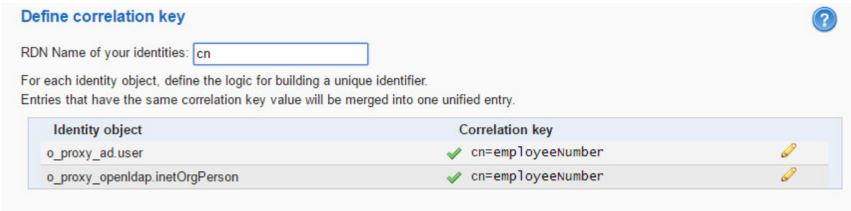
11. Define cn as the relative distingusihed name (RDN) Name of your identities.



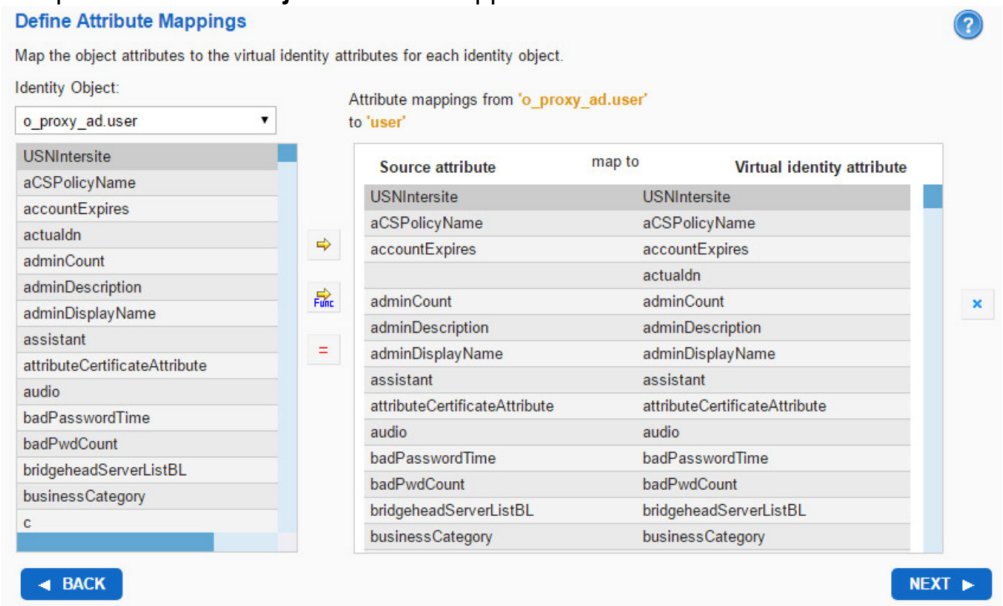
12. Select the button next to the user identity object. Set the correlation key as the employee number. Click **Next.**



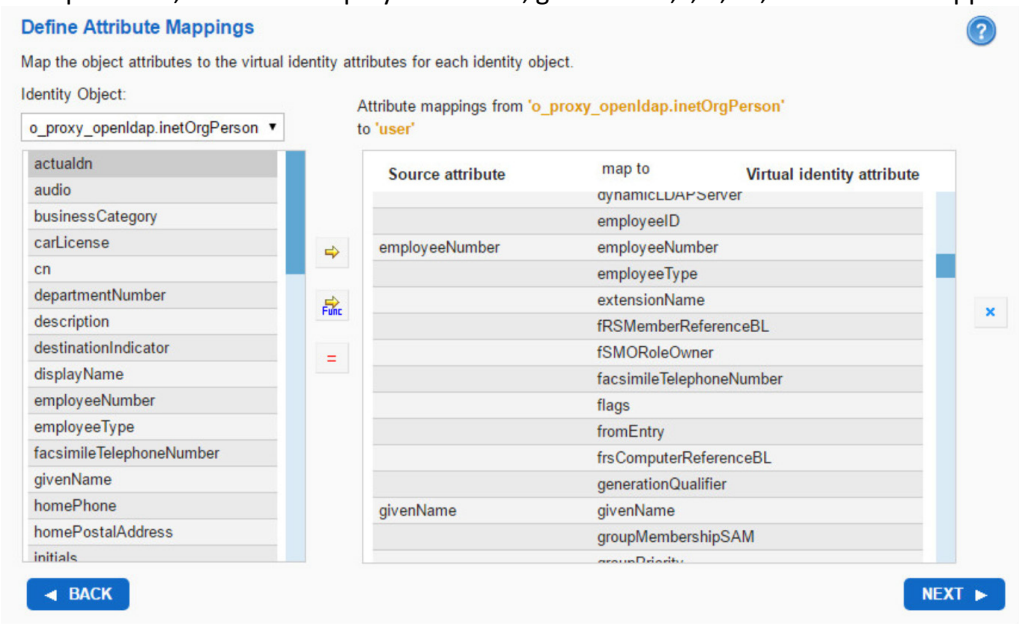
13. Repeat Step 12 for the inetOrgPerson identity object. Your correlation keys should have a green check to them as shown below. Click **Next**.



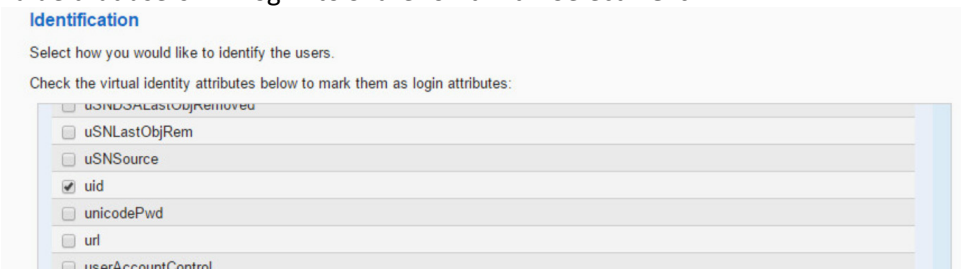
Here you define the attributes you want to return from each source. In this example, all attributes except **acutaldn** and **objectclass** are mapped from AD.



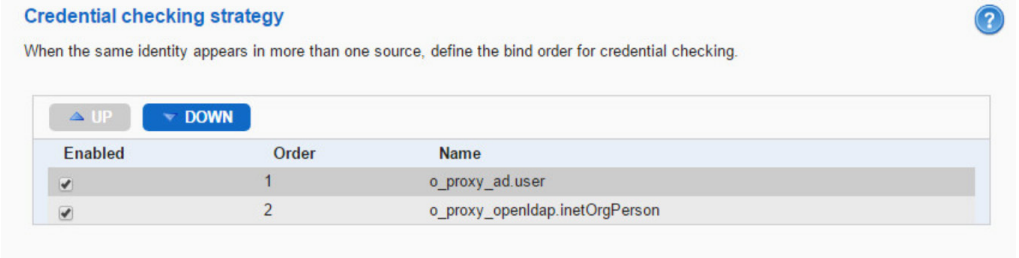
14. For OpenLDAP, note that employeeNumber, givenName, l, o, sn, and uid are mapped.



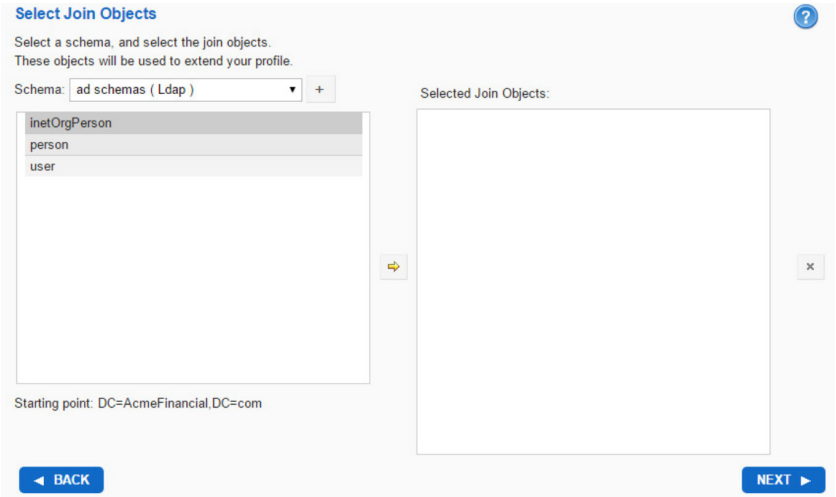
15. Select **Next** once the source attributes are mapped to the Virtual identity attribute.
16. Select the **uid** attribute as the identification attribute for user. The **uid** attribute contains the value that users will log in to SharePoint with. Select **Next**.



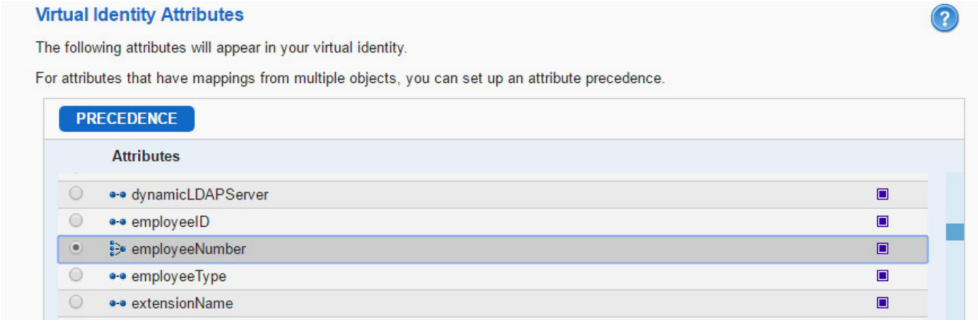
17. Enable both AD and OpenLDAP for credential checking. Give ADprecedence in the bind order. Click **Next**.



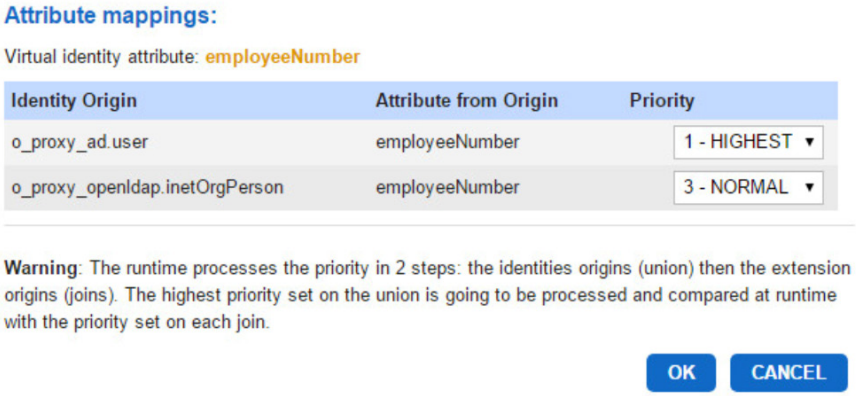
18. Do not select **Join Objects**. Click **Next**.



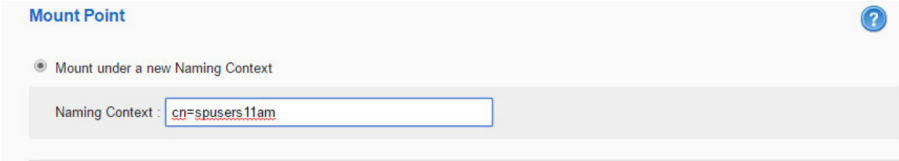
19. You can set each attribute precedence for any attributes that have mappings from multiple objects. Select the employeeNumber attribute. Click **PRECEDENCE**.



20. Give AD the highest priority. Click **O**



21. Click **Next**.
22. Name the naming context. For example, cn=spusers. Click **Next.**

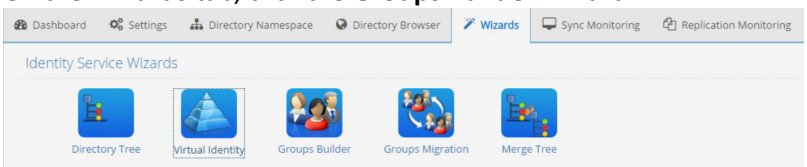


23. Select **Yes, I want a Periodic Cache Refresh**. Click **Next**.

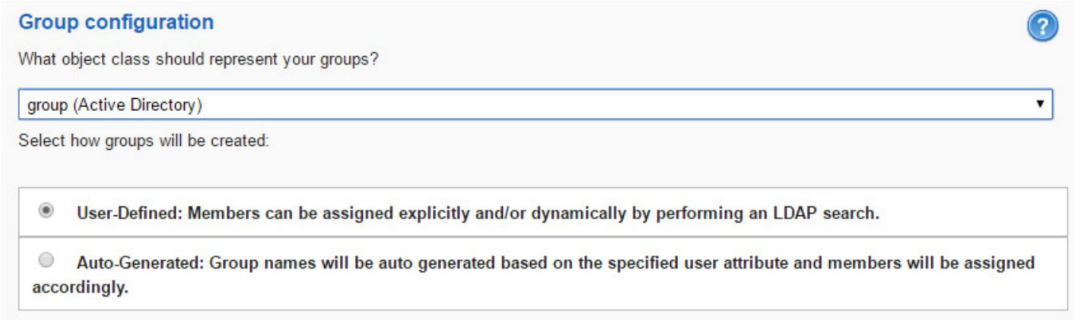
24. Define the refresh interval. Click **Next**.
25. Click **Initialize Cache Now**. Click **Finish**.

Follow these steps to configure the groups for SharePoint:

1. On the **Wizards** tab, click the **Groups Builder Wizard**.

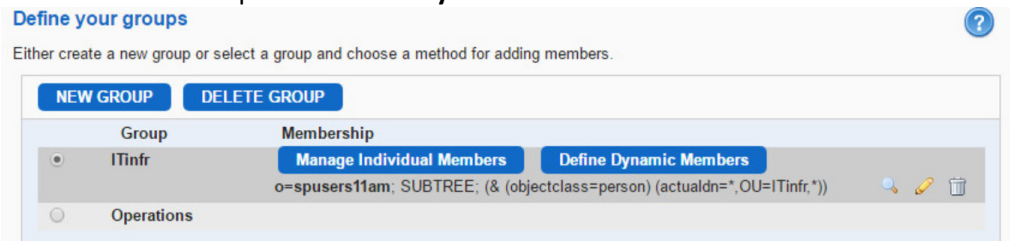


2. Click **Next**.
3. Name the project. Click **Next**.
4. From the drop-down menu select **group (Active Directory).** Select **User-Defined**. Click **Next**. For more information on user-defined and auto-generated group, see the *RadiantOne FID System Admin Guide*.



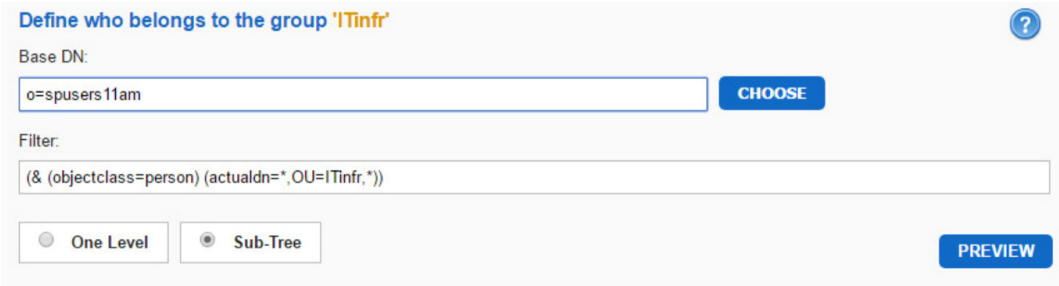
5. Select **New Group**. Name the group ITinfr. Click **Next**.

6. Repeat Step 5. Name the group Operations.
7. Select the first Group. Click **Define Dynamic Members.**

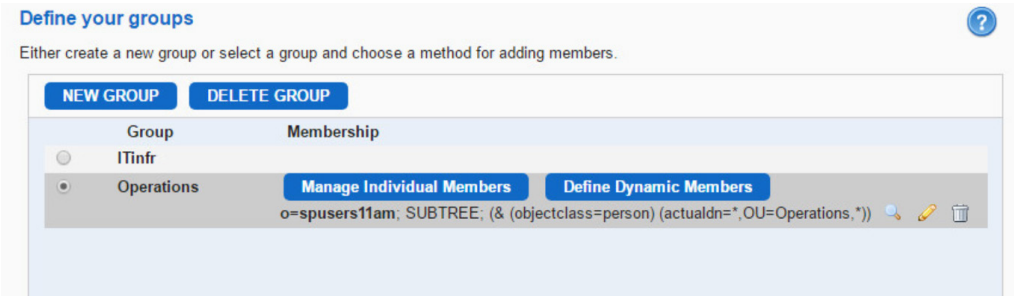


8. Choose the naming context created in Step 23 of using the Virtual Identity Wizard. Type in the following in the filter field: `(& (objectclass=person)(actualdn=*,OU=ITinfr,*))`. Select

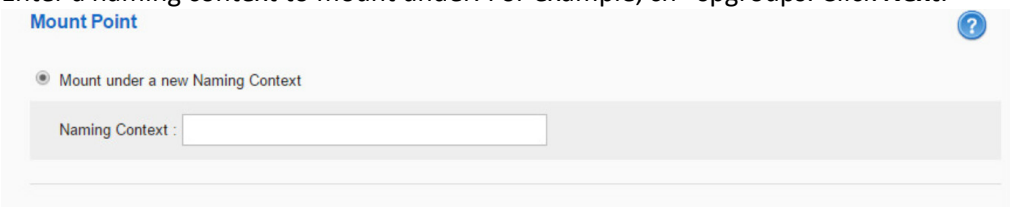
Sub-Tree. Click **Next**.



9. Repeat Steps 7 and 8 with the following filter: `(& (objectclass=person)(actualdn=*,OU=Operations,*))`.
10. Click **Next**.



11. Enter a naming context to mount under. For example, cn= spgroups. Click **Next**.



12. Select **Yes, I want a Periodic Cache Refresh**. Click **Next**.

13. Define the refresh interval. Click **Next**.
14. Click **Initialize Cache Now**. Click **Finish**.

2.6.7 Scripts

Two PowerShell scripts are scheduled to run on regular intervals on RadiantOne VDS server. The goal of these scripts is to determine if the virtual directory server (RadiantOne VDS) and the RACF directory server are online or offline. The first script determines if RadiantOne VDS is online or offline and writes the corresponding status message to a local file being monitored by Splunk. The second script, which also runs on the RadiantOne VDS server, determines if the Vanguard RACF directory is reachable and writes corresponding offline or online messages to a local file also being monitored by Splunk.

2.6.8 Script: RadiantOnlineStatus.ps1

```
#This script checks determines if this server is online or offline
#If gateway route exists and VDS server is running, the script will
#output the current time, hostname, status and previous time (last
#time it wrote to output file)
#Check if gateway route exists and if the VDS service is running
if ((Get-Netroute 0.0.0.0/0) -And (Get-Process vdsserver))
   {
   #Store date in PrevTime variable
   $PrevTime = Get-Date -format "ddd MMM dd HH:mm:ss \EST yyyy"
   #Check if prevtime-file.txt exists
   if (ls C:\scripts\Radiant\prevtime-file.txt)
      {
          #Place the contents of prevtime-file.txt in the PrevTime variable
      $PrevTime=Get-Content C:\scripts\Radiant\prevtime-file.txt
      }
   #Place the current date in CurrentTime
   $CurrentTime = Get-Date -format "ddd MMM dd HH:mm:ss \EST yyy"
   #Overwrite the contents of prevtime-file.txt with the current date
   Get-Date -format "ddd MMM dd HH:mm:ss \EST yyy" > C:\scripts\Radiant\prevtime-
file.txt
   $HostVar = hostname
   $Status = 'online'
   #Add the contents of the variables CurrentTime, HostVar, Status, PrevTime to
Radiant-Status-Output.csv
   Add-Content C:\scripts\Radiant\Radiant-Status-Output.csv
$CurrentTime','$HostVar','$Status','$PrevTime
   }
else
   {
   $PrevTime = Get-Date -format "ddd MMM dd HH:mm:ss \EST yyyy"
   if (ls C:\scripts\Radiant\prevtime-file.txt)
      {
      $PrevTime=Get-Content C:\scripts\Radiant\prevtime-file.txt
      }
   $CurrentTime = Get-Date -format "ddd MMM dd HH:mm:ss \EST yyy"
   Get-Date -format "ddd MMM dd HH:mm:ss \EST yyy" > C:\scripts\Radiant\prevtime-
file.txt
   $HostVar = hostname
   $Status = 'offline'
```

```
   Add-Content C:\scripts\Radiant\Radiant-Status-Output.csv
$CurrentTime','$HostVar','$Status','$PrevTime
   }
```

2.6.9 Script: VanguardOnlineStatus.ps1

```
#Script checks if the RACF mainframe is online and outputs status messages to file

#Check if the RACF mainframe is reachable with pings

if (ping -n 3 172.17.212.10 | select-string "Reply from 172.17.212.10")
   {
   #Store date in PrevTime variable
   $PrevTime = Get-Date -format "ddd MMM dd HH:mm:ss \EST yyyy"
    #Check if prevtime-file.txt exists
   if (ls C:\scripts\Vanguard\prevtime-file.txt)
      {
          #Place the contents of prevtime-file.txt in the PrevTime variable
      $PrevTime=Get-Content C:\scripts\Vanguard\prevtime-file.txt
      }
   #Place the current date in CurrentTime
   $CurrentTime = Get-Date -format "ddd MMM dd HH:mm:ss \EST yyy"
   #Overwrite the contents of prevtime-file.txt with the current date
   Get-Date -format "ddd MMM dd HH:mm:ss \EST yyy" > C:\scripts\Vanguard\prevtime-
file.txt
   $HostVar = "VanguardMainframe.acmefinancial.com"
   $Status = 'online'
   Add-Content C:\scripts\Vanguard\VanguardServer-Output.csv
$CurrentTime','$HostVar','$Status','$PrevTime
   }
else
   {
   $PrevTime = Get-Date -format "ddd MMM dd HH:mm:ss \EST yyyy"
   if (ls C:\scripts\Vanguard\prevtime-file.txt)
      {
      $PrevTime=Get-Content C:\scripts\Vanguard\prevtime-file.txt
      }
   $CurrentTime = Get-Date -format "ddd MMM dd HH:mm:ss \EST yyy"
   Get-Date -format "ddd MMM dd HH:mm:ss \EST yyy" > C:\scripts\Vanguard\prevtime-
file.txt
   $HostVar = "VanguardMainframe.acmefinancial.com"
   $Status = 'offline'
```

```
   Add-Content C:\scripts\Vanguard\VanguardServer-Output.csv
$CurrentTime','$HostVar','$Status','$PrevTime
   }
```

2.6.10 LDAPS Configuration

RadiantOne VDS virtual directory service connects to the Active Directory, OpenLDAP, and RACF backend directory servers and takes snapshots of the directory contents. Configuring LDAPS ensures that this process is encrypted with SSL. To use LDAPS to make these connections, follow these steps:

1. Copy the certificates of the backend directories to the RadiantOne VDS virtual directory server.
2. Import each certificate into the client trust store by opening the **Main Control Panel.**
3. Click **Settings** tab > **Security** section > **Client Certificate Trust Store.**
4. The certificates will be dynamically loaded into the Client Certificate Trust Store.
5. Configure the backend connections to use LDAPS by going to the **Settings** tab.
6. **Click Server Backend** > **LDAP Data Sources** > **Edit LDAP Data Source.**
7. Check the **SSL** box and type **636** into the **Por**t text box.

2.7 SharePoint

SharePoint is a web-based, collaborative platform. SharePoint is primarily used as a document management and storage system. It also supports workflow and applications.

2.7.1 How It's Used

SharePoint 2013 is used as the web application to demonstrate the capability of the Access Rights Management example solution.

2.7.2 Virtual Machine Configuration

The SharePoint virtual machine is configured as follows:

- Ubuntu Linux 16.04 LTS
- 4 CPU cores
- 32GB of RAM
- 2 NICs
- 120GB of storage

Network Configuration (Interface 1)
IPv4 Manual
IPv6 Disabled
IP Address: 192.168.17.113
Netmask: 255.255.255.0
Gateway: 192.168.17.1
DNS Name Servers: 192.168.19.10
DNS-Search Domains: acmefinancial.com

2.7.3 Prerequisites

See the Microsoft online documentation for hardware and software prerequisites.

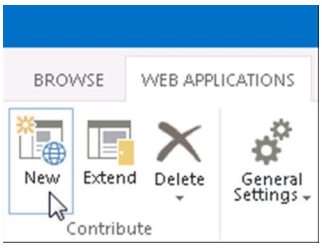
2.7.4 Installing SharePoint 2013

1. Installing SQL Server 2012: On the server where SharePoint 2013 is going to be installed, follow the steps from this link to install SQL Server 2012: https://technet.microsoft.com/en-us/library/ms143219(v=sql.110).aspx
2. Installing IIS on the SharePoint Server: On the server where SharePoint 2013 is going to be installed, follow the steps from this link to install IIS 8.0: http://www.iis.net/learn/get-started/whats-new-in-iis-8/installing-iis-8-on-windows-server-2012
3. Installing SharePoint Server 2013: On the server where SharePoint Server 2013 is going to be installed, follow the steps from this link to install SharePoint Server 2013: http://social.technet.microsoft.com/wiki/contents/articles/14209.sharepoint-2013-installation-step-by-step.aspx

2.7.5 Configuring SharePoint

SharePoint must be integrated with the Radiant Logic Virtual Directory using Forms-Based Authentication. To integrate with the VD, complete the following steps:

1. Open the SharePoint Central Administration Console, log in with your admin user, and click **Application Management**.
2. Below the **Web Applications** section, click on **Manage Web Applications**.

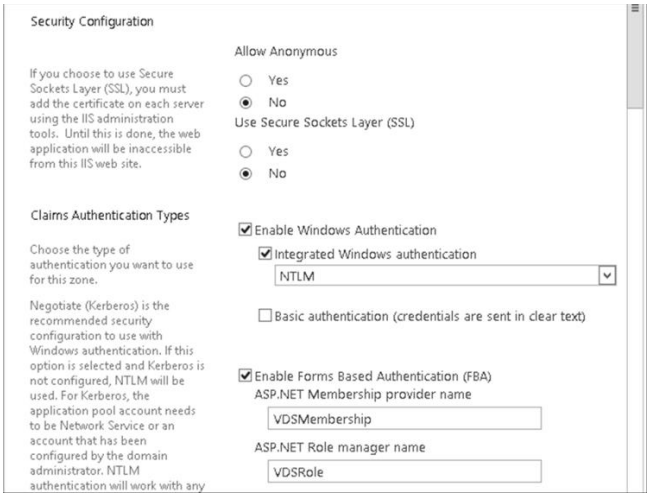


3. Click the **New** button.
4. You can choose to create a new IIS website and set a unique port.

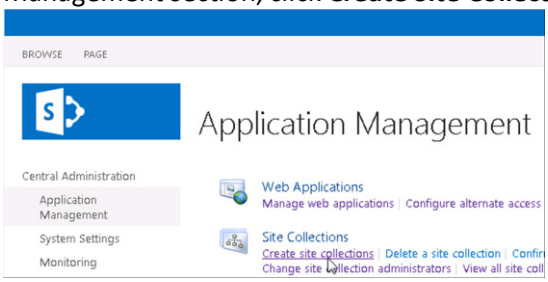
   Typically, you should accept the default path.

5. In the Security Configuration section, you can leave the default options (Allow Anonymous=No, Use SSL=No).
6. In the Claims Authentication Types section, check the option to **Enable Forms Based Authentication (FBA).**

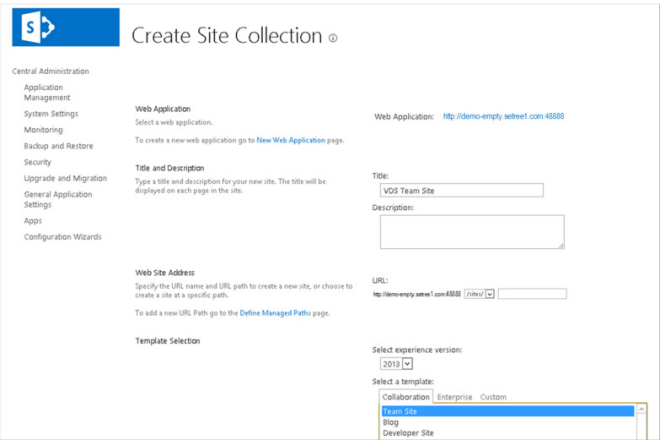
7. Enter a unique name for the ASP.NET Membership provider name and ASP.NET Role manager name.



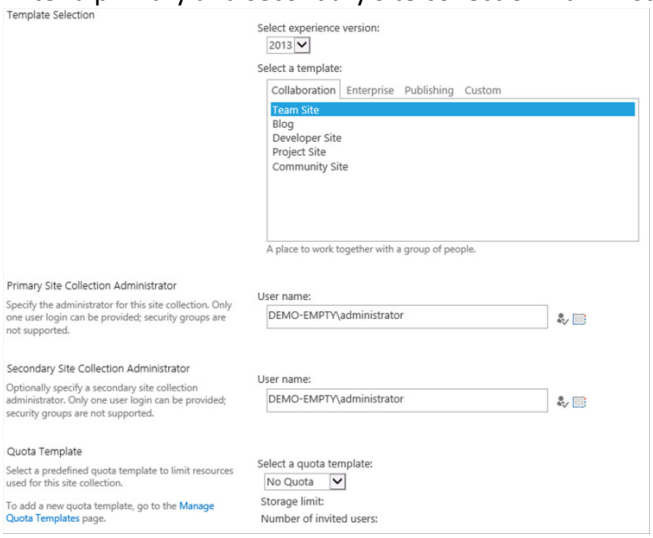
8. Leave the default sign-in page option selected.
9. In the Public URL section, leave the default URL and Zone.
10. In the Application Pool section, you can choose to “Create new application pool” and choose the “Predefined” option for the security account. Select the **Network Service** predefined option.
11. Leave the default values for the Database Name and Authentication, Failover Server, Search Server, Service Application Connections, and Customer Experience Improvement Program sections.
12. Click **OK** to create the new site.
13. Because this is a new site, you will also need to setup a Site Collection. In the Application Management section, click **Create Site Collections**.



14. Make sure your application shows in the Web Application parameter (if not, click in the drop-down list to select a new one). Enter a title description and web site address and choose a template.



15. Enter a primary and secondary site collection Administrator. Click **OK.**



2.7.6 Web Configs

Three web config files must be edited to complete the integration with Radiant Logic.

SharePoint STS web config file is located at C:\Program Files\Common Files\Microsoft Shared\Web Server Extensions\15\WebServices\SecurityToken.

The web.config file has a default membership provider and a default role provider. Do not change them. The names of the new membership provider and role manager that get added into the web.config file must match the names set in the Forms Based configuration for the web application.

Modify the file to include the following xml code in the <system.web> section.

```
<system.web>
<membership defaultProvider="i">
<providers>
<clear/>
<add name="i"
type="Microsoft.Sharepoint.Administration.Claims.SPClaimsAuthMembershipProvider,
Microsoft.SharePoint, Version=15.0.0.0, Culture=neutral,
PublicKeyToken=71e9bce111e9429c" />
```

```
<add name="VDSMembership"
type="Microsoft.Office.Server.Security.LdapMembershipProvider,
Microsoft.Office.Server, Version=15.0.0.0, Culture=neutral,
PublicKeyToken=71e9bce111e9429c"
        server="192.168.14.111"
        port="2389"
        useSSL="false"
        connectionUsername="cn=Directory Manager"
        connectionPassword="Fsarm@nccoe1"
        useDNAttribute="false"
        userDNAttribute="distinguishedName"
        userNameAttribute="uid"
        userContainer="o=spusers11am"
        userObjectClass="user"
        userFilter="(ObjectClass=user)"
        scope="Subtree"
        otherRequiredUserAttributes="sn,givenname,cn,employeeNumber"/>
</providers>
</membership>
<roleManager defaultProvider="c" enabled="true" cacheRolesInCookie="false" >
<providers>
<clear/>
<add name="c"
type="Microsoft.SharePoint.Administration.Claims.SPClaimsAuthRoleProvider,
Microsoft.SharePoint, Version=15.0.0.0, Culture=neutral,
PublicKeyToken=71e9bce111e9429c" />
<add name="VDSRole"
type="Microsoft.Office.Server.Security.LdapRoleProvider, Microsoft.Office.Server,
Version=15.0.0.0, Culture=neutral, PublicKeyToken=71e9bce111e9429c"
        server="192.168.14.111"
        port="2389"
        useSSL="false"
        groupContainer="o=spgroups11am"
        groupNameAttribute="cn"
        groupNameAlternateSearchAttribute="cn"
        groupMemberAttribute="member"
        userNameAttribute="uid"
        useUserDNAttribute="false"
        userContainer="o=spusers11am"
        dnAttribute="distinguishedName"
        groupFilter="(ObjectClass=group)"
        userFilter="(ObjectClass=user)"
```

```
        scope="Subtree" />
</providers>
</roleManager>
</system.web>
```

SharePoint Central Admin web config file is located at *C:\inetpub\wwwroot\wss\VirtualDirectories\<port the central admin is on>*.

There is a default membership provider and a default role provider in the web.config file. Do not change them. The names of the new membership provider and role manager that get added into the web.config file must match the names set in the Forms Based configuration for the web application.

Modify the file to include the following xml code in the <system.web> section:

```
<membership defaultProvider="i">
<providers>
<clear />
<add name="i"
type="Microsoft.SharePoint.Administration.Claims.SPClaimsAuthMembershipProvider,
Microsoft.SharePoint, Version=15.0.0.0, Culture=neutral,
PublicKeyToken=71e9bce111e9429c" />
<add name="VDSMembership"
type="Microsoft.Office.Server.Security.LdapMembershipProvider,
Microsoft.Office.Server, Version=15.0.0.0, Culture=neutral,
PublicKeyToken=71e9bce111e9429c"
        server="192.168.14.111"
        port="2389"
        useSSL="false"
        connectionUsername="cn=Directory Manager"
        connectionPassword="Fsarm@nccoe1"
        useDNAttribute="false"
        userDNAttribute="distinguishedName"
        userNameAttribute="uid"
        userContainer="o=spusers11am"
        userObjectClass="user"
        userFilter="(ObjectClass=user)"
        scope="Subtree"
        otherRequiredUserAttributes="sn,givenname,cn,employeeNumber"/>
</providers>
</membership>
<roleManager defaultProvider="c" enabled="true" cacheRolesInCookie="false">
<providers>
<clear />
<add name="c"
type="Microsoft.SharePoint.Administration.Claims.SPClaimsAuthRoleProvider,
Microsoft.SharePoint, Version=15.0.0.0, Culture=neutral,
PublicKeyToken=71e9bce111e9429c" />
```

```
<add name="VDSRole"
type="Microsoft.Office.Server.Security.LdapRoleProvider, Microsoft.Office.Server,
Version=15.0.0.0, Culture=neutral, PublicKeyToken=71e9bce111e9429c"
      server="192.168.14.111"
      port="2389"
      useSSL="false"
      groupContainer="o=spgroups11am"
      groupNameAttribute="cn"
      groupNameAlternateSearchAttribute="cn"
      groupMemberAttribute="member"
      userNameAttribute="uid"
      useUserDNAttribute="false"
      userContainer="o=spusers11am"
      cacheDurationInMinutes="0"
      dnAttribute="distinguishedName"
      groupFilter="(ObjectClass=group)"
      userFilter="(ObjectClass=user)"
      scope="Subtree" />
</providers>
</roleManager>
```

SharePoint Web Application web config is located at *C:\inetpub\wwwroot\wss\VirtualDirectories\<port the application is on>*.

There is a default membership provider and a default role provider in the web.config file. Do not change them. The names of the new membership provider and role manager that get added into the web.config file must match the names set in the Forms Based configuration for the web application.

Modify the file to include the following xml code in the <system.web> section:

```
<roleManager enabled="true" defaultProvider="AspNetWindowsTokenRoleProvider"
<providers>
<add name="VDSRole"
type="Microsoft.Office.Server.Security.LdapRoleProvider, Microsoft.Office.Server,
Version=15.0.0.0, Culture=neutral,
PublicKeyToken=71e9bce111e9429c"
      server="192.168.14.111"
      port="2389"
      useSSL="false"
      groupContainer="o=spgroups11am"
      groupNameAttribute="cn"
      groupNameAlternateSearchAttribute="cn"
      groupMemberAttribute="member"
      userNameAttribute="uid"
```

```
        dnAttribute="distinguishedName"
        groupFilter="(ObjectClass=group)"
        userFilter="(ObjectClass=person)"
        scope="Subtree" />
</providers>
</roleManager>
<membership>
<providers>
<add name="VDSMembership"
type="Microsoft.Office.Server.Security.LdapMembershipProvider,
Microsoft.Office.Server, Version=15.0.0.0, Culture=neutral,
PublicKeyToken=71e9bce111e9429c"
        server="192.168.14.111"
        port="2389"
        useSSL="false"
        connectionUsername="cn=Directory Manager"
        connectionPassword="Fsarm@nccoe1"
        useDNAttribute="false"
        userDNAttribute="distinguishedName"
        userNameAttribute="uid"
        userContainer="o=spusers11am"
        userObjectClass="person"
        userFilter="(ObjectClass=person)"
        scope="Subtree"
        otherRequiredUserAttributes="sn,givenname,cn"/>
</providers>
</membership>
</system.web>
```

To leverage RadiantOne Federated Identity for the SharePoint people picker, add the following line in the <PeoplePickerWildcards> section of the web.config files for the SharePoint site and the Central Admin (where VDSMembership is the name of the custom membership provider used):

```
<add key=”VDSMembership” value=”*” />
<PeoplePickerWildcards> <clear />
<add key="AspNetSqlMembershipProvider" value="%" />
<add key="VDSMembership" value="*" /> </PeoplePickerWildcards>
```

2.8 Splunk

Splunk is a Security Information and Event Management system that allows for the collection and parsing of logs and data from multiple systems.

