Implementing a Zero Trust Architecture

Volume C: How-To Guides

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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: nccoe-zta-project@list.nist.gov.

Public comment period: July 19, 2023 through September 4, 2023

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

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NIST Cybersecurity Practice Guides (Special Publication 1800 series) 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 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

A zero trust architecture (ZTA) focuses on protecting data and resources. It enables secure authorized access to enterprise resources that are distributed across on-premises and multiple cloud environments, while enabling a hybrid workforce and partners to access resources from anywhere, at any time, from any device in support of the organization’s mission. Each access request is evaluated by verifying the context available at access time, including the requester’s identity and role, the requesting device’s health and credentials, and the sensitivity of the resource. If the enterprise’s defined access policy is met, a secure session is created to protect all information transferred to and from the resource. A real-time and continuous policy-driven, risk-based assessment is performed to establish and maintain the...
access. In this project, the NCCoE and its collaborators use commercially available technology to build interoperable, open, standards-based ZTA implementations that align to the concepts and principles in NIST Special Publication (SP) 800-207, Zero Trust Architecture. This NIST Cybersecurity Practice Guide explains how commercially available technology can be integrated and used to build various ZTAs.

**KEYWORDS**

enhanced identity governance (EIG); identity, credential, and access management (ICAM); microsegmentation; software-defined perimeter (SDP); zero trust; zero trust architecture (ZTA).

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1 Introduction

The following volume of this guide shows information technology (IT) professionals and security engineers how we implemented ten example zero trust architecture (ZTA) solutions. We cover all of the products employed in this reference design.

Note: This is not comprehensive documentation. There are many possible service and security configurations for these products that are out of scope for these demonstrations.

1.1 How to Use this Guide

This NIST Cybersecurity Practice Guide will help users develop a plan for migrating to ZTA. It demonstrates a standards-based reference design for implementing a ZTA and provides users with the information they need to replicate ten different implementations of this reference design. Each of these implementations, which are known as builds, are standards-based and align to the concepts and principles in NIST Special Publication (SP) 800-207, Zero Trust Architecture. The reference design described in this practice guide is modular and can be deployed in whole or in part, enabling organizations to incorporate ZTA into their legacy environments gradually, in a process of continuous improvement that brings them closer and closer to achieving the ZTA goals that they have prioritized based on risk, cost, and resources.

NIST is adopting an agile process to publish this content. Each volume is being made available as soon as possible rather than delaying release until all volumes are completed. Work continues on implementing the example solutions and developing other parts of the content. As a third preliminary draft, we will publish at least one additional draft for public comment before it is finalized.

When complete, this guide will contain five volumes:

- NIST SP 1800-35A: Executive Summary – why we wrote this guide, the challenge we address, why it could be important to your organization, and our approach to solving this challenge
- NIST SP 1800-35C: How-To Guides – instructions for building the example implementations, including all the security-relevant details that would allow you to replicate all or parts of this project (you are here)
- NIST SP 1800-35D: Functional Demonstrations – use cases that have been defined to showcase ZTA security capabilities and the results of demonstrating them with each of the example implementations
- NIST SP 1800-35E: Risk and Compliance Management – risk analysis and mapping of ZTA security characteristics to cybersecurity standards and recommended practices
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 1800-35A, which describes the following topics:

- challenges that enterprises face in migrating to the use of ZTA
- example solution built at the National Cybersecurity Center of Excellence (NCCoE)
- benefits of adopting the example solution

**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 1800-35B, which describes what we did and why.

Also, Section 3 of Risk and Compliance Management, NIST SP 1800-35E, will be of particular interest. Section 3, ZTA Reference Architecture Security Mappings, maps logical components of the general ZTA reference design to security characteristics listed in various cybersecurity guidelines and recommended practices documents, including Framework for Improving Critical Infrastructure Cybersecurity (NIST Cybersecurity Framework), Security and Privacy Controls for Information Systems and Organizations (NIST SP 800-53), and Security Measures for “EO-Critical Software” Use Under Executive Order (EO) 14028.

You might share the Executive Summary, NIST SP 1800-35A, with your leadership team members to help them understand the importance of migrating toward standards-based ZTA implementations that align to the concepts and principles in NIST SP 800-207, Zero Trust Architecture.

**IT professionals** who want to implement similar solutions will find the whole practice guide useful. You can use the how-to portion of the guide, NIST SP 1800-35C, to replicate all or parts of the builds created in our lab. The how-to portion of the guide provides specific product installation, configuration, and integration instructions for implementing the example solutions. We do not re-create the product manufacturers’ documentation, which is generally widely available. Rather, we show how we incorporated the products together in our environment to create an example solution. Also, you can use Functional Demonstrations, NIST SP 1800-35D, which provides the use cases that have been defined to showcase ZTA security capabilities and the results of demonstrating them with each of the example implementations.

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. 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 ZTA. Your organization’s security experts should identify the products that will best integrate with your existing tools and IT system infrastructure. We hope that you will seek products that are congruent with applicable standards and best practices.
A NIST Cybersecurity Practice Guide does not describe “the” solution, but example solutions. This is a third preliminary draft guide. As the project progresses, the third preliminary draft will be updated, and additional volumes will also be released for comment. We seek feedback on the publication’s contents and welcome your input. Comments, suggestions, and success stories will improve subsequent versions of this guide. Please contribute your thoughts to nccoe-zta-project@list.nist.gov.

1.2 Build Overview

This NIST Cybersecurity Practice Guide addresses the challenge of using standards-based protocols and available technologies to build a ZTA. In our lab at the NCCoE and using our collaborators’ cloud infrastructure, we plan to implement and demonstrate a variety of builds that serve as example ZTA solutions, each of which is designed to dynamically and securely manage access to resources across a set of use cases that a medium or large enterprise might typically deploy. Our plan is to implement these builds in a series of phases, starting with a baseline enterprise architecture that represents the typical legacy components that an enterprise might start with when deciding to begin adding zero trust capabilities.

We began with builds for enhanced identity governance (EIG) that were restricted to a limited set of capabilities. We call these EIG crawl phase builds. The central capabilities of these builds are identity, credential, and access management (ICAM) and endpoint protection. In particular, these EIG crawl phase builds do not include separate, centralized policy engine (PE) or policy administration (PA) components. Instead, these initial EIG crawl phase builds rely upon the PE and PA capabilities provided by their ICAM components. We did not perform an EIG walk phase. After completing the EIG crawl phase builds, we enhanced these implementations by adding specialized PE and PA components, device discovery, and cloud-based resources in the EIG run phase. Next, we began the software-defined perimeter (SDP) and microsegmentation phase of the project. As its name suggests, this phase involved integrating ZTA components that support one or both of the SDP and microsegmentation deployment models. It also integrated additional supporting components and features to provide an increasingly rich set of ZTA functionalities.

This practice guide provides instructions for reproducing the builds that we have implemented so far:

- EIG crawl phase builds:
  - Enterprise 1 Build 1 (E1B1)
  - Enterprise 2 Build 1 (E2B1)
  - Enterprise 3 Build 1 (E3B1)

- EIG run phase builds:
  - Enterprise 1 Build 2 (E1B2)
  - Enterprise 3 Build 2 (E3B2)
The NCCoE worked with members of the ZTA community of interest to develop a diverse but non-comprehensive set of use cases and scenarios to demonstrate the capabilities of the builds. The use cases are summarized in NIST SP 1800-35D, Functional Demonstrations.

1.2.1 EIG Crawl Phase Build Features

A general ZTA reference design is depicted in Figure 4-1 of Volume B. It consists of ZTA core components: a policy decision point (PDP), which includes both a PE and a PA, and one or more policy enforcement points (PEPs); and ZTA functional components for ICAM, security analytics, data security, and endpoint security. The EIG crawl phase builds that have been created so far differ from this reference design insofar as they do not include separate, dedicated PDP components. Their ICAM component serves as their PDP, and they include very limited data security and security analytics functionality. These limitations were intentionally placed on the initial builds in an attempt to demonstrate the ZTA functionality that an enterprise that currently has ICAM and endpoint protection solutions deployed will be able to support without having to add additional ZTA-specific capabilities.

Each EIG crawl phase build is instantiated in a unique way, depending on the equipment used and the capabilities supported. Briefly, the three builds are as follows:

- E1B1 uses products from IBM, Ivanti, Mandiant, Okta, Radiant Logic, SailPoint, Tenable, and Zimperium. Certificates from DigiCert are also used.
- E2B1 uses products from Cisco Systems, IBM, Mandiant, Palo Alto Networks, Ping Identity, Radiant Logic, SailPoint, and Tenable. Certificates from DigiCert are also used.
- E3B1 uses products from F5, ForeScout, Lookout, Mandiant, Microsoft, Palo Alto Networks, PC Matic, and Tenable. Certificates from DigiCert are also used.