2.8.1 How It’s Used

Splunk can receive data from a plethora of different sources. The most reliable option is installing Splunk's "Universal Forwarder" on each system you want to collect data from. Other options include syslogs, file and directory monitoring, network events, and more. Once data has been collected by Splunk, it can then be parsed and displayed using prebuilt rules or custom criteria.

2.8.2 Installation

Note: You will need a Splunk account to download Splunk Enterprise. The account is free and can be set up at https://www.splunk.com/page/sign_up

Download Splunk Enterprise from https://www.splunk.com/en_us/download/splunk-enterprise.htmlSplunk can be installed on Windows, Linux, Solaris, and Mac OS X. Each of these installation instructions can be found at:

- Windows
  - GUI: http://docs.splunk.com/Documentation/Splunk/6.5.2/Installation/InstallonWindows
  - Command line: http://docs.splunk.com/Documentation/Splunk/6.5.2/Installation/InstallonWindowsviathecommandline
- Linux: http://docs.splunk.com/Documentation/Splunk/6.5.2/Installation/InstallonLinux
- Solaris: http://docs.splunk.com/Documentation/Splunk/6.5.2/Installation/InstallonSolaris
- Mac OS X: http://docs.splunk.com/Documentation/Splunk/6.5.2/Installation/InstallonMacOS

2.8.3 Queries

Splunk reports, alerts, and dashboards are powered by queries written in the Splunk Search Processing Language (SPL). These queries are used to perform the analytics responsible for capturing events, identifying trends, and detecting anomalies. Once a query is written, it can be saved as a report, an alert, or as a dashboard panel. The following queries were also saved to dashboards to provide a central viewing location for operators, managers, and decision makers.

2.8.4 Query: Detect User Provisioning Accounts Events

The following search query detects when a user account is provisioned or when the user account attributes are modified. The provisioning and modification events detected include those that are in compliance with the established workflow and originate from the approved provisioning system, as well as those that violate the workflow. The output of the query shows which events were authorized and which were not.

```
(index=main sourcetype="wineventlog:security" EventCode=5136 OR EventCode=4720) OR
(index=sandbox sourcetype="alertstatictest" OR sourcetype="RadiantSourceTest") OR
(index=main sourcetype="openldap-outlog")|rex "givenName:(?P<FirstName>\w+)"|rex
"sn:(?P<LastName>\w+)"|rex mode=sed "s/;;/ /g"|rex
"changetype:(?P<RLICHANGETYPE>\w+)"|rex "employeeNumber:(?P<EmployeeNumber>\w+)"|rex
"changetype:modify (?P<CHANGE>.+)"|rex "conn=\d+\s\w+\:cn=(?P<LDAP_UID>\w+\S\w+)"|rex
"A user account was (?P<RLICHANGETYPE>\w+)"|rex "A directory service object was
(?P<RLICHANGETYPE>\w+)"|eval
RLICHANGETYPE=if(RLICHANGETYPE=="modified","update",RLICHANGETYPE)|eval
RLICHANGETYPE=if(RLICHANGETYPE=="created","insert", RLICHANGETYPE)|eval
RLICHANGETYPE=if(RLICHANGETYPE=="add","insert",RLICHANGETYPE)|fields _time host
checkStatus checkAuthFields EmployeeNo FirstName LastName ADUserId LDAPUserId
```

```
RLICHANGETYPE employeeNumber givenName sn uid gidnumber RLICHANGES LDAP_UID LDAP_MSG
AD_UID AD_MSG |rex "\-create\(\):User: (?P<LDAP_UID>\w+\.\w+)"|rex "\-create\(\):User:
(?P<AD_UID>\w+\s)"|rex "\-create\(\):User: (?P<LDAP_MSG>\w+\.\w+\s\w+\s\w+)"|rex "\-
create\(\):User: (?P<AD_MSG>\w+\s\w+\s\w+)" |rex
"<RLICHANGETYPE>(?P<RLICHANGETYPE>\w+)"|rex
"<RLICHANGES>(?P<RLICHANGES>.+)\<\/RLICHANGES\>"|rex "employeeNumber:
(?P<EmployeeNumber>\w+)"|rex "sn: (?P<SurName>\w+)"|rex "givenName:
(?P<GivenName>\w+)"|rex "gidNumber: (?P<GidNumber>\w+)"|rex "mail: (?P<mail>\S+)"|rex
"departmentNumber: (?P<DeptNumber>\w+)"|rex "## l: (?P<L>\w+)"|rex "## o:
(?P<O>\w+)"|rex "## pager: (?P<Pager>\w+)"|rex "## initials: (?P<Initials>\w+)"|rex
"mobile: (?P<Mobile>\w+)"|rex "modifiersName: (?P<ModifiersName>\S+\s*\S+)"|rex
"\<givenName\>(?P<GivenName>\S+\s*\S+)\<\/givenName\>"|rex
"\<sn\>(?P<SurName>\S+\s*\S+)\<\/sn\>" |rex
"\<employeeNumber\>(?P<EmployeeNumber>\S+\s*\S+)\<\/employeeNumber\>" |table _time
host checkStatus EmployeeNo FirstName LastName EmployeeNumber GivenName SurName
RLICHANGETYPE RLICHANGES checkAuthFields LDAP_UID LDAP_MSG AD_UID AD_MSG ADUserId
LDAPUserId |where (isnotnull(FirstName)) OR (isnotnull(RLICHANGES) OR
(isnotnull(LDAP_MSG)) OR (isnotnull(AD_MSG))) OR isnotnull(RLICHANGETYPE)|eval
F_Name=coalesce(FirstName,GivenName)|eval L_Name=coalesce(LastName,SurName)|eval
EmpNo=coalesce(EmployeeNo,EmployeeNumber)|eval
LDAP_UID=coalesce(LDAP_UID,LDAPUserId)|eval AD_UID=coalesce(AD_UserId,AD_UID) |table
_time host checkStatus EmpNo F_Name L_Name RLICHANGETYPE RLICHANGES checkAuthFields
LDAP_UID AD_UID LDAP_MSG AD_MSG|eval RLICHANGES=if(RLICHANGETYPE=="insert","New User
Record",RLICHANGES)| eval LDAP_UID=if((isnull(LDAP_UID) AND host=="RadiantOne
VDS"),lower(F_Name+"."+L_Name),LDAP_UID)|eval
AD_UID=if(isnull(AD_UID),lower(substr(F_Name,1,1) + substr(L_Name,1)),AD_UID)|eval
RLICHANGES=if(Like(LDAP_MSG,"%created%"),"New User Record",RLICHANGES)|eval
RLICHANGES=if(Like(AD_MSG,"%created%"),"New User Record",RLICHANGES)|eval
RLICHANGES=if(Like(LDAP_MSG,"%created%"),"New User Record",RLICHANGES)|eval
RLICHANGES=if(Like(AD_MSG,"%created%"),"New User Record",RLICHANGES)|eval
UniqueKey=lower(LDAP_UID+"."+AD_UID)|eval host=if(host=="WIN-
CHSUIS3NKVR","AlertEnterprise-WIN",host)|transaction UniqueKey, RLICHANGES
maxspan=120s|eval host1=if(Like(host,"%RadiantOne VDS%"),"RadiantOne VDS","NULL")|eval
host2=if(Like(host, "%WIN%"),"AlertE","NULL")|eval Authority=if((host1=="RadiantOne
VDS" AND host2=="AlertE"), "Authorized", "Not Legal")|eval
Authority=if((host1=="RadiantOne VDS" AND host2=="NULL"), "Unauthorized", Authority)
|table _time host Authority RLICHANGETYPE RLICHANGES EmpNo F_Name L_Name LDAP_UID
AD_UID ADCHANGETYPE|where isnotnull(EmpNo)|table _time host Authority RLICHANGETYPE
RLICHANGES EmpNo F_Name L_Name LDAP_UID AD_UID|where Authority !="Not Legal"|eval
CHANGES=if(isnotnull(RLICHANGES),RLICHANGES,RLICHANGES)|eval
CHANGETYPE=if(isnotnull(RLICHANGETYPE),RLICHANGETYPE,RLICHANGETYPE)|table _time host
Authority CHANGETYPE CHANGES EmpNo F_Name L_Name LDAP_UID AD_UID|where Not
Like(CHANGES, "%lastLogonTimestamp%")
```

2.8.5 Query: Authorized and Unauthorized Provisioning Trend Line Chart

The following search query generates a line chart showing the trends for both the authorized and unauthorized provisioning events:

```
earliest="1/25/2017:00:00:00" latest="2/15/2017:00:00:00" index=sandbox
sourcetype="alertstatictest" OR sourcetype="RadiantSourceTest"|fields _time host
checkStatus checkAuthFields EmployeeNo FirstName LastName ADUserId LDAPUserId
RLICHANGETYPE employeeNumber givenName sn uid gidnumber RLICHANGES LDAP_UID LDAP_MSG
AD_UID AD_MSG|rex "\-create\(\):User: (?P<LDAP_UID>\w+\.\w+)"|rex "\-create\(\):User:
(?P<AD_UID>\w+\s)"|rex "\-create\(\):User: (?P<LDAP_MSG>\w+\.\w+\s\w+\s\w+)"|rex "\-
create\(\):User: (?P<AD_MSG>\w+\s\w+\s\w+)" |rex
"<RLICHANGETYPE>(?P<RLICHANGETYPE>\w+)"|rex
"<RLICHANGES>(?P<RLICHANGES>.+)\<\/RLICHANGES\>"|rex "employeeNumber:
(?P<EmployeeNumber>\w+)"|rex "sn: (?P<SurName>\w+)"|rex "givenName:
(?P<GivenName>\w+)"|rex "gidNumber: (?P<GidNumber>\w+)"|rex "mail: (?P<mail>\S+)"|rex
"departmentNumber: (?P<DeptNumber>\w+)"|rex "## l: (?P<L>\w+)"|rex "## o:
(?P<O>\w+)"|rex "## pager: (?P<Pager>\w+)"|rex "## initials: (?P<Initials>\w+)"|rex
"mobile: (?P<Mobile>\w+)"|rex "modifiersName: (?P<ModifiersName>\S+\s*\S+)"|rex
```

```
"\<givenName\>(?P<GivenName>\S+\s*\S+)\<\/givenName\>"|rex
"\<sn\>(?P<SurName>\S+\s*\S+)\<\/sn\>" |rex
"\<employeeNumber\>(?P<EmployeeNumber>\S+\s*\S+)\<\/employeeNumber\>" |table _time
host checkStatus EmployeeNo FirstName LastName EmployeeNumber GivenName SurName
RLICHANGETYPE RLICHANGES checkAuthFields LDAP_UID LDAP_MSG AD_UID AD_MSG ADUserId
LDAPUserId|where (isnotnull(FirstName)) OR (isnotnull(RLICHANGES) OR
(isnotnull(LDAP_MSG)) OR (isnotnull(AD_MSG)))|eval
F_Name=coalesce(FirstName,GivenName)|eval L_Name=coalesce(LastName,SurName)|eval
EmpNo=coalesce(EmployeeNo,EmployeeNumber)|eval
LDAP_UID=coalesce(LDAP_UID,LDAPUserId)|eval AD_UID=coalesce(AD_UserId,AD_UID) |table
_time host checkStatus EmpNo F_Name L_Name RLICHANGETYPE RLICHANGES checkAuthFields
LDAP_UID AD_UID LDAP_MSG AD_MSG|eval RLICHANGES=if(RLICHANGETYPE=="insert","New User
Record",RLICHANGES)| eval LDAP_UID=if((isnull(LDAP_UID) AND host=="RadiantOne
VDS"),lower(F_Name+"."+L_Name),LDAP_UID)|eval
AD_UID=if(isnull(AD_UID),lower(substr(F_Name,1,1) + substr(L_Name,1)),AD_UID)|eval
RLICHANGES=if(Like(LDAP_MSG,"%created%"),"New User Record",RLICHANGES)|eval
RLICHANGES=if(Like(AD_MSG,"%created%"),"New User Record",RLICHANGES)|eval
RLICHANGES=if(Like(LDAP_MSG,"%created%"),"New User Record",RLICHANGES)|eval
RLICHANGES=if(Like(AD_MSG,"%created%"),"New User Record",RLICHANGES)|eval
UniqueKey=lower(LDAP_UID+"."+AD_UID)|eval host=if(host=="WIN-
CHSUIS3NKVR","AlertEnterprise-WIN",host)|transaction UniqueKey, RLICHANGES
maxspan=120s|eval host1=if(Like(host,"%RadiantOne VDS%"),"RadiantOne VDS","NULL")|eval
host2=if(Like(host, "%WIN%"),"AlertE","NULL")|eval Authority=if((host1=="RadiantOne
VDS" AND host2=="AlertE"), "Authorized", "Not Legal")|eval
Authority=if((host1=="RadiantOne VDS" AND host2=="NULL"), "Unauthorized", Authority)
|table _time host Authority RLICHANGETYPE RLICHANGES EmpNo F_Name L_Name LDAP_UID
AD_UID|where isnotnull(EmpNo)|table _time host Authority RLICHANGETYPE RLICHANGES
EmpNo F_Name L_Name LDAP_UID AD_UID|where Authority !="Not Legal"|eval
CHANGES=if(isnotnull(RLICHANGES),RLICHANGES,RLICHANGES)|eval
CHANGETYPE=if(isnotnull(RLICHANGETYPE),RLICHANGETYPE,RLICHANGETYPE)|table _time host
Authority CHANGETYPE CHANGES EmpNo F_Name L_Name LDAP_UID AD_UID|timechart span=2d
count BY Authority
```

2.8.6 Query: Combined Provisioning Trend Line Chart

The following search query generates a line chart that shows the total authorized and unauthorized provisioning events combined in a single trend line:

```
index=sandbox sourcetype="alertstatictest" OR sourcetype="RadiantSourceTest"|fields
_time host checkStatus checkAuthFields EmployeeNo FirstName LastName ADUserId
LDAPUserId  RLICHANGETYPE employeeNumber givenName sn uid gidnumber RLICHANGES
LDAP_UID LDAP_MSG AD_UID AD_MSG|rex "\-create\(\):User: (?P<LDAP_UID>\w+\.\w+)"|rex
"\-create\(\):User: (?P<AD_UID>\w+\s)"|rex "\-create\(\):User:
(?P<LDAP_MSG>\w+\.\w+\s\w+\s\w+)"|rex "\-create\(\):User: (?P<AD_MSG>\w+\s\w+\s\w+)"
|rex "<RLICHANGETYPE>(?P<RLICHANGETYPE>\w+)"|rex
"<RLICHANGES>(?P<RLICHANGES>.+)\<\/RLICHANGES\>"|rex "employeeNumber:
(?P<EmployeeNumber>\w+)"|rex "sn: (?P<SurName>\w+)"|rex "givenName:
(?P<GivenName>\w+)"|rex "gidNumber: (?P<GidNumber>\w+)"|rex "mail: (?P<mail>\S+)"|rex
"departmentNumber: (?P<DeptNumber>\w+)"|rex "## l: (?P<L>\w+)"|rex "## o:
(?P<O>\w+)"|rex "## pager: (?P<Pager>\w+)"|rex "## initials: (?P<Initials>\w+)"|rex
"mobile: (?P<Mobile>\w+)"|rex "modifiersName: (?P<ModifiersName>\S+\s*\S+)"|rex
"\<givenName\>(?P<GivenName>\S+\s*\S+)\<\/givenName\>"|rex
"\<sn\>(?P<SurName>\S+\s*\S+)\<\/sn\>" |rex
"\<employeeNumber\>(?P<EmployeeNumber>\S+\s*\S+)\<\/employeeNumber\>" |table _time
host checkStatus EmployeeNo FirstName LastName EmployeeNumber GivenName SurName
RLICHANGETYPE RLICHANGES checkAuthFields LDAP_UID LDAP_MSG AD_UID AD_MSG ADUserId
LDAPUserId|where (isnotnull(FirstName)) OR (isnotnull(RLICHANGES) OR
(isnotnull(LDAP_MSG)) OR (isnotnull(AD_MSG)))|eval
F_Name=coalesce(FirstName,GivenName)|eval L_Name=coalesce(LastName,SurName)|eval
EmpNo=coalesce(EmployeeNo,EmployeeNumber)|eval
LDAP_UID=coalesce(LDAP_UID,LDAPUserId)|eval AD_UID=coalesce(AD_UserId,AD_UID) |table
_time host checkStatus EmpNo F_Name L_Name RLICHANGETYPE RLICHANGES checkAuthFields
LDAP_UID AD_UID LDAP_MSG AD_MSG|eval RLICHANGES=if(RLICHANGETYPE=="insert","New User
```

```
Record",RLICHANGES)| eval LDAP_UID=if((isnull(LDAP_UID) AND host=="RadiantOne
VDS"),lower(F_Name+"."+L_Name),LDAP_UID)|eval
AD_UID=if(isnull(AD_UID),lower(substr(F_Name,1,1) + substr(L_Name,1)),AD_UID)|eval
RLICHANGES=if(Like(LDAP_MSG,"%created%"),"New User Record",RLICHANGES)|eval
RLICHANGES=if(Like(AD_MSG,"%created%"),"New User Record",RLICHANGES)|eval
RLICHANGES=if(Like(LDAP_MSG,"%created%"),"New User Record",RLICHANGES)|eval
RLICHANGES=if(Like(AD_MSG,"%created%"),"New User Record",RLICHANGES)|eval
UniqueKey=lower(LDAP_UID+"."+AD_UID)|eval host=if(host=="WIN-
CHSUIS3NKVR","AlertEnterprise-WIN",host)|transaction UniqueKey, RLICHANGES
maxspan=120s|eval host1=if(Like(host,"%RadiantOne VDS%"),"RadiantOne VDS","NULL")|eval
host2=if(Like(host, "%WIN%"),"AlertE","NULL")|eval Authority=if((host1=="RadiantOne
VDS" AND host2=="AlertE"), "Authorized", "Not Legal")|eval
Authority=if((host1=="RadiantOne VDS" AND host2=="NULL"), "Unauthorized", Authority)
|table _time host Authority RLICHANGETYPE RLICHANGES EmpNo F_Name L_Name LDAP_UID
AD_UID|where isnotnull(EmpNo)|table _time host Authority RLICHANGETYPE RLICHANGES
EmpNo F_Name L_Name LDAP_UID AD_UID|where Authority !="Not Legal"|eval
CHANGES=if(isnotnull(RLICHANGES),RLICHANGES,RLICHANGES)|eval
CHANGETYPE=if(isnotnull(RLICHANGETYPE),RLICHANGETYPE,RLICHANGETYPE)|table _time host
Authority CHANGETYPE CHANGES EmpNo F_Name L_Name LDAP_UID AD_UID |eval
Event=if(isnotnull(Authority),"Provisioning", "Null")|timechart span=2d count BY Event
```

2.8.7 Query: Detect modifications to High Value or Privileged Accounts

The following search query detects any modification to high-value accounts or privileged accounts, such as managers and system administrators. It detects modifications that violate corporate policy as well as those that are performed in accordance to policy.

```
(index=main sourcetype="wineventlog:security" EventCode=5136 OR EventCode=4720) OR
(index=sandbox sourcetype="alertstatictest" OR sourcetype="RadiantSourceTest") OR
(index=main sourcetype="openldap-outlog")|rex "givenName:(?P<FirstName>\w+)"|rex
"sn:(?P<LastName>\w+)"|rex mode=sed "s/;;/ /g"|rex
"changetype:(?P<RLICHANGETYPE>\w+)"|rex "employeeNumber:(?P<EmployeeNumber>\w+)"|rex
"changetype:modify (?P<CHANGE>.+)"|rex "conn=\d+\s\w+\:cn=(?P<LDAP_UID>\w+\S\w+)"|rex
"A user account was (?P<RLICHANGETYPE>\w+)"|rex "A directory service object was
(?P<RLICHANGETYPE>\w+)"|eval
RLICHANGETYPE=if(RLICHANGETYPE=="modified","update",RLICHANGETYPE)|eval
RLICHANGETYPE=if(RLICHANGETYPE=="created","insert", RLICHANGETYPE)|eval
RLICHANGETYPE=if(RLICHANGETYPE=="add","insert",RLICHANGETYPE)|fields _time host
checkStatus checkAuthFields EmployeeNo FirstName LastName ADUserId LDAPUserId
RLICHANGETYPE employeeNumber givenName sn uid gidnumber RLICHANGES LDAP_UID LDAP_MSG
AD_UID AD_MSG |rex "\-create\(\):User: (?P<LDAP_UID>\w+\.\w+)"|rex "\-create\(\):User:
(?P<AD_UID>\w+\s)"|rex "\-create\(\):User: (?P<LDAP_MSG>\w+\.\w+\s\w+\s\w+)"|rex "\-
create\(\):User: (?P<AD_MSG>\w+\s\w+\s\w+)" |rex
"<RLICHANGETYPE>(?P<RLICHANGETYPE>\w+)"|rex
"<RLICHANGES>(?P<RLICHANGES>.+)\<\/RLICHANGES\>"|rex "employeeNumber:
(?P<EmployeeNumber>\w+)"|rex "sn: (?P<SurName>\w+)"|rex "givenName:
(?P<GivenName>\w+)"|rex "gidNumber: (?P<GidNumber>\w+)"|rex "mail: (?P<mail>\S+)"|rex
"departmentNumber: (?P<DeptNumber>\w+)"|rex "## l: (?P<L>\w+)"|rex "## o:
(?P<O>\w+)"|rex "## pager: (?P<Pager>\w+)"|rex "## initials: (?P<Initials>\w+)"|rex
"mobile: (?P<Mobile>\w+)"|rex "modifiersName: (?P<ModifiersName>\S+\s*\S+)"|rex
"\<givenName\>(?P<GivenName>\S+\s*\S+)\<\/givenName\>"|rex
"\<sn\>(?P<SurName>\S+\s*\S+)\<\/sn\>" |rex
"\<employeeNumber\>(?P<EmployeeNumber>\S+\s*\S+)\<\/employeeNumber\>" |table _time
host checkStatus EmployeeNo FirstName LastName EmployeeNumber GivenName SurName
RLICHANGETYPE RLICHANGES checkAuthFields LDAP_UID LDAP_MSG AD_UID AD_MSG ADUserId
LDAPUserId |where (isnotnull(FirstName)) OR (isnotnull(RLICHANGES) OR
(isnotnull(LDAP_MSG)) OR (isnotnull(AD_MSG))) OR isnotnull(RLICHANGETYPE)|eval
F_Name=coalesce(FirstName,GivenName)|eval L_Name=coalesce(LastName,SurName)|eval
EmpNo=coalesce(EmployeeNo,EmployeeNumber)|eval
LDAP_UID=coalesce(LDAP_UID,LDAPUserId)|eval AD_UID=coalesce(AD_UserId,AD_UID) |table
_time host checkStatus EmpNo F_Name L_Name RLICHANGETYPE RLICHANGES checkAuthFields
LDAP_UID AD_UID LDAP_MSG AD_MSG|eval RLICHANGES=if(RLICHANGETYPE=="insert","New User
```

```
Record",RLICHANGES)| eval LDAP_UID=if((isnull(LDAP_UID) AND host=="RadiantOne
VDS"),lower(F_Name+"."+L_Name),LDAP_UID)|eval
AD_UID=if(isnull(AD_UID),lower(substr(F_Name,1,1) + substr(L_Name,1)),AD_UID)|eval
RLICHANGES=if(Like(LDAP_MSG,"%created%"),"New User Record",RLICHANGES)|eval
RLICHANGES=if(Like(AD_MSG,"%created%"),"New User Record",RLICHANGES)|eval
RLICHANGES=if(Like(LDAP_MSG,"%created%"),"New User Record",RLICHANGES)|eval
RLICHANGES=if(Like(AD_MSG,"%created%"),"New User Record",RLICHANGES)|eval
UniqueKey=lower(LDAP_UID+"."+AD_UID)|eval host=if(host=="WIN-
CHSUIS3NKVR","AlertEnterprise-WIN",host)|transaction UniqueKey, RLICHANGES
maxspan=120s|eval host1=if(Like(host,"%RadiantOne VDS%"),"RadiantOne VDS","NULL")|eval
host2=if(Like(host, "%WIN%"),"AlertE","NULL")|eval Authority=if((host1=="RadiantOne
VDS" AND host2=="AlertE"), "Authorized", "Not Legal")|eval
Authority=if((host1=="RadiantOne VDS" AND host2=="NULL"), "Unauthorized", Authority)
|table _time host Authority RLICHANGETYPE RLICHANGES EmpNo F_Name L_Name LDAP_UID
AD_UID ADCHANGETYPE|where isnotnull(EmpNo)|table _time host Authority RLICHANGETYPE
RLICHANGES EmpNo F_Name L_Name LDAP_UID AD_UID|where Authority !="Not Legal"|eval
CHANGES=if(isnotnull(RLICHANGES),RLICHANGES,RLICHANGES)|eval
CHANGETYPE=if(isnotnull(RLICHANGETYPE),RLICHANGETYPE,RLICHANGETYPE)|table _time host
Authority CHANGETYPE CHANGES EmpNo F_Name L_Name LDAP_UID AD_UID|where Not
Like(CHANGES, "%lastLogonTimestamp%")|table _time host Authority CHANGETYPE CHANGES
EmpNo F_Name L_Name LDAP_UID AD_UID|where isnotnull(CHANGETYPE) AND ((Like(CHANGES,
"%MNGR%")) OR (Like(CHANGES, "%Manager%") OR Like(CHANGES, "%Administrator%")))
```

2.8.8 Query: Virtual Directory Server Offline Detection

The following search query detects when the virtual directory server goes offline. The virtual directory server is configured to send online status messages to Splunk at regular intervals. This query searches for those messages and declares the virtual directory server offline if the last online message received has exceeded the expected interval.

```
earliest=-24h sourcetype="radiant-status"|table _time CurrentTime Hostname Status|sort
1 -_time|eval SearchTime_Epoch=now()|eval CTime_Epoch=strptime(CurrentTime,"%a %b %d
%H:%M:%S %Z %Y")|eval TimeDiff=(SearchTime_Epoch - CTime_Epoch)|eval Status=if(TimeDiff
> 900, "Offline", Status)|where Status=="offline"|table CurrentTime Hostname Status
```

2.8.9 Query: Critical Servers Offline

The following search query detects when a directory server goes offline. The query uses the results of multiple data sources to determine when a server is offline and when it is online.

```
earliest=-12h (index=sandbox sourcetype="radiantsourcetest" ERROR) OR (index=main
sourcetype=openldap-status1) OR (index=main sourcetype=AD-Status) OR
(sourcetype="Vanguard-Status") OR (sourcetype="Radiant-Status") |rex "Exception taking
snapshot. Entries in snapshot: 0 Error :com.rli.slapd.server.LDAPException:
(?P<IPAddress>\d+\.\d+\.\d+\.\d+)"|rex "ERROR (?P<ConnectionStatus>\w+\s\w+)"|table
_time CurrentTime PrevTime Hostname Status IPAddress ConnectionStatus|eval
CTime=strptime(CurrentTime,"%a %b %d %H:%M:%S %Z %Y")|eval PTime=strptime(PrevTime,"%a
%b %d %H:%M:%S %Z %Y")|eval TimeDiff=(CTime-PTime)|eval
Hostname=if(IPAddress=="192.168.19.11", "openldap.acmefinancial.com", Hostname)|eval
Hostname=if(IPAddress=="192.168.19.10", "ActiveDirectory.acmefinancial.com",
Hostname)|eval Hostname=if(Hostname=="RadiantOne VDS", "RadiantOne
VDS.acmefinancial.com", Hostname)|eval Hostname=if(Hostname=="ActiveDirectory",
"ActiveDirectory.acmefinancial.com", Hostname)|eval
Status=if(ConnectionStatus=="Connection error", "offline", Status)|where
isnotnull(Hostname)|transaction Hostname Status|table _time Hostname Status
```

2.8.10 SSL Forwarding

We took advantage Splunk's built in SSL forwarding capability and configured SSL encryption between forwarders and the indexer. Instructions to enable SSL forwarding can be found at

http://docs.splunk.com/Documentation/Splunk/6.5.3/Security/ConfigureSplunkforwardingtousesignedcertificates.

2.9 TDI ConsoleWorks

ConsoleWorks is a product that provides a portal for remote access to devices, a logging facility with advanced hashing and pattern matching features, and role-based access control for administrators.

2.9.1 How It's Used

ConsoleWorks provides a portal through which privileged users access directory servers and core systems in the lab infrastructure. There are two primary types of access connectors that are configured. The first is a console connector that is either an SSH or Telnet connection to an internal LAN system. The other is a graphical user interface (GUI) connector that can be either through Remote Desktop Protocol (RDP) or Virtual Network Computing (VNC). In this build, SSH was used for the console connections, whereas RDP was used for the GUI connections.

The ConsoleWorks Server sits on a separate subnet that is connected to the Internet via a virtual private network. It is configured to allow connections initiated from the VPN, but it drops connections initiated from the LAN.

Additionally, ConsoleWorks maintains logs of what systems were accessed, the time of access, and by whom. These logs are formatted and prepared for consumption by the Splunk indexer.

2.9.2 Virtual Machine Configuration

ConsoleWorks virtual machine is configured as follows:

- CentOS 7.2.1511
- 1CPU cor
- 8GB of RAM
- 2 NICs
- 100GB of storage.

Network Configuration (LAN)
IPv4 Manual
IPv6 Enabled
IP Address: 192.168.17.11
Netmask: 255.255.255.0
Gateway: 192.168.17.1
DNS Name Servers 192.168.19.10
DNS-Search Domains: acmefinancial.com

Network Configuration (WAN)
IPv4 Manual
IPv6 Enabled
IP Address: 10.33.50.164
Netmask: 255.255.240.0

2.9.3 Firewall Configuration

Enter the following commands in sequence to allow traffic to ports 5176 and 22 ports only. The ConsoleWorks web service listens on port 5176.

1. **firewall-cmd – zone=public – add-port=5176/tcp**
2. **firewall-cmd – zone=public – add-port=22/tcp**

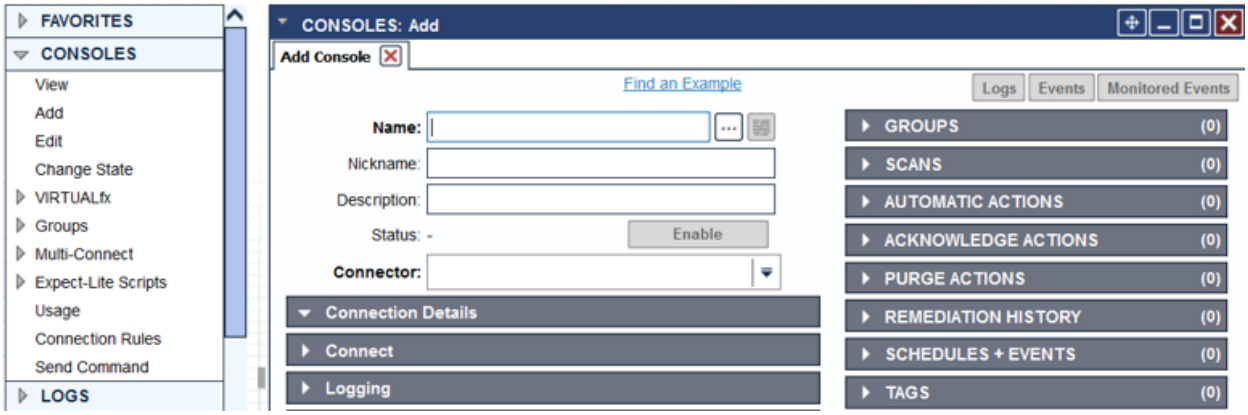
2.9.4 Installation

Installation for Windows, Linux, and Solaris systems can be found at http://support.tditechnologies.com/tags/installation-guides

2.9.5 Console Connection Configuration

To create a console connection:

1. Click on **Consoles>Add.**
2. Type in the name of the Console (for example, **OpenLDAPServer**).
3. Choose the **Connector** type (for example, **SSH on Demand**).
4. Click **Connection Details.** Check the **Exclusive Connect** checkbox.
5. Type in the **Host IP, Port, Username,** and **Password** fields.
6. Click **Save.**



2.9.6 Graphical Gateway Configuration

A Graphical Gateway is required to make an RDP or VNC connection to a server.

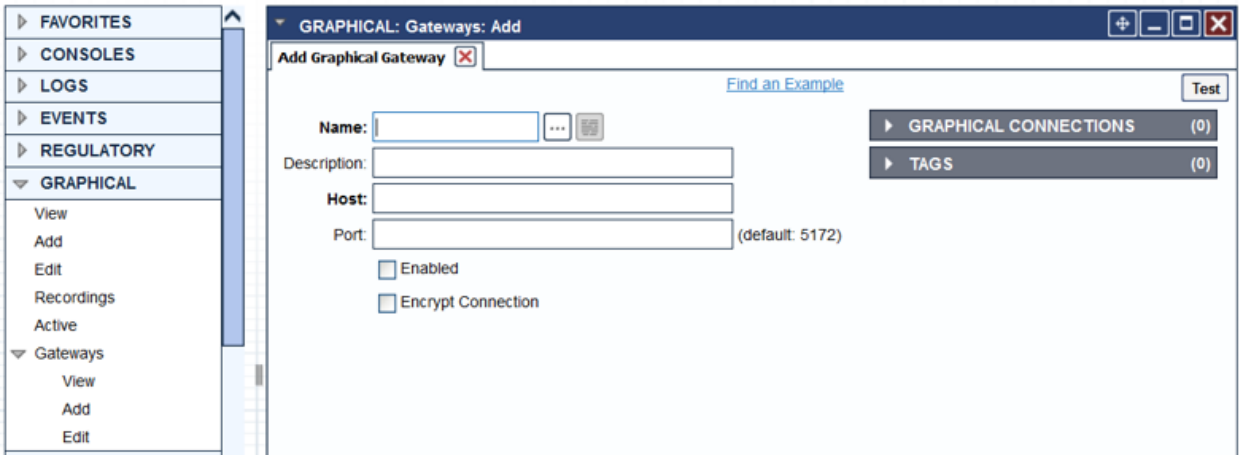
To configure a Graphical Gateway, you need to obtain and install the graphical gateway package from TDi Technologies Inc. The following steps describe installing and starting the service once the package is obtained.

```
rpm -ivh /tmp/consoleworks/ConsoleWorks_gui_gateway-version>.rpm
/opt/gui_gateway/install_local.sh
/opt/ConsoleWorks/bin/cw_start <invocation name>
service gui_gatewayd start
```

(created during installation)

Install the Graphical gateway:

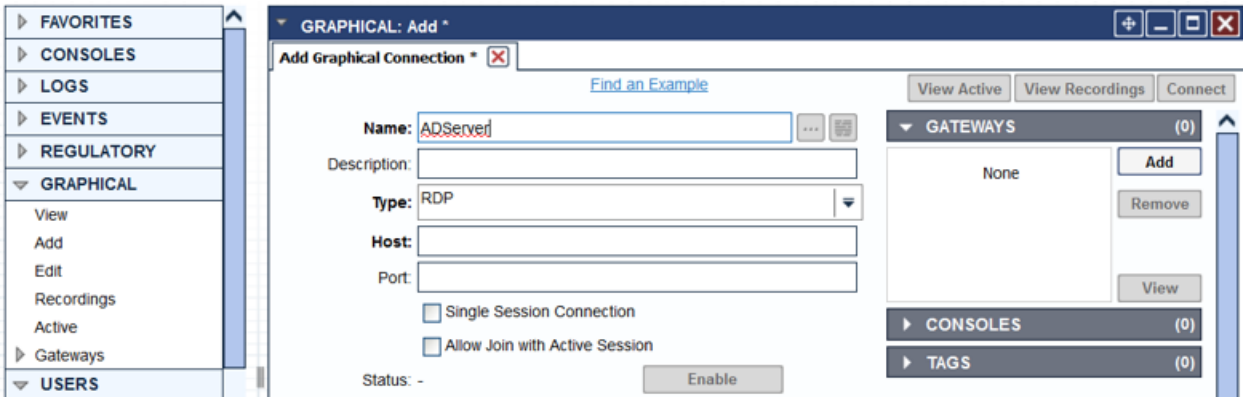
1. On the landing page on your ConsoleWorks server, click **GRAPHICAL>Gateways>Add**.
2. Give it a name, then set **Host** as Localhost and **Port** as 5172.
3. Check **Enabled** checkbox and click **Save**.
4. Verify it works by clicking **Test** in the top-left corner.