1.2.2 EIG Run Phase Build Features

The EIG run phase, as its name suggests, builds upon the EIG crawl phase architecture. The EIG run phase no longer imposes the requirement that the PE and PA components must be provided by the ICAM products used in the build. It also adds capabilities to the EIG crawl phase. In addition to protecting access to resources that are located on-premises, the run phase also protects access to some resources that are hosted in the cloud. The EIG run phase includes a device discovery capability, which is
performed as part of the baseline. In addition to monitoring and alerting when new devices are detected, enforcement can be enabled to deny access to devices that are not compliant. The run phase also includes the capability to establish a tunnel between the requesting endpoint and the resource being accessed over which access to the resource can be brokered.

Each EIG run phase build is instantiated in a unique way, depending on the equipment used and the capabilities supported. Briefly, the three builds are as follows:

- E1B2 uses products from Amazon Web Services, IBM, Ivanti, Mandiant, Okta, Radiant Logic, SailPoint, Tenable, and Zscaler. Certificates from DigiCert are also used.
- E3B2 uses products from F5, Forescout, Mandiant, Microsoft, Palo Alto Networks, PC Matic, and Tenable. Certificates from DigiCert are also used.
- E4B3 uses products from IBM, Mandiant, Palo Alto Networks, Tenable, and VMware. Certificates from DigiCert are also used.

1.2.3 SDP and Microsegmentation Phase Build Features

The SDP and microsegmentation phase builds are based on the general ZTA reference design that is depicted in Figure 4-1 of Volume B. It consists of ZTA core components: a PDP, which includes both a PE and a PA, and one or more PEPs; and ZTA functional components for ICAM, security analytics, data security, and endpoint security. The builds implemented in the SDP and microsegmentation phase of the project each deploy elements of either the SDP deployment model, the microsegmentation deployment model, or both.

Each SDP and microsegmentation phase build is instantiated in a unique way, depending on the equipment used and the capabilities supported. Briefly, the four builds are as follows:

- E1B3 uses all of the same products and technologies as E1B2, so there is no separate section for E1B3 in this document.
- E2B3 uses products from Cisco Systems, IBM, Mandiant, Palo Alto Networks, Ping Identity, Radiant Logic, SailPoint, Tenable, and VMware. Certificates from DigiCert are also used.
- E3B3 uses products from F5, Forescout, Mandiant, Microsoft, Palo Alto Networks, PC Matic, and Tenable. Certificates from DigiCert are also used.
- E1B4 uses products from Amazon Web Services, Appgate, IBM, Ivanti, Mandiant, Okta, Radiant Logic, SailPoint, Tenable, and Zimperium. Certificates from DigiCert are also used.

1.2.4 Physical Architecture Overview

The laboratory environment in which the builds have been implemented is depicted and described in detail in Section 4.3 of Volume B. The laboratory architecture drawing from that volume is reproduced here in Figure 1-1. As shown, this laboratory environment includes four separate enterprise
environments, each hosting its own distinct implementation of a ZTA architecture. The enterprises may interoperate as needed by a given use case, and the baseline enterprise environments have the flexibility to support enhancements. The laboratory environment also includes a management virtual local area network (VLAN) on which the following components are installed: Ansible, Terraform, MSV Director, and MSV Protected Theater. These management components support infrastructure as code (IaC) automation and orchestration.
Figure 1-1 Laboratory Infrastructure for the EIG Builds
The following builds are supported within the physical architecture depicted in Figure 1-1 and documented in the remainder of this guide:


- E2B1 components consist of Cisco Duo, DigiCert CertCentral, IBM Security QRadar XDR, Mandiant MSV, Palo Alto Networks Next Generation Firewall (NGFW), PingFederate, which is a service in the Ping Identity Software as a Service (SaaS) offering of PingOne, Radiant Logic RadiantOne Intelligent Identity Data Platform, SailPoint IdentityIQ, Tenable.ad, Tenable.io, and Tenable Nessus Network Monitor (NNM).

- E3B1 components consist of DigiCert CertCentral, F5 BIG-IP, Forescout eyeSight, Lookout Mobile Endpoint Security (MES), Mandiant MSV, Microsoft Azure Active Directory (AD), Microsoft Defender for Endpoint, Microsoft Endpoint Manager, Microsoft Sentinel, Palo Alto Networks NGFW, PC Matic Pro, Tenable.ad, and Tenable.io.

- E1B2 and E1B3 components consist of Amazon Web Services (AWS) Infrastructure as a Service (IaaS), DigiCert CertCentral, IBM CP4S, IBM Security QRadar XDR, Mandiant MSV, Okta Identity Cloud, Okta Verify App, Radiant Logic RadiantOne Intelligent Identity Data Platform, SailPoint IdentityIQ, Tenable.ad, Tenable.io, Tenable NNM, Zscaler Admin Portal, Zscaler Application Connector, Zscaler Central Authority, Zscaler Client Connector (ZCC), Zscaler Internet Access (ZIA) Public Service Edges, and Zscaler Private Access (ZPA) Public Service Edges.

- E3B2 components consist of DigiCert CertCentral, F5 BIG-IP, Forescout eyeControl, Forescout eyeExtend, Forescout eyeSegment, Forescout eyeSight, Mandiant MSV, Microsoft AD, Microsoft Azure AD, Microsoft Azure AD (Conditional Access), Microsoft Azure AD Identity Protection, Microsoft Azure (IaaS), Microsoft Defender for Cloud, Microsoft Defender for Cloud Apps, Microsoft Defender for Endpoint, Microsoft Intune, Microsoft Office 365 (SaaS), Microsoft Sentinel, Palo Alto Networks NGFW, PC Matic Pro, Tenable.ad, Tenable.io, and Tenable NNM.

- E2B3 components consist of Cisco Duo, Cisco Identity Services Engine (ISE), Cisco network devices, Cisco Secure Endpoint (CSE), Cisco Secure Network Analytics (SNA), Cisco Secure Workload, DigiCert CertCentral, IBM Security QRadar XDR, Mandiant MSV, Palo Alto Networks NGFW, Ping Identity PingOne, Radiant Logic RadiantOne Intelligent Identity Data Platform, SailPoint IdentityIQ, Tenable.ad, Tenable.io, Tenable NNM, VMware Workspace ONE UEM and Access.

- E3B3 components consist of DigiCert CertCentral, F5 BIG-IP, Forescout eyeControl, Forescout eyeExtend, Forescout eyeSight, Forescout eyeSegment, Mandiant MSV, Microsoft AD, Microsoft Azure AD, Microsoft Azure AD (Conditional Access), Microsoft Azure AD Identity Governance, Microsoft Intune, Microsoft Sentinel, Microsoft Azure App Proxy, Microsoft Defender for Endpoint, Microsoft Azure AD Identity Protection, Microsoft Defender for Identity, Microsoft...
Defender for Office, Microsoft Entra Permissions Management, Microsoft Defender for Cloud Apps, Microsoft Purview – Data Loss Prevention (DLP), Microsoft Purview Information Protection, Microsoft Purview Information Protection Scanner, Microsoft Intune VPN Tunnel, Microsoft Azure Arc, Microsoft Azure Automanage, Microsoft Intune Privilege Access Workstation, Microsoft Azure Virtual Desktop Windows 365, Microsoft Defender for Cloud, Microsoft Azure (IaaS), Microsoft Office 365 (SaaS), Palo Alto Networks NGFW, PC Matic Pro, Tenable.io, Tenable.ad, and Tenable NNM.

- E4B3 components consist of DigiCert CertCentral, IBM CP4S, IBM QRadar XDR, IBM Security Guardium Data Encryption, IBM Security MaaS360 (for both laptops and mobile devices), IBM Security Verify, Mandiant MSV, Palo Alto Networks GlobalProtect VPN, Tenable.ad, Tenable.io, Tenable NN, and VMware infrastructure.

- E1B4 components consist of Appgate SDP Controller, Appgate SDP Gateway, Appgate SDP client, Appgate Portal, AWS IaaS and SaaS, DigiCert CertCentral, IBM CP4S, IBM Security QRadar XDR, Ivanti Neurons for UEM Platform, Mandiant MSV, Okta Identity Cloud, Okta Verify App, Radiant Logic RadiantOne Intelligent Identity Data Platform, SailPoint IdentityIQ, Tenable.ad, Tenable.io, Tenable NN, and Zimperium MTD.

For a detailed description of the architecture of each build, see Volume B, Appendices D to M. The remainder of this guide describes how to implement the EIG crawl, EIG run, and SDP and microsegmentation phase builds.
1.3 Typographic Conventions

The following table presents typographic conventions used in this volume.

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<tr>
<th>Typeface/Symbol</th>
<th>Meaning</th>
<th>Example</th>
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<tbody>
<tr>
<td><em>Italics</em></td>
<td>file names and path names; references to documents that are not hyperlinks; new terms; and placeholders</td>
<td>For language use and style guidance, see the <em>NCCoE Style Guide</em>.</td>
</tr>
<tr>
<td><strong>Bold</strong></td>
<td>names of menus, options, command buttons, and fields</td>
<td>Choose <em>File &gt; Edit</em>.</td>
</tr>
<tr>
<td>Monospace</td>
<td>command-line input, onscreen computer output, sample code examples, and status codes</td>
<td><em>mkdir</em></td>
</tr>
<tr>
<td><strong>Monospace Bold</strong></td>
<td>command-line user input contrasted with computer output</td>
<td><em>service sshd start</em></td>
</tr>
<tr>
<td><strong>blue text</strong></td>
<td>link to other parts of the document, a web URL, or an email address</td>
<td>All publications from NIST’s NCCoE are available at <a href="https://www.nccoe.nist.gov">https://www.nccoe.nist.gov</a>.</td>
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2 Enterprise 1 Build 1 (E1B1) Product Guides

This section of the practice guide contains detailed instructions for installing, configuring, and integrating all of the products used to implement E1B1. For additional details on E1B1’s logical and physical architectures, please refer to Volume B.

2.1 Okta Identity Cloud

The Okta Identity Cloud is a SaaS solution that provides ICAM capabilities to an enterprise. The following sections describe the setup of the Okta Identity Cloud, the Okta Access Gateway, and the Okta Verify application. Okta integrates with Radiant Logic for identity information, SailPoint to receive governance information, and Ivanti to delegate authentication for users accessing resources using mobile devices.

2.1.1 Configuration and Integration

The purpose of this subsection is to set up NCCoE’s own instance of the Okta cloud so it can integrate with other ICAM tools and enable Okta to manage authentication and authorization of users accessing resources. Most configurations are completed within this instance of the Okta cloud.

1. Sign up for an account with Okta (okta.com) and follow steps to set up an admin account, along with configuring Okta Verify for the admin account. This will allow the admin to start configuring integrations and services.
2. Set up directory integration with Radiant Logic. User identity information is pulled from Radiant Logic into Okta for authentication and authorization. An Okta Lightweight Directory Access Protocol (LDAP) agent is installed on the Radiant Logic server for integration. Note: This step should be completed after Radiant Logic is configured.

3. Create Groups for Okta to apply a specific set of users to specific services or applications. This allows for automation of user governance at a large scale rather than manual configuration of individual users.

4. Create application programming interface (API) tokens to be used by SailPoint and Radiant Logic for communication. These tokens will allow Okta to give specific read/write privileges to other applications.

5. Create a delegated authentication for Okta to be able to import users from Radiant Logic via LDAP. This allows Okta to delegate the actual authentication to Radiant Logic. Okta does not store or know the password of the user. Note that a service account, created in the Radiant Logic Integration section 2.2.3, needs to be created and used in this configuration.

6. Create application integration via Security Assertion Markup Language (SAML). We have Ivanti Neurons for UEM and 2 GitLab instances in Enterprise 1. Okta Access Gateway (AG) needs to be installed in order to configure on-premises applications. The Okta AG gives the Okta Identity Cloud visibility to the resources inside the enterprise. See Section 2.1.3 for installation instructions, which include information on configuring on-premises applications.

7. Create Identity Provider integration for Ivanti Access ZSO. This will allow delegated authentication for Ivanti for mobile devices. This involves creating a custom application using SAML and then creating a SAML Identity Provider.

8. Configure Device Trust on iOS and Android devices to create device integrations.

9. Create authentication policies. These policies define how users will authenticate. By default, a “Catch All” policy is created when an application is created. We are creating an authentication policy that will allow Okta to trust Ivanti Access ZSO to be the delegated Identity Provider (IdP). To do this, when Okta checks that Okta Verify is a managed application on a device, it will delegate authentication to Ivanti Access ZSO.

2.1.2 Okta Verify App

The Okta Verify app is installed, usually on a mobile device, when a new user is onboarded. It serves as a tool to provide a second factor for authentication. The user can log in to the Okta Identity Cloud for the first time. For this setup, the user will be asked to change their password and perform setup. After the password update, the user can set up Okta Verify. Follow the instructions for Android or iOS devices to install Okta Verify and complete the process.


2.1.3 Okta Access Gateway

The Okta Access Gateway (AG) is part of the Okta Identity Cloud. It can be leveraged to integrate legacy, on-prem applications into the Okta Identity Cloud. Since the Okta Identity Cloud cannot communicate with Enterprise 1 resources directly, the Okta AG acts as a proxy to facilitate that communication. More information on installing and configuring the Okta AG is available online.

2.2 Radiant Logic RadiantOne

Radiant Logic RadiantOne is an ICAM solution that unifies identity data, making access reusable and scalable for the enterprise.

2.2.1 Installation

RadiantOne is to be installed on a Microsoft Windows 2019 server. See the RadiantOne v7.4.1 documentation from the Radiant Logic website for system specifications. Prerequisites are in Chapter 1 of the RadiantOne Installation Guide. Note: You need to create an account within the Radiant Logic website in order to access the installation and configuration documentation.

Once you download and launch the executable for a Windows server installation, follow the step-by-step instructions provided on the screen. We used default settings unless specified below. Instructions can also be found in Chapter 2 of the RadiantOne Installation Guide.

- Choose RadiantOne Federated Identity Suite New Cluster/Standalone for the Install Set.
- Provide a name and password for the Cluster settings.
- For the Server Configuration step, use the following ports: LDAP = 389, LDAPS = 636, and Scheduler Port = 1099.

2.2.2 Configuration

2.2.2.1 Sync with an LDAP server

1. Once installation is complete, log in to RadiantOne from a web browser on the Radiant Logic server, https://localhost:7171. Note: ensure the proper SSL certificate is on the server for HTTPS.

2. Initial configuration is to sync up with an LDAP server. Go to Settings > Server Backend > LDAP Data Sources. The screenshot below shows the information created for Enterprise 1 AD. See the RadiantOne Namespace Configuration Guide Chapter 3 for details.
3. Once the connection is tested and successful, the integration is completed.

4. Next, create a Directory Namespace by going to **Directory Namespace** and selecting **Create New Naming Context**. Click **Next** and click **OK**.

5. Find **DC=NCCOE,DC=ORG** under **Root Naming Contexts** on the left side of the screen. Click the **New Level** button. Enter **ent1** as the name for the **OU** and click **OK**.

6. Click on **ou=ent1** on the left side and click the **New Level** button on the right to create a sub-ou called **groups**.

7. Click on **ou=ent1** on the left side and click the **New Level** button on the right to create a sub-ou called **users**.

8. Once configured and saved, click on **ou=users** and click on **Backend Mapping** on the right. Select **LDAP Backend**. Click **Next** and **Browse** for the proper **Remote Base DN**. Then click **OK**. The screenshot is the completed configuration for the sub-ou users Proxy Backend.
9. Go to Objects and create a primary object and Join Profile by clicking Add on each object. Click Save. Now we have data sources from LDAP and our database.

2.2.2.2 Create a namespace to bring in users

1. In Directory Namespace, click the + sign. Create a naming context: ou=hr,ou=lab,ou=nccoe,ou=org and select Virtual Tree for the naming context type, then click Next.

2. Configure the Virtual Tree by choosing Create a new view (.dvx), setting the Directory View to dv=ou_hr_ou_lab_ou_nccoe_ou_org and clicking OK.

3. Next, create a sub-Namespace by clicking the + New level button and entering the information depicted below.
4. Click on the sub-Namespace that was just created and click on Backend Mapping. Specify `ou=east, ou=hr, ou=lab, ou=nccoe, ou=org` as the naming context and select HDAP Store as the type, then click Next. Note: Instead of having an actual HR database, we are importing sample users from a text file.

5. Click on `ou=east` to edit properties. Scroll down to the bottom of the screen and click on the Initialize button. Then select a file with database users to import for initializing the High-Availability Directory Access Protocol (HDAP) store. Note: We are emulating an HR database with this file.

6. Go to the Directory Browser tab and refresh the data by clicking the Refresh Tree button.

7. Go to the OU that you just configured and expand it. The new users should now be available.

8. Go to Directory Namespace and click the + button to add new naming context (in our build, we used `ou=testing`). This is used to map to the LDAP backend the database information that was imported.

9. Click on the OU that was created. Click OK and Save.

10. Go to Directory Browser and hit the Refresh button.
11. Go to **Settings > Configuration > ORX Schema**, and find **OU=Testing** and check it. Click on **Generate LDAP Schema** at the bottom of the screen and click **OK**.

### 2.2.3 Integration

Other applications, including SailPoint and Okta, will need the following information in order to integrate with Radiant Logic and pull information from it:

- **Hostname**: radiant1.lab.nccoe.org (hostname of the Radiant Logic server)
- **Port**: 389 (LDAP) and 636 (LDAPS)

Also, a service account and password need to be created on Radiant Logic for each application to be integrated. The service account is in the form of: `uid=sailpointadmin,ou=globalusers,cn=config`.