2.9.7 Graphical Connection Configuration

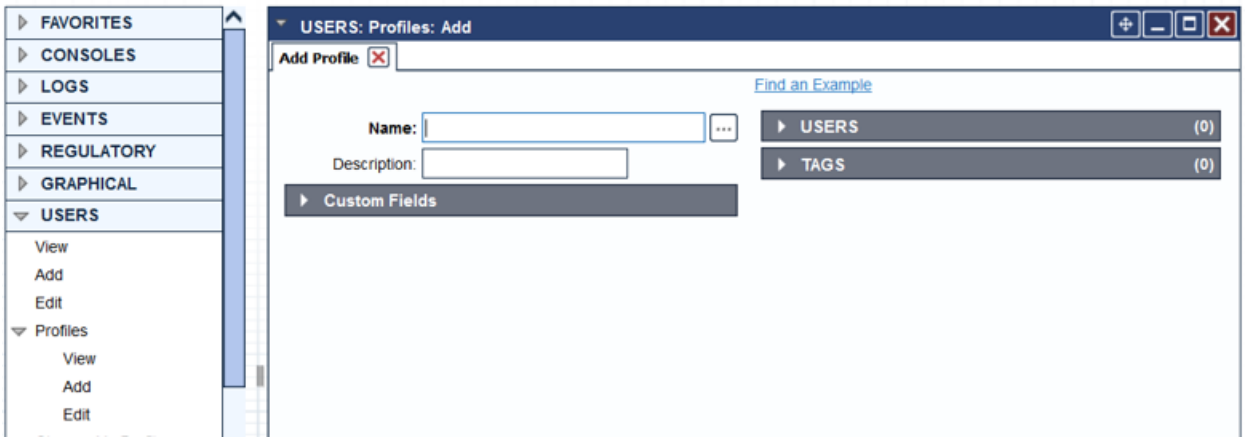
Configure the Graphical gateway:

1. On the landing page of your ConsoleWorks server, click **GRAPHICAL>Add.**
2. Type in the name of the Graphical connection (for example, **ADServer**).
3. Choose a protocol in the **Type** drop-down list (for example, **RDP**).
4. Enter the name or IP address of the server in the **Host** field.
5. Type in the port number in the **Port** field. Enter **3389** for RDP.
6. Click **Save.**



2.9.8 Profile Creation

1. Click **USERS>Profiles>Add.**
2. Type in the name of the profile in the **Name** field.
3. Click **Save.**

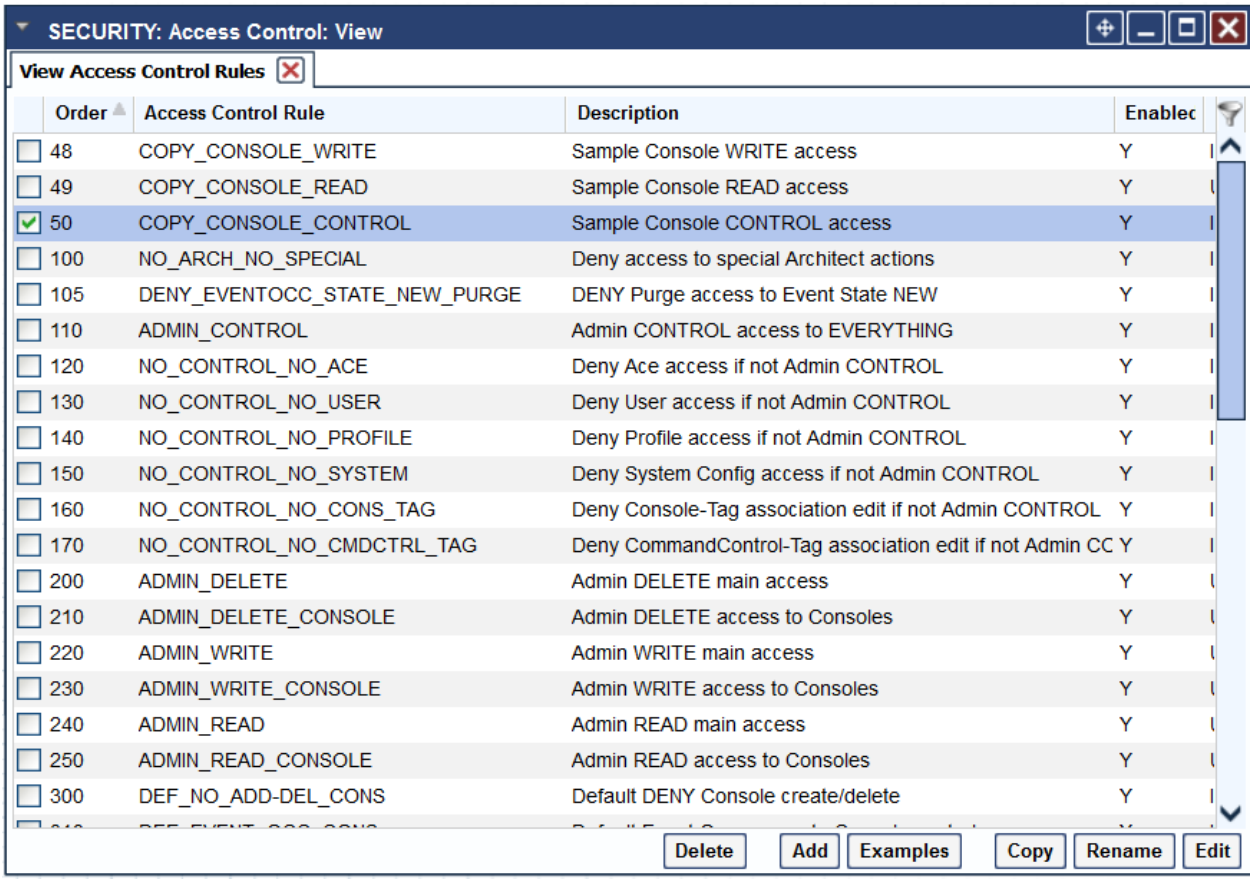


2.9.9 Access Controls

Access controls are rules that determine the level of access a user has to a Console or Graphical connection. These rules can be associated with profiles and tags, which in turn can be associated with a user to determine what a user has access to when logged in. In our build, we grouped privileged users based on the servers they needed access to, created profiles that mirrored these groups, linked the users to these profiles, and associated the access rules to the profiles.

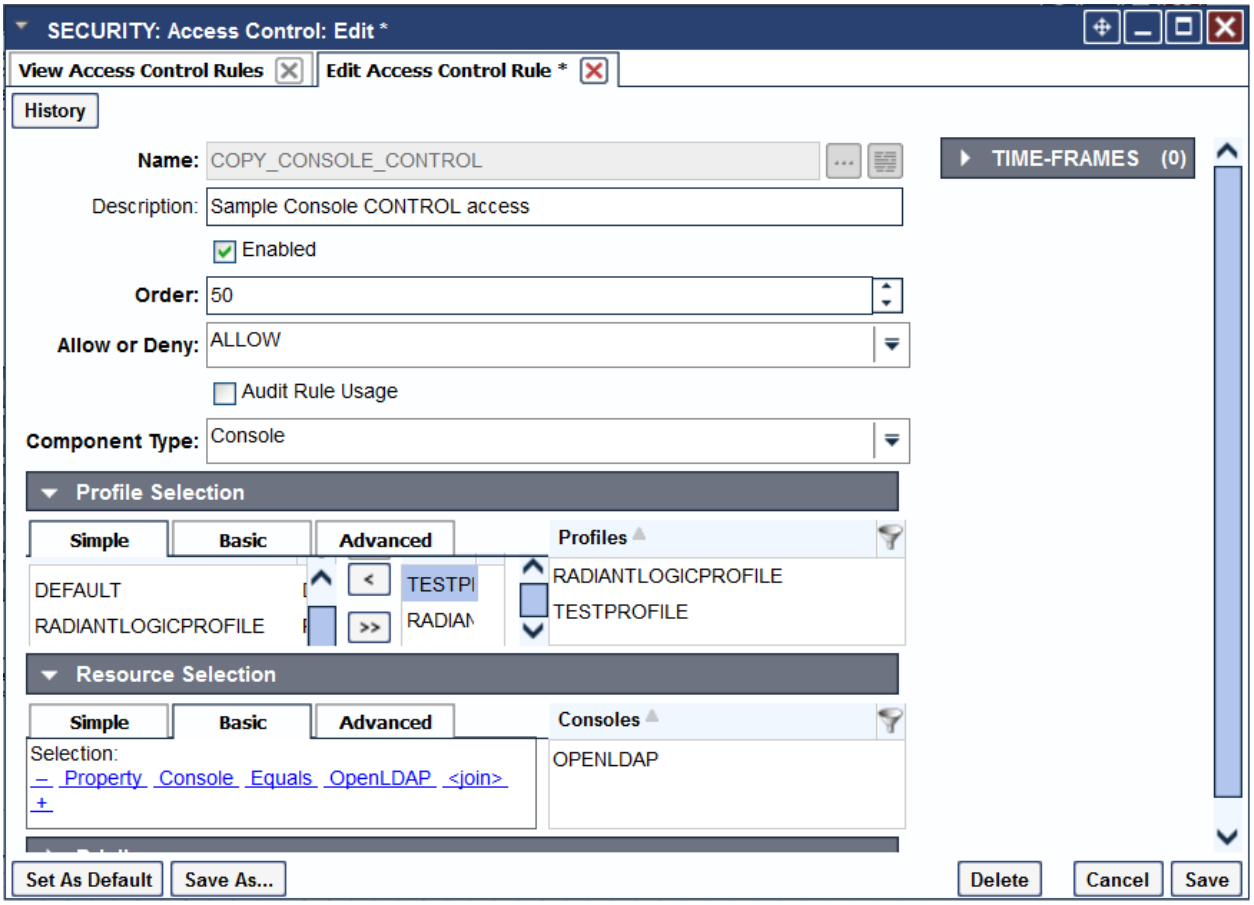
Create new access control rules:

1. Copy the **CONSOLE_CONTROL** access control rule and assign it a number below 100. Access control rules with lower numbers have priority over higher numbers.
2. Select the newly copied access rule and click Edit.



To create a profile:

1. In the **Allow or Deny** field, Select **ALLOW**.
2. In the component **Type**, select **Console.**
3. In the **Profile Selection** area, select the profile of choice from the **Simple** tab and click the double arrows. Make sure it appears in the **Profiles** section.
4. In the **Resource Selection** section, select the Console you want users associated with this profile to connect to. Select the **OpenLDAP** console.



1. To set access control rules for Graphical connections: Copy the **DEF_GRAPHICAL_DENY** and rename as **ALLOW_COPY_DEF_GRAPHICAL_1**.
2. Click **Edit.**

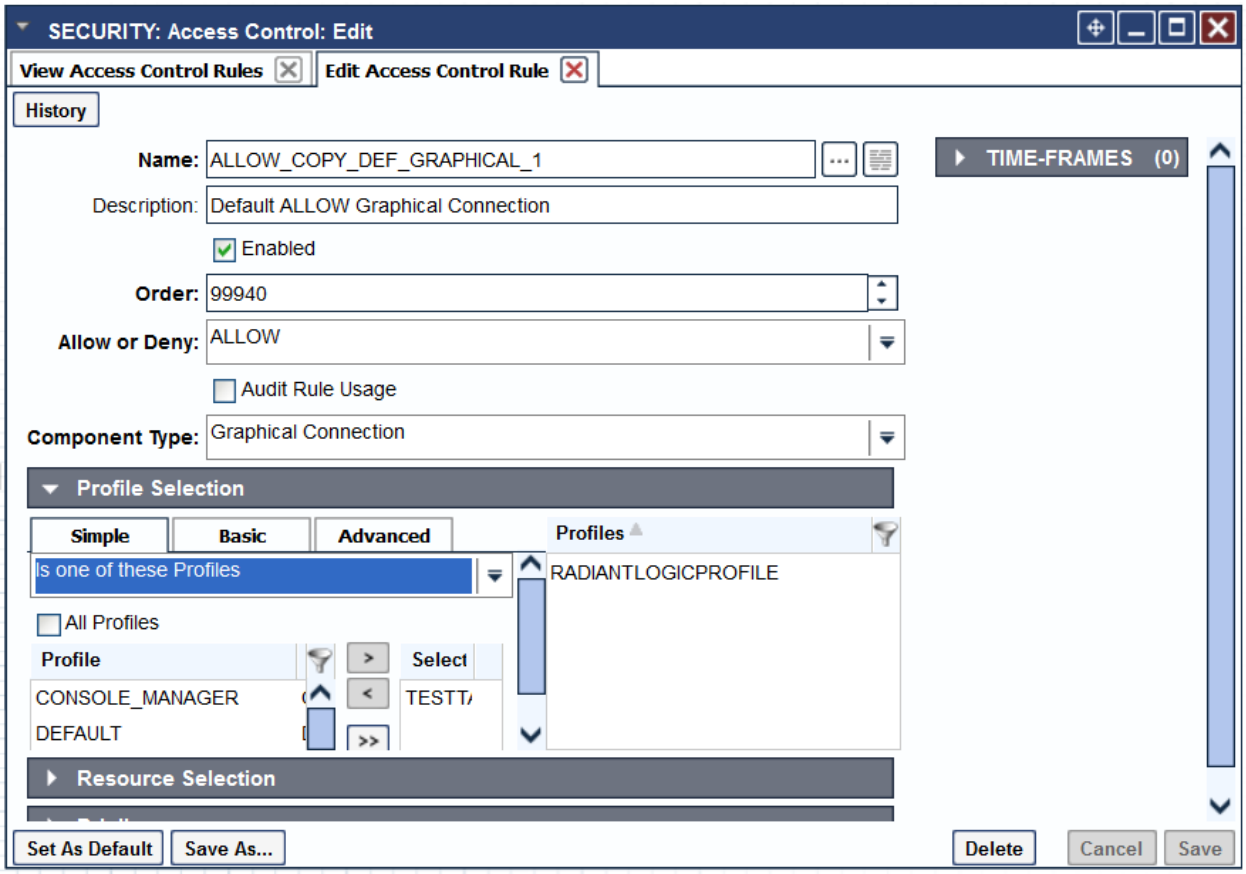
SECURITY: Access Control: View

View Access Control Rules

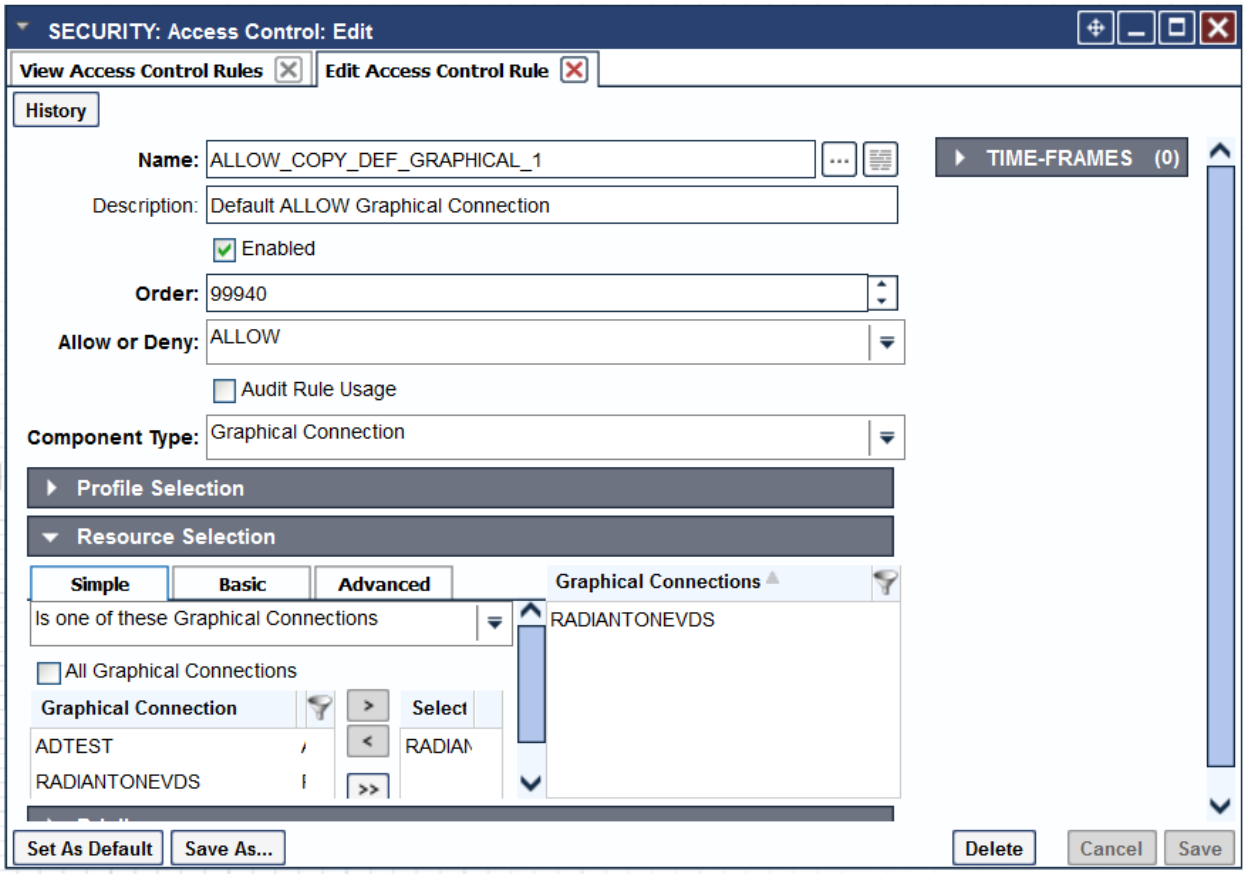
Order	Access Control Rule	Description	Enablec
99905	DEF_SSH_KEY_DENY	Default DENY SSH Key	Y
99907	DEF_TEMPLATE_DENY	Default DENY Template	Y
99913	DEF_BASELINE_DENY	Default DENY Baseline	Y
99915	DEF_SCHEDULER_DENY	Default DENY Schedule	Y
99917	DEF_REPORT_DENY	Default DENY Report	Y
99921	DEF_REGULATION_DENY	Default DENY Regulation	Y
99923	DEF_REGULATION_SET_DENY	Default DENY Regulation Set	Y
99925	DEF_REGULATORY_EVENT_DENY	Default DENY Regulatory Event	Y
99927	DEF_REGULATION_SEVERITY_DENY	Default DENY Regulation Severity	Y
99931	DEF_REGISTRATION_DENY	Default DENY Registration	Y
99933	DEF_CWSSHCLI_CONFIG_DENY	Default DENY CW SSH CLI Config	Y
99935	DEF_CWSCRIPT_DENY	Default DENY CWScript	Y
99940	ALLOW_COPY_DEF_GRAPHICAL_1	Default ALLOW Graphical Connection	Y
99941	DEF_GRAPHICAL_DENY	Default DENY Graphical Connection	Y
99943	DEF_GUIGATEWAY_DENY	Default DENY Graphical Gateway	Y
99990	DEF_CONSOLE_DENY	Default DENY Console	Y
99993	DEF_VIRTUAL_DENY	Default DENY Virtual Machine	Y
99995	DEF_MULTICONN_DENY	Default DENY Multi-Connect	Y
100000	DEF_AWARE	Default view	Y

Delete Add Examples Copy Rename Edit

1. To link an access control rule to a profile and a resource, first follow these steps:Edit this rule and change the **Allow or Deny** field from DENY to **ALLOW.**
2. Change the Description to **Default ALLOW Graphical Connection.**
3. Ensure that the order number is lower than the Default DENY Graphical Connection rule (DEF_GRAPHICAL_DENY).
4. Under Profile Selection, click the **Simple** tab and select “Is one of these Profiles.”
5. Select the profile of choice and make sure it appears on the right under Profiles.

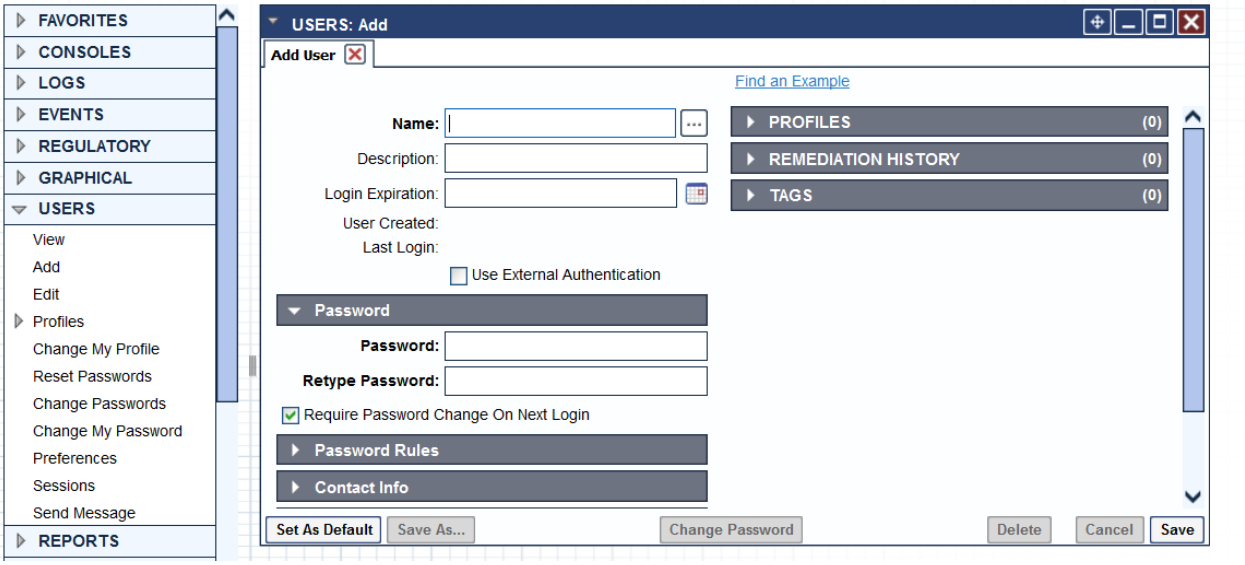


1. Next, you will need to **Select** the Graphical Connection of choice such as RADIANTONE VDS.
2. Click the double arrow and ensure that it appears on the right.



To add users and link to a profile:

1. Click on **USERS > Add.**
2. Type in the username in **Name** field.
3. Enter the password in the **Password** and **Retype Password** fields.
4. Click on **PROFILES > Add.**
5. Select the profile of choice.



2.9.10 pUser Auditing

An audit trail of ConsoleWorks user activity is captured in a file and forwarded to Splunk for further analysis. The the information includes username, logon timestamp, and the target server to which the user is connecting. The connection reporting script below parses the ConsoleWorks logs and writes the output to a file. The bash connectionreporting script removes duplicate lines. The bashconenctionreporting script is scheduled using cron to run every minute using the following /etc/crontab configuration.

2.9.11 Cron Configuration: /etc/crontab

```
SHELL=/bin/bash
PATH=/sbin:/bin:/usr/sbin:/usr/bin
MAILTO=root
# For details see man 4 crontabs
# Example of job definition:
# .---------------- minute (0 - 59)
# |  .------------- hour (0 - 23)
# |  |  .---------- day of month (1 - 31)
# |  |  |  .------- month (1 - 12) OR jan,feb,mar,apr ...
# |  |  |  |  .---- day of week (0 - 6) (Sunday=0 or 7) OR sun,mon,tue,wed,thu,fri,sat
# |  |  |  |  |
# *  *  *  *  * user-name  command to be executed
 *  *  *  *  * root      /etc/cron.daily/bashconnectionreporting
```

2.9.12 Scripts: connectionreporting

```
#!/usr/bin/python3.5
#Script identifies ConsoleWorks users, connection times and their targets
#import the OS module
import os
#Store the ConsoleWorks log directory in the "directory" variable
directory = "/opt/ConsoleWorks/FSARM/log"
#Change directory to the Log dir
os.chdir(directory)
#Iterate through files in log dir and look for strings shown in the
#IF statements. Matching lines are written to file
for file in os.listdir(directory):
  with open(file, 'r') as file_object:
    for line in file_object:
      if "CONWRKS Audit:: User:" in line:
        with open('/var/log/connections.out','a') as outfile_object:
          outfile_object.write(line)
      if "connecting" in line:
```

```
            with open('/var/log/connections.out','a') as outfile_object:
              outfile_object.write(line)
          if "disconnecting" in line:
            with open('/var/log/connections.out','a') as outfile_object:
              outfile_object.write(line)
```

2.9.13 Scripts: bashconnectionreporting

```
#!/bin/bash
#Calls python script that reads ConsoleWorks log files and outputs to
#/var/log/connections.out
/etc/cron.daily/connectionreporting
#This line removes duplicate lines from the connections.out file and outputs them
# to connections.log
awk '!seen[$0]++' /var/log/connections.out > /var/log/connections.log
```

2.10 Network Firewall Configuration

pfSense virtual devices were used as firewall routers for each subnet and were configured to restrict traffic as appropriate. The subnets listed below have critical services and resources that need to be accessed from devices external to the LAN. We have made the exact configuration used in each pfSense firewall available in XML format. This can be imported directly into another pfSense device. It is important to note that an IPSEC VPN connection was made to the offsite RACF LDAP directory server. The IPSEC VPN configuration was set up in the firewall for the backbone subnet.