Follow these steps to create each service account for SailPoint, Okta, and any other desired applications:

1. Go to **Directory Browser**.
2. On the left, go to `cn=config`, then `ou=globalusers` underneath it. Right-click on `ou=globalusers`, click **Add**, then click **New InetOrgPerson**.
3. Fill in the necessary entries. Click **Confirm** to save the configuration.

### 2.3 SailPoint IdentityIQ

SailPoint IdentityIQ is the identity and access management software platform for governing the lifecycle of the enterprise user’s identity.

#### 2.3.1 Installation and Configuration

The steps below explain the installation of the IdentityIQ server, initial configuration to import users from the Radiant Logic identity store, and configuration to manage the lifecycle of users.

1. To install IdentityIQ, first identify the platform and prerequisites. For this build, we used Windows 2019 with Apache Tomcat 9.0 and MS SQL Server 2019 as recommended requirements for release 8.2. Download the installation file from the SailPoint website and [follow the installation instructions](#).
2. Login into IdentityIQ from a web browser (http://localhost:8080) using the default login and password identified in the IdentityIQ Installation Guide. Make sure to change the default password by following the instructions provided in the Guide.
3. **Configure IQService**. This is needed in order to set up integration with AD.
4. Govern permissions by pushing employee and contractor users and groups to AD and Okta.

Note: This step should be completed after the integration with AD and Okta is completed. Steps
to configure integration are in Sections 2.3.3 and 2.3.4. After integration with AD and Okta is completed, navigate to the Setup drop-down menu and select Roles. Here we will create a birthright role and access profile for employees and contractors.

- Select the New Role drop-down button and select Role. The screenshot lists the four roles that are created for this build.

- For the Employee Birthright Role, use the configuration shown in the next two screenshots. Note that the Assignment Rule is where the value of employee is used to identify the users. This will push users into AD as a birthright. Once that role is configured, configure the corresponding contractor role the same way. Note that the Assignment Rule should be different for the contractor based on user information in SailPoint.
c. For the Employee Access Profile role, add the groups that the employees belong to. This means that these users will have access to these groups as a birthright. Perform the same for the corresponding contractor role. Note that the Entitlements should be different for the contractor based on group information in Okta and AD.

5. The next step is to synchronize users and groups. To begin, navigate to the Setup tab and select Tasks.

   a. To create user aggregation, select the New Task drop down button and select Account Aggregation. The screenshot below depicts the aggregation configuration for Radiant Logic. This allows SailPoint to sync with Radiant Logic on any updates made to users. Repeat this step for AD and Okta accounts. Note that the Account Aggregation Options section is where the AD and Okta applications need to be selected to create the proper account aggregation.
To create group aggregation, select the **New Task** drop down button and select **Account Aggregation**. This allows SailPoint to sync with AD on any updates made to users in the groups. Repeat this step for the Okta account. Note that the **Account Group Aggregation Options** section is where the Okta applications need to be selected to create the proper account aggregation.

6. Configure lifecycle processes through Rapid Setup Configuration. Click on the **Setup** cog and select **Rapid Setup** to begin. The Rapid Setup Configuration process allows onboarding of applications and manage functions such as joiner, mover, and leaver of identities. Use the “Using Rapid Setup” section of the **IdentityIQ Rapid Setup Guide** to guide the configuration.

   a. Configure **Joiner**, **Mover**, and **Leaver**.

   b. Configure **Identity Operations**.

   c. Configure Rapid Setup specific to AD users: Aggregation, Joiner, Mover, and Leaver.

7. Govern user permissions to applications on an individual basis. Configure procedures to provision and approve user access to resources. For Enterprise 1, the process is for an administrator or user to request approval to access an application. That request goes to the user’s manager for review and approval. Once the manager approves the request, SailPoint kicks off an API call to Okta to configure access for that user.
2.3.2 Integration with Radiant Logic

1. In the **Applications** tab, select **Application Definition**. When the screen comes up, click on the **Add New Application** button.

2. Enter values for the **Name** (e.g., “Ent1-HR”) and **Owner** (e.g., “The Administrator”) fields. Select **LDAP** as the **Application Type** and ensure that **Authoritative Application** is enabled.

3. Click on the **Configuration** tab next to the current tab. The credentials that were created in Radiant Logic will need to be added.

4. Scroll down the screen and under the **Account** tab, add the Search DN, which is the one created from Radiant Logic.

5. Click on **Test Connection** to make sure that SailPoint is able to connect to Radiant Logic. Click **Save**.

6. You can go back into the **Configuration** tab and **Schema** sub-tab. Toward the bottom of the screen, there is a **Preview** button. You can click on that to preview the imported attributes. Note: We manually added schema attributes. This can be completed from Radiant Logic and imported. Please ensure that you have the correct attributes to integrate this.

7. To complete the setup, click **Save** to finish and import users from Radiant Logic.

8. Go to the **Setup** tab and click **Tasks**. Once in the new tab, click on the **New Task** button at the top right corner to create the account aggregation for Radiant Logic.

9. Perform identity attribute mapping. The screenshot shows mappings specific to this build only.
2.3.3 Integration with AD

1. Navigate to the Applications tab, click on Application Definition, then click the Add New Application button. Fill out the Name (e.g., “Ent1-AD-Ent-Users”), Owner (e.g., “The Administrator”), and Application Type (“Active Directory – Direct”).

2. Navigate to the Configuration tab. From here, input information for the IQ Service Host. The IP address is this server, the IdentityIQ server. IQ Service User is a user that was created in AD for this integration.

3. Scroll down to the Domain Configuration section. Input the domain information for where the users will be provisioned.
4. Scroll down to the **User Search Scope** section and input the Search DN information. This should be the AD domain location for your enterprise.

5. Navigate to the **Schema** and **Provisioning Policies** sub-tabs, and update information as necessary.

6. Then navigate to the **Correlation** tab to configure the correlation for application and identity attributes between SailPoint and AD.

7. Click **Save** to complete the configuration.

8. Go to **Setup** tab and click **Tasks**. Once in the new tab, click on the **New Task** button at the top right corner to create the account aggregation for AD.

### 2.3.4 Integration with Okta

1. Go into the **Applications** tab and select **Application Definition**. When the screen comes up, click on the **Add New Application** button.

2. Fill out the **Name** (e.g., “Ent1-Okta”) and **Owner** (“The Administrator”), select **Okta** as the **Application Type**, and enable the **Authoritative Application** option.

3. In the **Configuration** settings tab, the Okta URL and API token are needed. Note that the API token is created in Okta. Click **Save** to finish the setup.
2.4 Ivanti Neurons for UEM

Ivanti Neurons for UEM is a unified endpoint management (UEM) solution which is used to provision endpoints, grant access to enterprise resources, protect data, distribute applications, and enforce measures as required.

2.4.1 Installation and Configuration

2.4.1.1 Install an MDM certificate for Apple devices

The Apple Push Notification service (APNs) certificate needs to be installed in Ivanti Neurons for UEM to communicate with Apple devices. Apple devices use an APNs certificate to learn about updates, MDM policies, and incoming messages.

To acquire and install the MDM certificate:

1. Open the Ivanti Neurons for UEM console and go to Admin > Apple > MDM Certificate page to download a certificate signing request (CSR).

2. Upload the CSR to the Apple Push Certificates Portal to create a new certificate.

3. Save the resulting certificate.

4. Install the certificate for the Ivanti Neurons for UEM tenant.
2.4.1.2 Configure Android Enterprise

Android Enterprise allows personal and corporate applications on the same Android device. Android Enterprise configuration depends on the type of Google subscription. Please follow Ivanti documentation to set up the integration.

The Android Enterprise Work Profile configuration defines which features and apps are allowed, and which are restricted on Android enterprise devices. Do the following to configure the profile:

1. In the Cloud portal, go to Configurations and click Add.
2. Select the Lockdown & Kiosk: Android Enterprise configuration.
3. Enter a configuration name and description.
4. Click the Work Profile lockdown type.
5. Select the lockdown settings for Android devices.

2.4.1.3 Add a certificate authority

A certificate authority (CA) generates self-signed certificates to be used by the devices that Ivanti Neurons for UEM manages. For this implementation we used an external certificate authority (DigiCert) and a Connector to access it. Ivanti Cloud Connector provides access from the Ivanti Neurons for UEM service to corporate resources, such as an LDAP server or CA.

1. Install and configure a Connector (Admin > Connector).
2. In the Certificate Management page, click Add under the Certificate Authority section.
3. Choose Connect to a publicly-trusted Cloud Certificate Authority.
4. Enter a name for the CA.
5. Download the certificate from DigiCert and upload it to Ivanti Neurons for UEM.
2.4.1.4 Configure user settings

User settings define device registration options. Access them by opening Ivanti Neurons for UEM and going to Users > User Settings. Configure device and password settings there.