2.10.1 Firewall Configuration for Backbone Subnet

```
<?xml version="1.0"?>
<pfsense>
      <version>15.4</version>
      <lastchange/>
      <theme>pfsense_ng</theme>
      <system>
            <optimization>normal</optimization>
            <hostname>pfsenseVLAN13</hostname>
            <domain>acmefinancial.com</domain>
            <group>
                  <name>all</name>
                  <description><![CDATA[All Users]]></description>
                  <scope>system</scope>
                  <gid>1998</gid>
                  <member>0</member>
            </group>
            <group>
                  <name>admins</name>
```

```
            <description><![CDATA[System Administrators]]></description>
            <scope>system</scope>
            <gid>1999</gid>
            <member>0</member>
            <priv>page-all</priv>
        </group>
        <user>
            <name>admin</name>
            <descr><![CDATA[System Administrator]]></descr>
            <scope>system</scope>
            <groupname>admins</groupname>
            <password>$1$dSJImFph$GvZ7.1UbuWu.Yb8etC0re.</password>
            <uid>0</uid>
            <priv>user-shell-access</priv>
        </user>
        <nextuid>2000</nextuid>
        <nextgid>2000</nextgid>
        <timezone>America/New_York</timezone>
        <time-update-interval/>
        <timeservers>10.97.74.8</timeservers>
        <webgui>
            <protocol>http</protocol>
            <loginautocomplete/>
            <ssl-certref>5720a0502b277</ssl-certref>
            <dashboardcolumns>2</dashboardcolumns>
            <webguicss>pfsense.css</webguicss>
        </webgui>
        <disablesegmentationoffloading/>
        <disablelargereceiveoffloading/>
        <ipv6allow/>
        <powerd_ac_mode>hadp</powerd_ac_mode>
        <powerd_battery_mode>hadp</powerd_battery_mode>
        <powerd_normal_mode>hadp</powerd_normal_mode>
        <bogons>
            <interval>monthly</interval>
        </bogons>
        <language>en_US</language>
        <dns1gw>GW_WAN</dns1gw>
        <dns2gw>GW_WAN</dns2gw>
        <dns3gw>none</dns3gw>
```

```
            <dns4gw>none</dns4gw>
            <maximumstates/>
            <aliasesresolveinterval/>
            <maximumtableentries/>
            <maximumfrags/>
            <enablenatreflectionpurenat>yes</enablenatreflectionpurenat>
            <enablebinatreflection>yes</enablebinatreflection>
            <enablenatreflectionhelper>yes</enablenatreflectionhelper>
            <reflectiontimeout/>
            <dnsserver>10.97.74.8</dnsserver>
            <dnsserver>10.63.255.2</dnsserver>
      </system>
      <interfaces>
            <wan>
                  <if>em0</if>
                  <descr><![CDATA[WAN]]></descr>
                  <enable/>
                  <spoofmac/>
                  <ipaddr>10.33.50.34</ipaddr>
                  <subnet>28</subnet>
                  <gateway>GW_WAN</gateway>
                  <ipaddrv6/>
                  <subnetv6/>
                  <gatewayv6/>
            </wan>
            <lan>
                  <enable/>
                  <if>em1</if>
                  <ipaddr>192.168.13.1</ipaddr>
                  <subnet>24</subnet>
                  <ipaddrv6/>
                  <subnetv6/>
                  <media/>
                  <mediaopt/>
                  <track6-interface>wan</track6-interface>
                  <track6-prefix-id>0</track6-prefix-id>
                  <gateway/>
                  <gatewayv6/>
            </lan>
      </interfaces>
```

```
        <staticroutes>
                <route>
                        <network>192.168.14.0/24</network>
                        <gateway>VLAN2014</gateway>
                        <descr/>
                </route>
                <route>
                        <network>192.168.19.0/24</network>
                        <gateway>VLAN2019</gateway>
                        <descr/>
                </route>
                <route>
                        <network>192.168.18.0/24</network>
                        <gateway>VLAN2018</gateway>
                        <descr/>
                </route>
                <route>
                        <network>192.168.15.0/24</network>
                        <gateway>VLAN2015</gateway>
                        <descr/>
                </route>
                <route>
                        <network>192.168.16.0/24</network>
                        <gateway>VLAN2016</gateway>
                        <descr/>
                </route>
                <route>
                        <network>192.168.17.0/24</network>
                        <gateway>VLAN2017</gateway>
                        <descr/>
                </route>
                <route>
                        <network>192.168.20.0/24</network>
                        <gateway>VLAN2020</gateway>
                        <descr/>
                </route>
                <route>
                        <network>10.33.50.160/28</network>
                        <gateway>VLAN2066</gateway>
                        <descr><![CDATA[Route to Vendor Net]]></descr>
```

```
            </route>
        </staticroutes>
        <dhcpd>
            <lan>
                <enable/>
                <range>
                    <from>192.168.13.100</from>
                    <to>192.168.13.150</to>
                </range>
                <failover_peerip/>
                <dhcpleaseinlocaltime/>
                <defaultleasetime/>
                <maxleasetime/>
                <netmask/>
                <dnsserver>192.168.19.10</dnsserver>
                <gateway/>
                <domain>acmefinancial.com</domain>
                <domainsearchlist>acmefinancial.com</domainsearchlist>
                <ddnsdomain/>
                <ddnsdomainprimary/>
                <ddnsdomainkeyname/>
                <ddnsdomainkey/>
                <mac_allow/>
                <mac_deny/>
                <tftp/>
                <ldap/>
                <nextserver/>
                <filename/>
                <filename32/>
                <filename64/>
                <rootpath/>
                <numberoptions/>
            </lan>
            <opt1>
                <enable/>
                <range>
                    <from>192.168.14.100</from>
                    <to>192.168.14.150</to>
                </range>
                <dhcpleaseinlocaltime/>
```

```
            </opt1>
            <opt2>
                  <enable/>
                  <range>
                        <from>192.168.15.100</from>
                        <to>192.168.15.150</to>
                  </range>
                  <dhcpleaseinlocaltime/>
            </opt2>
            <opt3>
                  <enable/>
                  <range>
                        <from>192.168.16.100</from>
                        <to>192.168.16.150</to>
                  </range>
                  <dhcpleaseinlocaltime/>
            </opt3>
      </dhcpd>
      <snmpd>
            <syslocation/>
            <syscontact/>
            <rocommunity>public</rocommunity>
      </snmpd>
      <diag>
            <ipv6nat>
                  <ipaddr/>
            </ipv6nat>
      </diag>
      <bridge/>
      <syslog/>
      <nat>
            <outbound>
                  <mode>automatic</mode>
            </outbound>
            <onetoone>
                  <external>10.33.50.44</external>
                  <descr><![CDATA[mapping to 2020 pfsense firewall ]]></descr>
                  <interface>wan</interface>
                  <source>
                        <address>192.168.13.20</address>
```

```
                        </source>
                        <destination>
                                <any/>
                        </destination>
                </onetoone>
                <onetoone>
                        <external>10.33.50.42</external>
                        <descr><![CDATA[Mapping to Pfsense firewall]]></descr>
                        <interface>wan</interface>
                        <source>
                                <address>192.168.13.17</address>
                        </source>
                        <destination>
                                <any/>
                        </destination>
                </onetoone>
                <onetoone>
                        <external>10.33.50.35</external>
                        <descr><![CDATA[Mapping to Splunk]]></descr>
                        <interface>wan</interface>
                        <source>
                                <address>192.168.17.11</address>
                        </source>
                        <destination>
                                <any/>
                        </destination>
                </onetoone>
                <onetoone>
                        <external>10.33.50.41</external>
                        <descr><![CDATA[Mapping to Pfsense firewall]]></descr>
                        <interface>wan</interface>
                        <source>
                                <address>192.168.19.11</address>
                        </source>
                        <destination>
                                <any/>
                        </destination>
                </onetoone>
                <onetoone>
                        <external>10.33.50.36</external>
```

```
                <descr><![CDATA[Mapping to Hytrust ESXi Server]]></descr>
                <interface>wan</interface>
                <source>
                        <address>192.168.20.12</address>
                </source>
                <destination>
                        <any/>
                </destination>
        </onetoone>
        <onetoone>
                <external>10.33.50.37</external>
                <descr><![CDATA[NAT Mapping to RadiantOne VDS]]></descr>
                <interface>wan</interface>
                <source>
                        <address>192.168.14.11</address>
                </source>
                <destination>
                        <any/>
                </destination>
        </onetoone>
        <onetoone>
                <external>10.33.50.38</external>
                <descr><![CDATA[NAT Mapping to Hytrust CloudControl VM]]></descr>
                <interface>wan</interface>
                <source>
                        <address>192.168.20.11</address>
                </source>
                <destination>
                        <any/>
                </destination>
        </onetoone>
        <onetoone>
                <external>10.33.50.40</external>
                <descr><![CDATA[Mapping to ActiveDirectory]]></descr>
                <interface>wan</interface>
                <source>
                        <address>192.168.19.10</address>
                </source>
                <destination>
                        <any/>
```

```
                        </destination>
                </onetoone>
                <onetoone>
                        <external>10.33.50.43</external>
                        <descr><![CDATA[VIP for ConsoleWorks -- Mapping to Internal
Address]]></descr>
                        <interface>wan</interface>
                        <source>
                                <address>192.168.17.11</address>
                        </source>
                        <destination>
                                <any/>
                        </destination>
                </onetoone>
                <onetoone>
                        <external>10.33.50.45</external>
                        <descr><![CDATA[VIP for CentOSToAD-- Mapping to Internal
Address]]></descr>
                        <interface>wan</interface>
                        <source>
                                <address>192.168.19.30</address>
                        </source>
                        <destination>
                                <any/>
                        </destination>
                </onetoone>
                <onetoone>
                        <external>10.33.50.46</external>
                        <descr><![CDATA[AlertEnterprise Enterprise Guardian]]></descr>
                        <interface>wan</interface>
                        <source>
                                <address>192.168.17.114</address>
                        </source>
                        <destination>
                                <any/>
                        </destination>
                </onetoone>
                <rule>
                        <source>
                                <any/>
```

```
                    </source>
                    <destination>
                          <network>wanip</network>
                          <port>1322</port>
                    </destination>
                    <protocol>tcp</protocol>
                    <target>192.168.13.130</target>
                    <local-port>80</local-port>
                    <interface>wan</interface>
                    <descr><![CDATA[Mapping to pfsense 192.168.13.130]]></descr>
                    <associated-rule-id>nat_581795efbc2944.51341500</associated-rule-id>
                    <created>
                          <time>1477940719</time>
                          <username>admin@192.168.13.139</username>
                    </created>
                    <updated>
                          <time>1477940861</time>
                          <username>admin@192.168.13.139</username>
                    </updated>
              </rule>
              <rule>
                    <source>
                          <any/>
                    </source>
                    <destination>
                          <address>10.33.50.41</address>
                          <port>80</port>
                    </destination>
                    <protocol>tcp/udp</protocol>
                    <target>192.168.19.11</target>
                    <local-port>80</local-port>
                    <interface>wan</interface>
                    <descr><![CDATA[Port forward to openldap; Add /phpldapadmin to address]]></descr>
                    <associated-rule-id>nat_57bf0c96d083f4.07194849</associated-rule-id>
                    <created>
                          <time>1472138390</time>
                          <username>admin@10.97.67.137</username>
                    </created>
```

```
                        <updated>
                                <time>1473431620</time>
                                <username>admin@10.97.67.134</username>
                        </updated>
                </rule>
                <rule>
                        <source>
                                <any/>
                        </source>
                        <destination>
                                <address>10.33.50.41</address>
                                <port>22</port>
                        </destination>
                        <protocol>tcp/udp</protocol>
                        <target>192.168.19.11</target>
                        <local-port>22</local-port>
                        <interface>wan</interface>
                        <descr><![CDATA[Port forward to openldap; ]]></descr>
                        <associated-rule-id>nat_57f555406f2de3.01889708</associated-rule-
id>
                        <created>
                                <time>1475695936</time>
                                <username>admin@10.97.67.145</username>
                        </created>
                        <updated>
                                <time>1475695966</time>
                                <username>admin@10.97.67.145</username>
                        </updated>
                </rule>
                <rule>
                        <source>
                                <any/>
                        </source>
                        <destination>
                                <address>10.33.50.35</address>
                                <port>8000</port>
                        </destination>
                        <protocol>tcp/udp</protocol>
                        <target>192.168.17.10</target>
                        <local-port>8000</local-port>
```

```
                    <interface>wan</interface>
                    <descr><![CDATA[Splunk port 8000 Web Interface]]></descr>
                    <associated-rule-id>nat_57d825ba865df6.65796295</associated-rule-id>
                    <created>
                        <time>1473783226</time>
                        <username>admin@10.97.67.152</username>
                    </created>
                    <updated>
                        <time>1473785552</time>
                        <username>admin@10.97.67.152</username>
                    </updated>
                </rule>
                <rule>
                    <source>
                        <any/>
                    </source>
                    <destination>
                        <address>10.33.50.35</address>
                        <port>22</port>
                    </destination>
                    <protocol>tcp/udp</protocol>
                    <target>192.168.17.10</target>
                    <local-port>22</local-port>
                    <interface>wan</interface>
                    <descr><![CDATA[Splunk SSH ]]></descr>
                    <associated-rule-id>nat_582ef78ed63d23.63868026</associated-rule-id>
                    <updated>
                        <time>1479473038</time>
                        <username>admin@10.97.67.135</username>
                    </updated>
                    <created>
                        <time>1479473038</time>
                        <username>admin@10.97.67.135</username>
                    </created>
                </rule>
                <rule>
                    <source>
                        <any/>
```

```
                    </source>
                    <destination>
                          <address>10.33.50.42</address>
                          <port>1314</port>
                    </destination>
                    <protocol>tcp/udp</protocol>
                    <target>192.168.13.14</target>
                    <local-port>80</local-port>
                    <interface>wan</interface>
                    <descr><![CDATA[Port Forward to 192.168.13.14 Pf]]></descr>
                    <associated-rule-id>nat_57c01545c247f0.43308393</associated-rule-
id>
                    <updated>
                          <time>1472206149</time>
                          <username>admin@10.97.67.135</username>
                    </updated>
                    <created>
                          <time>1472206149</time>
                          <username>admin@10.97.67.135</username>
                    </created>
              </rule>
              <rule>
                    <source>
                          <any/>
                    </source>
                    <destination>
                          <address>10.33.50.42</address>
                          <port>1315</port>
                    </destination>
                    <protocol>tcp/udp</protocol>
                    <target>192.168.13.15</target>
                    <local-port>80</local-port>
                    <interface>wan</interface>
                    <descr><![CDATA[Port Forward to 192.168.13.15 Pf]]></descr>
                    <associated-rule-id>nat_57c0163d6e2de9.62906352</associated-rule-
id>
                    <updated>
                          <time>1472206397</time>
                          <username>admin@10.97.67.135</username>
                    </updated>
```

```
                <created>
                        <time>1472206397</time>
                        <username>admin@10.97.67.135</username>
                </created>
        </rule>
        <rule>
                <source>
                        <any/>
                </source>
                <destination>
                        <address>10.33.50.42</address>
                        <port>1316</port>
                </destination>
                <protocol>tcp/udp</protocol>
                <target>192.168.13.16</target>
                <local-port>80</local-port>
                <interface>wan</interface>
                <descr><![CDATA[Port Forward to 192.168.13.16 Pf]]></descr>
                <associated-rule-id>nat_57c01682da98c4.72334719</associated-rule-
id>
                <updated>
                        <time>1472206466</time>
                        <username>admin@10.97.67.135</username>
                </updated>
                <created>
                        <time>1472206466</time>
                        <username>admin@10.97.67.135</username>
                </created>
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        <rule>
                <source>
                        <any/>
                </source>
                <destination>
                        <address>10.33.50.42</address>
                        <port>1317</port>
                </destination>
                <protocol>tcp/udp</protocol>
                <target>192.168.13.17</target>
                <local-port>80</local-port>
```

```
                <interface>wan</interface>
                <descr><![CDATA[Port Forward to 192.168.13.17 Pf]]></descr>
                <associated-rule-id>nat_57c01787b4e891.75909166</associated-rule-id>
                <updated>
                        <time>1472206727</time>
                        <username>admin@10.97.67.135</username>
                </updated>
                <created>
                        <time>1472206727</time>
                        <username>admin@10.97.67.135</username>
                </created>
        </rule>
        <rule>
                <source>
                        <any/>
                </source>
                <destination>
                        <address>10.33.50.42</address>
                        <port>1318</port>
                </destination>
                <protocol>tcp/udp</protocol>
                <target>192.168.13.18</target>
                <local-port>80</local-port>
                <interface>wan</interface>
                <descr><![CDATA[Port Forward to 192.168.13.18 Pf]]></descr>
                <associated-rule-id>nat_57c017be3dffa1.16882401</associated-rule-id>
                <updated>
                        <time>1472206782</time>
                        <username>admin@10.97.67.135</username>
                </updated>
                <created>
                        <time>1472206782</time>
                        <username>admin@10.97.67.135</username>
                </created>
        </rule>
        <rule>
                <source>
                        <any/>
```

```
                    </source>
                    <destination>
                          <address>10.33.50.42</address>
                          <port>1319</port>
                    </destination>
                    <protocol>tcp/udp</protocol>
                    <target>192.168.13.19</target>
                    <local-port>80</local-port>
                    <interface>wan</interface>
                    <descr><![CDATA[Port Forward to 192.168.13.19 Pf]]></descr>
                    <associated-rule-id>nat_57c017e1e48d65.86612217</associated-rule-
id>
                    <updated>
                          <time>1472206817</time>
                          <username>admin@10.97.67.135</username>
                    </updated>
                    <created>
                          <time>1472206817</time>
                          <username>admin@10.97.67.135</username>
                    </created>
              </rule>
              <rule>
                    <source>
                          <any/>
                    </source>
                    <destination>
                          <address>10.33.50.42</address>
                          <port>1320</port>
                    </destination>
                    <protocol>tcp/udp</protocol>
                    <target>192.168.13.20</target>
                    <local-port>80</local-port>
                    <interface>wan</interface>
                    <descr><![CDATA[Port Forward to 192.168.13.20 Pf]]></descr>
                    <associated-rule-id>nat_57c0187fd4a074.12397754</associated-rule-
id>
                    <created>
                          <time>1472206975</time>
                          <username>admin@10.97.67.135</username>
                    </created>
```

```
                        <updated>
                                <time>1477940348</time>
                                <username>admin@192.168.13.139</username>
                        </updated>
                </rule>
                <rule>
                        <source>
                                <any/>
                        </source>
                        <destination>
                                <address>10.33.50.42</address>
                                <port>2006</port>
                        </destination>
                        <protocol>tcp/udp</protocol>
                        <target>192.168.20.6</target>
                        <local-port>443</local-port>
                        <interface>wan</interface>
                        <descr><![CDATA[Port Forward to Hytrust Cloud Control
192.168.20.6]]></descr>
                        <associated-rule-id>nat_585ab274d8bce0.68941358</associated-rule-
id>
                        <updated>
                                <time>1482338932</time>
                                <username>admin@10.97.67.139</username>
                        </updated>
                        <created>
                                <time>1482338932</time>
                                <username>admin@10.97.67.139</username>
                        </created>
                </rule>
                <separator/>
        </nat>
        <filter>
                <rule>
                        <id/>
                        <tracker>1483547179</tracker>
                        <type>pass</type>
                        <interface>enc0</interface>
                        <ipprotocol>inet</ipprotocol>
                        <tag/>
```

```
                    <tagged/>
                    <direction>any</direction>
                    <quick>yes</quick>
                    <floating>yes</floating>
                    <max/>
                    <max-src-nodes/>
                    <max-src-conn/>
                    <max-src-states/>
                    <statetimeout/>
                    <statetype>keep state</statetype>
                    <os/>
                    <source>
                          <any/>
                    </source>
                    <destination>
                          <any/>
                    </destination>
                    <descr><![CDATA[Allow IPSEC Traffic in both directions to
pass]]></descr>
                    <updated>
                          <time>1483547179</time>
                          <username>admin@10.97.67.165</username>
                    </updated>
                    <created>
                          <time>1483547179</time>
                          <username>admin@10.97.67.165</username>
                    </created>
              </rule>
              <rule>
                    <id/>
                    <tracker>1481038469</tracker>
                    <type>pass</type>
                    <interface>lan</interface>
                    <ipprotocol>inet</ipprotocol>
                    <tag/>
                    <tagged/>
                    <direction>any</direction>
                    <quick>yes</quick>
                    <floating>yes</floating>
                    <max/>
```

```
                    <max-src-nodes/>
                    <max-src-conn/>
                    <max-src-states/>
                    <statetimeout/>
                    <statetype>keep state</statetype>
                    <os/>
                    <source>
                          <address>192.168.14.111</address>
                    </source>
                    <destination>
                          <any/>
                    </destination>
                    <descr><![CDATA[Allow Radiant (192.168.14.111) to go anywhere -
LAN]]></descr>
                    <updated>
                          <time>1481038469</time>
                          <username>admin@10.97.67.155</username>
                    </updated>
                    <created>
                          <time>1481038469</time>
                          <username>admin@10.97.67.155</username>
                    </created>
              </rule>
              <rule>
                    <id/>
                    <tracker>1481134883</tracker>
                    <type>pass</type>
                    <interface>lan</interface>
                    <ipprotocol>inet</ipprotocol>
                    <tag/>
                    <tagged/>
                    <direction>any</direction>
                    <quick>yes</quick>
                    <floating>yes</floating>
                    <max/>
                    <max-src-nodes/>
                    <max-src-conn/>
                    <max-src-states/>
                    <statetimeout/>
                    <statetype>keep state</statetype>
```

```
                <os/>
                <source>
                        <address>192.168.13.135</address>
                </source>
                <destination>
                        <any/>
                </destination>
                <descr><![CDATA[Allow CA.acmefinancial to go anywhere]]></descr>
                <updated>
                        <time>1481134883</time>
                        <username>admin@10.97.67.146</username>
                </updated>
                <created>
                        <time>1481134883</time>
                        <username>admin@10.97.67.146</username>
                </created>
        </rule>
        <rule>
                <id/>
                <tracker>1481038517</tracker>
                <type>pass</type>
                <interface>lan</interface>
                <ipprotocol>inet</ipprotocol>
                <tag/>
                <tagged/>
                <direction>any</direction>
                <quick>yes</quick>
                <floating>yes</floating>
                <max/>
                <max-src-nodes/>
                <max-src-conn/>
                <max-src-states/>
                <statetimeout/>
                <statetype>keep state</statetype>
                <os/>
                <source>
                        <address>192.168.17.100</address>
                </source>
                <destination>
                        <any/>
```

```
                    </destination>
                    <descr><![CDATA[Allow Radiant (192.168.17.100) to go anywhere -
LAN]]></descr>
                    <updated>
                          <time>1481038517</time>
                          <username>admin@10.97.67.155</username>
                    </updated>
                    <created>
                          <time>1481038517</time>
                          <username>admin@10.97.67.155</username>
                    </created>
              </rule>
              <rule>
                    <id/>
                    <tracker>1478010422</tracker>
                    <type>pass</type>
                    <interface>wan</interface>
                    <ipprotocol>inet</ipprotocol>
                    <tag/>
                    <tagged/>
                    <direction>any</direction>
                    <quick>yes</quick>
                    <floating>yes</floating>
                    <max/>
                    <max-src-nodes/>
                    <max-src-conn/>
                    <max-src-states/>
                    <statetimeout/>
                    <statetype>keep state</statetype>
                    <os/>
                    <source>
                          <any/>
                    </source>
                    <destination>
                          <any/>
                    </destination>
                    <descr/>
                    <updated>
                          <time>1478010422</time>
                          <username>admin@10.97.66.18</username>
```

```
                    </updated>
                    <created>
                        <time>1478010422</time>
                        <username>admin@10.97.66.18</username>
                    </created>
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                <rule>
                    <id/>
                    <tracker>1480540664</tracker>
                    <type>pass</type>
                    <interface>lan</interface>
                    <ipprotocol>inet</ipprotocol>
                    <tag/>
                    <tagged/>
                    <direction>any</direction>
                    <quick>yes</quick>
                    <floating>yes</floating>
                    <max/>
                    <max-src-nodes/>
                    <max-src-conn/>
                    <max-src-states/>
                    <statetimeout/>
                    <statetype>keep state</statetype>
                    <os/>
                    <source>
                        <any/>
                    </source>
                    <destination>
                        <any/>
                    </destination>
                    <descr><![CDATA[Allow all LAN traffic to go to anywhere]]></descr>
                    <updated>
                        <time>1480540664</time>
                        <username>admin@10.97.67.140</username>
                    </updated>
                    <created>
                        <time>1480540664</time>
                        <username>admin@10.97.67.140</username>
                    </created>
                </rule>
```

```
            <rule>
                <id/>
                <tracker>1472208251</tracker>
                <type>pass</type>
                <interface>lan</interface>
                <ipprotocol>inet</ipprotocol>
                <tag/>
                <tagged/>
                <direction>any</direction>
                <quick>yes</quick>
                <floating>yes</floating>
                <max/>
                <max-src-nodes/>
                <max-src-conn/>
                <max-src-states/>
                <statetimeout/>
                <statetype>keep state</statetype>
                <os/>
                <protocol>tcp/udp</protocol>
                <source>
                    <address>192.168.0.0/16</address>
                </source>
                <destination>
                    <address>192.168.0.0/16</address>
                </destination>
                <descr><![CDATA[Allow traffic going from local subnet to local
subne]]></descr>
                <updated>
                    <time>1472208251</time>
                    <username>admin@10.97.67.135</username>
                </updated>
                <created>
                    <time>1472208251</time>
                    <username>admin@10.97.67.135</username>
                </created>
            </rule>
            <rule>
                <id/>
                <tracker>1472216936</tracker>
                <type>pass</type>
```

```
                    <interface>lan</interface>
                    <ipprotocol>inet</ipprotocol>
                    <tag/>
                    <tagged/>
                    <direction>any</direction>
                    <quick>yes</quick>
                    <floating>yes</floating>
                    <max/>
                    <max-src-nodes/>
                    <max-src-conn/>
                    <max-src-states/>
                    <statetimeout/>
                    <statetype>keep state</statetype>
                    <os/>
                    <protocol>tcp/udp</protocol>
                    <source>
                          <address>192.168.0.0/16</address>
                    </source>
                    <destination>
                          <any/>
                    </destination>
                    <descr><![CDATA[Allow traffic going from local subnet to
anywhere]]></descr>
                    <updated>
                          <time>1472216936</time>
                          <username>admin@10.97.67.135</username>
                    </updated>
                    <created>
                          <time>1472216936</time>
                          <username>admin@10.97.67.135</username>
                    </created>
              </rule>
              <rule>
                    <id/>
                    <tracker>1476720725</tracker>
                    <type>pass</type>
                    <interface>enc0</interface>
                    <ipprotocol>inet</ipprotocol>
                    <tag/>
                    <tagged/>
```

```
                    <direction>any</direction>
                    <quick>yes</quick>
                    <floating>yes</floating>
                    <max/>
                    <max-src-nodes/>
                    <max-src-conn/>
                    <max-src-states/>
                    <statetimeout/>
                    <statetype>keep state</statetype>
                    <os/>
                    <source>
                          <any/>
                    </source>
                    <destination>
                          <any/>
                    </destination>
                    <descr><![CDATA[Allow  All traffic sourced from Tunnel to Anywhere
o]]></descr>
                    <updated>
                          <time>1476720725</time>
                          <username>admin@10.97.67.137</username>
                    </updated>
                    <created>
                          <time>1476720725</time>
                          <username>admin@10.97.67.137</username>
                    </created>
              </rule>
              <rule>
                    <id/>
                    <tracker>1471551236</tracker>
                    <type>pass</type>
                    <interface>wan</interface>
                    <ipprotocol>inet</ipprotocol>
                    <tag/>
                    <tagged/>
                    <max/>
                    <max-src-nodes/>
                    <max-src-conn/>
                    <max-src-states/>
                    <statetimeout/>
```

```
                    <statetype>keep state</statetype>
                    <os/>
                    <protocol>tcp/udp</protocol>
                    <source>
                          <any/>
                    </source>
                    <destination>
                          <any/>
                    </destination>
                    <descr><![CDATA[Allow all TCP/UDP Traffic sourced from WAN
interface]]></descr>
                    <updated>
                          <time>1471551236</time>
                          <username>admin@10.97.67.136</username>
                    </updated>
                    <created>
                          <time>1471551236</time>
                          <username>admin@10.97.67.136</username>
                    </created>
              </rule>
              <rule>
                    <id/>
                    <tracker>1470759134</tracker>
                    <type>pass</type>
                    <interface>wan</interface>
                    <ipprotocol>inet</ipprotocol>
                    <tag/>
                    <tagged/>
                    <max/>
                    <max-src-nodes/>
                    <max-src-conn/>
                    <max-src-states/>
                    <statetimeout/>
                    <statetype>keep state</statetype>
                    <os/>
                    <protocol>tcp/udp</protocol>
                    <source>
                          <any/>
                    </source>
                    <destination>
```

```
                        <network>(self)</network>
                    </destination>
                    <descr><![CDATA[Rule to allow connection to firewall -can be
tighten]]></descr>
                    <updated>
                        <time>1470759134</time>
                        <username>admin@192.168.13.135</username>
                    </updated>
                    <created>
                        <time>1470759134</time>
                        <username>admin@192.168.13.135</username>
                    </created>
                </rule>
                <rule>
                    <id/>
                    <tracker>1461788221</tracker>
                    <type>pass</type>
                    <interface>wan</interface>
                    <ipprotocol>inet</ipprotocol>
                    <tag/>
                    <tagged/>
                    <max/>
                    <max-src-nodes/>
                    <max-src-conn/>
                    <max-src-states/>
                    <statetimeout/>
                    <statetype>keep state</statetype>
                    <os/>
                    <protocol>tcp</protocol>
                    <source>
                        <any/>
                    </source>
                    <destination>
                        <any/>
                    </destination>
                    <descr/>
                    <updated>
                        <time>1461788221</time>
                        <username>admin@192.168.1.2</username>
                    </updated>
```

```
                        <created>
                                <time>1461788221</time>
                                <username>admin@192.168.1.2</username>
                        </created>
                </rule>
                <rule>
                        <id/>
                        <tracker>1465934823</tracker>
                        <type>pass</type>
                        <interface>wan</interface>
                        <ipprotocol>inet</ipprotocol>
                        <tag/>
                        <tagged/>
                        <max/>
                        <max-src-nodes/>
                        <max-src-conn/>
                        <max-src-states/>
                        <statetimeout/>
                        <statetype>keep state</statetype>
                        <os/>
                        <protocol>icmp</protocol>
                        <source>
                                <any/>
                        </source>
                        <destination>
                                <any/>
                        </destination>
                        <descr><![CDATA[Easy Rule: Passed from Firewall Log
View]]></descr>
                        <created>
                                <time>1465934786</time>
                                <username>Easy Rule</username>
                        </created>
                        <updated>
                                <time>1465934839</time>
                                <username>admin@192.168.13.101</username>
                        </updated>
                </rule>
                <rule>
                        <source>
```

```
                        <any/>
                    </source>
                    <interface>wan</interface>
                    <protocol>tcp/udp</protocol>
                    <destination>
                        <address>192.168.19.11</address>
                        <port>80</port>
                    </destination>
                    <descr><![CDATA[NAT Port forward to openldap; Add /phpldapadmin to address]]></descr>
                    <associated-rule-id>nat_57bf0c96d083f4.07194849</associated-rule-id>
                    <tracker>1472138390</tracker>
                    <created>
                        <time>1472138390</time>
                        <username>NAT Port Forward</username>
                    </created>
                </rule>
                <rule>
                    <source>
                        <any/>
                    </source>
                    <interface>wan</interface>
                    <protocol>tcp/udp</protocol>
                    <destination>
                        <address>192.168.13.14</address>
                        <port>80</port>
                    </destination>
                    <descr><![CDATA[NAT Port Forward to 192.168.13.14 Pf]]></descr>
                    <associated-rule-id>nat_57c01545c247f0.43308393</associated-rule-id>
                    <tracker>1472206149</tracker>
                    <created>
                        <time>1472206149</time>
                        <username>NAT Port Forward</username>
                    </created>
                </rule>
                <rule>
                    <source>
                        <any/>
                    </source>
```

```
                <interface>wan</interface>
                <protocol>tcp/udp</protocol>
                <destination>
                        <address>192.168.13.15</address>
                        <port>80</port>
                </destination>
                <descr><![CDATA[NAT Port Forward to 192.168.13.15 Pf]]></descr>
                <associated-rule-id>nat_57c0163d6e2de9.62906352</associated-rule-
id>
                <tracker>1472206397</tracker>
                <created>
                        <time>1472206397</time>
                        <username>NAT Port Forward</username>
                </created>
        </rule>
        <rule>
                <source>
                        <any/>
                </source>
                <interface>wan</interface>
                <protocol>tcp/udp</protocol>
                <destination>
                        <address>192.168.13.16</address>
                        <port>80</port>
                </destination>
                <descr><![CDATA[NAT Port Forward to 192.168.13.16 Pf]]></descr>
                <associated-rule-id>nat_57c01682da98c4.72334719</associated-rule-
id>
                <tracker>1472206466</tracker>
                <created>
                        <time>1472206466</time>
                        <username>NAT Port Forward</username>
                </created>
        </rule>
        <rule>
                <source>
                        <any/>
                </source>
                <interface>wan</interface>
                <protocol>tcp/udp</protocol>
```

```
                        <destination>
                                <address>192.168.13.17</address>
                                <port>80</port>
                        </destination>
                        <descr><![CDATA[NAT Port Forward to 192.168.13.17 Pf]]></descr>
                        <associated-rule-id>nat_57c01787b4e891.75909166</associated-rule-
id>
                        <tracker>1472206727</tracker>
                        <created>
                                <time>1472206727</time>
                                <username>NAT Port Forward</username>
                        </created>
                </rule>
                <rule>
                        <source>
                                <any/>
                        </source>
                        <interface>wan</interface>
                        <protocol>tcp/udp</protocol>
                        <destination>
                                <address>192.168.13.18</address>
                                <port>80</port>
                        </destination>
                        <descr><![CDATA[NAT Port Forward to 192.168.13.18 Pf]]></descr>
                        <associated-rule-id>nat_57c017be3dffa1.16882401</associated-rule-
id>
                        <tracker>1472206782</tracker>
                        <created>
                                <time>1472206782</time>
                                <username>NAT Port Forward</username>
                        </created>
                </rule>
                <rule>
                        <source>
                                <any/>
                        </source>
                        <interface>wan</interface>
                        <protocol>tcp/udp</protocol>
                        <destination>
                                <address>192.168.13.19</address>
```

```
                        <port>80</port>
                    </destination>
                    <descr><![CDATA[NAT Port Forward to 192.168.13.19 Pf]]></descr>
                    <associated-rule-id>nat_57c017e1e48d65.86612217</associated-rule-
id>
                    <tracker>1472206817</tracker>
                    <created>
                        <time>1472206817</time>
                        <username>NAT Port Forward</username>
                    </created>
                </rule>
                <rule>
                    <source>
                        <any/>
                    </source>
                    <interface>wan</interface>
                    <protocol>tcp/udp</protocol>
                    <destination>
                        <address>192.168.13.20</address>
                        <port>80</port>
                    </destination>
                    <descr><![CDATA[NAT Port Forward to 192.168.13.20 Pf]]></descr>
                    <associated-rule-id>nat_57c0187fd4a074.12397754</associated-rule-
id>
                    <tracker>1472206975</tracker>
                    <created>
                        <time>1472206975</time>
                        <username>NAT Port Forward</username>
                    </created>
                </rule>
                <rule>
                    <source>
                        <any/>
                    </source>
                    <interface>wan</interface>
                    <protocol>tcp/udp</protocol>
                    <destination>
                        <address>192.168.17.10</address>
                        <port>8000</port>
                    </destination>
```

```
                    <descr><![CDATA[NAT Splunk port 8000 Web Interface]]></descr>
                    <associated-rule-id>nat_57d825ba865df6.65796295</associated-rule-id>
                    <tracker>1473783226</tracker>
                    <created>
                          <time>1473783226</time>
                          <username>NAT Port Forward</username>
                    </created>
              </rule>
              <rule>
                    <source>
                          <any/>
                    </source>
                    <interface>wan</interface>
                    <protocol>tcp/udp</protocol>
                    <destination>
                          <address>192.168.19.11</address>
                          <port>22</port>
                    </destination>
                    <descr><![CDATA[NAT Port forward to openldap; ]]></descr>
                    <associated-rule-id>nat_57f555406f2de3.01889708</associated-rule-id>
                    <tracker>1475695936</tracker>
                    <created>
                          <time>1475695936</time>
                          <username>NAT Port Forward</username>
                    </created>
              </rule>
              <rule>
                    <source>
                          <any/>
                    </source>
                    <interface>wan</interface>
                    <protocol>tcp</protocol>
                    <destination>
                          <address>192.168.13.130</address>
                          <port>80</port>
                    </destination>
                    <descr><![CDATA[NAT Mapping to pfsense 192.168.13.130]]></descr>
                    <associated-rule-id>nat_581795efbc2944.51341500</associated-rule-id>
```

```
                        <tracker>1477940719</tracker>
                        <created>
                              <time>1477940719</time>
                              <username>NAT Port Forward</username>
                        </created>
                  </rule>
                  <rule>
                        <source>
                              <any/>
                        </source>
                        <interface>wan</interface>
                        <protocol>tcp/udp</protocol>
                        <destination>
                              <address>192.168.17.10</address>
                              <port>22</port>
                        </destination>
                        <descr><![CDATA[NAT Splunk SSH ]]></descr>
                        <associated-rule-id>nat_582ef78ed63d23.63868026</associated-rule-id>
                        <tracker>1479473038</tracker>
                        <created>
                              <time>1479473038</time>
                              <username>NAT Port Forward</username>
                        </created>
                  </rule>
                  <rule>
                        <source>
                              <any/>
                        </source>
                        <interface>wan</interface>
                        <protocol>tcp/udp</protocol>
                        <destination>
                              <address>192.168.20.6</address>
                              <port>443</port>
                        </destination>
                        <descr><![CDATA[NAT Port Forward to Hytrust Cloud Control 192.168.20.6]]></descr>
                        <associated-rule-id>nat_585ab274d8bce0.68941358</associated-rule-id>
                        <tracker>1482338932</tracker>
                        <created>
```

```
                        <time>1482338932</time>
                        <username>NAT Port Forward</username>
                    </created>
            </rule>
            <rule>
                    <id/>
                    <tracker>1480540738</tracker>
                    <type>pass</type>
                    <interface>lan</interface>
                    <ipprotocol>inet</ipprotocol>
                    <tag/>
                    <tagged/>
                    <max/>
                    <max-src-nodes/>
                    <max-src-conn/>
                    <max-src-states/>
                    <statetimeout/>
                    <statetype>keep state</statetype>
                    <os/>
                    <source>
                        <any/>
                    </source>
                    <destination>
                        <any/>
                    </destination>
                    <descr><![CDATA[Allow all LAN traffic to go to anywhere]]></descr>
                    <updated>
                        <time>1480540738</time>
                        <username>admin@10.97.67.140</username>
                    </updated>
                    <created>
                        <time>1480540738</time>
                        <username>admin@10.97.67.140</username>
                    </created>
            </rule>
            <rule>
                    <id/>
                    <tracker>1465934857</tracker>
                    <type>pass</type>
                    <interface>lan</interface>
```

```
                <ipprotocol>inet</ipprotocol>
                <tag/>
                <tagged/>
                <max/>
                <max-src-nodes/>
                <max-src-conn/>
                <max-src-states/>
                <statetimeout/>
                <statetype>keep state</statetype>
                <os/>
                <protocol>icmp</protocol>
                <source>
                        <any/>
                </source>
                <destination>
                        <any/>
                </destination>
                <descr/>
                <updated>
                        <time>1465934857</time>
                        <username>admin@192.168.13.101</username>
                </updated>
                <created>
                        <time>1465934857</time>
                        <username>admin@192.168.13.101</username>
                </created>
        </rule>
        <rule>
                <type>pass</type>
                <ipprotocol>inet</ipprotocol>
                <descr><![CDATA[Default allow LAN to any rule]]></descr>
                <interface>lan</interface>
                <tracker>0100000101</tracker>
                <source>
                        <network>lan</network>
                </source>
                <destination>
                        <any/>
                </destination>
        </rule>
```

```
            <rule>
                <type>pass</type>
                <ipprotocol>inet6</ipprotocol>
                <descr><![CDATA[Default allow LAN IPv6 to any rule]]></descr>
                <interface>lan</interface>
                <tracker>0100000102</tracker>
                <source>
                    <network>lan</network>
                </source>
                <destination>
                    <any/>
                </destination>
            </rule>
            <rule>
                <id/>
                <tracker>1476720530</tracker>
                <type>pass</type>
                <interface>enc0</interface>
                <ipprotocol>inet</ipprotocol>
                <tag/>
                <tagged/>
                <max/>
                <max-src-nodes/>
                <max-src-conn/>
                <max-src-states/>
                <statetimeout/>
                <statetype>keep state</statetype>
                <os/>
                <source>
                    <any/>
                </source>
                <destination>
                    <any/>
                </destination>
                <descr><![CDATA[Allow  All traffic sourced from Tunnel to Anywhere
o]]></descr>
                <created>
                    <time>1476720530</time>
                    <username>admin@10.97.67.137</username>
                </created>
```

```
                        <updated>
                                <time>1476720628</time>
                                <username>admin@10.97.67.137</username>
                        </updated>
                </rule>
                <separator>
                        <lan/>
                        <wan/>
                        <floatingrules/>
                        <enc0/>
                </separator>
                <bypassstaticroutes>yes</bypassstaticroutes>
        </filter>
        <shaper/>
        <ipsec>
                <phase1>
                        <ikeid>1</ikeid>
                        <iketype>ikev1</iketype>
                        <mode>main</mode>
                        <interface>wan</interface>
                        <remote-gateway>174.47.13.99</remote-gateway>
                        <protocol>inet</protocol>
                        <myid_type>myaddress</myid_type>
                        <myid_data/>
                        <peerid_type>peeraddress</peerid_type>
                        <peerid_data/>
                        <encryption-algorithm>
                                <name>aes</name>
                                <keylen>256</keylen>
                        </encryption-algorithm>
                        <hash-algorithm>sha1</hash-algorithm>
                        <dhgroup>2</dhgroup>
                        <lifetime>28800</lifetime>
                        <pre-shared-key>78J%3AkmP*Krr294xYE=v@</pre-shared-key>
                        <private-key/>
                        <certref/>
                        <caref/>
                        <authentication_method>pre_shared_key</authentication_method>
                        <descr><![CDATA[IPSEC IKEv1 Tunnel to Vanguard's Firewall Public
IP address]]></descr>
```

```
                <nat_traversal>force</nat_traversal>
                <mobike>off</mobike>
                <dpd_delay>10</dpd_delay>
                <dpd_maxfail>5</dpd_maxfail>
        </phase1>
        <client/>
        <phase2>
                <ikeid>1</ikeid>
                <uniqid>5804f45c4f196</uniqid>
                <mode>tunnel</mode>
                <reqid>1</reqid>
                <localid>
                        <type>network</type>
                        <address>192.168.19.0</address>
                        <netbits>24</netbits>
                </localid>
                <remoteid>
                        <type>network</type>
                        <address>172.17.212.0</address>
                        <netbits>24</netbits>
                </remoteid>
                <protocol>esp</protocol>
                <encryption-algorithm-option>
                        <name>aes</name>
                        <keylen>256</keylen>
                </encryption-algorithm-option>
                <hash-algorithm-option>hmac_sha1</hash-algorithm-option>
                <pfsgroup>0</pfsgroup>
                <lifetime>3600</lifetime>
                <pinghost/>
                <descr><![CDATA[Phase 2 IPSEC Tunnel to Vanguard]]></descr>
        </phase2>
        <phase2>
                <ikeid>1</ikeid>
                <uniqid>586d5ecf7f516</uniqid>
                <mode>tunnel</mode>
                <reqid>2</reqid>
                <localid>
                        <type>network</type>
                        <address>192.168.17.0</address>
```

```
                        <netbits>24</netbits>
                    </localid>
                    <remoteid>
                        <type>network</type>
                        <address>172.17.212.0</address>
                        <netbits>24</netbits>
                    </remoteid>
                    <protocol>esp</protocol>
                    <encryption-algorithm-option>
                        <name>aes</name>
                        <keylen>256</keylen>
                    </encryption-algorithm-option>
                    <hash-algorithm-option>hmac_sha1</hash-algorithm-option>
                    <pfsgroup>0</pfsgroup>
                    <lifetime>3600</lifetime>
                    <pinghost/>
                    <descr><![CDATA[Phase 2 IPSEC Tunnel to Vanguard]]></descr>
                </phase2>
                <phase2>
                    <ikeid>1</ikeid>
                    <uniqid>586d5eeb02957</uniqid>
                    <mode>tunnel</mode>
                    <reqid>3</reqid>
                    <localid>
                        <type>network</type>
                        <address>192.168.13.0</address>
                        <netbits>24</netbits>
                    </localid>
                    <remoteid>
                        <type>network</type>
                        <address>172.17.212.0</address>
                        <netbits>24</netbits>
                    </remoteid>
                    <protocol>esp</protocol>
                    <encryption-algorithm-option>
                        <name>aes</name>
                        <keylen>256</keylen>
                    </encryption-algorithm-option>
                    <hash-algorithm-option>hmac_sha1</hash-algorithm-option>
                    <pfsgroup>0</pfsgroup>
```

```
                <lifetime>3600</lifetime>
                <pinghost/>
                <descr><![CDATA[Phase 2 IPSEC Tunnel to Vanguard]]></descr>
            </phase2>
            <phase2>
                <ikeid>1</ikeid>
                <uniqid>586d5f54943b4</uniqid>
                <mode>tunnel</mode>
                <reqid>4</reqid>
                <localid>
                    <type>network</type>
                    <address>192.168.14.0</address>
                    <netbits>24</netbits>
                </localid>
                <remoteid>
                    <type>network</type>
                    <address>172.17.212.0</address>
                    <netbits>24</netbits>
                </remoteid>
                <protocol>esp</protocol>
                <encryption-algorithm-option>
                    <name>aes</name>
                    <keylen>256</keylen>
                </encryption-algorithm-option>
                <hash-algorithm-option>hmac_sha1</hash-algorithm-option>
                <pfsgroup>0</pfsgroup>
                <lifetime>3600</lifetime>
                <pinghost/>
                <descr><![CDATA[Phase 2 IPSEC Tunnel to Vanguard]]></descr>
            </phase2>
        </ipsec>
        <aliases/>
        <proxyarp/>
        <cron>
            <item>
                <minute>1,31</minute>
                <hour>0-5</hour>
                <mday>*</mday>
                <month>*</month>
                <wday>*</wday>
```

```
                <who>root</who>
                <command>/usr/bin/nice -n20 adjkerntz -a</command>
        </item>
        <item>
                <minute>1</minute>
                <hour>3</hour>
                <mday>1</mday>
                <month>*</month>
                <wday>*</wday>
                <who>root</who>
                <command>/usr/bin/nice -n20 /etc/rc.update_bogons.sh</command>
        </item>
        <item>
                <minute>*/60</minute>
                <hour>*</hour>
                <mday>*</mday>
                <month>*</month>
                <wday>*</wday>
                <who>root</who>
                <command>/usr/bin/nice -n20 /usr/local/sbin/expiretable -v -t 3600
sshlockout</command>
        </item>
        <item>
                <minute>*/60</minute>
                <hour>*</hour>
                <mday>*</mday>
                <month>*</month>
                <wday>*</wday>
                <who>root</who>
                <command>/usr/bin/nice -n20 /usr/local/sbin/expiretable -v -t 3600
webConfiguratorlockout</command>
        </item>
        <item>
                <minute>1</minute>
                <hour>1</hour>
                <mday>*</mday>
                <month>*</month>
                <wday>*</wday>
                <who>root</who>
                <command>/usr/bin/nice -n20 /etc/rc.dyndns.update</command>
```

```
            </item>
            <item>
                  <minute>*/60</minute>
                  <hour>*</hour>
                  <mday>*</mday>
                  <month>*</month>
                  <wday>*</wday>
                  <who>root</who>
                  <command>/usr/bin/nice -n20 /usr/local/sbin/expiretable -v -t 3600
virusprot</command>
            </item>
            <item>
                  <minute>30</minute>
                  <hour>12</hour>
                  <mday>*</mday>
                  <month>*</month>
                  <wday>*</wday>
                  <who>root</who>
                  <command>/usr/bin/nice -n20 /etc/rc.update_urltables</command>
            </item>
      </cron>
      <wol/>
      <rrd>
            <enable/>
      </rrd>
      <load_balancer>
            <monitor_type>
                  <name>ICMP</name>
                  <type>icmp</type>
                  <descr><![CDATA[ICMP]]></descr>
                  <options/>
            </monitor_type>
            <monitor_type>
                  <name>TCP</name>
                  <type>tcp</type>
                  <descr><![CDATA[Generic TCP]]></descr>
                  <options/>
            </monitor_type>
            <monitor_type>
                  <name>HTTP</name>
```

```
                        <type>http</type>
                        <descr><![CDATA[Generic HTTP]]></descr>
                        <options>
                              <path>/</path>
                              <host/>
                              <code>200</code>
                        </options>
                </monitor_type>
                <monitor_type>
                        <name>HTTPS</name>
                        <type>https</type>
                        <descr><![CDATA[Generic HTTPS]]></descr>
                        <options>
                              <path>/</path>
                              <host/>
                              <code>200</code>
                        </options>
                </monitor_type>
                <monitor_type>
                        <name>SMTP</name>
                        <type>send</type>
                        <descr><![CDATA[Generic SMTP]]></descr>
                        <options>
                              <send/>
                              <expect>220 *</expect>
                        </options>
                </monitor_type>
        </load_balancer>
        <widgets>

        <sequence>system_information:col1:open,gateways:col1:open,interfaces:col2:open<
/sequence>
        </widgets>
        <openvpn/>
        <dnshaper/>
        <unbound>
                <enable/>
                <dnssec/>
                <active_interface/>
                <outgoing_interface/>
                <custom_options/>
```

```
            <hideidentity/>
            <hideversion/>
            <dnssecstripped/>
        </unbound>
        <dhcpdv6>
            <lan>
                <range>
                    <from>::1000</from>
                    <to>::2000</to>
                </range>
                <ramode>assist</ramode>
                <rapriority>medium</rapriority>
            </lan>
        </dhcpdv6>
        <cert>
            <refid>5720a0502b277</refid>
            <descr><![CDATA[webConfigurator default (5720a0502b277)]]></descr>
            <type>server</type>

        <crt>LS0tLS1CRUdJTiBDRVJUSUZJQ0FURS0tLS0tCk1JSUZiVENDQkZXZ0F3SUJBZ0lCQURBTkJna3
Foa2lHOXcwQkFRc0ZBRENCdERFTE1Ba0dBMVVFQmhNQ1ZWTXgKRGpBTUJnTlZCQWdUQlZOMFlYUmxNUkV3RHdZ
RFZRUUhFd2hNYjJOaGJHbDBlVEU0TURZR0ExVUVDaE12Y0daVApaVzV6WlNCM1pXSkRiMjVtYVdkMWNtRjBiM0
lnVTJWc1ppMVRhV2R1WldRZ1EyVnlkR2xtYVdOaGRHVXhLREFtCkJna3Foa2lHOXcwQkNRRVdHV0ZrYldsdVFI
Qm1VMlZ1YzJVdWJHOWpZV3hrYjIxaGFXNHhIakFjQmdOVkJBTVQKRlhCbVUyVnVjMlV0TlRjeU1HRXdOVEF5WW
pJM056QWVGdzB4TmpBME1qY3hNVEU1TkRSYUZ3MHlNVEV3TVRneApNVEU1TkRSYU1JRzBNUXN3Q1FZRFZRUUdF
d0pWVXpFT01Bd0dBMVVFQ0JNRlUzUmhkR1V4RVRBUEJnTlZCQWNUCkNFeHZZMkZzYVhSNU1UZ3dOZ1lEVlFRS0
V5OXdabE5sYm5ObElIZGxZa052Ym1acFozVnlZWFJ2Y2lCVFpXeG0KTFZOcFoyNWxaQ0JEWlhKMGFXWnBZMkYw
WlRFb01DWUdDU3FHU0liM0RRRUpBUllaWVdSdGFXNUFjR1pUWlc1egpaUzVzYjJOaGJHUnZiV0ZwYmpFZU1Cd0
dBMVVFQXhNVmNHWlRaVzV6WlMwMU56SXdZVEExTURKaU1qYzNNSUlCCklqQU5CZ2txaGtpRzl3MEJBUUVGQUFP
Q0FROEFNSUlCQ2dLQ0FRRUF0L085aDlnT2R5R20yTnQ4R3dpUmw1bDAKVmZ2NGJsQ2NWcGJNYXFMUE1aVzNMdG
hDODBHU0dhZnJENWdqcTRwZkNNMHlzbEFPaVlZK1hDYjdNa2o0dmtTMgpmbzl4emNyaDUrNVlaYlBHeXR1a2ls
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VUVCeE1JVEc5allXeHBkSGt4T0RBMkJnTlZCQW9UTDNCbVUyVnVjMlVnZDJWaQpRMjl1Wm1sbmRYSmhkRzl5SU
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bE5sYm5ObExteHZZMkZzWkc5dFlXbHVNUjR3SEFZRFZRUURFeFZ3WmxObGJuTmwKTFRVM01qQmhNRFV3TW1JeU
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b0RBTkJna3Foa2lHOXcwQkFRc0ZBQU9DQVFFQXJxZFpQdXd2MVZuUC82NmJDWFJ5CkVmaW1LRWlPcmtNaTB5M0
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IENFUlRJRklDQVRFLS0tLS0K</crt>

        <prv>LS0tLS1CRUdJTiBQUklWQVRFIEtFWS0tLS0tCk1JSUV2Z0lCQURBTkJna3Foa2lHOXcwQkFRRU
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```

eGxiY3UyRUx6UVpJWnArc1BtQ09yaWw4SXpUS3lVQTZKaGo1YwpKdnN5U1BpK1JMWitqM0hOeXVIbjdsaGxzOG
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c1YrRFk5cmpGMmpZNDdrSEliU1JZSWxLUHo1TzVtNTA5TWcwdkEKQVdEQkQzNDg5OHRUalhROVNpb1NaclREbn
dKTmo3cHAwQnM4ZHhlRDBjL2poUGFWSWNKem1vbkpEdDc2dmFGVwozdWdQcG5VR0FFK3ZMQzRjV25DdTcvNWRj
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R3RYSmZ2ai9jSnY3cmJIWGIzYkJtVW9hcDhxY0RjdnVSMmlHRUZYWQpCL3hjNVpINTlaTUFabWE1VWVQLzNjcD
lzNVhhcHNpclNXV1I4cFFZc3Z6Mmt6ci8zMXdrQXd4SGJZWHhJVDk1CjNLRmk4VTZUM1hnU1c2eFowZHp1ZnlP
UzAvbXlmNU5YLzVoRklPNmFDc0xlUjZ4N1RZa2FDQU9FYlViT29qUXkKc09XeWphbEtTUWZ3WEdzdVM0bXdyR2
hMZ0NRYlB2MnE5V0Nia0VMNEZUZmRzRlZXcHBRNGlZVWtwNzhMY1FPMgpsSGR5cTJxTmJsNDIwa3h5M2FnZlF2
YTVqYUgyRm5LdkExR2YxY05hcGRVQ2dZRUE0NzNMUWoxcExLSmRZN2JxCmtMU3NVT0ZhTUZlZG1xU2ttbzh3Qj
lpMXhzbElLQUd0M3U4dTdMZlZtU2lybnMwVVBTMHRVUDRyQXMzVFJocEgKU2Z4VXVsbGVGaktjZk9xRE11TTBC
OGttbFJnUFRmVHVPaGNwMGVkamQwK1E5Y2VlY25kaFp3UEl6TUc3TWRTSApKOG5yU2t5TFdMdWUxUVJNZHNhbm
NBRDhVYThDZ1lFQXpzYjYzbzRBSHlYNjZkcEJ6TGlzYzZxS2d2ZG4xazhVCm02N3RuK2M3NkVhSEtZTlk0Rjdh
S0dFSk1yeU0yQTJTelAzdm03Rmk4eGRtblgrSXd5cUx5T1VwSnZXQ012TVIKRDFpNWVFTVVoZVo2OUpOK0I3Sm
Z2RjYrK2tHa1NHOGxaN0VLY21Uc1kzRVJxOURsSk94Nk1ROFEwMDNsTHVtQQpJZm1DWlpRSUQ1OENnWUJjamFO
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8rVEcwYVpKOTZHKy9nNTRWZmZqWTRlelVScHhUT3QzdEx0cm5SV2NmT2ZMM2MKS2RHN0ZuaGI0cUFjNHBWSUc3
QWY5Mi9CbHZJR25FS1pMdnhLWTdVMXlIb1NRLzczUG1DSnFqemd6UUtCZ1FDZgpJQjE3RzRnWWNGL3hpdGJNTn
VudmNUUjZxTzR0ekZtdG5TYWN3WlFtb2UvdUVIaGE0bU84WTBCeTNRcitVU1BCCndVR2RiUnNhdTgxcU12VUtU
RG1hZGsvKy9Ud2UvVk1Kbmx2TW9zS3VjTG42Y1c2eGVhR1hFc3FoUjlhbkwzRjMKcEpUSGg4Y3FsNTdqdkRRN0
FBamdyQmxrb3pOVnNMZThiWWpkcHRlMVBRS0JnQ0xDR0R1RXNBYUxwZlRtOG44bgoyQ1h1NE52K1l3a1Rlczdu
WjRoM3ZRODI1ZkQxbGVzVjBYdDJ1cVJqeFEvSDgxMHRGd1p3cC9uSVdycnRCZlZLClUzSThhYnpnUUtwOEwrZj
VadTAxY1pZVk5TU0FIUFRHYm5jb1IzbGVPYjNLeUVXQjdsZFBHQWpOS3UwNkd5TEkKakh5TDhadEFBRXVBZ1FU
OVFOVGJkQWJrCi0tLS0tRU5EIFBSSVZBVEUgS0VZLS0tLS0K</prv>