2.4.1.5 Add a policy

Policies define requirements for devices and compliance actions (what happens if the rule is violated).

To add a policy:

1. Go to Policies and click +Add (upper right).

2. Select a policy type and complete the settings. Policy types include Compromised Devices, Data Protection/Encryption Disabled, MDM/Device Administration Disabled, Out of Contact, and Allowed Apps.

3. Select the device groups that will receive this policy.

The following screenshots show an example of a Data Protection policy to be distributed to a custom group of devices.
2.4.1.6 Add a configuration for managed devices

Configurations are collections of settings that Ivanti Neurons for UEM sends to devices. To add a configuration:

1. Click Add.

2. Select the type of configuration. There are numerous types of configurations available, including Privacy, Certificate, Default App Runtime Permissions, Passcode, Exchange, Wi-Fi, VPN, iOS/macOS/Windows Restrictions, and Software Updates.
3. Click **Next**.

4. Select a distribution level for the configuration.

Here is an example of a Privacy configuration:

<table>
<thead>
<tr>
<th>Name</th>
<th>Privacy policy</th>
</tr>
</thead>
</table>

**Configuration Setup**

- **Collect Location Data**
  - Collect the device’s last known location based on check-in.

- **Removable Device Wipe Action (User Owned Devices Only)**
  - Prevent admins and users from wiping the device

- **Prompt user to enable location services if NIS/MDM configuration is pushed (Fully Managed and Work profile for Company Owned Devices)**

**Collect App Inventory**

- For Apps on the Device that are in the App Catalog
- For All Apps on the Device
  - This must be selected in order to use the Allowed Apps Policy

**Note:** Device Wipe action and option to collect App Inventory for all Apps on device is not applicable for User Enrollment.
This is an example of an iOS AppConnect configuration:

**Device Out Of Contact**

Wipe AppConnect data after
1 day Enter 1-90 days or Enter 0 for never

Block AppConnect data after
1 day Enter 1-90 days or Enter 0 for never

**Data Loss Prevention Settings**

- Allow copy/paste to
  - All Apps
  - AppConnect apps
- Allow printing
- Allow open-in
  - All Apps
  - Whitelist Apps only
  - Enter the name of an app in your App catalog to Whitelist

This screenshot shows a list of configurations pushed to a device:
2.4.2 Integration with Ivanti Connector

Ivanti Connector provides access from Ivanti Neurons for UEM to corporate resources, such as an LDAP server. For the latest Connector installation instructions, select the appropriate version of the Cloud Connector Guide.

1. Once the Ivanti Connector has been set up and configured, navigate to the Ivanti Neurons for UEM console.
2. Connect to an LDAP Server to import users and groups. Navigate to Admin > Infrastructure > LDAP > Add Server. Complete configurations and save. Users can now be imported from the LDAP server.

2.4.3 Integration with Okta

2.4.3.1 IdP setup

1. Go to Admin > Infrastructure > Identity > Add IdP.
2. Generate a key for uploading to Okta IdP.
3. Log in to Okta IdP. Search IdP for the MobileIron Cloud App and add it to the IdP account.
4. Configure the MobileIron Cloud App on the IdP by pasting the above-generated key and the host information.
5. Export metadata from Okta to the Ivanti Neurons for UEM console.
6. In Admin > Infrastructure > Identity > Add IdP, select Choose File to import the downloaded metadata file to Ivanti Neurons for UEM and complete the setup.
7. When an IdP is added, user authentication automatically switches from LDAP to IdP.

2.4.3.2 Okta Verify app configuration preparation

1. In the Okta Admin console, navigate to Security > Device Integrations and click Add Platform.
2. Select platform and click Next.
3. Copy the Secret Key for later usage and enter Device Management Provider and Enrollment Link settings.
4. Repeat for any other device platforms.

2.4.3.3 Okta Verify app configuration - Android

1. In the Ivanti Neurons for UEM console, navigate to Apps > App Catalog. Click Add.
2. Select the Google Play Store and search for **Okta Verify**. Select the official **Okta Verify** app.

3. Continue through the wizard until you reach the App Configurations page. Click the + button in the Managed Configurations for Android section.

4. Add desired settings. Under **Managed Configurations**, add the **Org URL** and **Management Hint** from the Okta Admin console. The Management hint will be the **Secret Key** you saved from the Okta console during preparation.

5. Click **Next**, then click **Done**.

### 2.4.3.4 Okta Verify app configuration - iOS

1. In the Ivanti Neurons for UEM console, navigate to **Apps > App Catalog**. Click **Add**.

2. Select the iOS Store and search for **Okta Verify**. Select the official **Okta Verify** app.

3. Continue through the wizard until you reach the App Configurations page. Click the + button in the Apple Managed App Configuration section.


   a. For the first item, the key will be **domainName**, the value will be your Org URL, and the type will be **STRING**.

   b. For the second item, the key will be **managementHint**, the value will be the **Secret Key** you saved from the Okta console during preparation, and the type will be **STRING**.

5. Click **Next**, then click **Done**.

### 2.4.4 Integration with QRadar

#### 2.4.4.1 Ivanti log transfer setup

1. Set up an SSH server to host log files. Create a user account that can be used to host/transfer Ivanti Log Files.

2. In the Ivanti Neurons for UEM console, navigate to **Admin > Infrastructure > Audit Trails**.

3. Turn on **Audit Trails Export** and **Device Check-in Trails**.


5. Enter the IP address or hostname for the SSH server you set up previously.

6. Enter the username and password for the user you set up previously.

7. Enter the server path for where you would like the Ivanti log files to be stored on the SSH server.
Click Test Connection and Save. Ivanti log files will now be transferred to the SSH server on a regular basis.

2.4.4.2 QRadar setup

1. In the QRadar console, navigate to Admin > Extensions Management. Click Add.
2. Select the Ivanti extension file provided by IBM. Click Add.
3. Continue through the wizard until you completed the extension installation.
4. In the QRadar console, navigate to Admin > Log Sources. Click +New Log Source.
5. In the search box, type Ivanti. Make sure Ivanti is selected in the menu and click Step 2: Select Protocol Type.
6. In the search box, type Log File. Make sure Log File is selected in the menu and click Step 3: Configure Log Source Parameters.
7. Enter a name for the log source and turn off Coalescing Events. Click Step 4: Configure Protocol Parameters. The settings are as follows:
   a. Log Source Identifier: MobileIron Cloud
   b. Service Type: SFTP
   c. Remote IP or Hostname: <Log server you set up previously>
   d. Remote port: 22
   e. Remote User/Password: <Credentials created earlier, if not using key file authentication>
   f. SSH Key File: <Credentials created earlier, if not using password authentication>
   g. Remote directory: Directory where Ivanti logs are being stored
   h. Recursive: On
   i. FTP File Type Pattern (Regex for Ivanti log files): ^.*\.(zip|ZIP)$
   j. Processor: ZIP
   k. All other settings can be left as default
8. Click Step 5: Test Protocol Parameters. Run the tests and ensure the configuration is valid.
9. From the QRadar console, navigate to the Admin tab. Click Deploy Changes.
2.5 Ivanti Sentry

Ivanti Sentry is an inline gateway that manages, encrypts, and secures traffic between the mobile device and back-end enterprise systems. In this build, Ivanti Sentry acts as a PEP that controls access to enterprise resources.

2.5.1 Installation and Configuration

For this implementation we used a Standalone Sentry installation on-premises. For the latest Sentry installation instructions, select the appropriate version of the Standalone Sentry On-Premises Installation Guide at https://www.ivanti.com/support/product-documentation.

Next, create a profile for Standalone Sentry in the Ivanti Neurons for UEM console. For information on how to create a profile for Standalone Sentry and configure Standalone Sentry for ActiveSync and AppTunnel, see the Sentry Guide for Cloud. For the latest Sentry installation instructions, click on Sentry, then select the appropriate version of the Standalone Sentry On-Premises Installation Guide.

2.5.2 Ivanti Tunnel Configuration and Deployment

Ivanti Tunnel is an application that connects a mobile device to the Ivanti Sentry. The process to deploy this app is similar to the deployment of the Okta Verify app in Section 2.1.2.

1. On the App Configurations page for the Tunnel app, create a Managed Configuration.

2. Set the Tunnel Profile Mode to MobileIron Sentry + Access.

3. Set the Sentry Server to the Sentry instance you created previously.

4. Set the SentryService to the name of the IP Tunnel defined on the Sentry.

5. Set the ClientCertAlias to the Sentry certificates you defined during Sentry configuration.

6. Set any other options as needed.

7. Save the Managed Configuration and deploy to devices as needed.

2.6 Ivanti Access ZSO

Ivanti Access ZSO is a cloud-based service that allows access to enterprise cloud resources based on user and device posture, and whether apps are managed or not. In this build, Ivanti Access ZSO functions as a delegated IdP, with Okta passing certain responsibilities to Ivanti Access ZSO.
2.6.1 Integration with Ivanti Neurons for UEM

1. Ensure that you have the **Manage MobileIron Access Integration** role in Ivanti Neurons for UEM enabled at **Admin > System > Roles Management**.

2. Navigate to **Users > Users** and click **Add > API User**.

3. Next, navigate to **Users > Users** and click on the username of the user you just created. Navigate to the **Roles** tab of that user and add the **Manage MobileIron Access Integration** role.

4. In the Ivanti Neurons for UEM console, go to **Admin > Infrastructure > Access**.

5. Enter the following: **Access Admin URL**, **Access Admin Username** (username for the Access administrator account created for Access integration), and **Access Admin Password**.

6. Click **Register**.

7. When Access is registered with Ivanti Neurons for UEM, you should see the following:

2.6.2 Integration with Okta

1. In the Okta Admin console, navigate to **Security > API** and generate an API token. Save this token for use in Access.

2. In the Ivanti Access ZSO console, navigate to **Profile > Federation**.

3. Select **Add Pair > Delegated IDP** and choose **Okta**.

4. Enter the Okta Domain URL and the Okta API Token you generated in Step 1. Click **Verify**.

5. Once the verification is complete, select the routing rules you’d like configured and click **Next**.

6. Verify the Signing Certificate settings and Encryption Certificate settings are correct and click **Next**.

7. Choose the desired **Unmanaged Device Authentication** setting and click **Done**.

8. You will see Okta in the Delegated IDP section. Okta will route authentication requests based on your settings.
2.7 Zimperium Mobile Threat Defense (MTD)

Zimperium MTD can retrieve various device attributes, such as device name, model, OS, OS version, and owner’s email address. It then continuously monitors the device’s risk posture and reports any changes in the posture to Ivanti Neurons for UEM.

2.7.1 Installation, Configuration, and Integration

2.7.1.1 Create an API user

To configure a Zimperium MTD console to work with Ivanti Neurons for UEM, an API user needs to be created and assigned a few roles.

1. In the Ivanti Neurons for UEM admin console, select Users.
2. Click + Add > API user. The Add API User dialog page opens.
3. Enter the following details: Username, Email, First Name, Last Name, Display Name, and Password.
4. Confirm the password.
5. Deselect the Cisco ISE Operations option.
6. Click Done.

2.7.1.2 Assign roles to the API user

1. From the admin console, go to Users.
2. Select the new API user created previously.
3. Click Actions.
4. From the User details page, select Assign Roles.
5. Select the following roles: App & Content Management, App & Content Read Only, Common Platform Services (CPS), Device Actions, Device Management, Device Read Only, System Read Only, and User Read Only.

2.7.1.3 Add an MDM server to the Zimperium console

1. Log in to the Zimperium MTD console.
2. Navigate to Manage > Integrations > Add MDM.
3. Select Cloud to add it to the MTD console as an MDM server.
4. Enter the following required information: **URL, Username/Password, MDM Name,** and **Background Sync.**

5. Click **Finish.**

### 2.7.1.4 Activate MTD on Ivanti Neurons for UEM

1. From the Ivanti Neurons for UEM admin console, go to **Configurations.**
2. Click **+Add.**
3. Click **Mobile Threat Defense Activation.**
4. In the **Create Mobile Threat Defense Configuration** page, enter a name for the configuration.
5. In the Configuration Setup section, select the vendor **Zimperium.**
6. In the **License Key** field, enter a unique encrypted Mobile Threat Defense activation code.
7. In the **Wake up Intervals (mins)** field, set a time.
8. Click **Next.**
9. Select the **Enable this configuration** option.
10. Select **All Devices.**
11. Click **Done.**

### 2.7.1.5 Add custom attributes in Ivanti Neurons for UEM

Custom device attributes will be applied to both Android and iOS devices based on threat severity.

1. To create custom attributes, in the Ivanti Neurons for UEM admin console go to **Admin > System > Attributes.** Enter each attribute name in lower case.
2. Create the custom attribute **mtdnotify** for **Low or Normal** severity threats:
   a. Click **Add New.** The **Attribute Name** and **Attribute Type** fields are displayed.
   b. Select **Device** as the attribute type.
   c. Name the custom attribute **mtdnotify.**
   d. Click **Save** to monitor and notify.
3. Create the custom attribute **mtdblock** for **Elevated** or **Critical** severity threats:
   a. Click **Add New.**
b. Select **Device** as the attribute type.

c. Name the custom attribute **mtdblock**.

d. Click **Save** to monitor and notify.

4. Create the custom attribute **mtdquarantine** for **Elevated** or **Critical** severity threats:

   a. Click **Add New**.

   b. Select **Device** as the attribute type.

   c. Name the custom attribute **mtdquarantine**.

   d. Click **Save** to monitor, notify, and quarantine.

5. Create the custom attribute **mtdtiered4hours** for **Low**, **Normal**, **Elevated**, or **Critical** severity threats:

   a. Click **Add New**.

   b. Select **Device** as the attribute type.

   c. Name the custom attribute **mtdtiered4hours**.

   d. Click **Save** to monitor and notify, wait for four hours, block, wait for another four hours, and quarantine.

2.7.1.6 **Create compliance policy**

Create compliance actions using custom policies based on the MTD custom attributes created above.

1. In Ivanti Neurons for UEM admin console, go to **Policies**.

2. Click **Add**.

3. Select **Custom Policy**.

4. Enter **mtdnotify** as the policy name.

5. Under **Conditions**, select **Custom Device Attribute**.

6. Select **mtdnotify** from the drop-down box and set the condition **is equal to** 1.

7. Under **Choose Actions**, select **Monitor** and **Send Email and Push Notification**.

8. Under **Email Message** fields, enter the subject and body text.

10. Click Yes, Next, and Done.

11. Repeat this procedure to add the following policies: mtdblock, mtdquarantine, mtdtiered4hours.

12. Add other policies if needed.

---

### 2.7.1.7 Create device groups and match with custom policies and custom device attributes created above

1. In Ivanti Neurons for UEM admin console, go to Devices > Device Groups.
2. Click + Add.
3. Enter mtdNotify as the device group name.
4. Under Dynamically Managed groups, select Custom Device Attribute.
5. Select mtdnotify from the drop-down box and set the condition is equal to 1.
6. Click Save.
7. Repeat this procedure to add the following groups: mtdBlock, mtdQuarantine, mtdTiered4hours.

### 2.7.1.8 Configure Zimperium MTD management console

Set up, configure, and use the MTD console for supported MTD activities. When configuring policies in the Zimperium admin console, use the available MDM actions and mitigation actions.
2.8 IBM Cloud Pak for Security

IBM Cloud Pak for Security platform enables the integration of existing security tools and provides understanding and management of threats in the environment.

1. **Deploy an OpenShift cluster.** OpenShift needs to be in place before Cloud Pak for Security can be installed.

2. **Install Cloud Pak for Security.**

3. **Configure LDAP authentication** so Cloud Pak for Security can leverage an existing LDAP directory server for authentication.

Once those steps are complete, open a web browser and navigate to the DNS name for Cloud Pak for Security. Additional documentation can be found at [Cloud Pak for Security Documentation](#).

2.9 IBM Security QRadar XDR

IBM Security QRadar platform provides various security capabilities including threat detection and response, security information and event management (SIEM), and security orchestration, automation, and response (SOAR).

Install and configure QRadar following IBM’s [QRadar Installation and Configuration Guide](#).

Once that is complete, open a web browser and navigate to the QRadar server web interface by using its IP address or DNS name.
2.10  **Tenable.io**

Tenable.io is a cloud-based platform that is used in this build to provide network discovery, vulnerability, and scanning capabilities for enterprise components.

2.10.1  **Installation and Configuration**

As a cloud-based platform, a license must first be obtained, and a cloud instance deployed by Tenable. Once that is completed, Tenable.io can be accessed through the web interface located at [https://cloud.tenable.com](https://cloud.tenable.com).

2.10.1.1  **Deploy an agent**

1. In Tenable.io, click the hamburger menu (☰) in the top left corner and navigate to **Settings > Sensors > Nessus Agents**.

2. Click **Add Nessus Agent** and save the Linking Key.

3. On the target endpoint, download the agent from [https://downloads.tenable.com](https://downloads.tenable.com). When the download completes, run the executable file.

4. In the setup window, fill in the key from step 2, the server (in our case, cloud.tenable.com:443), and the agent groups that this agent will be part of (in our case, Default). Click **Next**.

5. Click **Install** and approve the request if User Account Control (UAC) comes up.

6. When installation completes, updates will continue running in the background. The update and connection process may take some time. The endpoint will then be shown in the cloud tenant.