```
        </cert>
        <revision>
                <time>1493217875</time>
                <description><![CDATA[admin@10.97.67.148: /firewall_nat_1to1_edit.php
made unknown change]]></description>
                <username>admin@10.97.67.148</username>
        </revision>
        <gateways>
                <gateway_item>
                        <interface>wan</interface>
                        <gateway>10.33.50.33</gateway>
                        <name>GW_WAN</name>
                        <weight>1</weight>
                        <ipprotocol>inet</ipprotocol>
                        <interval/>
                        <descr><![CDATA[Interface wan Gateway]]></descr>
                        <defaultgw/>
                </gateway_item>
                <gateway_item>
                        <interface>lan</interface>
                        <gateway>192.168.13.14</gateway>
                        <name>VLAN2014</name>
                        <weight>1</weight>
                        <ipprotocol>inet</ipprotocol>
```

```
                <descr/>
        </gateway_item>
        <gateway_item>
                <interface>lan</interface>
                <gateway>192.168.13.19</gateway>
                <name>VLAN2019</name>
                <weight>1</weight>
                <ipprotocol>inet</ipprotocol>
                <descr><![CDATA[VLAN2019]]></descr>
        </gateway_item>
        <gateway_item>
                <interface>lan</interface>
                <gateway>192.168.13.18</gateway>
                <name>VLAN2018</name>
                <weight>1</weight>
                <ipprotocol>inet</ipprotocol>
                <descr><![CDATA[VLAN2018]]></descr>
        </gateway_item>
        <gateway_item>
                <interface>lan</interface>
                <gateway>192.168.13.15</gateway>
                <name>VLAN2015</name>
                <weight>1</weight>
                <ipprotocol>inet</ipprotocol>
                <descr/>
        </gateway_item>
        <gateway_item>
                <interface>lan</interface>
                <gateway>192.168.13.16</gateway>
                <name>VLAN2016</name>
                <weight>1</weight>
                <ipprotocol>inet</ipprotocol>
                <descr/>
        </gateway_item>
        <gateway_item>
                <interface>lan</interface>
                <gateway>192.168.13.17</gateway>
                <name>VLAN2017</name>
                <weight>1</weight>
                <ipprotocol>inet</ipprotocol>
```

```
                <descr/>
            </gateway_item>
            <gateway_item>
                <interface>lan</interface>
                <gateway>192.168.13.20</gateway>
                <name>VLAN2020</name>
                <weight>1</weight>
                <ipprotocol>inet</ipprotocol>
                <descr/>
            </gateway_item>
            <gateway_item>
                <interface>lan</interface>
                <gateway>192.168.13.10</gateway>
                <name>VLAN2066</name>
                <weight>1</weight>
                <ipprotocol>inet</ipprotocol>
                <descr><![CDATA[Gateway to Vendor Net]]></descr>
            </gateway_item>
        </gateways>
        <ppps/>
        <dyndnses/>
        <virtualip>
            <vip>
                <mode>ipalias</mode>
                <interface>wan</interface>
                <uniqid>576b23658af3d</uniqid>
                <descr><![CDATA[Virtual IP for Splunk]]></descr>
                <type>single</type>
                <subnet_bits>32</subnet_bits>
                <subnet>10.33.50.35</subnet>
            </vip>
            <vip>
                <mode>ipalias</mode>
                <interface>wan</interface>
                <uniqid>5773d4c39ae54</uniqid>
                <descr><![CDATA[Virtual IP for RadiantOne VDS]]></descr>
                <type>single</type>
                <subnet_bits>32</subnet_bits>
                <subnet>10.33.50.37</subnet>
            </vip>
```

```
        <vip>
            <mode>ipalias</mode>
            <interface>wan</interface>
            <uniqid>57a8ce7868f78</uniqid>
            <descr><![CDATA[Virtual IP for Hytrust ESXi Server]]></descr>
            <type>single</type>
            <subnet_bits>32</subnet_bits>
            <subnet>10.33.50.36</subnet>
        </vip>
        <vip>
            <mode>ipalias</mode>
            <interface>wan</interface>
            <uniqid>57aa0a09a4d09</uniqid>
            <descr><![CDATA[VIP for Hytrust CloudControl VM]]></descr>
            <type>single</type>
            <subnet_bits>32</subnet_bits>
            <subnet>10.33.50.38</subnet>
        </vip>
        <vip>
            <mode>ipalias</mode>
            <interface>wan</interface>
            <uniqid>57b615eac1f16</uniqid>
            <descr><![CDATA[VIP for VCenter Server]]></descr>
            <type>single</type>
            <subnet_bits>32</subnet_bits>
            <subnet>10.33.50.39</subnet>
        </vip>
        <vip>
            <mode>ipalias</mode>
            <interface>wan</interface>
            <uniqid>57bd089e9ab62</uniqid>
            <descr><![CDATA[VIP for ActiveDirectory]]></descr>
            <type>single</type>
            <subnet_bits>32</subnet_bits>
            <subnet>10.33.50.40</subnet>
        </vip>
        <vip>
            <mode>ipalias</mode>
            <interface>wan</interface>
            <uniqid>57bf0bbc594c5</uniqid>
```

```
                    <descr><![CDATA[VIP for  OpenLDAP]]></descr>
                    <type>single</type>
                    <subnet_bits>32</subnet_bits>
                    <subnet>10.33.50.41</subnet>
              </vip>
              <vip>
                    <mode>ipalias</mode>
                    <interface>wan</interface>
                    <uniqid>57bf97481ae8c</uniqid>
                    <descr><![CDATA[VIP for Internal Pfsense Firewalls]]></descr>
                    <type>single</type>
                    <subnet_bits>32</subnet_bits>
                    <subnet>10.33.50.42</subnet>
              </vip>
              <vip>
                    <mode>ipalias</mode>
                    <interface>wan</interface>
                    <uniqid>581788c622d42</uniqid>
                    <descr><![CDATA[VIP for ConsoleWorks -- Mapping to Internal
Address]]></descr>
                    <type>single</type>
                    <subnet_bits>32</subnet_bits>
                    <subnet>10.33.50.43</subnet>
              </vip>
              <vip>
                    <mode>ipalias</mode>
                    <interface>wan</interface>
                    <uniqid>58179833f127e</uniqid>
                    <descr><![CDATA[Testing ]]></descr>
                    <type>single</type>
                    <subnet_bits>32</subnet_bits>
                    <subnet>10.33.50.44</subnet>
              </vip>
              <vip>
                    <mode>ipalias</mode>
                    <interface>wan</interface>
                    <uniqid>58e410a9241f1</uniqid>
                    <descr><![CDATA[Mapping to CentOSToAD VM (test machine)]]></descr>
                    <type>single</type>
                    <subnet_bits>32</subnet_bits>
```

```
                        <subnet>10.33.50.45</subnet>
                </vip>
                <vip>
                        <mode>ipalias</mode>
                        <interface>wan</interface>
                        <uniqid>5900b1ef3b079</uniqid>
                        <descr><![CDATA[AlertEnterprise Enterprise Guardian]]></descr>
                        <type>single</type>
                        <subnet_bits>32</subnet_bits>
                        <subnet>10.33.50.46</subnet>
                </vip>
        </virtualip>
</pfSense>
```


2.10.2 Firewall Configuration for Common Services Subnet


```
<?xml version="1.0"?>
<pfSense>
        <version>15.4</version>
        <lastchange/>
        <theme>pfSense_ng</theme>
        <system>
                <optimization>normal</optimization>
                <hostname>FS-ARM</hostname>
                <domain>FS-ARM.gov</domain>
                <group>
                        <name>all</name>
                        <description><![CDATA[All Users]]></description>
                        <scope>system</scope>
                        <gid>1998</gid>
                        <member>0</member>
                </group>
                <group>
                        <name>admins</name>
                        <description><![CDATA[System Administrators]]></description>
                        <scope>system</scope>
                        <gid>1999</gid>
                        <member>0</member>
                        <priv>page-all</priv>
                </group>
                <user>
```

```
                <name>admin</name>
                <descr><![CDATA[System Administrator]]></descr>
                <scope>system</scope>
                <groupname>admins</groupname>
                <password>$1$dSJImFph$GvZ7.1UbuWu.Yb8etC0re.</password>
                <uid>0</uid>
                <priv>user-shell-access</priv>
        </user>
        <nextuid>2000</nextuid>
        <nextgid>2000</nextgid>
        <timezone>America/New_York</timezone>
        <time-update-interval/>
        <timeservers>10.97.74.8</timeservers>
        <webgui>
                <protocol>http</protocol>
                <loginautocomplete/>
                <ssl-certref>5720a0502b277</ssl-certref>
                <dashboardcolumns>2</dashboardcolumns>
                <port/>
                <max_procs>2</max_procs>
                <nohttpreferercheck/>
        </webgui>
        <disablenatreflection>yes</disablenatreflection>
        <disablesegmentationoffloading/>
        <disablelargereceiveoffloading/>
        <ipv6allow/>
        <powerd_ac_mode>hadp</powerd_ac_mode>
        <powerd_battery_mode>hadp</powerd_battery_mode>
        <powerd_normal_mode>hadp</powerd_normal_mode>
        <bogons>
                <interval>monthly</interval>
        </bogons>
        <language>en_US</language>
        <dns1gw>GW_WAN</dns1gw>
        <dns2gw>GW_WAN</dns2gw>
        <dns3gw>none</dns3gw>
        <dns4gw>none</dns4gw>
        <dnsserver>10.97.74.8</dnsserver>
        <dnsserver>10.63.255.2</dnsserver>
        <maximumstates/>
```

```
            <aliasesresolveinterval/>
            <maximumtableentries/>
            <maximumfrags/>
            <reflectiontimeout/>
            <serialspeed>115200</serialspeed>
            <primaryconsole>serial</primaryconsole>
      </system>
      <interfaces>
            <wan>
                  <if>em0</if>
                  <descr><![CDATA[WAN]]></descr>
                  <enable/>
                  <spoofmac/>
                  <ipaddr>192.168.13.19</ipaddr>
                  <subnet>24</subnet>
                  <gateway>GW_WAN_2</gateway>
                  <ipaddrv6/>
                  <subnetv6/>
                  <gatewayv6/>
            </wan>
            <lan>
                  <enable/>
                  <if>em1</if>
                  <ipaddr>192.168.19.1</ipaddr>
                  <subnet>24</subnet>
                  <ipaddrv6/>
                  <subnetv6/>
                  <media/>
                  <mediaopt/>
                  <track6-interface>wan</track6-interface>
                  <track6-prefix-id>0</track6-prefix-id>
                  <gateway/>
                  <gatewayv6/>
            </lan>
      </interfaces>
      <staticroutes>
            <route>
                  <network>192.168.17.0/24</network>
                  <gateway>GW_VLAN17</gateway>
                  <descr><![CDATA[Route to VLAN 17]]></descr>
```

```
            </route>
        </staticroutes>
        <dhcpd>
            <lan>
                <enable/>
                <range>
                    <from>192.168.19.100</from>
                    <to>192.168.19.150</to>
                </range>
            </lan>
            <opt1>
                <enable/>
                <range>
                    <from>192.168.14.100</from>
                    <to>192.168.14.150</to>
                </range>
            </opt1>
            <opt2>
                <enable/>
                <range>
                    <from>192.168.15.100</from>
                    <to>192.168.15.150</to>
                </range>
            </opt2>
            <opt3>
                <enable/>
                <range>
                    <from>192.168.16.100</from>
                    <to>192.168.16.150</to>
                </range>
            </opt3>
        </dhcpd>
        <snmpd>
            <syslocation/>
            <syscontact/>
            <rocommunity>public</rocommunity>
        </snmpd>
        <diag>
            <ipv6nat>
                <ipaddr/>
```

```
            </ipv6nat>
        </diag>
        <bridge/>
        <syslog/>
        <nat>
            <outbound>
                <mode>disabled</mode>
            </outbound>
        </nat>
        <filter>
            <rule>
                <id/>
                <tracker>1493319263</tracker>
                <type>pass</type>
                <interface>wan</interface>
                <ipprotocol>inet</ipprotocol>
                <tag/>
                <tagged/>
                <direction>any</direction>
                <quick>yes</quick>
                <floating>yes</floating>
                <max/>
                <max-src-nodes/>
                <max-src-conn/>
                <max-src-states/>
                <statetimeout/>
                <statetype>keep state</statetype>
                <os/>
                <protocol>tcp/udp</protocol>
                <source>
                    <any/>
                </source>
                <destination>
                    <network>lan</network>
                </destination>
                <descr><![CDATA[Allow Any to LAN net]]></descr>
                <updated>
                    <time>1493319263</time>
                    <username>admin@10.97.67.143</username>
                </updated>
```

```
                <created>
                        <time>1493319263</time>
                        <username>admin@10.97.67.143</username>
                </created>
                <disabled/>
        </rule>
        <rule>
                <id/>
                <tracker>1481038226</tracker>
                <type>pass</type>
                <interface>wan</interface>
                <ipprotocol>inet</ipprotocol>
                <tag/>
                <tagged/>
                <direction>any</direction>
                <quick>yes</quick>
                <floating>yes</floating>
                <max/>
                <max-src-nodes/>
                <max-src-conn/>
                <max-src-states/>
                <statetimeout/>
                <statetype>keep state</statetype>
                <os/>
                <source>
                        <address>192.168.14.111</address>
                </source>
                <destination>
                        <any/>
                </destination>
                <disabled/>
                <descr><![CDATA[Allow Radiant (192.168.14.111) in -WAN]]></descr>
                <created>
                        <time>1481038226</time>
                        <username>admin@10.97.67.155</username>
                </created>
                <updated>
                        <time>1493311659</time>
                        <username>admin@10.97.67.143</username>
                </updated>
```

```
        </rule>
        <rule>
            <id/>
            <tracker>1481038269</tracker>
            <type>pass</type>
            <interface>wan</interface>
            <ipprotocol>inet</ipprotocol>
            <tag/>
            <tagged/>
            <direction>any</direction>
            <quick>yes</quick>
            <floating>yes</floating>
            <max/>
            <max-src-nodes/>
            <max-src-conn/>
            <max-src-states/>
            <statetimeout/>
            <statetype>keep state</statetype>
            <os/>
            <protocol>tcp/udp</protocol>
            <source>
                <any/>
            </source>
            <destination>
                <network>lan</network>
                <port>389</port>
            </destination>
            <descr><![CDATA[Allow LDAP traffic to AD and OpenLDAP]]></descr>
            <created>
                <time>1481038269</time>
                <username>admin@10.97.67.155</username>
            </created>
            <updated>
                <time>1493319675</time>
                <username>admin@10.97.67.143</username>
            </updated>
        </rule>
        <rule>
            <id/>
            <tracker>1493314739</tracker>
```

```
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                    <interface>wan</interface>
                    <ipprotocol>inet</ipprotocol>
                    <tag/>
                    <tagged/>
                    <direction>any</direction>
                    <quick>yes</quick>
                    <floating>yes</floating>
                    <max/>
                    <max-src-nodes/>
                    <max-src-conn/>
                    <max-src-states/>
                    <statetimeout/>
                    <statetype>keep state</statetype>
                    <os/>
                    <protocol>tcp/udp</protocol>
                    <source>
                          <any/>
                    </source>
                    <destination>
                          <any/>
                          <port>636</port>
                    </destination>
                    <descr><![CDATA[Allow Connection to LDAPS on AD and
OpenLDAP]]></descr>
                    <created>
                          <time>1493314739</time>
                          <username>admin@10.97.67.143</username>
                    </created>
                    <updated>
                          <time>1493319543</time>
                          <username>admin@10.97.67.143</username>
                    </updated>
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              <rule>
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                    <interface>wan</interface>
                    <ipprotocol>inet</ipprotocol>
```

```
                        <tag/>
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                        <floating>yes</floating>
                        <max/>
                        <max-src-nodes/>
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                        <max-src-states/>
                        <statetimeout/>
                        <statetype>keep state</statetype>
                        <os/>
                        <protocol>tcp/udp</protocol>
                        <source>
                              <any/>
                        </source>
                        <destination>
                              <any/>
                        </destination>
                        <disabled/>
                        <descr><![CDATA[Testing to see if there will be communication
betwee]]></descr>
                        <created>
                              <time>1472179541</time>
                              <username>admin@192.168.13.135</username>
                        </created>
                        <updated>
                              <time>1493311684</time>
                              <username>admin@10.97.67.143</username>
                        </updated>
                  </rule>
                  <rule>
                        <id/>
                        <tracker>1493327079</tracker>
                        <type>pass</type>
                        <interface>wan</interface>
                        <ipprotocol>inet</ipprotocol>
                        <tag/>
                        <tagged/>
                        <direction>any</direction>
```

```
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                <floating>yes</floating>
                <max/>
                <max-src-nodes/>
                <max-src-conn/>
                <max-src-states/>
                <statetimeout/>
                <statetype>keep state</statetype>
                <os/>
                <protocol>icmp</protocol>
                <source>
                        <any/>
                </source>
                <destination>
                        <network>lan</network>
                </destination>
                <descr><![CDATA[Allow ICMP for troubleshooting]]></descr>
                <updated>
                        <time>1493327079</time>
                        <username>admin@10.97.67.143</username>
                </updated>
                <created>
                        <time>1493327079</time>
                        <username>admin@10.97.67.143</username>
                </created>
        </rule>
        <rule>
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                <tracker>1493327306</tracker>
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                <interface>wan</interface>
                <ipprotocol>inet</ipprotocol>
                <tag/>
                <tagged/>
                <direction>any</direction>
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                <floating>yes</floating>
                <max/>
                <max-src-nodes/>
                <max-src-conn/>
```

```
                <max-src-states/>
                <statetimeout/>
                <statetype>keep state</statetype>
                <os></os>
                <protocol>tcp/udp</protocol>
                <source>
                        <any/>
                </source>
                <destination>
                        <any/>
                        <port>53</port>
                </destination>
                <descr><![CDATA[Allow DNS Requests to AD]]></descr>
                <updated>
                        <time>1493327306</time>
                        <username>admin@10.97.67.143</username>
                </updated>
                <created>
                        <time>1493327306</time>
                        <username>admin@10.97.67.143</username>
                </created>
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        <rule>
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                <type>pass</type>
                <interface>wan</interface>
                <ipprotocol>inet</ipprotocol>
                <tag/>
                <tagged/>
                <max/>
                <max-src-nodes/>
                <max-src-conn/>
                <max-src-states/>
                <statetimeout/>
                <statetype>keep state</statetype>
                <os/>
                <protocol>tcp</protocol>
                <source>
                        <any/>
```

```
                </source>
                <destination>
                        <network>lan</network>
                        <port>389</port>
                </destination>
                <descr><![CDATA[Allow LDAP traffic to LAN nodes]]></descr>
                <updated>
                        <time>1493312171</time>
                        <username>admin@10.97.67.143</username>
                </updated>
                <created>
                        <time>1493312171</time>
                        <username>admin@10.97.67.143</username>
                </created>
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                <type>pass</type>
                <interface>wan</interface>
                <ipprotocol>inet</ipprotocol>
                <tag/>
                <tagged/>
                <max/>
                <max-src-nodes/>
                <max-src-conn/>
                <max-src-states/>
                <statetimeout/>
                <statetype>keep state</statetype>
                <os/>
                <protocol>tcp/udp</protocol>
                <source>
                        <any/>
                </source>
                <destination>
                        <network>lan</network>
                        <port>53</port>
                </destination>
                <descr><![CDATA[Allow DNS traffic to LAN nodes]]></descr>
                <updated>
```

```
                        <time>1493313314</time>
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                    </updated>
                    <created>
                        <time>1493313314</time>
                        <username>admin@10.97.67.143</username>
                    </created>
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                <rule>
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                    <type>pass</type>
                    <interface>wan</interface>
                    <ipprotocol>inet</ipprotocol>
                    <tag/>
                    <tagged/>
                    <max/>
                    <max-src-nodes/>
                    <max-src-conn/>
                    <max-src-states/>
                    <statetimeout/>
                    <statetype>keep state</statetype>
                    <os/>
                    <protocol>tcp</protocol>
                    <source>
                        <any/>
                    </source>
                    <destination>
                        <network>lan</network>
                        <port>636</port>
                    </destination>
                    <descr><![CDATA[Allow LDAPs traffic to LAN nodes]]></descr>
                    <updated>
                        <time>1493312231</time>
                        <username>admin@10.97.67.143</username>
                    </updated>
                    <created>
                        <time>1493312231</time>
                        <username>admin@10.97.67.143</username>
                    </created>
```

```
        </rule>
        <rule>
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            <type>pass</type>
            <interface>wan</interface>
            <ipprotocol>inet</ipprotocol>
            <tag/>
            <tagged/>
            <max/>
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            <max-src-states/>
            <statetimeout/>
            <statetype>keep state</statetype>
            <os/>
            <protocol>tcp</protocol>
            <source>
                <any/>
            </source>
            <destination>
                <network>lan</network>
                <port>22</port>
            </destination>
            <descr><![CDATA[Allow SSH traffic to LAN nodes ]]></descr>
            <updated>
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                <username>admin@10.97.67.143</username>
            </updated>
            <created>
                <time>1493311864</time>
                <username>admin@10.97.67.143</username>
            </created>
        </rule>
        <rule>
            <id/>
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            <type>pass</type>
            <interface>wan</interface>
            <ipprotocol>inet</ipprotocol>
```

```
                        <tag/>
                        <tagged/>
                        <max/>
                        <max-src-nodes/>
                        <max-src-conn/>
                        <max-src-states/>
                        <statetimeout/>
                        <statetype>keep state</statetype>
                        <os/>
                        <protocol>tcp/udp</protocol>
                        <source>
                              <network>lan</network>
                        </source>
                        <destination>
                              <any/>
                        </destination>
                        <descr><![CDATA[Allow all LAN traffic to go to anywhere --Applied
to]]></descr>
                        <updated>
                              <time>1493311502</time>
                              <username>admin@10.97.67.143</username>
                        </updated>
                        <created>
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                        </created>
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                        <interface>wan</interface>
                        <ipprotocol>inet</ipprotocol>
                        <tag/>
                        <tagged/>
                        <max/>
                        <max-src-nodes/>
                        <max-src-conn/>
                        <max-src-states/>
                        <statetimeout/>
```

```
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                <protocol>tcp</protocol>
                <source>
                        <any/>
                </source>
                <destination>
                        <network>wanip</network>
                        <port>80</port>
                </destination>
                <descr><![CDATA[Allow to Port 80 on Firewall WAN]]></descr>
                <updated>
                        <time>1493311408</time>
                        <username>admin@10.97.67.143</username>
                </updated>
                <created>
                        <time>1493311408</time>
                        <username>admin@10.97.67.143</username>
                </created>
        </rule>
        <rule>
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                <tracker>1493312279</tracker>
                <type>pass</type>
                <interface>wan</interface>
                <ipprotocol>inet</ipprotocol>
                <tag/>
                <tagged/>
                <max/>
                <max-src-nodes/>
                <max-src-conn/>
                <max-src-states/>
                <statetimeout/>
                <statetype>keep state</statetype>
                <os/>
                <protocol>tcp</protocol>
                <source>
                        <any/>
                </source>
                <destination>
```

```
                        <network>wanip</network>
                        <port>443</port>
                    </destination>
                    <descr><![CDATA[Allow to Port 443 on Firewall WAN]]></descr>
                    <updated>
                        <time>1493312279</time>
                        <username>admin@10.97.67.143</username>
                    </updated>
                    <created>
                        <time>1493312279</time>
                        <username>admin@10.97.67.143</username>
                    </created>
                </rule>
                <rule>
                    <id/>
                    <tracker>1493311302</tracker>
                    <type>pass</type>
                    <interface>wan</interface>
                    <ipprotocol>inet</ipprotocol>
                    <tag/>
                    <tagged/>
                    <max/>
                    <max-src-nodes/>
                    <max-src-conn/>
                    <max-src-states/>
                    <statetimeout/>
                    <statetype>keep state</statetype>
                    <os/>
                    <protocol>tcp</protocol>
                    <source>
                        <any/>
                    </source>
                    <destination>
                        <network>lan</network>
                        <port>3389</port>
                    </destination>
                    <descr><![CDATA[Allow RDP to LAN nodes]]></descr>
                    <updated>
                        <time>1493311302</time>
                        <username>admin@10.97.67.143</username>
```

```
                        </updated>
                        <created>
                                <time>1493311302</time>
                                <username>admin@10.97.67.143</username>
                        </created>
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                <rule>
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                        <interface>wan</interface>
                        <ipprotocol>inet</ipprotocol>
                        <tag/>
                        <tagged/>
                        <max/>
                        <max-src-nodes/>
                        <max-src-conn/>
                        <max-src-states/>
                        <statetimeout/>
                        <statetype>keep state</statetype>
                        <os/>
                        <protocol>tcp/udp</protocol>
                        <source>
                                <any/>
                        </source>
                        <destination>
                                <any/>
                        </destination>
                        <disabled/>
                        <descr/>
                        <created>
                                <time>1469127156</time>
                                <username>admin@192.168.13.132</username>
                        </created>
                        <updated>
                                <time>1493311628</time>
                                <username>admin@10.97.67.143</username>
                        </updated>
                </rule>
                <rule>
```

```
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                        <interface>wan</interface>
                        <ipprotocol>inet</ipprotocol>
                        <tag/>
                        <tagged/>
                        <max/>
                        <max-src-nodes/>
                        <max-src-conn/>
                        <max-src-states/>
                        <statetimeout/>
                        <statetype>keep state</statetype>
                        <os/>
                        <source>
                              <address>192.168.14.111</address>
                        </source>
                        <destination>
                              <any/>
                        </destination>
                        <disabled/>
                        <descr><![CDATA[Allow Radiant (192.168.14.111) to Get Subnet 19
with]]></descr>
                        <created>
                              <time>1480964347</time>
                              <username>admin@10.97.67.144</username>
                        </created>
                        <updated>
                              <time>1493311596</time>
                              <username>admin@10.97.67.143</username>
                        </updated>
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                  <rule>
                        <id/>
                        <tracker>1480964466</tracker>
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                        <interface>wan</interface>
                        <ipprotocol>inet</ipprotocol>
                        <tag/>
                        <tagged/>
```

```
                        <max/>
                        <max-src-nodes/>
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                        <max-src-states/>
                        <statetimeout/>
                        <statetype>keep state</statetype>
                        <os/>
                        <source>
                              <address>192.168.17.100</address>
                        </source>
                        <destination>
                              <any/>
                        </destination>
                        <disabled/>
                        <descr><![CDATA[Allow Radiant (192.168.17.100) to Get Subnet 19
from]]></descr>
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                              <username>admin@10.97.67.144</username>
                        </created>
                        <updated>
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                              <username>admin@10.97.67.143</username>
                        </updated>
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                  <rule>
                        <id/>
                        <tracker>1465935224</tracker>
                        <type>pass</type>
                        <interface>wan</interface>
                        <ipprotocol>inet</ipprotocol>
                        <tag/>
                        <tagged/>
                        <max/>
                        <max-src-nodes/>
                        <max-src-conn/>
                        <max-src-states/>
                        <statetimeout/>
                        <statetype>keep state</statetype>
                        <os/>
```

```
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                        <any/>
                </source>
                <destination>
                        <any/>
                </destination>
                <descr/>
                <updated>
                        <time>1465935224</time>
                        <username>admin@192.168.18.100</username>
                </updated>
                <created>
                        <time>1465935224</time>
                        <username>admin@192.168.18.100</username>
                </created>
        </rule>
        <rule>
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                <type>pass</type>
                <interface>lan</interface>
                <ipprotocol>inet</ipprotocol>
                <tag/>
                <tagged/>
                <max/>
                <max-src-nodes/>
                <max-src-conn/>
                <max-src-states/>
                <statetimeout/>
                <statetype>keep state</statetype>
                <os/>
                <protocol>tcp/udp</protocol>
                <source>
                        <any/>
                </source>
                <destination>
                        <any/>
                </destination>
                <disabled/>
```

```
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                        <username>admin@192.168.13.132</username>
                </created>
                <updated>
                        <time>1493322054</time>
                        <username>admin@10.97.67.143</username>
                </updated>
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                <statetimeout/>
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                <os/>
                <protocol>icmp</protocol>
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                        <any/>
                </source>
                <destination>
                        <any/>
                </destination>
                <descr/>
                <updated>
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                        <username>admin@192.168.18.100</username>
                </updated>
                <created>
                        <time>1465935241</time>
                        <username>admin@192.168.18.100</username>
```