2.10.1.2  **Deploy a scanner**

1. In Tenable.io, navigate to **Settings > Sensors > Cloud Scanners**.

2. Click **Add Nessus Scanner** and save the Linking Key.

3. Download the Nessus Scanner .ova file from [https://downloads.tenable.com](https://downloads.tenable.com).

4. Deploy the .ova file in your virtual environment.
5. Once the scanner is running, navigate to the IP address shown in the console in a web browser.
6. Login with the default username \textit{wizard} and default password \textit{admin}.
7. Enter new administrator credentials and click \textbf{Create Account}.
8. Click \textbf{Finish Setup} and authenticate with the new administrator credentials.
9. On the left-side navigation pane, click \textit{Nessus}.
10. Click the URL shown in the \textit{Nessus Installation Info} pane.
11. Click the radio button next to \textit{Managed Scanner} and click \textbf{Continue}.
12. Enter the Linking Key from step 2 and click \textbf{Continue}.
13. Enter credentials for a new administrator account and click \textbf{Submit}.
14. The scanner will initialize and be visible on tenable.io. Scans can now be scheduled.

2.10.2 Integration with QRadar

For Tenable.io and QRadar integration, follow the \textit{Tenable and IBM QRadar SIEM Integration Guide}.

2.11 Tenable.ad

Tenable.ad provides AD monitoring to detect attacks and identify vulnerabilities. In this build, Tenable.ad is integrated with the on-premises AD installation and configured to forward alerts to the IBM QRadar SIEM.

For Tenable.ad installation and configuration, follow the \textit{Tenable.ad On-Premise Installation Guide}.

For Tenable.ad and QRadar integration, follow the \textit{Tenable and IBM QRadar SIEM Integration Guide}.

2.12 Tenable NNM

Tenable Nessus Network Monitoring (NNM) monitors network traffic at the packet level to provide visibility into both server and client-side vulnerabilities. In this build, NNM was set to Asset Discovery mode and linked to Tenable.io in order to provide visibility into all network actors.

For Tenable.ad installation and configuration, follow the \textit{Tenable NNM Documentation}.

2.12.1 Deploy a Tenable NNM instance

1. In Tenable.io, navigate to \textit{Settings > Sensors > Nessus Network Monitors}.
2. Click \textit{Add Nessus Network Monitor} and save the Linking Key.
3. Download the NNM .ova file from [https://downloads.tenable.com](https://downloads.tenable.com).

4. Deploy the .ova file in your virtual environment.

5. Once the NNM instance is running, navigate to the IP address shown in the console in a web browser on port 8835.

6. Enter credentials for a new administrator account and click **Submit**.

7. Enter the Linking Key from step 2 and click **Continue**.

8. The NNM instance will initialize and be visible on Tenable.io. Additional NNM configuration can now occur if needed.

### 2.13 Mandiant Security Validation (MSV)

Mandiant Security Validation (MSV) allows organizations to continuously validate the effectiveness of their cybersecurity controls by running actions that may conflict with the organization’s policy and determining if those actions are detected and/or blocked. In this build, MSV is configured to regularly test the build’s zero trust policies and report on the results.

#### 2.13.1 MSV Director Installation/Configuration

1. Download the MSV Director software from the Mandiant web portal and deploy it in a virtual environment.

2. Log into the MSV command line interface using credentials provided by Mandiant.

3. Run the command `sudo vsetnet` to apply network configuration.

4. Run the command `sudo vsetdb --password new_password` to set a new password for the Director database.

5. Use a web browser to access the MSV Director web interface at [https://Director IP/](https://Director IP/).

6. Sign into the web interface using credentials provided by Mandiant.

7. Review and accept the End User Licensing Agreement, and apply the license provide by Mandiant.

8. Configure the DNS settings by navigating to **Settings > Director Settings > DNS Servers**.

9. Configure the NTP settings by navigating to **Settings > Director Settings > NTP Servers**.

10. Add Security Zones corresponding with the enterprise’s network segments by navigating to **Environment > Security Zones**.
11. Download security content from the Mandiant web portal.
12. Navigate to Settings > Director Settings > Content.
13. Select Import, browse to the downloaded security content, and select the content files.
14. Click Upload Import and upload the files into the MSV Director web interface.
15. Once the upload is complete, click Apply Import to import the content files into MSV.

2.13.2 MSV Network Actor Installation/Configuration
1. Download the MSV Network Actor software from the Mandiant web portal and deploy it in a virtual environment.
2. Log into the MSV command line interface using credentials provided by Mandiant.
3. Run the command `sudo vsetnet` to apply network configuration.
4. In the MSV Director web interface, navigate to Environment > Actors.
5. Click Add Network Actors and fill out the new Actor form.
6. Identify the Actor you just created in the Pending Actors table, expand the Actions menu, and click Connect to initiate a Director-to-Actor registration.
7. Enter the Actor’s fully qualified domain name (FQDN) or IP address.

2.13.3 MSV Endpoint Actor Installation/Configuration
1. Deploy an endpoint machine running Windows, macOS, or Linux.
2. In the MSV Director web interface, navigate to Library > Actor Installer Files and download the relevant installer onto the endpoint.
3. Navigate to Environment > Actors, click Add Endpoint Actors, and fill out the new Actor form.
4. Execute the Actor installer on the endpoint and proceed through the install process.
5. At the end of the install process, identify the actor you just created in the Pending Actors table and enter the value from the Code field into the Actor configuration field.
6. The endpoint will register itself with the MSV Director, and setup will be complete.

2.13.4 MSV Evaluation Configuration

1. Once the MSV Director and Actors have been configured, evaluations can be created to test security controls and policies. In the MSV Director web interface, navigate to Library > Actions.

2. Find the action(s) you would like to use for the evaluation and select the +Queue button to add the action to the Queue. Repeat this process until you have added all needed actions to the Queue.

3. After actions have been added to the Queue, click the Queue button in the upper right side of the web interface.

4. Select each of the actions in the Unassigned section and drag them to the Current Actions section.

5. Scroll up to the top of the page and click the Save button.
6. Under the **Test Type** dropdown, choose **Evaluation**.

7. Enter a name and a description, then select the **Save** button to save the evaluation.

8. Your new evaluation can be found by navigating to **Library > Evaluations** and filtering on **User Created**.

### 2.13.5 MSV Evaluation Execution

1. Navigate to **Library > Evaluations** and select the evaluation you’d like to run. Click the **Run** button.

2. From the Evaluation screen, press the **Run Evaluation** button.

3. Select the **Source Actor** and **Destination Actor** from the dropdown menus. Click **Run Now**.

4. The evaluation will run, providing results once the actions have been attempted/completed.
2.14 DigiCert CertCentral

CertCentral simplifies digital trust and automates certificate management by consolidating tasks for issuing, installing, inspecting, remediating, and renewing TLS/SSL certificates in one place. In this build, CertCentral provided TLS/SSL certificates to any system needing those services.

For the latest CertCentral setup and usage instructions, see https://docs.digicert.com/get-started/.

2.14.1 Requesting a certificate

1. Generate a Certificate Signing Request. This can be done with OpenSSL or DigiCert’s Certificate Utility. Save the private key for later use.

2. In the DigiCert CertCentral dashboard, navigate to Certificates > Requests and click Request a Certificate. Select the certificate type.

3. Upload or paste the Certificate Signing Request in the provided field.

4. Select the coverage length, and add any other additional options as needed.

5. Click Submit Request.
2.14.2 Obtaining and implementing a certificate

1. In the DigiCert CertCentral dashboard, navigate to Certificates > Orders and select the request that you previously created.

2. Click Download certificate as and select More Options...

3. You will be presented with a list of certificate format options. Select the option/format that best pertains to the platform you will be using the certificate on. Click Download.

4. Obtain the private key that was originally generated with your Certificate Signing Request. If using DigiCert’s Certificate Utility, this can be found using the Export function.

5. The certificate and private key can now be imported/installed and used on the intended platform.

3 Enterprise 2 Build 1 (E2B1) Product Guides

This section of the practice guide contains detailed instructions for installing, configuring, and integrating all of the products used to implement E2B1. For additional details on E2B1’s logical and physical architectures, please refer to Volume B.

3.1 Ping Identity PingOne

Ping Identity PingOne is a SaaS solution that provides ICAM capabilities to an enterprise. The following sections describe the setup of PingOne and its PingFederate service, and various integrations to other products. Ping Identity integrates with Radiant Logic for identity information, and with Cisco Duo to delegate the second authentication factor for users accessing resources.

3.1.1 Configuration: PingOne and PingFederate

1. PingOne setup: From your web browser, type pingone.com and click the “Try Ping” at the top right of the screen. Follow the instructions to sign up.

2. Once the PingOne environment is set up and functioning, scroll down the screen and click on the PingFederate service. A new browser tab will open. Most of the configuration will be performed on PingFederate for this build.