```
                        </created>
                </rule>
                <rule>
                        <type>pass</type>
                        <ipprotocol>inet</ipprotocol>
                        <descr><![CDATA[Default allow LAN to any rule]]></descr>
                        <interface>lan</interface>
                        <tracker>0100000101</tracker>
                        <source>
                                <network>lan</network>
                        </source>
                        <destination>
                                <any/>
                        </destination>
                </rule>
                <rule>
                        <type>pass</type>
                        <ipprotocol>inet6</ipprotocol>
                        <descr><![CDATA[Default allow LAN IPv6 to any rule]]></descr>
                        <interface>lan</interface>
                        <tracker>0100000102</tracker>
                        <source>
                                <network>lan</network>
                        </source>
                        <destination>
                                <any/>
                        </destination>
                </rule>
                <separator>
                        <wan/>
                        <lan/>
                        <floatingrules/>
                </separator>
                <bypassstaticroutes>yes</bypassstaticroutes>
        </filter>
        <shaper>
        </shaper>
        <ipsec/>
        <aliases/>
        <proxyarp/>
```

```
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                        <hour>0-5</hour>
                        <mday>*</mday>
                        <month>*</month>
                        <wday>*</wday>
                        <who>root</who>
                        <command>/usr/bin/nice -n20 adjkerntz -a</command>
                </item>
                <item>
                        <minute>1</minute>
                        <hour>3</hour>
                        <mday>1</mday>
                        <month>*</month>
                        <wday>*</wday>
                        <who>root</who>
                        <command>/usr/bin/nice -n20 /etc/rc.update_bogons.sh</command>
                </item>
                <item>
                        <minute>*/60</minute>
                        <hour>*</hour>
                        <mday>*</mday>
                        <month>*</month>
                        <wday>*</wday>
                        <who>root</who>
                        <command>/usr/bin/nice -n20 /usr/local/sbin/expiretable -v -t 3600
sshlockout</command>
                </item>
                <item>
                        <minute>*/60</minute>
                        <hour>*</hour>
                        <mday>*</mday>
                        <month>*</month>
                        <wday>*</wday>
                        <who>root</who>
                        <command>/usr/bin/nice -n20 /usr/local/sbin/expiretable -v -t 3600
webConfiguratorlockout</command>
                </item>
                <item>
```

```
                        <minute>1</minute>
                        <hour>1</hour>
                        <mday>*</mday>
                        <month>*</month>
                        <wday>*</wday>
                        <who>root</who>
                        <command>/usr/bin/nice -n20 /etc/rc.dyndns.update</command>
                </item>
                <item>
                        <minute>*/60</minute>
                        <hour>*</hour>
                        <mday>*</mday>
                        <month>*</month>
                        <wday>*</wday>
                        <who>root</who>
                        <command>/usr/bin/nice -n20 /usr/local/sbin/expiretable -v -t 3600
virusprot</command>
                </item>
                <item>
                        <minute>30</minute>
                        <hour>12</hour>
                        <mday>*</mday>
                        <month>*</month>
                        <wday>*</wday>
                        <who>root</who>
                        <command>/usr/bin/nice -n20 /etc/rc.update_urltables</command>
                </item>
        </cron>
        <wol/>
        <rrd>
                <enable/>
        </rrd>
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                        <name>ICMP</name>
                        <type>icmp</type>
                        <descr><![CDATA[ICMP]]></descr>
                        <options/>
                </monitor_type>
                <monitor_type>
```

```
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                <type>tcp</type>
                <descr><![CDATA[Generic TCP]]></descr>
                <options/>
            </monitor_type>
            <monitor_type>
                <name>HTTP</name>
                <type>http</type>
                <descr><![CDATA[Generic HTTP]]></descr>
                <options>
                    <path>/</path>
                    <host/>
                    <code>200</code>
                </options>
            </monitor_type>
            <monitor_type>
                <name>HTTPS</name>
                <type>https</type>
                <descr><![CDATA[Generic HTTPS]]></descr>
                <options>
                    <path>/</path>
                    <host/>
                    <code>200</code>
                </options>
            </monitor_type>
            <monitor_type>
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                <type>send</type>
                <descr><![CDATA[Generic SMTP]]></descr>
                <options>
                    <send/>
                    <expect>220 *</expect>
                </options>
            </monitor_type>
        </load_balancer>
        <widgets>

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/sequence>
        </widgets>
        <openvpn/>
```

```
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        </dnshaper>
        <unbound>
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                <dnssec/>
                <active_interface/>
                <outgoing_interface/>
                <custom_options/>
                <hideidentity/>
                <hideversion/>
                <dnssecstripped/>
        </unbound>
        <dhcpdv6>
                <lan>
                        <range>
                                <from>::1000</from>
                                <to>::2000</to>
                        </range>
                        <ramode>assist</ramode>
                        <rapriority>medium</rapriority>
                </lan>
        </dhcpdv6>
        <cert>
                <refid>5720a0502b277</refid>
                <descr><![CDATA[webConfigurator default (5720a0502b277)]]></descr>
                <type>server</type>

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Foa2lHOXcwQkFRc0ZBRENCdERFTE1Ba0dBMVVFQmhNQ1ZWTXgKRGpBTUJnTlZCQWdUQlZOMFlYUmxNUkV3RHdZ
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lnVTJWc1ppMVRhV2R1WldRZ1EyVnlkR2xtYVdOaGRHVXhLREFtCkJna3Foa2lHOXcwQkNRRVdHV0ZrYldsdVFI
Qm1VMlZ1YzJVdWJHOWpZV3hrYjIxaGFXNHhIakFjQmdOVkJBTVQKRlhCbVUyVnVjMlV0TlRjeU1HRXdOVEF5WW
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V5OXdabE5sYm5ObElIZGxZa052Ym1acFozVnlZWFJ2Y2lCVFpXeG0KTFZOcFoyNWxaQ0JEWlhKMGFXWnBZMkYw
WlRFb01DWUdDU3FHU0liM0RRRUpBUllaWVdSdGFXNUFjR1pUWlc1egpaUzVzYjJOaGJHUnZiV0ZwYmpFZU1Cd0
dBMVVFQXhNVmNHWlRaVzV6WlMwMU56SXdZVEExTURKaU1qYzNNSUlCCklqQU5CZ2txaGtpRzl3MEJBUUVGQUFP
Q0FROEFNSUlCQ2dLQ0FRRUF0L085aDlnT2R5R20yTnQ4R3dpUmw1bDAKVmZ2NGJsQ2NWcGJNYXFMUE1aVzNMdG
hDODBHU0dhZnJENWdqcTRwZkNNMHlzbEFPaVlZK1hDYjdNa2o0dmtTMgpmbzl4emNyaDUrNVlaYlBHeXR1a2ls
ZWR4bjFWeFl6SllzYXZKdnlKb1lRMCtNTkx0dkFjYnRhTUFoZjh1ZkRFClhrclNVQ0N5YTFrbEYxNWJGZmcyUG
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ZEFiUEhjWGc5SFA0NFQybFNIQ2M1cUp5UTdlK3IyaFZ0N29ENloxQmdCUApyeXd1SEZwd3J1LytYWExieEcrcD
dwYXI0aHR0UFRDcml1NmFqQVVTNmpvN05kOElQNWpzZ1kzR0h2ZjhzUUlECkFRQUJvNElCaGpDQ0FZSXdDUVlE
VlIwVEJBSXdBREFSQmdsZ2hrZ0JodmhDQVFFRUJBTUNCa0F3TXdZSllJWkkKQVliNFFnRU5CQ1lXSkU5d1pXNV
RVMHdnUjJWdVpYSmhkR1ZrSUZObGNuWmxjaUJEWlhKMGFXWnBZMkYwWlRBZApCZ05WSFE0RUZnUVU3K1lLRmNp
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NKd0FLaGdicWtnYmN3Z2JReEN6QUpCZ05WQkFZVEFsVlRNUTR3REFZRFZRUUkKRXdWVGRHRjBaVEVSTUE4R0Ex
VUVCeE1JVEc5allXeHBkSGt4T0RBMkJnTlZCQW9UTDNCbVUyVnVjMlVnZDJWaQpRMjl1Wm1sbmRYSmhkRzl5SU
```

ZObGJHWXRVMmxuYm1Wa0lFTmxjblJwWm1sallYUmxNU2d3SmdZSktvWklodmNOCkFRa0JGaGxoWkcxcGJrQnda
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56ZUNBUUF3SFFZRFZSMGxCQll3RkFZSUt3WUJCUVVIQXdFR0NDc0dBUVVGQ0FJQwpNQXNHQTFVZER3UUVBd0lG
b0RBTkJna3Foa2lHOXcwQkFRc0ZBQU9DQVFFQXJxZFpQdXd2MVZuUC82NmJDWFJ5CkVmaW1LRWlPcmtNaTB5M0
9PWGtzWEs1cEM2dTd6Ukl3WjEvRjYyRUp3ODlUOWx4Y01ZelZOTm5Idlg0bXFPRUcKUWJhRU42NEkxOHFud3Zm
S2JrREZvRThMR1hSdzBkMnAyTGVmYTd4YTIvSGNHc0xHTktPbkJxb3N4ejUrQ1B3ZwpWeVRaTS9wV3p3aDdQRG
c4bGdrcVc3dStlb01DNDJIbVJkOURCTmlzdFJ4RVlNMkFLQkFsZG1LYStvRUY1VUwwCm43aXpvNlZ4dHJWMTJv
TTdySllRQ05kY00xZkVSeUwvb3ZkUnVpa0F5Wm1VVnFUL1dDZGo3dDdIVG9ob0RFYzEKSklkOVpPSmR2QmZLVU
1sUWlELyswSVpTalFXRDczWkdsaEhTK2tOeWc1aDJhUjUwYjh3Wm9zQnNjSUZDa0pFbgp0UT09Ci0tLS0tRU5E
IENFUlRJRklDQVRFLS0tLS0K


```
        <prv>LS0tLS1CRUdJTiBQUklWQVRFIEtFWS0tLS0tCk1JSUV2Z0lCQURBTkJna3Foa2lHOXcwQkFRRU
ZBQVNDQktnd2dnU2tBZ0VBQW9JQkFRQzM4NzJIMkE1M0lhYlkKMjN3YkNKR1htWFJWKy9odVVKeFdsc3hxb3M4
eGxiY3UyRUx6UVpJWnArc1BtQ09yaWw4SXpUS3lVQTZKaGo1YwpKdnN5U1BpK1JMWitqM0hOeXVIbjdsaGxzOG
JLMjZTS1Y1M0dmVlhGak1saXhxOG0vSW1oaERUNHcwdTI4Qnh1CjFvd0NGL3k1OE1SZVN0SlFJTEpyV1NVWFhs
c1YrRFk5cmpGMmpZNDdrSEliU1JZSWxLUHo1TzVtNTA5TWcwdkEKQVdEQkQzNDg5OHRUalhROVNpb1NaclREbn
dKTmo3cHAwQnM4ZHhlRDBjL2poUGFWSWNKem1vbkpEdDc2dmFGVwozdWdQcG5VR0FFK3ZMQzRjV25DdTcvNWRj
dHZFYjZudWxxdmlHMjA5TUt1SzdwcU1CUkxxT2pzMTN3Zy9tT3lCCmpjWWU5L3l4QWdNQkFBRUNnZ0VCQUpRRF
pxU3duMnNTUTh0SVNBTUVrUW0zcXhrb3BzdzB4cWNScmFlOEd4VmQKejBpOU1KbkZVQWFleTQvL3Jldndh ZW1P
R3RYSmZ2ai9jSnY3cmJIWGIzYkJtVW9hcDhxY0RjdnVSMmlHRUZYWQpCL3hjNVpINTlaTUFabWE1VWVQLzNjcD
lzNVhhcHNpclNXV1I4cFFZc3Z6Mmt6ci8zMXdrQXd4SGJZWHhJVDk1CjNLRmk4VTZUM1hnU1c2eFowZHp1ZnlP
UzAvbXlmNU5YLzVoRklPNmFDc0xlUjZ4N1RZa2FDQU9FYlViT29qUXkKc09XeWphbEtTUWZ3WEdzdVM0bXdyR2
hMZ0NRYlB2MnE5V0Nia0VMNEZUZmRzRlZXcHBRNGlZVWtwNzhMY1FPMgpsSGR5cTJxTmJsNDIwa3h5M2FnZlF2
YTVqYUgyRm5LdkExR2YxY05hcGRVQ2dZRUE0NzNMUWoxcExLSmRZN2JxCmtMU3NVT0ZhTUZlZG1xU2ttbzh3Qj
lpMXhzbElLQUd0M3U4dTdMZlZtU2lybMwVVBTMHRVUDRyQXMzVFJocEgKU2Z4VXVsbGVGaktjZk9xRE11TTBC
OGttbFJnUFRmVHVPaGNwMGVkamQwK1E5Y2VlY25kaFp3UEl6TUc3TWRTSApKOG5yU2t5TFdMdWUxUVJNZHNhbm
NBRDhVYThDZ1lFQXpzYjYzbzRBSHlYNjZkcEJ6TGlzYzZxS2d2ZG4xazhVCm02N3RuK2M3NkVhSEtZTlk0Rjdh
S0dFSk1yeU0yQTJTelAzdm03Rmk4eGRtblgrSXd5cUx5T1VwSnZXQ012TVIKRDFpNWVFTVVoZVo2OUpOK0I3Sm
Z2RjYrK2tHa1NHOGxaN0VLY21Uc1kzRVJxOURsSk94Nk1ROFEwMDNsTHVtQQpJZm1DWlpRSUQ1OENnWUJjamFO
dk5obnFJOG9rWGhBUjR2c3NtNGpWb0tYU1ZScjRIVHo5MDFwOGdReXNCWkt0CnlUS2V6VThuUVZvTjNYWmVMbC
8rVEcwYVpKOTZHKy9nNTRWZmZqWTRlelVScHhUT3QzdEx0cm5SV2NmT2ZMM2MKS2RHN0ZuaGI0cUFjNHBWSUc3
QWY5Mi9CbHZJR25FS1pMdnhLWTdVMXlIb1NRLzczUG1DSnFqemd6UUtCZ1FDZgpJQjE3RzRnWWNGL3hpdGJNTn
VudmNUUjZxTzR0ekZtdG5TYWN3WlFtb2UvdUVIaGE0bU84WTBCeTNRcitVU1BCCndVR2RiUnNhdTgxcU12VUtU
RG1hZGsvKy9Ud2UvVk1Kbmx2TW9zS3VjTG42Y1c2eGVhR1hFc3FoUjlhbkwzRjMKcEpUSGg4Y3FsNTdqdkRRN0
FBamdyQmxrb3pOVnNMZThiWWpkcHRlMVBRS0JnQ0xDR0R1RXNBYUxwZlRtOG44bgoyQ1h1NE52K1l3a1Rlczdu
WjRoM3ZRODI1ZkQxbGVzVjBYdDJ1cVJqeFEvSDgxMHRGd1p3cC9uSVdycnRCZlZLClUzSThhYnpnUUtwOEwrZj
VadTAxY1pZVk5TU0FIUFRHYm5jb1IzbGVPYjNLeUVXQjdsZFBHQWpOS3UwNkd5TEkKakh5TDhadEFBRXVBZ1FU
OVFOVGJkQWJrCi0tLS0tRU5EIFBSSVZBVEUgS0VZLS0tLS0K</prv>
```


```
        </cert>
        <revision>
                <time>1493327306</time>
                <description><![CDATA[admin@10.97.67.143: /firewall_rules_edit.php made
unknown change]]></description>
                <username>admin@10.97.67.143</username>
        </revision>
        <gateways>
                <gateway_item>
                        <interface>wan</interface>
                        <gateway>192.168.13.1</gateway>
                        <name>GW_WAN_2</name>
                        <weight>1</weight>
                        <ipprotocol>inet</ipprotocol>
                        <interval/>
                        <descr><![CDATA[Interface wan Gateway]]></descr>
```

```
            </gateway_item>
            <gateway_item>
                  <interface>wan</interface>
                  <gateway>192.168.13.17</gateway>
                  <name>GW_VLAN17</name>
                  <weight>1</weight>
                  <ipprotocol>inet</ipprotocol>
                  <descr><![CDATA[Gateway to VLAN 17]]></descr>
            </gateway_item>
      </gateways>
      <ppps/>
      <dyndnses/>
</pfSense>
```


2.10.3 Firewall Configuration for ID-ARM Subnet


```
<?xml version="1.0"?>
<pfSense>
      <version>15.4</version>
      <lastchange/>
      <theme>pfSense_ng</theme>
      <system>
            <optimization>normal</optimization>
            <hostname>FS-ARM</hostname>
            <domain>FS-ARM.gov</domain>
            <group>
                  <name>all</name>
                  <description><![CDATA[All Users]]></description>
                  <scope>system</scope>
                  <gid>1998</gid>
                  <member>0</member>
            </group>
            <group>
                  <name>admins</name>
                  <description><![CDATA[System Administrators]]></description>
                  <scope>system</scope>
                  <gid>1999</gid>
                  <member>0</member>
                  <priv>page-all</priv>
            </group>
            <user>
```

```
                <name>admin</name>
                <descr><![CDATA[System Administrator]]></descr>
                <scope>system</scope>
                <groupname>admins</groupname>
                <password>$1$dSJImFph$GvZ7.1UbuWu.Yb8etC0re.</password>
                <uid>0</uid>
                <priv>user-shell-access</priv>
        </user>
        <nextuid>2000</nextuid>
        <nextgid>2000</nextgid>
        <timezone>America/New_York</timezone>
        <time-update-interval/>
        <timeservers>10.97.74.8</timeservers>
        <webgui>
                <protocol>http</protocol>
                <loginautocomplete/>
                <ssl-certref>5720a0502b277</ssl-certref>
                <dashboardcolumns>2</dashboardcolumns>
                <port/>
                <max_procs>2</max_procs>
                <nohttpreferercheck/>
        </webgui>
        <disablenatreflection>yes</disablenatreflection>
        <disablesegmentationoffloading/>
        <disablelargereceiveoffloading/>
        <ipv6allow/>
        <powerd_ac_mode>hadp</powerd_ac_mode>
        <powerd_battery_mode>hadp</powerd_battery_mode>
        <powerd_normal_mode>hadp</powerd_normal_mode>
        <bogons>
                <interval>monthly</interval>
        </bogons>
        <language>en_US</language>
        <dns1gw>GW_WAN</dns1gw>
        <dns2gw>GW_WAN</dns2gw>
        <dns3gw>none</dns3gw>
        <dns4gw>none</dns4gw>
        <dnsserver>10.97.74.8</dnsserver>
        <dnsserver>10.63.255.2</dnsserver>
        <serialspeed>115200</serialspeed>
```

```
            <primaryconsole>serial</primaryconsole>
        </system>
        <interfaces>
            <wan>
                <if>em0</if>
                <descr><![CDATA[WAN]]></descr>
                <enable/>
                <spoofmac/>
                <ipaddr>192.168.13.14</ipaddr>
                <subnet>24</subnet>
                <gateway>GW_WAN</gateway>
            </wan>
            <lan>
                <enable/>
                <if>em1</if>
                <ipaddr>192.168.14.1</ipaddr>
                <subnet>24</subnet>
                <ipaddrv6/>
                <subnetv6/>
                <media/>
                <mediaopt/>
                <track6-interface>wan</track6-interface>
                <track6-prefix-id>0</track6-prefix-id>
                <gateway/>
                <gatewayv6/>
            </lan>
        </interfaces>
        <staticroutes>
            <route>
                <network>192.168.17.0/24</network>
                <gateway>GW_VLAN17</gateway>
                <descr><![CDATA[Route to VLAN 2017]]></descr>
            </route>
            <route>
                <network>192.168.16.0/24</network>
                <gateway>GW_VLAN16</gateway>
                <descr><![CDATA[Route to VLAN 2016]]></descr>
            </route>
            <route>
                <network>192.168.15.0/24</network>
```

```
                <gateway>GW_VLAN15</gateway>
                <descr><![CDATA[Route to VLAN 2015]]></descr>
            </route>
            <route>
                <network>192.168.18.0/24</network>
                <gateway>GW_VLAN18</gateway>
                <descr><![CDATA[Route to VLAN 2018]]></descr>
            </route>
            <route>
                <network>192.168.19.0/24</network>
                <gateway>GW_VLAN19</gateway>
                <descr><![CDATA[Route to VLAN 2019]]></descr>
            </route>
        </staticroutes>
        <dhcpd>
            <lan>
                <enable/>
                <range>
                    <from>192.168.14.100</from>
                    <to>192.168.14.150</to>
                </range>
            </lan>
            <opt1>
                <enable/>
                <range>
                    <from>192.168.14.100</from>
                    <to>192.168.14.150</to>
                </range>
            </opt1>
            <opt2>
                <enable/>
                <range>
                    <from>192.168.15.100</from>
                    <to>192.168.15.150</to>
                </range>
            </opt2>
            <opt3>
                <enable/>
                <range>
                    <from>192.168.16.100</from>
```

```
                        <to>192.168.16.150</to>
                    </range>
                </opt3>
        </dhcpd>
        <snmpd>
                <syslocation/>
                <syscontact/>
                <rocommunity>public</rocommunity>
        </snmpd>
        <diag>
                <ipv6nat>
                        <ipaddr/>
                </ipv6nat>
        </diag>
        <bridge/>
        <syslog/>
        <nat>
                <outbound>
                        <mode>disabled</mode>
                </outbound>
        </nat>
        <filter>
                <rule>
                        <id/>
                        <tracker>1481037990</tracker>
                        <type>pass</type>
                        <interface>wan</interface>
                        <ipprotocol>inet</ipprotocol>
                        <tag/>
                        <tagged/>
                        <direction>any</direction>
                        <quick>yes</quick>
                        <floating>yes</floating>
                        <max/>
                        <max-src-nodes/>
                        <max-src-conn/>
                        <max-src-states/>
                        <statetimeout/>
                        <statetype>keep state</statetype>
                        <os/>
```

```
                <protocol>tcp/udp</protocol>
                <source>
                        <any/>
                </source>
                <destination>
                        <network>lan</network>
                        <port>3389</port>
                </destination>
                <descr><![CDATA[Allow RDP to LAN nodes]]></descr>
                <created>
                        <time>1481037990</time>
                        <username>admin@10.97.67.155</username>
                </created>
                <updated>
                        <time>1493324042</time>
                        <username>admin@10.97.67.143</username>
                </updated>
        </rule>
        <rule>
                <id/>
                <tracker>1481038086</tracker>
                <type>pass</type>
                <interface>wan</interface>
                <ipprotocol>inet</ipprotocol>
                <tag/>
                <tagged/>
                <direction>any</direction>
                <quick>yes</quick>
                <floating>yes</floating>
                <max/>
                <max-src-nodes/>
                <max-src-conn/>
                <max-src-states/>
                <statetimeout/>
                <statetype>keep state</statetype>
                <os/>
                <protocol>tcp/udp</protocol>
                <source>
                        <any/>
                </source>
```

```
                <destination>
                        <network>lan</network>
                        <port>2389</port>
                </destination>
                <descr><![CDATA[Allow Connection to Radiant Port 2389]]></descr>
                <created>
                        <time>1481038086</time>
                        <username>admin@10.97.67.155</username>
                </created>
                <updated>
                        <time>1493324258</time>
                        <username>admin@10.97.67.143</username>
                </updated>
        </rule>
        <rule>
                <id/>
                <tracker>1493650861</tracker>
                <type>pass</type>
                <interface>wan</interface>
                <ipprotocol>inet</ipprotocol>
                <tag/>
                <tagged/>
                <direction>any</direction>
                <quick>yes</quick>
                <floating>yes</floating>
                <max/>
                <max-src-nodes/>
                <max-src-conn/>
                <max-src-states/>
                <statetimeout/>
                <statetype>keep state</statetype>
                <os/>
                <protocol>tcp/udp</protocol>
                <source>
                        <any/>
                </source>
                <destination>
                        <network>lan</network>
                        <port>389</port>
                </destination>
```

```
                <descr><![CDATA[Allow Connection to Port 389 in LAN]]></descr>
                <updated>
                        <time>1493650861</time>
                        <username>admin@10.97.67.135</username>
                </updated>
                <created>
                        <time>1493650861</time>
                        <username>admin@10.97.67.135</username>
                </created>
        </rule>
        <rule>
                <id/>
                <tracker>1493650905</tracker>
                <type>pass</type>
                <interface>wan</interface>
                <ipprotocol>inet</ipprotocol>
                <tag/>
                <tagged/>
                <direction>any</direction>
                <quick>yes</quick>
                <floating>yes</floating>
                <max/>
                <max-src-nodes/>
                <max-src-conn/>
                <max-src-states/>
                <statetimeout/>
                <statetype>keep state</statetype>
                <os></os>
                <protocol>tcp/udp</protocol>
                <source>
                        <any/>
                </source>
                <destination>
                        <network>lan</network>
                        <port>636</port>
                </destination>
                <descr><![CDATA[Allow Connection to Port 636 in LAN]]></descr>
                <updated>
                        <time>1493650905</time>
                        <username>admin@10.97.67.135</username>
```

```
                </updated>
                <created>
                        <time>1493650905</time>
                        <username>admin@10.97.67.135</username>
                </created>
        </rule>
        <rule>
                <id/>
                <tracker>1493328157</tracker>
                <type>pass</type>
                <interface>wan</interface>
                <ipprotocol>inet</ipprotocol>
                <tag/>
                <tagged/>
                <direction>any</direction>
                <quick>yes</quick>
                <floating>yes</floating>
                <max/>
                <max-src-nodes/>
                <max-src-conn/>
                <max-src-states/>
                <statetimeout/>
                <statetype>keep state</statetype>
                <os/>
                <protocol>tcp/udp</protocol>
                <source>
                        <any/>
                </source>
                <destination>
                        <network>lan</network>
                        <port>8089</port>
                </destination>
                <descr><![CDATA[Allow Connection to Radiant Port 8089]]></descr>
                <updated>
                        <time>1493328157</time>
                        <username>admin@10.97.67.143</username>
                </updated>
                <created>
                        <time>1493328157</time>
                        <username>admin@10.97.67.143</username>
```

```
                        </created>
                </rule>
                <rule>
                        <id/>
                        <tracker>1493328202</tracker>
                        <type>pass</type>
                        <interface>wan</interface>
                        <ipprotocol>inet</ipprotocol>
                        <tag/>
                        <tagged/>
                        <direction>any</direction>
                        <quick>yes</quick>
                        <floating>yes</floating>
                        <max/>
                        <max-src-nodes/>
                        <max-src-conn/>
                        <max-src-states/>
                        <statetimeout/>
                        <statetype>keep state</statetype>
                        <os/>
                        <protocol>tcp/udp</protocol>
                        <source>
                                <any/>
                        </source>
                        <destination>
                                <network>lan</network>
                                <port>8090</port>
                        </destination>
                        <descr><![CDATA[Allow Connection to Radiant Port 8090]]></descr>
                        <updated>
                                <time>1493328202</time>
                                <username>admin@10.97.67.143</username>
                        </updated>
                        <created>
                                <time>1493328202</time>
                                <username>admin@10.97.67.143</username>
                        </created>
                </rule>
                <rule>
                        <id/>
```

```
                <tracker>1493327695</tracker>
                <type>pass</type>
                <interface>wan</interface>
                <ipprotocol>inet</ipprotocol>
                <tag/>
                <tagged/>
                <direction>any</direction>
                <quick>yes</quick>
                <floating>yes</floating>
                <max/>
                <max-src-nodes/>
                <max-src-conn/>
                <max-src-states/>
                <statetimeout/>
                <statetype>keep state</statetype>
                <os/>
                <protocol>tcp/udp</protocol>
                <source>
                        <any/>
                </source>
                <destination>
                        <network>lan</network>
                        <port>8443</port>
                </destination>
                <descr><![CDATA[Allow Connection to Nextlabs port 8443]]></descr>
                <updated>
                        <time>1493327695</time>
                        <username>admin@10.97.67.143</username>
                </updated>
                <created>
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                        <username>admin@10.97.67.143</username>
                </created>
        </rule>
        <rule>
                <id/>
                <tracker>1493327739</tracker>
                <type>pass</type>
                <interface>wan</interface>
                <ipprotocol>inet</ipprotocol>
```

```
                <tag/>
                <tagged/>
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                <quick>yes</quick>
                <floating>yes</floating>
                <max/>
                <max-src-nodes/>
                <max-src-conn/>
                <max-src-states/>
                <statetimeout/>
                <statetype>keep state</statetype>
                <os/>
                <protocol>tcp</protocol>
                <source>
                        <any/>
                </source>
                <destination>
                        <network>lan</network>
                        <port>443</port>
                </destination>
                <descr><![CDATA[Allow Connection to Nextlabs port 443]]></descr>
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                </updated>
                <created>
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                        <username>admin@10.97.67.143</username>
                </created>
        </rule>
        <rule>
                <id/>
                <tracker>1493327782</tracker>
                <type>pass</type>
                <interface>wan</interface>
                <ipprotocol>inet</ipprotocol>
                <tag/>
                <tagged/>
                <direction>any</direction>
                <quick>yes</quick>
```

```
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            <max/>
            <max-src-nodes/>
            <max-src-conn/>
            <max-src-states/>
            <statetimeout/>
            <statetype>keep state</statetype>
            <os/>
            <protocol>tcp/udp</protocol>
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                  <any/>
            </source>
            <destination>
                  <any/>
                  <port>9233</port>
            </destination>
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                  <username>admin@10.97.67.143</username>
            </created>
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                  <time>1493327896</time>
                  <username>admin@10.97.67.143</username>
            </updated>
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      <rule>
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            <tracker>1493327859</tracker>
            <type>pass</type>
            <interface>wan</interface>
            <ipprotocol>inet</ipprotocol>
            <tag/>
            <tagged/>
            <direction>any</direction>
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            <floating>yes</floating>
            <max/>
            <max-src-nodes/>
            <max-src-conn/>
```

```
                <max-src-states/>
                <statetimeout/>
                <statetype>keep state</statetype>
                <os/>
                <protocol>tcp/udp</protocol>
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                        <any/>
                </source>
                <destination>
                        <any/>
                        <port>19888</port>
                </destination>
                <descr><![CDATA[Allow Connection to Nextlabs port 19888]]></descr>
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                        <username>admin@10.97.67.143</username>
                </updated>
                <created>
                        <time>1493327859</time>
                        <username>admin@10.97.67.143</username>
                </created>
        </rule>
        <rule>
                <id/>
                <tracker>1493325919</tracker>
                <type>pass</type>
                <interface>wan</interface>
                <ipprotocol>inet</ipprotocol>
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                <tagged/>
                <direction>any</direction>
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                <floating>yes</floating>
                <max/>
                <max-src-nodes/>
                <max-src-conn/>
                <max-src-states/>
                <statetimeout/>
                <statetype>keep state</statetype>
                <os/>
```

```
                <protocol>tcp/udp</protocol>
                <source>
                        <network>lan</network>
                </source>
                <destination>
                        <any/>
                        <port>53</port>
                </destination>
                <descr><![CDATA[Allow DNS port 53 going out]]></descr>
                <created>
                        <time>1493325919</time>
                        <username>admin@10.97.67.143</username>
                </created>
                <updated>
                        <time>1493326213</time>
                        <username>admin@10.97.67.143</username>
                </updated>
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        <rule>
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                <tracker>1493328002</tracker>
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                <ipprotocol>inet</ipprotocol>
                <tag/>
                <tagged/>
                <direction>any</direction>
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                <floating>yes</floating>
                <max/>
                <max-src-nodes/>
                <max-src-conn/>
                <max-src-states/>
                <statetimeout/>
                <statetype>keep state</statetype>
                <os/>
                <protocol>tcp/udp</protocol>
                <source>
                        <any/>
                </source>
                <destination>
```

```
                        <any/>
                        <port>2000</port>
                    </destination>
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                        <username>admin@10.97.67.143</username>
                    </updated>
                    <created>
                        <time>1493328002</time>
                        <username>admin@10.97.67.143</username>
                    </created>
            </rule>
            <rule>
                    <id/>
                    <tracker>1481037313</tracker>
                    <type>pass</type>
                    <interface>wan</interface>
                    <ipprotocol>inet</ipprotocol>
                    <tag/>
                    <tagged/>
                    <max/>
                    <max-src-nodes/>
                    <max-src-conn/>
                    <max-src-states/>
                    <statetimeout/>
                    <statetype>keep state</statetype>
                    <os/>
                    <source>
                        <address>192.168.14.111</address>
                    </source>
                    <destination>
                        <any/>
                    </destination>
                    <descr><![CDATA[Allow Radiant (192.168.14.111) to get out with any
p]]></descr>
                    <created>
                        <time>1481037313</time>
                        <username>admin@10.97.67.155</username>
                    </created>
```

```
                <updated>
                        <time>1481037359</time>
                        <username>admin@10.97.67.155</username>
                </updated>
                <disabled/>
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        <rule>
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                <type>pass</type>
                <interface>wan</interface>
                <ipprotocol>inet</ipprotocol>
                <tag/>
                <tagged/>
                <max/>
                <max-src-nodes/>
                <max-src-conn/>
                <max-src-states/>
                <statetimeout/>
                <statetype>keep state</statetype>
                <os/>
                <source>
                        <any/>
                </source>
                <destination>
                        <any/>
                </destination>
                <descr><![CDATA[Allow Everything]]></descr>
                <updated>
                        <time>1480537443</time>
                        <username>admin@192.168.13.139</username>
                </updated>
                <created>
                        <time>1480537443</time>
                        <username>admin@192.168.13.139</username>
                </created>
                <disabled/>
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        <rule>
                <id/>
```

```
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                <ipprotocol>inet</ipprotocol>
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                <tagged/>
                <max/>
                <max-src-nodes/>
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                <max-src-states/>
                <statetimeout/>
                <statetype>keep state</statetype>
                <os/>
                <protocol>udp</protocol>
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                        <any/>
                </source>
                <destination>
                        <any/>
                </destination>
                <descr/>
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                        <time>1466105351</time>
                        <username>admin@192.168.13.101</username>
                </updated>
                <created>
                        <time>1466105351</time>
                        <username>admin@192.168.13.101</username>
                </created>
                <disabled/>
        </rule>
        <rule>
                <id/>
                <tracker>1465934980</tracker>
                <type>pass</type>
                <interface>wan</interface>
                <ipprotocol>inet</ipprotocol>
                <tag/>
                <tagged/>
                <max/>
```

```
                <max-src-nodes/>
                <max-src-conn/>
                <max-src-states/>
                <statetimeout/>
                <statetype>keep state</statetype>
                <os/>
                <protocol>icmp</protocol>
                <source>
                        <any/>
                </source>
                <destination>
                        <any/>
                </destination>
                <descr/>
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                        <username>admin@192.168.14.100</username>
                </updated>
                <created>
                        <time>1465934980</time>
                        <username>admin@192.168.14.100</username>
                </created>
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        <rule>
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                <type>pass</type>
                <interface>wan</interface>
                <ipprotocol>inet</ipprotocol>
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                <tagged/>
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                <max-src-nodes/>
                <max-src-conn/>
                <max-src-states/>
                <statetimeout/>
                <statetype>keep state</statetype>
                <os/>
                <protocol>tcp</protocol>
                <source>
```

```
                        <any/>
                    </source>
                    <destination>
                        <network>wanip</network>
                        <port>80</port>
                    </destination>
                    <descr><![CDATA[Allow to Port 80 on Firewall WAN]]></descr>
                    <created>
                        <time>1461788221</time>
                        <username>admin@192.168.1.2</username>
                    </created>
                    <updated>
                        <time>1493323649</time>
                        <username>admin@10.97.67.143</username>
                    </updated>
                </rule>
                <rule>
                    <type>pass</type>
                    <interface>wan</interface>
                    <ipprotocol>inet</ipprotocol>
                    <descr><![CDATA[Easy Rule: Passed from Firewall Log
View]]></descr>
                    <protocol>udp</protocol>
                    <source>
                        <address>192.168.13.101</address>
                    </source>
                    <destination>
                        <address>192.168.13.102</address>
                        <port>137</port>
                    </destination>
                    <created>
                        <time>1466105470</time>
                        <username>Easy Rule</username>
                    </created>
                </rule>
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                    <id/>
                    <tracker>1480537570</tracker>
                    <type>pass</type>
                    <interface>lan</interface>
```

```
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                <tagged/>
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                <max-src-nodes/>
                <max-src-conn/>
                <max-src-states/>
                <statetimeout/>
                <statetype>keep state</statetype>
                <os/>
                <source>
                        <any/>
                </source>
                <destination>
                        <any/>
                </destination>
                <descr><![CDATA[All Everything from LAN Interface]]></descr>
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                        <time>1480537570</time>
                        <username>admin@192.168.13.139</username>
                </updated>
                <created>
                        <time>1480537570</time>
                        <username>admin@192.168.13.139</username>
                </created>
                <disabled/>
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        <rule>
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                <interface>lan</interface>
                <ipprotocol>inet</ipprotocol>
                <tag/>
                <tagged/>
                <max/>
                <max-src-nodes/>
                <max-src-conn/>
                <max-src-states/>
                <statetimeout/>
```

```
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                <os/>
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                        <any/>
                </source>
                <destination>
                        <any/>
                </destination>
                <descr/>
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                        <username>admin@192.168.13.101</username>
                </updated>
                <created>
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                        <username>admin@192.168.13.101</username>
                </created>
                <disabled/>
        </rule>
        <rule>
                <id/>
                <tracker>1465934995</tracker>
                <type>pass</type>
                <interface>lan</interface>
                <ipprotocol>inet</ipprotocol>
                <tag/>
                <tagged/>
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                <max-src-nodes/>
                <max-src-conn/>
                <max-src-states/>
                <statetimeout/>
                <statetype>keep state</statetype>
                <os/>
                <protocol>icmp</protocol>
                <source>
                        <any/>
                </source>
                <destination>
```

```
                        <any/>
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                    <descr/>
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                    </updated>
                    <created>
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                        <username>admin@192.168.14.100</username>
                    </created>
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                <rule>
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                    <interface>lan</interface>
                    <ipprotocol>inet</ipprotocol>
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                    <tagged/>
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                    <max-src-conn/>
                    <max-src-states/>
                    <statetimeout/>
                    <statetype>keep state</statetype>
                    <os/>
                    <protocol>tcp</protocol>
                    <source>
                        <any/>
                    </source>
                    <destination>
                        <any/>
                    </destination>
                    <descr><![CDATA[Allow Any Any]]></descr>
                    <updated>
                        <time>1465915373</time>
                        <username>admin@192.168.14.100</username>
                    </updated>
                    <created>
```

```
                        <time>1465915373</time>
                        <username>admin@192.168.14.100</username>
                    </created>
                    <disabled/>
                </rule>
                <rule>
                    <type>pass</type>
                    <ipprotocol>inet</ipprotocol>
                    <descr><![CDATA[Default allow LAN to any rule]]></descr>
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                    <tracker>0100000101</tracker>
                    <source>
                        <network>lan</network>
                    </source>
                    <destination>
                        <any/>
                    </destination>
                </rule>
                <rule>
                    <type>pass</type>
                    <ipprotocol>inet6</ipprotocol>
                    <descr><![CDATA[Default allow LAN IPv6 to any rule]]></descr>
                    <interface>lan</interface>
                    <tracker>0100000102</tracker>
                    <source>
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                    </source>
                    <destination>
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                    </destination>
                </rule>
                <separator>
                    <wan/>
                    <lan/>
                    <floatingrules/>
                </separator>
            </filter>
            <shaper>
            </shaper>
            <ipsec/>
```

```
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        <proxyarp/>
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                        <hour>0-5</hour>
                        <mday>*</mday>
                        <month>*</month>
                        <wday>*</wday>
                        <who>root</who>
                        <command>/usr/bin/nice -n20 adjkerntz -a</command>
                </item>
                <item>
                        <minute>1</minute>
                        <hour>3</hour>
                        <mday>1</mday>
                        <month>*</month>
                        <wday>*</wday>
                        <who>root</who>
                        <command>/usr/bin/nice -n20 /etc/rc.update_bogons.sh</command>
                </item>
                <item>
                        <minute>*/60</minute>
                        <hour>*</hour>
                        <mday>*</mday>
                        <month>*</month>
                        <wday>*</wday>
                        <who>root</who>
                        <command>/usr/bin/nice -n20 /usr/local/sbin/expiretable -v -t 3600
sshlockout</command>
                </item>
                <item>
                        <minute>*/60</minute>
                        <hour>*</hour>
                        <mday>*</mday>
                        <month>*</month>
                        <wday>*</wday>
                        <who>root</who>
                        <command>/usr/bin/nice -n20 /usr/local/sbin/expiretable -v -t 3600
webConfiguratorlockout</command>
```

```
                </item>
                <item>
                        <minute>1</minute>
                        <hour>1</hour>
                        <mday>*</mday>
                        <month>*</month>
                        <wday>*</wday>
                        <who>root</who>
                        <command>/usr/bin/nice -n20 /etc/rc.dyndns.update</command>
                </item>
                <item>
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                        <hour>*</hour>
                        <mday>*</mday>
                        <month>*</month>
                        <wday>*</wday>
                        <who>root</who>
                        <command>/usr/bin/nice -n20 /usr/local/sbin/expiretable -v -t 3600
virusprot</command>
                </item>
                <item>
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                        <hour>12</hour>
                        <mday>*</mday>
                        <month>*</month>
                        <wday>*</wday>
                        <who>root</who>
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                </item>
        </cron>
        <wol/>
        <rrd>
                <enable/>
        </rrd>
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                        <type>icmp</type>
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                        <options/>
```

```
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                  <type>tcp</type>
                  <descr><![CDATA[Generic TCP]]></descr>
                  <options/>
            </monitor_type>
            <monitor_type>
                  <name>HTTP</name>
                  <type>http</type>
                  <descr><![CDATA[Generic HTTP]]></descr>
                  <options>
                        <path>/</path>
                        <host/>
                        <code>200</code>
                  </options>
            </monitor_type>
            <monitor_type>
                  <name>HTTPS</name>
                  <type>https</type>
                  <descr><![CDATA[Generic HTTPS]]></descr>
                  <options>
                        <path>/</path>
                        <host/>
                        <code>200</code>
                  </options>
            </monitor_type>
            <monitor_type>
                  <name>SMTP</name>
                  <type>send</type>
                  <descr><![CDATA[Generic SMTP]]></descr>
                  <options>
                        <send/>
                        <expect>220 *</expect>
                  </options>
            </monitor_type>
      </load_balancer>
      <widgets>

      <sequence>system_information:col1:open,gateways:col1:open,interfaces:col2:open<
/sequence>
```

```
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        <openvpn/>
        <dnshaper>
        </dnshaper>
        <unbound>
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                <dnssec/>
                <active_interface/>
                <outgoing_interface/>
                <custom_options/>
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                <dnssecstripped/>
        </unbound>
        <dhcpdv6>
                <lan>
                        <range>
                                <from>::1000</from>
                                <to>::2000</to>
                        </range>
                        <ramode>assist</ramode>
                        <rapriority>medium</rapriority>
                </lan>
        </dhcpdv6>
        <cert>
                <refid>5720a0502b277</refid>
                <descr><![CDATA[webConfigurator default (5720a0502b277)]]></descr>
                <type>server</type>

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OFFVSGhTZ0xEdjhFQ3NjQ0p3QUl3Z2VFR0ExVWRJd1NCMlRDQjFvQVU3K1lLCkZjaThRVUhoU2dMRHY4RUNzY0
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ZObGJHWXRVMmxuYm1Wa0lFTmxjblJwWm1sallYUmxNU2d3SmdZSktvWklodmNOCkFRa0JGaGxoWkcxcGJrQnda
bE5sYm5ObExteHZZMkZzWkc5dFlXbHVNUjR3SEFZRFZRUURFeFZ3WmxObGJuTmwKTFRVM01qQmhNRFV3TW1JeU
56ZUNBUUF3SFFZRFZSMGxCQll3RkFZSUt3WUJCUVVIQXdFR0NDc0dBUVVGQ0FJQwpNQXNHQTFVZER3UUVBd0lG
b0RBTkJna3Foa2lHOXcwQkFRc0ZBQU9DQVFFQXJxZFpQdXd2MVZuUC82NmJDWFJ5CkVmaW1LRWlPcmtNaTB5M0
9PWGtzWEs1cEM2dTd6Ukl3WjEvRjYyRUp3ODlUOWx4Y01ZelZOTm5Idlg0bXFPRUcKUWJhRU42NEkxOHFud3Zm
S2JrREZvRThMR1hSdzBkMnAyTGVmYTd4YTIvSGNHc0xHTktPbkJxb3N4ejUrQ1B3ZwpWeVRaTS9wV3p3aDdQRG
c4bGdrcVc3dStlb01DNDJIbVJkOURCTmlzdFJ4RVlNMkFLQkFsZG1LYStvRUY1VUwwCm43aXpvNlZ4dHJWMTJv
TTdySllRQ05kY00xZkVSeUwvb3ZkUnVpa0F5Wm1VVnFUL1dDZGo3dDdIVG9ob0RFYzEKSklkOVpPSmR2QmZLVU
1sUWlELyswSVpTalFXRDczWkdsaEhTK2tOeWc1aDJhUjUwYjh3Wm9zQnNjSUZDa0pFbgp0UT09Ci0tLS0tRU5E
IENFUlRJRklDQVRFLS0tLS0K</crt>

<prv>LS0tLS1CRUdJTiBQUklWQVRFIEtFWS0tLS0tCk1JSUV2Z0lCQURBTkJna3Foa2lHOXcwQkFRRU
ZBQVNDQktnd2dnU2tBZ0VBQW9JQkFRQzM4NzJIMkE1M0lhYlkKMjN3YkNKR1htWFJWKy9odVVKeFdsc3hxb3M4
eGxiY3UyRUx6UVpJWnArc1BtQ09yaWw4SXpUS3lVQTZKaGo1YwpKdnN5U1BpK1JMWitqM0hOeXVIbjdsaGxzOG
JLMjZTS1Y1M0dmVlhGak1saXhxOG0vSW1oaERUNHcwdTI4Qnh1CjFvd0NGL3k1OE1SZVN0SlFJTEpyV1NVWFhs
c1YrRFk5cmpGMmpZNDdrSEliU1JZSWxLUHo1TzVtNTA5TWcwdkEKQVdEQkQzNDg5OHRUalhROVNpb1NaclREbn
dKTmo3cHAwQnM4ZHhlRDBjL2poUGFWSWNKem1vbkpEdDc2dmFGVwozdWdQcG5VR0FFK3ZMQzRjV25DdTcvNWRj
dHZFYjZudWxxdmlHMjA5TUt1SzdwcU1CUkxxT2pzMTN3Zy9tT3lCCmpjWWU5L3l4QWdNQkFBRUNnZ0VCQUpRRF
pxU3duMnNTUTh0SVNBTUVrUW0zcXhrb3BzdzB4cWNScmFlOEd4VmQKejBpOU1KbkZVQWFleTQvL3JldndhZW1P
R3RYSmZ2ai9jSnY3cmJIWGIzYkJtVW9hcDhxY0RjdnVSMmlHRUZYWQpCL3hjNVpINTlaTUFabWE1VWVQLzNjcD
lzNVhhcHNpclNXV1I4cFFZc3Z6Mmt6ci8zMXdrQXd4SGJZWHhJVDk1CjNLRmk4VTZUM1hnU1c2eFowZHp1ZnlP
UzAvbXlmNU5YLzVoRklPNmFDc0xlUjZ4N1RZa2FDQU9FYlViT29qUXkKc09XeWphbEtTUWZ3WEdzdVM0bXdyR2
hMZ0NRYlB2MnE5V0Nia0VMNEZUZmRzRlZXcHBRNGlZVWtwNzhMY1FPMgpsSGR5cTJxTmJsNDIwa3h5M2FnZlF2
YTVqYUgyRm5LdkExR2YxY05hcGRVQ2dZRUE0NzNMUWoxcExLSmRZN2JxCmtMU3NVT0ZhTUZlZG1xU2ttbzh3Qj
lpMXhzbElLQUd0M3U4dTdMZlZtU2lybnMwVVBTMHRVUDRyQXMzVFJocEgKU2Z4VXVsbGVGaktjZk9xRE11TTBC
OGttbFJnUFRmVHVPaGNwMGVkamQwK1E5Y2VlY25kaFp3UEl6TUc3TWRTSApKOG5yU2t5TFdMdWUxUVJNZHNhbm
NBRDhVYThDZ1lFQXpzYjYzbzRBSHlYNjZkcEJ6TGlzYzZxS2d2ZG4xazhVCm02N3RuK2M3NkVhSEtZTlk0Rjdh
S0dFSk1yeU0yQTJTelAzdm03Rmk4eGRtblgrSXd5cUx5T1VwSnZXQ012TVIKRDFpNWVFTVVoZVo2OUpOK0I3Sm
Z2RjYrK2tHa1NHOGxaN0VLY21Uc1kzRVJxOURsSk94Nk1ROFEwMDNsTHVtQQpJZm1DWlpRSUQ1OENnWUJjamFO
dk5obnFJOG9rWGhBUjR2c3NtNGpWb0tYU1ZScjRIVHo5MDFwOGdReXNCWkt0CnlUS2V6VThuUVZvTjNYWmVMbC
8rVEcwYVpKOTZHKy9nNTRWZmZqWTRlelVScHhUT3QzdEx0cm5SV2NmT2ZMM2MKS2RHN0ZuaGI0cUFjNHBWSUc3
QWY5Mi9CbHZJR25FS1pMdnhLWTdVMXlIb1NRLzczUG1DSnFqemd6UUtCZ1FDZgpJQjE3RzRnWWNGL3hpdGJNTn
VudmNUUjZxTzR0ekZtdG5TYWN3WlFtb2UvdUVIaGE0bU84WTBCeTNRcitVU1BCCndVR2RiUnNhdTgxcU12VUtU
RG1hZGsvKy9Ud2UvVk1Kbmx2TW9zS3VjTG42Y1c2eGVhR1hFc3FoUjlhbkwzRjMKcEpUSGg4Y3FsNTdqdkRRN0
FBamdyQmxrb3pOVnNMZThiWWpkcHRlMVBRS0JnQ0xDR0R1RXNBYUxwZlRtOG44bgoyQ1h1NE52K1l3a1Rlczdu
WjRoM3ZRODI1ZkQxbGVzVjBYdDJ1cVJqeFEvSDgxMHRGd1p3cC9uSVdycnRCZlZLClUzSThhYnpnUUtwOEwrZj
VadTAxY1pZVk5TU0FIUFRHYm5jb1IzbGVPYjNLeUVXQjdsZFBHQWpOS3UwNkd5TEkKakh5TDhadEFBRXVBZ1FU
OVFOVGJkQWJrCi0tLS0tRU5EIFBSSVZBVEUgS0VZLS0tLS0K</prv>

```
        </cert>
        <revision>
                <time>1493650905</time>
                <description><![CDATA[admin@10.97.67.135: /firewall_rules_edit.php made
unknown change]]></description>
                <username>admin@10.97.67.135</username>
        </revision>
        <gateways>
                <gateway_item>
                        <interface>lan</interface>
                        <gateway>dynamic</gateway>
                        <name>WAN_DHCP</name>
                        <weight>1</weight>
                        <ipprotocol>inet</ipprotocol>
```

```
            <descr><![CDATA[Interface WAN_DHCP Gateway]]></descr>
        </gateway_item>
        <gateway_item>
            <interface>lan</interface>
            <gateway>dynamic</gateway>
            <name>WAN_DHCP</name>
            <weight>1</weight>
            <ipprotocol>inet</ipprotocol>
            <descr><![CDATA[Interface WAN_DHCP Gateway]]></descr>
        </gateway_item>
        <gateway_item>
            <interface>lan</interface>
            <gateway>dynamic</gateway>
            <name>WAN_DHCP6</name>
            <weight>1</weight>
            <ipprotocol>inet6</ipprotocol>
            <descr><![CDATA[Interface WAN_DHCP6 Gateway]]></descr>
            <defaultgw/>
        </gateway_item>
        <gateway_item>
            <interface>wan</interface>
            <gateway>192.168.13.1</gateway>
            <name>GW_WAN</name>
            <weight>1</weight>
            <ipprotocol>inet</ipprotocol>
            <interval/>
            <descr><![CDATA[Interface wan Gateway]]></descr>
            <defaultgw/>
        </gateway_item>
        <gateway_item>
            <interface>wan</interface>
            <gateway>192.168.13.17</gateway>
            <name>GW_VLAN17</name>
            <weight>1</weight>
            <ipprotocol>inet</ipprotocol>
            <descr><![CDATA[Gateway to VLAN 17]]></descr>
        </gateway_item>
        <gateway_item>
            <interface>wan</interface>
            <gateway>192.168.13.16</gateway>
```

```
                <name>GW_VLAN16</name>
                <weight>1</weight>
                <ipprotocol>inet</ipprotocol>
                <descr><![CDATA[Gateway to VLAN 16]]></descr>
            </gateway_item>
            <gateway_item>
                <interface>wan</interface>
                <gateway>192.168.13.15</gateway>
                <name>GW_VLAN15</name>
                <weight>1</weight>
                <ipprotocol>inet</ipprotocol>
                <descr><![CDATA[Gateway to VLAN 15]]></descr>
            </gateway_item>
            <gateway_item>
                <interface>wan</interface>
                <gateway>192.168.13.18</gateway>
                <name>GW_VLAN18</name>
                <weight>1</weight>
                <ipprotocol>inet</ipprotocol>
                <descr><![CDATA[Gateway to VLAN 18]]></descr>
            </gateway_item>
            <gateway_item>
                <interface>wan</interface>
                <gateway>192.168.13.19</gateway>
                <name>GW_VLAN19</name>
                <weight>1</weight>
                <ipprotocol>inet</ipprotocol>
                <descr><![CDATA[Gateway to VLAN 19]]></descr>
            </gateway_item>
        </gateways>
        <ppps/>
        <dyndnses/>
</pfSense>
```

2.10.4 Firewall Configuration for Private Cloud Subnet

```
<?xml version="1.0"?>
<pfSense>
        <version>15.4</version>
        <lastchange/>
        <theme>pfSense_ng</theme>
```

```
        <system>
                <optimization>normal</optimization>
                <hostname>FS-ARM</hostname>
                <domain>FS-ARM.gov</domain>
                <group>
                        <name>all</name>
                        <description><![CDATA[All Users]]></description>
                        <scope>system</scope>
                        <gid>1998</gid>
                        <member>0</member>
                </group>
                <group>
                        <name>admins</name>
                        <description><![CDATA[System Administrators]]></description>
                        <scope>system</scope>
                        <gid>1999</gid>
                        <member>0</member>
                        <priv>page-all</priv>
                </group>
                <user>
                        <name>admin</name>
                        <descr><![CDATA[System Administrator]]></descr>
                        <scope>system</scope>
                        <groupname>admins</groupname>
                        <password>$1$dSJImFph$GvZ7.1UbuWu.Yb8etC0re.</password>
                        <uid>0</uid>
                        <priv>user-shell-access</priv>
                </user>
                <nextuid>2000</nextuid>
                <nextgid>2000</nextgid>
                <timezone>America/New_York</timezone>
                <time-update-interval/>
                <timeservers>10.97.74.8</timeservers>
                <webgui>
                        <protocol>http</protocol>
                        <loginautocomplete/>
                        <ssl-certref>5720a0502b277</ssl-certref>
                        <dashboardcolumns>2</dashboardcolumns>
                        <port/>
                        <max_procs>2</max_procs>
```

```
                <nohttpreferercheck/>
            </webgui>
            <disablesegmentationoffloading/>
            <disablelargereceiveoffloading/>
            <ipv6allow/>
            <powerd_ac_mode>hadp</powerd_ac_mode>
            <powerd_battery_mode>hadp</powerd_battery_mode>
            <powerd_normal_mode>hadp</powerd_normal_mode>
            <bogons>
                <interval>monthly</interval>
            </bogons>
            <language>en_US</language>
            <dns1gw>GW_WAN</dns1gw>
            <dns2gw>GW_WAN</dns2gw>
            <dns3gw>none</dns3gw>
            <dns4gw>none</dns4gw>
            <dnsserver>10.97.74.8</dnsserver>
            <dnsserver>10.63.255.2</dnsserver>
            <maximumstates/>
            <aliasesresolveinterval/>
            <maximumtableentries/>
            <maximumfrags/>
            <enablenatreflectionpurenat>yes</enablenatreflectionpurenat>
            <enablebinatreflection>yes</enablebinatreflection>
            <enablenatreflectionhelper>yes</enablenatreflectionhelper>
            <reflectiontimeout/>
            <serialspeed>115200</serialspeed>
            <primaryconsole>serial</primaryconsole>
        </system>
        <interfaces>
            <wan>
                <if>em0</if>
                <descr><![CDATA[WAN]]></descr>
                <enable/>
                <spoofmac/>
                <ipaddr>192.168.13.20</ipaddr>
                <subnet>24</subnet>
                <gateway>GW_WAN_2</gateway>
                <ipaddrv6/>
                <subnetv6/>
```

```
                <gateway6/>
            </wan>
            <lan>
                <enable/>
                <if>em1</if>
                <ipaddr>192.168.20.1</ipaddr>
                <subnet>24</subnet>
                <ipaddrv6/>
                <subnetv6/>
                <media/>
                <mediaopt/>
                <track6-interface>wan</track6-interface>
                <track6-prefix-id>0</track6-prefix-id>
                <gateway/>
                <gateway6/>
            </lan>
        </interfaces>
        <staticroutes/>
        <dhcpd>
            <lan>
                <enable/>
                <range>
                    <from>192.168.20.100</from>
                    <to>192.168.20.150</to>
                </range>
            </lan>
            <opt1>
                <enable/>
                <range>
                    <from>192.168.14.100</from>
                    <to>192.168.14.150</to>
                </range>
            </opt1>
            <opt2>
                <enable/>
                <range>
                    <from>192.168.15.100</from>
                    <to>192.168.15.150</to>
                </range>
            </opt2>
```

```
            <opt3>
                <enable/>
                <range>
                    <from>192.168.16.100</from>
                    <to>192.168.16.150</to>
                </range>
            </opt3>
        </dhcpd>
        <snmpd>
            <syslocation/>
            <syscontact/>
            <rocommunity>public</rocommunity>
        </snmpd>
        <diag>
            <ipv6nat>
                <ipaddr/>
            </ipv6nat>
        </diag>
        <bridge/>
        <syslog/>
        <nat>
            <outbound>
                <mode>automatic</mode>
            </outbound>
        </nat>
        <filter>
            <rule>
                <id/>
                <tracker>1493654453</tracker>
                <type>pass</type>
                <interface>wan</interface>
                <ipprotocol>inet</ipprotocol>
                <tag/>
                <tagged/>
                <direction>any</direction>
                <quick>yes</quick>
                <floating>yes</floating>
                <max/>
                <max-src-nodes/>
                <max-src-conn/>
```

```
                <max-src-states/>
                <statetimeout/>
                <statetype>keep state</statetype>
                <os/>
                <protocol>tcp</protocol>
                <source>
                        <any/>
                </source>
                <destination>
                        <network>lan</network>
                        <port>443</port>
                </destination>
                <descr><![CDATA[Allow HTTPS connection to LAN server]]></descr>
                <updated>
                        <time>1493654453</time>
                        <username>admin@10.97.67.135</username>
                </updated>
                <created>
                        <time>1493654453</time>
                        <username>admin@10.97.67.135</username>
                </created>
        </rule>
        <rule>
                <id/>
                <tracker>1493654529</tracker>
                <type>pass</type>
                <interface>wan</interface>
                <ipprotocol>inet</ipprotocol>
                <tag/>
                <tagged/>
                <direction>any</direction>
                <quick>yes</quick>
                <floating>yes</floating>
                <max/>
                <max-src-nodes/>
                <max-src-conn/>
                <max-src-states/>
                <statetimeout/>
                <statetype>keep state</statetype>
                <os/>
```

```
                <protocol>tcp</protocol>
                <source>
                        <any/>
                </source>
                <destination>
                        <network>lan</network>
                        <port>80</port>
                </destination>
                <descr><![CDATA[Allow HTTP connection to LAN server]]></descr>
                <updated>
                        <time>1493654529</time>
                        <username>admin@10.97.67.135</username>
                </updated>
                <created>
                        <time>1493654529</time>
                        <username>admin@10.97.67.135</username>
                </created>
        </rule>
        <rule>
                <id/>
                <tracker>1493654337</tracker>
                <type>pass</type>
                <interface>wan</interface>
                <ipprotocol>inet</ipprotocol>
                <tag/>
                <tagged/>
                <direction>any</direction>
                <quick>yes</quick>
                <floating>yes</floating>
                <max/>
                <max-src-nodes/>
                <max-src-conn/>
                <max-src-states/>
                <statetimeout/>
                <statetype>keep state</statetype>
                <os/>
                <protocol>tcp</protocol>
                <source>
                        <any/>
                </source>
```

```
                <destination>
                        <network>lan</network>
                        <port>3389</port>
                </destination>
                <descr><![CDATA[Allow RDP Connection to LAN servers]]></descr>
                <created>
                        <time>1493654337</time>
                        <username>admin@10.97.67.135</username>
                </created>
                <updated>
                        <time>1493654474</time>
                        <username>admin@10.97.67.135</username>
                </updated>
        </rule>
        <rule>
                <id/>
                <tracker>1469131237</tracker>
                <type>pass</type>
                <interface>wan</interface>
                <ipprotocol>inet</ipprotocol>
                <tag/>
                <tagged/>
                <max/>
                <max-src-nodes/>
                <max-src-conn/>
                <max-src-states/>
                <statetimeout/>
                <statetype>keep state</statetype>
                <os/>
                <protocol>tcp</protocol>
                <source>
                        <any/>
                </source>
                <destination>
                        <network>wanip</network>
                        <port>80</port>
                </destination>
                <descr><![CDATA[Allow Port 80 on WAN ]]></descr>
                <created>
                        <time>1469131237</time>
```

```
                        <username>admin@192.168.20.103</username>
                    </created>
                    <updated>
                        <time>1493654100</time>
                        <username>admin@10.97.67.135</username>
                    </updated>
            </rule>
            <rule>
                    <id/>
                    <tracker>1465935224</tracker>
                    <type>pass</type>
                    <interface>wan</interface>
                    <ipprotocol>inet</ipprotocol>
                    <tag/>
                    <tagged/>
                    <max/>
                    <max-src-nodes/>
                    <max-src-conn/>
                    <max-src-states/>
                    <statetimeout/>
                    <statetype>keep state</statetype>
                    <os/>
                    <protocol>icmp</protocol>
                    <source>
                        <any/>
                    </source>
                    <destination>
                        <any/>
                    </destination>
                    <descr/>
                    <updated>
                        <time>1465935224</time>
                        <username>admin@192.168.18.100</username>
                    </updated>
                    <created>
                        <time>1465935224</time>
                        <username>admin@192.168.18.100</username>
                    </created>
            </rule>
            <rule>
```

```
                <id/>
                <tracker>1461788221</tracker>
                <type>pass</type>
                <interface>wan</interface>
                <ipprotocol>inet</ipprotocol>
                <tag/>
                <tagged/>
                <max/>
                <max-src-nodes/>
                <max-src-conn/>
                <max-src-states/>
                <statetimeout/>
                <statetype>keep state</statetype>
                <os/>
                <protocol>tcp</protocol>
                <source>
                        <any/>
                </source>
                <destination>
                        <network>wanip</network>
                        <port>443</port>
                </destination>
                <descr><![CDATA[Allow Port 443 on WAN]]></descr>
                <created>
                        <time>1461788221</time>
                        <username>admin@192.168.1.2</username>
                </created>
                <updated>
                        <time>1493654159</time>
                        <username>admin@10.97.67.135</username>
                </updated>
        </rule>
        <rule>
                <id/>
                <tracker>1468437174</tracker>
                <type>pass</type>
                <interface>lan</interface>
                <ipprotocol>inet</ipprotocol>
                <tag/>
                <tagged/>
```

```
                <max/>
                <max-src-nodes/>
                <max-src-conn/>
                <max-src-states/>
                <statetimeout/>
                <statetype>keep state</statetype>
                <os/>
                <protocol>tcp/udp</protocol>
                <source>
                        <any/>
                </source>
                <destination>
                        <any/>
                </destination>
                <descr/>
                <updated>
                        <time>1468437174</time>
                        <username>admin@192.168.20.100</username>
                </updated>
                <created>
                        <time>1468437174</time>
                        <username>admin@192.168.20.100</username>
                </created>
                <disabled/>
        </rule>
        <rule>
                <id/>
                <tracker>1465935241</tracker>
                <type>pass</type>
                <interface>lan</interface>
                <ipprotocol>inet</ipprotocol>
                <tag/>
                <tagged/>
                <max/>
                <max-src-nodes/>
                <max-src-conn/>
                <max-src-states/>
                <statetimeout/>
                <statetype>keep state</statetype>
                <os/>
```

```
                <protocol>icmp</protocol>
                <source>
                        <any/>
                </source>
                <destination>
                        <any/>
                </destination>
                <descr/>
                <updated>
                        <time>1465935241</time>
                        <username>admin@192.168.18.100</username>
                </updated>
                <created>
                        <time>1465935241</time>
                        <username>admin@192.168.18.100</username>
                </created>
        </rule>
        <rule>
                <type>pass</type>
                <ipprotocol>inet</ipprotocol>
                <descr><![CDATA[Default allow LAN to any rule]]></descr>
                <interface>lan</interface>
                <tracker>0100000101</tracker>
                <source>
                        <network>lan</network>
                </source>
                <destination>
                        <any/>
                </destination>
        </rule>
        <rule>
                <type>pass</type>
                <ipprotocol>inet6</ipprotocol>
                <descr><![CDATA[Default allow LAN IPv6 to any rule]]></descr>
                <interface>lan</interface>
                <tracker>0100000102</tracker>
                <source>
                        <network>lan</network>
                </source>
                <destination>
```

```
                        <any/>
                    </destination>
            </rule>
            <separator>
                    <wan/>
                    <lan/>
                    <floatingrules/>
            </separator>
    </filter>
    <shaper>
    </shaper>
    <ipsec/>
    <aliases/>
    <proxyarp/>
    <cron>
            <item>
                    <minute>1,31</minute>
                    <hour>0-5</hour>
                    <mday>*</mday>
                    <month>*</month>
                    <wday>*</wday>
                    <who>root</who>
                    <command>/usr/bin/nice -n20 adjkerntz -a</command>
            </item>
            <item>
                    <minute>1</minute>
                    <hour>3</hour>
                    <mday>1</mday>
                    <month>*</month>
                    <wday>*</wday>
                    <who>root</who>
                    <command>/usr/bin/nice -n20 /etc/rc.update_bogons.sh</command>
            </item>
            <item>
                    <minute>*/60</minute>
                    <hour>*</hour>
                    <mday>*</mday>
                    <month>*</month>
                    <wday>*</wday>
                    <who>root</who>
```

```
                    <command>/usr/bin/nice -n20 /usr/local/sbin/expiretable -v -t 3600
sshlockout</command>
             </item>
             <item>
                    <minute>*/60</minute>
                    <hour>*</hour>
                    <mday>*</mday>
                    <month>*</month>
                    <wday>*</wday>
                    <who>root</who>
                    <command>/usr/bin/nice -n20 /usr/local/sbin/expiretable -v -t 3600
webConfiguratorlockout</command>
             </item>
             <item>
                    <minute>1</minute>
                    <hour>1</hour>
                    <mday>*</mday>
                    <month>*</month>
                    <wday>*</wday>
                    <who>root</who>
                    <command>/usr/bin/nice -n20 /etc/rc.dyndns.update</command>
             </item>
             <item>
                    <minute>*/60</minute>
                    <hour>*</hour>
                    <mday>*</mday>
                    <month>*</month>
                    <wday>*</wday>
                    <who>root</who>
                    <command>/usr/bin/nice -n20 /usr/local/sbin/expiretable -v -t 3600
virusprot</command>
             </item>
             <item>
                    <minute>30</minute>
                    <hour>12</hour>
                    <mday>*</mday>
                    <month>*</month>
                    <wday>*</wday>
                    <who>root</who>
                    <command>/usr/bin/nice -n20 /etc/rc.update_urltables</command>
             </item>
```

```
        </cron>
        <wol/>
        <rrd>
              <enable/>
        </rrd>
        <load_balancer>
              <monitor_type>
                    <name>ICMP</name>
                    <type>icmp</type>
                    <descr><![CDATA[ICMP]]></descr>
                    <options/>
              </monitor_type>
              <monitor_type>
                    <name>TCP</name>
                    <type>tcp</type>
                    <descr><![CDATA[Generic TCP]]></descr>
                    <options/>
              </monitor_type>
              <monitor_type>
                    <name>HTTP</name>
                    <type>http</type>
                    <descr><![CDATA[Generic HTTP]]></descr>
                    <options>
                          <path>/</path>
                          <host/>
                          <code>200</code>
                    </options>
              </monitor_type>
              <monitor_type>
                    <name>HTTPS</name>
                    <type>https</type>
                    <descr><![CDATA[Generic HTTPS]]></descr>
                    <options>
                          <path>/</path>
                          <host/>
                          <code>200</code>
                    </options>
              </monitor_type>
              <monitor_type>
                    <name>SMTP</name>
```

```
                        <type>send</type>
                        <descr><![CDATA[Generic SMTP]]></descr>
                        <options>
                              <send/>
                              <expect>220 *</expect>
                        </options>
                  </monitor_type>
            </load_balancer>
            <widgets>
            <sequence>system_information:col1:open,gateways:col1:open,interfaces:col2:open<
/sequence>
            </widgets>
            <openvpn/>
            <dnshaper>
            </dnshaper>
            <unbound>
                  <dnssec/>
                  <active_interface>all</active_interface>
                  <outgoing_interface>all</outgoing_interface>
                  <custom_options/>
                  <hideidentity/>
                  <hideversion/>
                  <dnssecstripped/>
                  <domainoverrides>
                        <domain>acmefinancial.com</domain>
                        <ip>192.168.19.10</ip>
                        <descr><![CDATA[Active Directory]]></descr>
                  </domainoverrides>
                  <port/>
            <system_domain_local_zone_type>transparent</system_domain_local_zone_type>
                  <enable/>
            </unbound>
            <dhcpdv6>
                  <lan>
                        <range>
                              <from>::1000</from>
                              <to>::2000</to>
                        </range>
                        <ramode>assist</ramode>
                        <rapriority>medium</rapriority>
```

```
            </lan>
        </dhcpdv6>
        <cert>
            <refid>5720a0502b277</refid>
            <descr><![CDATA[webConfigurator default (5720a0502b277)]]></descr>
            <type>server</type>

        <crt>LS0tLS1CRUdJTiBDRVJUSUZJQ0FURS0tLS0tCk1JSUZiVENDQkZXZ0F3SUJBZ0lCQURBTkJna3
Foa2lHOXcwQkFRc0ZBRENCdERFTE1Ba0dBMVVFQmhNQ1ZWTXgKRGpBTUJnTlZCQWdUQlZOMFlYUmxNUkV3RHdZ
RFZRUUhFd2hNYjJOaGJHbDBlVEU0TURZR0ExVUVDaE12Y0daVApaVzV6WlNCM1pXSkRiMjVtYVdkMWNtRjBiM0
lnVTJWc1ppMVRhV2R1WldRZ1EyVnlkR2xtYVdOaGRHVXhLREFtCkJna3Foa2lHOXcwQkNRRVdHV0ZrYldsdVFI
Qm1VMlZ1YzJVdWJHOWpZV3hrYjIxaGFXNHhIakFjQmdOVkJBTVQKRlhCbVUyVnVjMlV0TlRjeU1HRXdOVEF5WW
pJM056QWVGdzB4TmpBME1qY3hNVEU1TkRSYUZ3MHlNVEV3TVRneApNVEU1TkRSYU1JRzBNUXN3Q1FZRFZRUUdF
d0pWVXpFT01Bd0dBMVVFQ0JNRlUzUmhkR1V4RVRBUEJnTlZCQWNUCkNFeHZZMkZzYVhSNU1UZ3dOZ1lEVlFRS0
V5OXdabE5sYm5ObElZGxZa052Ym1acFozVnlZWFJ2Y2lCVFpXeG0KTFZOcFoyNWxaQ0JEWlhKMGFXWnBZMkYw
WlRFb01DWUdDU3FHU0liM0RRRUpBUllaWVdSdGFXNUFjR1pUWlc1egpaUzVzYjJOaGJHUnZiV0ZwYmpFZU1Cd0
dBMVVFQXhNVmNHWlRaVzV6WlMwMU56SXdZVEExTURKaU1qYzNNSUlCCklqQU5CZ2txaGtpRzl3MEJBUUVGQUFP
Q0FROEFNSUlCQ2dLQ0FRRUF0L085aDlnT2R5R20yTnQ4R3dpUmw1bDAKVmZ2NGJsQ2NWcGJNYXFMUE1aVzNMdG
hDODBHU0dhZnJENWdqcTRwZkNNMHlzbEFPaVlZK1hDYjdNa2o0dmtTMgpmbzl4emNyaDUrNVlaYlBHeXR1a2ls
ZWR4bjFWeFl6SllzYXZKdnlKb1lRMCtNTkx0dkFjYnRhTUFoZjh1ZkRFClhrclNVQ0N5YTFrbEYxNWJGZmcyUG
E0eGRvMk9PNUJ5RzBrV0NKU2o4K1R1WnVkUFRJTkx3QUZnd1E5K1BQZkwKVTQxMFBVb3FFbWEwdzU4Q1RZKzZh
ZEFiUEhjWGc5SFA0NFQybFNIQ2M1cUp5UTdlK3IyaFZ0N29ENloxQmdCUApyeXd1SEZwd3J1LytYWExieEcrcD
dwYXI0aHR0UFRDcml1NmFqQVVTNmpvN05kOElQNWpzZ1kzR0h2ZjhzUUlECkFRQUJvNElCaGpDQ0FZSXdDUVlE
VlIwVEJBSXdBREFSQmdsZ2hrZ0JodmhDQVFFRUJBTUNCa0F3TXdZSllJWkkKQVliNFFnRU5CQ1lXSkU5d1pXNV
RVMHdnUjJWdVpYSmhkR1ZrSUZObGNuWmxjaUJEWlhKMGFXWnBZMkYwWlRBZApCZ05WSFE0RUZnUVU3K1lLRmNp
OFFVSGhTZ0xEdjhFQ3NjQ0p3QUl3Z2VFR0ExVWRJd1NCMlRDQjFvQVU3K1lLCkZjaThRVUhoU2dMRHY4RUNzY0
NKd0FLaGdicWtnYmN3Z2JReEN6QUpCZ05WQkFZVEFsVlRNUTR3REFZRFZRUUkKRXdWVGRHRjBaVEVSTUE4R0Ex
VUVCeE1JVEc5allXeHBkSGt4T0RBMkJnTlZCQW9UTDNCbVUyVnVjMlVnZDJWaQpRMjl1Wm1sbmRYSmhkRzl5SU
ZObGJHWXRVMmxuYm1Wa0lFTmxjblJwWm1sallYUmxNU2d3SmdZSktvWklodmNOCkFRa0JGaGxoWkcxcGJrQnda
bE5sYm5ObExteHZZMkZzWkc5dFlXbHVNUjR3SEFZRFZRUURFeFZ3WmxObGJuTmwKTFRVM01qQmhNRFV3TW1JeU
56ZUNBUUF3SFFZRFZSMGxCQll3RkFZSUt3WUJCUVVIQXdFR0NDc0dBUVVGQ0FJQwpNQXNHQTFVZER3UUVBd0lG
b0RBTkJna3Foa2lHOXcwQkFRc0ZBQU9DQVFFQXJxZFpQdXd2MVZuUC82NmJDWFJ5CkVmaW1LRWlPcmtNaTB5M0
9PWGtzWEs1cEM2dTd6Ukl3WjEvRjYyRUp3ODlUOWx4Y01ZelZOTm5Idlg0bXFPRUcKUWJhRU42NEkxOHFud3Zm
S2JrREZvRThMR1hSdzBkMnAyTGVmYTd4YTIvSGNHc0xHTktPbkJxb3N4ejUrQ1B3ZwpWeVRaTS9wV3p3aDdQRG
c4bGdrcVc3dStlb01DNDJIbVJkOURCTmlzdFJ4RVlNMkFLQkFsZG1LYStvRUY1VUwwCm43aXpvNlZ4dHJWMTJv
TTdySllRQ05kY00xZkVSeUwvb3ZkUnVpa0F5Wm1VVnFUL1dDZGo3dDdIVG9ob0RFYzEKSklkOVpPSmR2QmZLVU
1sUWlELyswSVpTalFXRDczWkdsaEhTK2tOeWc1aDJhUjUwYjh3Wm9zQnNjSUZDa0pFbgp0UT09Ci0tLS0tRU5E
IENFUlRJRklDQVRFLS0tLS0K</crt>

        <prv>LS0tLS1CRUdJTiBQUklWQVRFIEtFWS0tLS0tCk1JSUV2Z0lCQURBTkJna3Foa2lHOXcwQkFRRU
ZBQVNDQktnd2dnU2tBZ0VBQW9JQkFRQzM4NzJIMkE1M0lhYlkKMjN3YkNKR1htWFJWKy9odVVKeFdsc3hxb3M4
eGxiY3UyRUx6UVpJWnArc1BtQ09yaWw4SXpUS3lVQTZKaGo1YwpKdnN5U1BpK1JMWitqM0hOeXVIbjdsaGxzOG
JLMjZTS1Y1M0dmVlhGak1saXhxOG0vSW1oaERUNHcwdTI4Qnh1CjFvd0NGL3k1OE1SZVN0SlFJTEpyV1NVWFhs
c1YrRFk5cmpGMmpZNDdrSEliU1JZSWxLUHo1TzVtNTA5TWcwdkEKQVdEQkQzNDg5OHRUalhROVNpb1NaclREbn
dKTmo3cHAwQnM4ZHhlRDBjL2poUGFWSWNKem1vbkpEdDc2dmFGVwozdWdQcG5VR0FFK3ZMQzRjV25DdTcvNWRj
dHZFYjZudWxxdmlHMjA5TUt1SzdwcU1CUkxxT2pzMTN3Zy9tT3lCCmpjWWU5L314QWdNQkFBRUNnZ0VCQUpRRF
pxU3duMnNTUTh0SVNBTUVrUW0zcXhrb3BzdzB4cWNScmFlOEd4VmQKejBpOU1KbkZVQWFleTQvL3JldndhZW1P
R3RYSmZ2ai9jSnY3cmJIWGIzYkJtVW9hcDhxY0RjdnVSMmlHRUZYWQpCL3hjNVpINTlaTUFabWE1VWVQLzNjcD
lzNVhhcHNpclNXV1I4cFFZc3Z6Mmt6ci8zMXdrQXd4SGJZWHhJVDk1CjNLRmk4VTZUM1hnU1c2eFowZHp1ZnlP
UzAvbXlmNU5YLzVoRklPNmFDc0xlUjZ4N1RZa2FDQU9FYlViT29qUXkKc09XeWphbEtTUWZ3WEdzdVM0bXdyR2
hMZ0NRYlB2MnE5V0Nia0VMNEZUZmRzRlZXcHBRNGlZVWtwNzhMY1FPMgpsSGR5cTJxTmJsNDIwa3h5M2FnZlF2
YTVqYUgyRm5LdkExR2YxY05hcGRVQ2dZRUE0NzNMUWoxcExLSmRZN2JxCmtMU3NVT0ZhTUZlZG1xU2ttbzh3Qj
lpMXhzbElLQUd0M3U4dTdMZlZtU2lybMwVVBTMHRVUDRyQXMzVFJocEgKU2Z4VXVsbGVGaktjZk9xRE11TTBC
OGttbFJnUFRmVHVPaGNwMGVkamQwK1E5Y2VlY25kaFp3UEl6TUc3TWRTSApKOG5yU2t5TFdMdWUxUVJNZHNhbm
NBRDhVYThDZ1lFQXpzYjYzbzRBSHlYNjZkcEJ6TGlzYzZxS2d2ZG4xazhVCm02N3RuK2M3NkVhSEtZTlk0Rjdh
S0dFSk1yeU0yQTJTelAzdm03Rmk4eGRtblgrSXd5cUx5T1VwSnZXQ012TVIKRDFpNWVFTVVoZVo2OUpOK0I3Sm
Z2RjYrK2tHa1NHOGxaN0VLY21Uc1kzRVJxOURsSk94Nk1ROFEwMDNsTHVtQQpJZm1DWlpRSUQ1OENnWUJjamFO
dk5obnFJOG9rWGhBUjR2c3NtNGpWb0tYU1ZScjRIVHo5MDFwOGdReXNCWkt0CnlUS2V6VThuUVZvTjNYWmVMbC
8rVEcwYVpKOTZHKy9nNTRWZmZqWTRlelVScHhUT3QzdEx0cm5SV2NmT2ZMM2MKS2RHN0ZuaGI0cUFjNHBWSUc3
QWY5Mi9CbHZJR25FS1pMdnhLWTdVMXlIb1NRLzczUG1DSnFqemd6UUtCZ1FDZgpJQjE3RzRnWWNGL3hpdGJNTn
```

```
VudmNUUjZxTzR0ekZtdG5TYWN3WlFtb2UvdUVIaGE0bU84WTBCeTNRcitVU1BCCndVR2RiUnNhdTgxcU12VUtU
RG1hZGsvKy9Ud2UvVk1Kbmx2TW9zS3VjTG42Y1c2eGVhR1hFc3FoUjlhbkwzRjMKcEpUSGg4Y3FsNTdqdkRRN0
FBamdyQmxrb3pOVnNMZThiWWpkcHRlMVBRS0JnQ0xDR0R1RXNBYUxwZlRtOG44bgoyQ1h1NE52K1l3a1Rlczdu
WjRoM3ZRODI1ZkQxbGVzVjBYdDJ1cVJqeFEvSDgxMHRGd1p3cC9uSVdycnRCZlZLClUzSThhYnpnUUtwOEwrZj
VadTAxY1pZVk5TU0FIUFRHYm5jb1IzbGVPYjNLeUVXQjdsZFBHQWpOS3UwNkd5TEkKakh5TDhadEFBRXVBZ1FU
OVFOVGJkQWJrCi0tLS0tRU5EIFBSSVZBVEUgS0VZLS0tLS0K</prv>
```


```
        </cert>
        <revision>
                <time>1493654529</time>
                <description><![CDATA[admin@10.97.67.135: /firewall_rules_edit.php made
unknown change]]></description>
                <username>admin@10.97.67.135</username>
        </revision>
        <gateways>
                <gateway_item>
                        <interface>wan</interface>
                        <gateway>192.168.13.1</gateway>
                        <name>GW_WAN_2</name>
                        <weight>1</weight>
                        <ipprotocol>inet</ipprotocol>
                        <interval/>
                        <descr><![CDATA[Interface wan Gateway]]></descr>
                </gateway_item>
        </gateways>
        <ppps/>
        <dyndnses/>
        <dnsmasq>
                <enable/>
                <custom_options/>
                <port>53</port>
                <interface/>
                <hosts>
                        <host>activedirectory</host>
                        <domain>acmefinancial.com</domain>
                        <ip>192.168.19.10</ip>
                        <descr/>
                        <aliases/>
                </hosts>
        </dnsmasq>
</pfSense>
```

2.10.5 Firewall Configuration for the Management and Monitoring Subnet

```xml
<?xml version="1.0"?>
<pfSense>
	<version>15.4</version>
	<lastchange/>
	<theme>pfSense_ng</theme>
	<system>
		<optimization>normal</optimization>
		<hostname>FS-ARM</hostname>
		<domain>FS-ARM.gov</domain>
		<group>
			<name>all</name>
			<description><![CDATA[All Users]]></description>
			<scope>system</scope>
			<gid>1998</gid>
			<member>0</member>
		</group>
		<group>
			<name>admins</name>
			<description><![CDATA[System Administrators]]></description>
			<scope>system</scope>
			<gid>1999</gid>
			<member>0</member>
			<priv>page-all</priv>
		</group>
		<user>
			<name>admin</name>
			<descr><![CDATA[System Administrator]]></descr>
			<scope>system</scope>
			<groupname>admins</groupname>
			<password>$1$dSJImFph$GvZ7.1UbuWu.Yb8etC0re.</password>
			<uid>0</uid>
			<priv>user-shell-access</priv>
		</user>
		<nextuid>2000</nextuid>
		<nextgid>2000</nextgid>
		<timezone>America/New_York</timezone>
		<time-update-interval/>
		<timeservers>10.97.74.8</timeservers>
		<webgui>
			<protocol>http</protocol>
```

```
                <loginautocomplete/>
                <ssl-certref>5720a0502b277</ssl-certref>
                <dashboardcolumns>2</dashboardcolumns>
                <port/>
                <max_procs>2</max_procs>
                <nohttpreferercheck/>
            </webgui>
            <disablenatreflection>yes</disablenatreflection>
            <disablesegmentationoffloading/>
            <disablelargereceiveoffloading/>
            <ipv6allow/>
            <powerd_ac_mode>hadp</powerd_ac_mode>
            <powerd_battery_mode>hadp</powerd_battery_mode>
            <powerd_normal_mode>hadp</powerd_normal_mode>
            <bogons>
                <interval>monthly</interval>
            </bogons>
            <language>en_US</language>
            <dns1gw>GW_WAN</dns1gw>
            <dns2gw>GW_WAN</dns2gw>
            <dns3gw>none</dns3gw>
            <dns4gw>none</dns4gw>
            <dnsserver>10.97.74.8</dnsserver>
            <dnsserver>10.63.255.2</dnsserver>
            <serialspeed>115200</serialspeed>
            <primaryconsole>serial</primaryconsole>
            <maximumstates/>
            <aliasesresolveinterval/>
            <maximumtableentries/>
            <maximumfrags/>
            <reflectiontimeout/>
        </system>
        <interfaces>
            <wan>
                <if>em0</if>
                <descr><![CDATA[WAN]]></descr>
                <enable/>
                <spoofmac/>
                <ipaddr>192.168.13.17</ipaddr>
                <subnet>24</subnet>
```

```
                <gateway>GW_WAN_2</gateway>
                <ipaddrv6/>
                <subnetv6/>
                <gatewayv6/>
        </wan>
        <lan>
                <enable/>
                <if>em1</if>
                <ipaddr>192.168.17.1</ipaddr>
                <subnet>24</subnet>
                <ipaddrv6/>
                <subnetv6/>
                <media/>
                <mediaopt/>
                <track6-interface>wan</track6-interface>
                <track6-prefix-id>0</track6-prefix-id>
                <gateway/>
                <gatewayv6/>
        </lan>
</interfaces>
<staticroutes>
        <route>
                <network>192.168.19.0/24</network>
                <gateway>GW_VLAN19</gateway>
                <descr><![CDATA[Route to VLAN 2019]]></descr>
        </route>
</staticroutes>
<dhcpd>
        <lan>
                <enable/>
                <range>
                        <from>192.168.17.100</from>
                        <to>192.168.17.150</to>
                </range>
        </lan>
        <opt1>
                <enable/>
                <range>
                        <from>192.168.14.100</from>
                        <to>192.168.14.150</to>
```

```
                        </range>
                </opt1>
                <opt2>
                        <enable/>
                        <range>
                                <from>192.168.15.100</from>
                                <to>192.168.15.150</to>
                        </range>
                </opt2>
                <opt3>
                        <enable/>
                        <range>
                                <from>192.168.16.100</from>
                                <to>192.168.16.150</to>
                        </range>
                </opt3>
        </dhcpd>
        <snmpd>
                <syslocation/>
                <syscontact/>
                <rocommunity>public</rocommunity>
        </snmpd>
        <diag>
                <ipv6nat>
                        <ipaddr/>
                </ipv6nat>
        </diag>
        <bridge/>
        <syslog/>
        <nat>
                <outbound>
                        <mode>disabled</mode>
                </outbound>
                <rule>
                        <source>
                                <any/>
                        </source>
                        <destination>
                                <address>192.168.13.171</address>
                                <port>5176</port>
```

```
                    </destination>
                    <protocol>tcp/udp</protocol>
                    <target>192.168.17.11</target>
                    <local-port>5176</local-port>
                    <interface>wan</interface>
                    <descr><![CDATA[Mapping to ConsoleWorks]]></descr>
                    <associated-rule-id>nat_57bf06b1aa4c21.26556306</associated-rule-id>
                    <natreflection>purenat</natreflection>
                    <created>
                          <time>1472136881</time>
                          <username>admin@192.168.13.135</username>
                    </created>
                    <updated>
                          <time>1472137126</time>
                          <username>admin@192.168.13.135</username>
                    </updated>
              </rule>
              <separator/>
        </nat>
        <filter>
              <rule>
                    <id/>
                    <tracker>1493655499</tracker>
                    <type>pass</type>
                    <interface>wan</interface>
                    <ipprotocol>inet</ipprotocol>
                    <tag/>
                    <tagged/>
                    <direction>any</direction>
                    <quick>yes</quick>
                    <floating>yes</floating>
                    <max/>
                    <max-src-nodes/>
                    <max-src-conn/>
                    <max-src-states/>
                    <statetimeout/>
                    <statetype>keep state</statetype>
                    <os></os>
                    <protocol>tcp/udp</protocol>
```

```
                <source>
                        <any/>
                </source>
                <destination>
                        <network>lan</network>
                        <port>514</port>
                </destination>
                <descr><![CDATA[Allow Connection to syslog in LAN]]></descr>
                <updated>
                        <time>1493655499</time>
                        <username>admin@10.97.67.135</username>
                </updated>
                <created>
                        <time>1493655499</time>
                        <username>admin@10.97.67.135</username>
                </created>
        </rule>
        <rule>
                <id/>
                <tracker>1493649494</tracker>
                <type>pass</type>
                <interface>wan</interface>
                <ipprotocol>inet</ipprotocol>
                <tag/>
                <tagged/>
                <direction>any</direction>
                <quick>yes</quick>
                <floating>yes</floating>
                <max/>
                <max-src-nodes/>
                <max-src-conn/>
                <max-src-states/>
                <statetimeout/>
                <statetype>keep state</statetype>
                <os/>
                <protocol>tcp</protocol>
                <source>
                        <any/>
                </source>
                <destination>
```

```
                        <network>lan</network>
                        <port>1433-1434</port>
                    </destination>
                    <descr><![CDATA[Allow Connection to Sharepoint database-1433 and
143]]></descr>
                    <created>
                        <time>1493649494</time>
                        <username>admin@10.97.67.135</username>
                    </created>
                    <updated>
                        <time>1493649550</time>
                        <username>admin@10.97.67.135</username>
                    </updated>
                </rule>
                <rule>
                    <id/>
                    <tracker>1493649686</tracker>
                    <type>pass</type>
                    <interface>wan</interface>
                    <ipprotocol>inet</ipprotocol>
                    <tag/>
                    <tagged/>
                    <direction>any</direction>
                    <quick>yes</quick>
                    <floating>yes</floating>
                    <max/>
                    <max-src-nodes/>
                    <max-src-conn/>
                    <max-src-states/>
                    <statetimeout/>
                    <statetype>keep state</statetype>
                    <os/>
                    <protocol>tcp</protocol>
                    <source>
                        <any/>
                    </source>
                    <destination>
                        <network>lan</network>
                        <port>3389</port>
                    </destination>
```

```
                <descr><![CDATA[Allow Connection to RDP in LAN]]></descr>
                <updated>
                        <time>1493649686</time>
                        <username>admin@10.97.67.135</username>
                </updated>
                <created>
                        <time>1493649686</time>
                        <username>admin@10.97.67.135</username>
                </created>
        </rule>
        <rule>
                <id/>
                <tracker>1493649754</tracker>
                <type>pass</type>
                <interface>wan</interface>
                <ipprotocol>inet</ipprotocol>
                <tag/>
                <tagged/>
                <direction>any</direction>
                <quick>yes</quick>
                <floating>yes</floating>
                <max/>
                <max-src-nodes/>
                <max-src-conn/>
                <max-src-states/>
                <statetimeout/>
                <statetype>keep state</statetype>
                <os/>
                <protocol>tcp</protocol>
                <source>
                        <any/>
                </source>
                <destination>
                        <network>lan</network>
                        <port>389</port>
                </destination>
                <descr><![CDATA[Allow LDAP Connection to LAN]]></descr>
                <created>
                        <time>1493649754</time>
                        <username>admin@10.97.67.135</username>
```

```
                        </created>
                        <updated>
                                <time>1493650257</time>
                                <username>admin@10.97.67.135</username>
                        </updated>
                </rule>
                <rule>
                        <id/>
                        <tracker>1493650231</tracker>
                        <type>pass</type>
                        <interface>wan</interface>
                        <ipprotocol>inet</ipprotocol>
                        <tag/>
                        <tagged/>
                        <direction>any</direction>
                        <quick>yes</quick>
                        <floating>yes</floating>
                        <max/>
                        <max-src-nodes/>
                        <max-src-conn/>
                        <max-src-states/>
                        <statetimeout/>
                        <statetype>keep state</statetype>
                        <os/>
                        <protocol>tcp</protocol>
                        <source>
                                <any/>
                        </source>
                        <destination>
                                <network>lan</network>
                                <port>2389</port>
                        </destination>
                        <descr><![CDATA[Allow Alternate LDAP Connection to Radiant
]]></descr>
                        <updated>
                                <time>1493650231</time>
                                <username>admin@10.97.67.135</username>
                        </updated>
                        <created>
                                <time>1493650231</time>
```

```
                        <username>admin@10.97.67.135</username>
                    </created>
            </rule>
            <rule>
                    <id/>
                    <tracker>1493649801</tracker>
                    <type>pass</type>
                    <interface>wan</interface>
                    <ipprotocol>inet</ipprotocol>
                    <tag/>
                    <tagged/>
                    <direction>any</direction>
                    <quick>yes</quick>
                    <floating>yes</floating>
                    <max/>
                    <max-src-nodes/>
                    <max-src-conn/>
                    <max-src-states/>
                    <statetimeout/>
                    <statetype>keep state</statetype>
                    <os/>
                    <protocol>tcp</protocol>
                    <source>
                        <any/>
                    </source>
                    <destination>
                        <network>lan</network>
                        <port>636</port>
                    </destination>
                    <descr><![CDATA[Allow LDAPS Connection to LAN]]></descr>
                    <created>
                        <time>1493649801</time>
                        <username>admin@10.97.67.135</username>
                    </created>
                    <updated>
                        <time>1493650283</time>
                        <username>admin@10.97.67.135</username>
                    </updated>
            </rule>
            <rule>
```

```
                        <id/>
                        <tracker>1493649895</tracker>
                        <type>pass</type>
                        <interface>wan</interface>
                        <ipprotocol>inet</ipprotocol>
                        <tag/>
                        <tagged/>
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                        <floating>yes</floating>
                        <max/>
                        <max-src-nodes/>
                        <max-src-conn/>
                        <max-src-states/>
                        <statetimeout/>
                        <statetype>keep state</statetype>
                        <os/>
                        <protocol>tcp</protocol>
                        <source>
                               <any/>
                        </source>
                        <destination>
                               <network>lan</network>
                               <port>8000</port>
                        </destination>
                        <descr><![CDATA[Allow Connection to Port 8000 -Splunk
Web]]></descr>
                        <created>
                               <time>1493649895</time>
                               <username>admin@10.97.67.135</username>
                        </created>
                        <updated>
                               <time>1493649933</time>
                               <username>admin@10.97.67.135</username>
                        </updated>
                 </rule>
                 <rule>
                        <id/>
                        <tracker>1493650131</tracker>
                        <type>pass</type>
```

```
                        <interface>wan</interface>
                        <ipprotocol>inet</ipprotocol>
                        <tag/>
                        <tagged/>
                        <direction>any</direction>
                        <quick>yes</quick>
                        <floating>yes</floating>
                        <max/>
                        <max-src-nodes/>
                        <max-src-conn/>
                        <max-src-states/>
                        <statetimeout/>
                        <statetype>keep state</statetype>
                        <os/>
                        <protocol>tcp</protocol>
                        <source>
                              <any/>
                        </source>
                        <destination>
                              <network>lan</network>
                              <port>8089</port>
                        </destination>
                        <descr><![CDATA[Allow Connection to Port 8089 -Splunk management
por]]></descr>
                        <updated>
                              <time>1493650131</time>
                              <username>admin@10.97.67.135</username>
                        </updated>
                        <created>
                              <time>1493650131</time>
                              <username>admin@10.97.67.135</username>
                        </created>
                  </rule>
                  <rule>
                        <id/>
                        <tracker>1493650643</tracker>
                        <type>pass</type>
                        <interface>wan</interface>
                        <ipprotocol>inet</ipprotocol>
                        <tag/>
```

```
                    <tagged/>
                    <direction>any</direction>
                    <quick>yes</quick>
                    <floating>yes</floating>
                    <max/>
                    <max-src-nodes/>
                    <max-src-conn/>
                    <max-src-states/>
                    <statetimeout/>
                    <statetype>keep state</statetype>
                    <os/>
                    <protocol>tcp</protocol>
                    <source>
                          <any/>
                    </source>
                    <destination>
                          <network>lan</network>
                          <port>9997</port>
                    </destination>
                    <descr><![CDATA[Allow Connection to Port 9997 -Splunk
Forwarding]]></descr>
                    <updated>
                          <time>1493650643</time>
                          <username>admin@10.97.67.135</username>
                    </updated>
                    <created>
                          <time>1493650643</time>
                          <username>admin@10.97.67.135</username>
                    </created>
              </rule>
              <rule>
                    <id/>
                    <tracker>1481037634</tracker>
                    <type>pass</type>
                    <interface>lan</interface>
                    <ipprotocol>inet</ipprotocol>
                    <tag/>
                    <tagged/>
                    <direction>any</direction>
                    <quick>yes</quick>
```

```
                        <floating>yes</floating>
                        <max/>
                        <max-src-nodes/>
                        <max-src-conn/>
                        <max-src-states/>
                        <statetimeout/>
                        <statetype>keep state</statetype>
                        <os/>
                        <source>
                              <address>192.168.17.100</address>
                        </source>
                        <destination>
                              <any/>
                        </destination>
                        <descr><![CDATA[Allow Radiant (192.168.17.100) to outside -
LAN]]></descr>
                        <created>
                              <time>1481037634</time>
                              <username>admin@10.97.67.155</username>
                        </created>
                        <updated>
                              <time>1481037861</time>
                              <username>admin@10.97.67.155</username>
                        </updated>
                        <disabled/>
                  </rule>
                  <rule>
                        <id/>
                        <tracker>1481037754</tracker>
                        <type>pass</type>
                        <interface>wan</interface>
                        <ipprotocol>inet</ipprotocol>
                        <tag/>
                        <tagged/>
                        <direction>any</direction>
                        <quick>yes</quick>
                        <floating>yes</floating>
                        <max/>
                        <max-src-nodes/>
                        <max-src-conn/>
```

```
                        <max-src-states/>
                        <statetimeout/>
                        <statetype>keep state</statetype>
                        <os/>
                        <source>
                              <address>192.168.17.100</address>
                        </source>
                        <destination>
                              <any/>
                        </destination>
                        <descr><![CDATA[Allow Radiant (192.168.17.100) to outside -
WAN]]></descr>
                        <created>
                              <time>1481037754</time>
                              <username>admin@10.97.67.155</username>
                        </created>
                        <updated>
                              <time>1481037814</time>
                              <username>admin@10.97.67.155</username>
                        </updated>
                        <disabled/>
                  </rule>
                  <rule>
                        <id/>
                        <tracker>1472179706</tracker>
                        <type>pass</type>
                        <interface>wan,lan</interface>
                        <ipprotocol>inet</ipprotocol>
                        <tag/>
                        <tagged/>
                        <direction>any</direction>
                        <quick>yes</quick>
                        <floating>yes</floating>
                        <max/>
                        <max-src-nodes/>
                        <max-src-conn/>
                        <max-src-states/>
                        <statetimeout/>
                        <statetype>keep state</statetype>
                        <os/>
```

```
                <protocol>tcp</protocol>
                <source>
                        <any/>
                </source>
                <destination>
                        <any/>
                </destination>
                <descr><![CDATA[Test for comms between 2017 and 2019]]></descr>
                <updated>
                        <time>1472179706</time>
                        <username>admin@10.97.67.137</username>
                </updated>
                <created>
                        <time>1472179706</time>
                        <username>admin@10.97.67.137</username>
                </created>
                <disabled/>
        </rule>
        <rule>
                <id/>
                <tracker>1469130242</tracker>
                <type>pass</type>
                <interface>wan</interface>
                <ipprotocol>inet</ipprotocol>
                <tag/>
                <tagged/>
                <max/>
                <max-src-nodes/>
                <max-src-conn/>
                <max-src-states/>
                <statetimeout/>
                <statetype>keep state</statetype>
                <os/>
                <protocol>tcp/udp</protocol>
                <source>
                        <any/>
                </source>
                <destination>
                        <network>wanip</network>
                        <port>80</port>
```

```
                    </destination>
                    <descr><![CDATA[Allow to Port 80 on Firewall WAN]]></descr>
                    <created>
                          <time>1469130242</time>
                          <username>admin@192.168.17.103</username>
                    </created>
                    <updated>
                          <time>1493649052</time>
                          <username>admin@10.97.67.135</username>
                    </updated>
              </rule>
              <rule>
                    <id/>
                    <tracker>1465935549</tracker>
                    <type>pass</type>
                    <interface>wan</interface>
                    <ipprotocol>inet</ipprotocol>
                    <tag/>
                    <tagged/>
                    <max/>
                    <max-src-nodes/>
                    <max-src-conn/>
                    <max-src-states/>
                    <statetimeout/>
                    <statetype>keep state</statetype>
                    <os/>
                    <protocol>icmp</protocol>
                    <source>
                          <any/>
                    </source>
                    <destination>
                          <any/>
                    </destination>
                    <descr/>
                    <updated>
                          <time>1465935549</time>
                          <username>admin@192.168.17.100</username>
                    </updated>
                    <created>
                          <time>1465935549</time>
```

```
                        <username>admin@192.168.17.100</username>
                    </created>
            </rule>
            <rule>
                    <id/>
                    <tracker>1461788221</tracker>
                    <type>pass</type>
                    <interface>wan</interface>
                    <ipprotocol>inet</ipprotocol>
                    <tag/>
                    <tagged/>
                    <max/>
                    <max-src-nodes/>
                    <max-src-conn/>
                    <max-src-states/>
                    <statetimeout/>
                    <statetype>keep state</statetype>
                    <os/>
                    <protocol>tcp</protocol>
                    <source>
                        <any/>
                    </source>
                    <destination>
                        <network>wanip</network>
                        <port>443</port>
                    </destination>
                    <descr><![CDATA[Allow to Port 443 on Firewall WAN]]></descr>
                    <created>
                        <time>1461788221</time>
                        <username>admin@192.168.1.2</username>
                    </created>
                    <updated>
                        <time>1493649121</time>
                        <username>admin@10.97.67.135</username>
                    </updated>
            </rule>
            <rule>
                    <source>
                        <any/>
                    </source>
```

```
                <interface>wan</interface>
                <protocol>tcp/udp</protocol>
                <destination>
                        <address>192.168.17.11</address>
                        <port>5176</port>
                </destination>
                <descr><![CDATA[NAT Mapping to ConsoleWorks]]></descr>
                <associated-rule-id>nat_57bf06b1aa4c21.26556306</associated-rule-id>
                <tracker>1472136881</tracker>
                <created>
                        <time>1472136881</time>
                        <username>NAT Port Forward</username>
                </created>
                <disabled/>
        </rule>
        <rule>
                <id/>
                <tracker>1469130278</tracker>
                <type>pass</type>
                <interface>lan</interface>
                <ipprotocol>inet</ipprotocol>
                <tag/>
                <tagged/>
                <max/>
                <max-src-nodes/>
                <max-src-conn/>
                <max-src-states/>
                <statetimeout/>
                <statetype>keep state</statetype>
                <os/>
                <protocol>tcp/udp</protocol>
                <source>
                        <any/>
                </source>
                <destination>
                        <any/>
                        <port>22</port>
                </destination>
                <descr><![CDATA[Test to port 22]]></descr>
```

```
                <created>
                        <time>1469130278</time>
                        <username>admin@192.168.17.103</username>
                </created>
                <updated>
                        <time>1472170372</time>
                        <username>admin@192.168.13.135</username>
                </updated>
                <disabled/>
        </rule>
        <rule>
                <id/>
                <tracker>1465935564</tracker>
                <type>pass</type>
                <interface>lan</interface>
                <ipprotocol>inet</ipprotocol>
                <tag/>
                <tagged/>
                <max/>
                <max-src-nodes/>
                <max-src-conn/>
                <max-src-states/>
                <statetimeout/>
                <statetype>keep state</statetype>
                <os/>
                <protocol>icmp</protocol>
                <source>
                        <any/>
                </source>
                <destination>
                        <any/>
                </destination>
                <descr/>
                <updated>
                        <time>1465935564</time>
                        <username>admin@192.168.17.100</username>
                </updated>
                <created>
                        <time>1465935564</time>
                        <username>admin@192.168.17.100</username>
```

```
                        </created>
                </rule>
                <rule>
                        <type>pass</type>
                        <ipprotocol>inet</ipprotocol>
                        <descr><![CDATA[Default allow LAN to any rule]]></descr>
                        <interface>lan</interface>
                        <tracker>0100000101</tracker>
                        <source>
                                <network>lan</network>
                        </source>
                        <destination>
                                <any/>
                        </destination>
                </rule>
                <rule>
                        <type>pass</type>
                        <ipprotocol>inet6</ipprotocol>
                        <descr><![CDATA[Default allow LAN IPv6 to any rule]]></descr>
                        <interface>lan</interface>
                        <tracker>0100000102</tracker>
                        <source>
                                <network>lan</network>
                        </source>
                        <destination>
                                <any/>
                        </destination>
                </rule>
                <separator>
                        <wan/>
                        <lan/>
                        <floatingrules/>
                </separator>
                <bypassstaticroutes>yes</bypassstaticroutes>
        </filter>
        <shaper>
        </shaper>
        <ipsec/>
        <aliases/>
        <proxyarp/>
```

```
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                <item>
                        <minute>1,31</minute>
                        <hour>0-5</hour>
                        <mday>*</mday>
                        <month>*</month>
                        <wday>*</wday>
                        <who>root</who>
                        <command>/usr/bin/nice -n20 adjkerntz -a</command>
                </item>
                <item>
                        <minute>1</minute>
                        <hour>3</hour>
                        <mday>1</mday>
                        <month>*</month>
                        <wday>*</wday>
                        <who>root</who>
                        <command>/usr/bin/nice -n20 /etc/rc.update_bogons.sh</command>
                </item>
                <item>
                        <minute>*/60</minute>
                        <hour>*</hour>
                        <mday>*</mday>
                        <month>*</month>
                        <wday>*</wday>
                        <who>root</who>
                        <command>/usr/bin/nice -n20 /usr/local/sbin/expiretable -v -t 3600
sshlockout</command>
                </item>
                <item>
                        <minute>*/60</minute>
                        <hour>*</hour>
                        <mday>*</mday>
                        <month>*</month>
                        <wday>*</wday>
                        <who>root</who>
                        <command>/usr/bin/nice -n20 /usr/local/sbin/expiretable -v -t 3600
webConfiguratorlockout</command>
                </item>
                <item>
```

```
                        <minute>1</minute>
                        <hour>1</hour>
                        <mday>*</mday>
                        <month>*</month>
                        <wday>*</wday>
                        <who>root</who>
                        <command>/usr/bin/nice -n20 /etc/rc.dyndns.update</command>
                </item>
                <item>
                        <minute>*/60</minute>
                        <hour>*</hour>
                        <mday>*</mday>
                        <month>*</month>
                        <wday>*</wday>
                        <who>root</who>
                        <command>/usr/bin/nice -n20 /usr/local/sbin/expiretable -v -t 3600
virusprot</command>
                </item>
                <item>
                        <minute>30</minute>
                        <hour>12</hour>
                        <mday>*</mday>
                        <month>*</month>
                        <wday>*</wday>
                        <who>root</who>
                        <command>/usr/bin/nice -n20 /etc/rc.update_urltables</command>
                </item>
        </cron>
        <wol/>
        <rrd>
                <enable/>
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processor&amp;right=&amp;resolution=300&amp;timePeriod=-
1d&amp;startDate=&amp;endDate=&amp;startTime=0&amp;endTime=0&amp;graphtype=line&amp;in
vert=true</category>
        </rrd>
        <load_balancer>
                <monitor_type>
                        <name>ICMP</name>
                        <type>icmp</type>
                        <descr><![CDATA[ICMP]]></descr>
```

```
                <options/>
            </monitor_type>
            <monitor_type>
                <name>TCP</name>
                <type>tcp</type>
                <descr><![CDATA[Generic TCP]]></descr>
                <options/>
            </monitor_type>
            <monitor_type>
                <name>HTTP</name>
                <type>http</type>
                <descr><![CDATA[Generic HTTP]]></descr>
                <options>
                    <path>/</path>
                    <host/>
                    <code>200</code>
                </options>
            </monitor_type>
            <monitor_type>
                <name>HTTPS</name>
                <type>https</type>
                <descr><![CDATA[Generic HTTPS]]></descr>
                <options>
                    <path>/</path>
                    <host/>
                    <code>200</code>
                </options>
            </monitor_type>
            <monitor_type>
                <name>SMTP</name>
                <type>send</type>
                <descr><![CDATA[Generic SMTP]]></descr>
                <options>
                    <send/>
                    <expect>220 *</expect>
                </options>
            </monitor_type>
        </load_balancer>
        <widgets>
```

```
        <sequence>system_information:col1:open,gateways:col1:open,interfaces:col2:open<
/sequence>
        </widgets>
        <openvpn/>
        <dnshaper>
        </dnshaper>
        <unbound>
                <enable/>
                <dnssec/>
                <active_interface/>
                <outgoing_interface/>
                <custom_options/>
                <hideidentity/>
                <hideversion/>
                <dnssecstripped/>
        </unbound>
        <dhcpdv6>
                <lan>
                        <range>
                                <from>::1000</from>
                                <to>::2000</to>
                        </range>
                        <ramode>assist</ramode>
                        <rapriority>medium</rapriority>
                </lan>
        </dhcpdv6>
        <cert>
                <refid>5720a0502b277</refid>
                <descr><![CDATA[webConfigurator default (5720a0502b277)]]></descr>
                <type>server</type>

        <crt>LS0tLS1CRUdJTiBDRVJUSUZJQ0FURS0tLS0tCk1JSUZiVENDQkZXZ0F3SUJBZ0lCQURBTkJna3
Foa2lHOXcwQkFRc0ZBRENCdERFTE1Ba0dBMVVFQmhNQ1ZWTXgKRGpBTUJnTlZCQWdUQlZOMFlYUmxNUkV3RHdZ
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pJM056QWVGdzB4TmpBME1qY3hNVEU1TkRSYUZ3MHlNVEV3TVRneApNVEU1TkRSYU1JRzBNUXN3Q1FZRFZRUUdF
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V5OXdabE5sYm5ObElIZGxZa052Ym1acFozVnlZWFJ2Y2lCVFpXeG0KTFZOcFoyNWxaQ0JEWlhKMGFXWnBZMkYw
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Appendix A List of Acronyms

AD Active Directory

ARM Access Rights Management

CA Certificate Authority

CSF Cybersecurity Framework

FBA Forms Based Authentication

GPO Government Printing Office, Group Policy Object (depending on context)

GUI Graphical User Interface

HTCC HyTrust CloudControl

IdAM Identity and Access Management

IT Information Technology

LDAP Lightweight Directory Access Protocol

LDAPS Lightweight Directory Access Protocol (Secure)

NCCoE National Cybersecurity Center of Excellence

NIST National Institute of Standards and Technology

PEP Policy Enforcement Point

RMF Risk Management Framework

SA Situational Awareness

SCM Security Compliance Manager

SIEM Security Information and Event Management

RDP Remote Desktop Protocol

VD Virtual Directory

VDS Virtual Directory System

VM Virtual Machine

VNC Virtual Network Computing

VPN Virtual Private Network