3. Create an IDP adaptor. This configuration should include some required values like mail and group membership (these will be mapped in steps below to the policy contract) and this adaptor is used as the first authentication factor and will be applied in the policy in the next step.
4. Create a policy contract as a list to map values to the connection(s). The policy contract will use a policy to fulfill the mappings from sources (such as LDAP or Third-Party Identity Provider using a Federated Hub).

5. Create an authentication policy that will be used to dictate application authentication. For our policies, we are using user ID and password for the first authentication factor (step 3 above) and Duo as the second authentication factor (Integration with Cisco Duo section).

6. Create a policy contract to connect that uses the above policy.

7. Configure SAML application integrations. Note that all applications are different. For our resources (applications), certain SAML formats and attributes are used. Follow the linked documentation above to configure the specific setup of your own application.

8. For this build, we developed policies that allow employees to access all resources (resource 1 and resource 2) and contractors to access resource 2 only. In order to do that, we leveraged the “memberof” attribute from Radiant Logic to identify employees and contractors. Once this information is identified, refer to:
   a. Authentication Policies to define the attribute mappings using this information
   b. SAML applications to configure issuance criteria to information retrieved from Radiant Logic

3.1.2 Integration with Radiant Logic

1. For this build we installed a PingOne Gateway, which is “on-premise software that allows PingOne to communicate with other systems like LDAP servers,” to communicate with RadiantOne. The PingOne Gateway was installed on a Windows Server on the same subnet as the RadiantOne server. We used the PingOne Gateway due to restrictions of multiple firewalls and NAT rules within our lab environments (some are not under our control) from allowing PingOne from the Internet to reach RadiantOne in Enterprise 2. In many environments, the LDAP gateway is not needed if NAT is not used, and opening the proper TCP/UDP ports on the enterprise firewalls will allow communication between PingOne and the on-prem resource. Note: Prerequisites and instructions for installing the gateway are available under Connections/Gateway in the PingOne console.

2. Once the Gateway is configured, click the Add button within the Connections/Gateway screen. Follow instructions on the screen to complete the integration with Radiant Logic. Note: A service account and other information from Radiant Logic is needed for the setup. Ensure this service account is created within Radiant Logic prior to configuring the PingOne Gateway.
3. From PingFederate, go to Data Stores and create a New Data Store for Radiant Logic. Select LDAP for your LDAP Type and fill in the variables to complete the configuration.

3.1.3 Integration with Cisco Duo

Make sure that configuration from Cisco Duo is completed before performing the integration.

For IDP application integration, from the Authentication tab, select IDP Adaptors, and click Create New Instance to create the integration with Cisco Duo to use Duo MFA as the second authentication factor. Specific API configuration information that was created from Cisco Duo is needed here to complete the setup.

Note: For this build, we are using Duo, although Ping Identity has its own MFA.

3.2 Radiant Logic RadiantOne

3.2.1 Installation and Configuration

Refer to Section 2.2.1.

3.2.2 Configuration

Refer to Section 2.2.2.

3.2.3 Integration

Refer to Section 2.2.3 for integration with SailPoint.

For integration with Ping Identity, a service account was created in RadiantOne. This service account, along with various credential information is used by PingFederate to communicate with RadiantOne to authenticate users. The communication between RadiantOne and PingFederate is through the Ping Gateway, which was installed on the same subnet as RadiantOne.

3.3 SailPoint IdentityIQ

3.3.1 Installation and Configuration

Refer to Section 2.3.1.

3.3.2 Integration with Radiant Logic

Refer to Section 2.3.2.
3.3.3 Integration with AD
Refer to Section 2.3.3.

3.3.4 Integration with Ping Identity
There is no integration with Ping Identity. For this build, SailPoint provides AD user information and Duo pulls from AD.

3.4 Cisco Duo
Cisco Duo is a SaaS solution that implements and enforces security policies and processes, using strong authentication to reduce the risk of data breaches due to compromised credentials and access from unauthorized devices. For this build, we use Cisco Duo as the second authentication factor for resources.

3.4.1 Configuration
Sign up with Cisco Duo to create a Duo instance. Once you have admin access, create policies and integration with AD and Ping Identity.
Create a policy to enable MFA for users. Navigate to Policy and click Edit Global Policy. In the Global Policy, there are many sub-policies that can be applied. For this build, we enabled the following:

- New User policy: prompt any user without the Duo app to enroll
- Authentication policy: require two-factor
- Authentication methods: Duo Mobile app (Duo Push)
- Device Health application: enable macOS and Windows (note: these are the only operating systems that are capable of device health monitoring when installed with Cisco Duo.)
- Custom Policies: create a policy to monitor device health if the authentication request comes from PingFederate. Self-enrollment is enabled so users will be prompted to install a Duo client on the end device for health monitoring. For this build, users will not be given access to a resource if their macOS or Windows firewall is turned off. There are other health checks available.

3.4.2 Integration
For integration with PingFederate, navigate to Applications and click Protect an application. Follow the instructions to complete the configuration. Note the three pieces of information provided: Client ID, Client secret, and API hostname. This information will be used to configure the integration within PingFederate to communicate with Duo.
For integration with Microsoft Active Directory, navigate to Users and click on Directory Sync. Follow the instructions to configure the AD integration. A Duo Authentication Proxy is needed for this build since the Enterprise 2 AD is not visible to the Internet.

### 3.5 Palo Alto Networks Next Generation Firewall

In this build, a virtualized Palo Alto Networks Next Generation Firewall (NGFW) was deployed on-premises as a security and access control device. The firewall provides zone-based network filtering for both inbound and outbound traffic, including remote access VPNs using the GlobalProtect clients. For GlobalProtect VPN access installation instructions, visit:

https://knowledgebase.paloaltonetworks.com/KCSArticleDetail?id=kA10g000000ClFbCAK

### 3.6 IBM Security QRadar XDR

For installation, configuration, and integration instructions, refer to Section 2.9.

### 3.7 Tenable.io

For installation, configuration, and integration instructions, refer to Section 2.10.

### 3.8 Tenable.ad

For installation, configuration, and integration instructions, refer to Section 2.11.

### 3.9 Tenable NNM

For installation, configuration, and integration instructions, refer to Section 2.12.

### 3.10 Mandiant Security Validation (MSV)

For installation, configuration, and integration instructions, refer to Section 2.13.

### 3.11 DigiCert CertCentral

For installation, configuration, and integration instructions, refer to Section 2.14.

### 4 Enterprise 3 Build 1 (E3B1) Product Guides

This section of the practice guide contains detailed instructions for installing, configuring, and integrating all of the products used to implement E3B1. For additional details on E3B1’s logical and physical architectures, please refer to NIST SP 1800-35B.
4.1 Microsoft Azure Active Directory (AD)

Azure AD is a SaaS identity and access management platform. No installation steps are required. You will need to create your organization’s instance of Azure AD and configure it to allow your users access to applications that use it for authentication and authorization.

1. After logging in to portal.azure.com, create an Azure AD Tenant.
2. Create a connection between your on-premises AD and Azure AD to replicate user, group, and authentication information from your AD to Azure AD.
3. Configure the Azure AD Tenant to enable Single Sign-On Password Reset (SSPR). This gives users the ability to reset their passwords from https://aka.ms/sspr or from within their profile in Azure AD. This will be effective for both their AD and Azure AD accounts.
4. Configure password writeback, which enables password changes in Azure AD to be replicated back to the on-premises AD.
5. The conditional access feature in Azure AD specifies conditions under which a user would be given access to a resource or application that uses Azure AD for authentication. MFA was configured as a requirement for access to all applications. Configure MFA for all users.
6. Access to resources based on device compliance was implemented as an essential feature in this solution. Access would only be granted to a user if the client device is compliant. Compliance is reported to Azure AD by Microsoft Endpoint Manager. Enable this feature, Conditional Access, Device Compliance.
7. Configure an enterprise application, GitLab, to use Azure AD for authentication:
   a. GitLab was configured to directly authenticate to Azure AD using the SAML protocol. GitLab must first be registered in Azure AD before Azure AD can be configured as the application’s IdP.
   b. Configure Azure AD as a SAML IdP for the GitLab application. Once that is implemented, access attempts to the target application will be redirected to Azure AD for authentication and authorization.

4.2 Microsoft Endpoint Manager

Microsoft Endpoint Manager is a cloud-based service that focuses on mobile device management (MDM) and mobile application management (MAM).
4.2.1 Configuration and Integration

4.2.1.1 Add and verify a custom domain
To connect an organization’s domain name with Intune, a DNS registration needs to be configured. This gives users a familiar domain when connecting to Intune and using resources. Use the information found at the hyperlink to create a custom domain.

4.2.1.2 Add users
Use the information at the hyperlink to add users to Intune.

4.2.1.3 Enroll devices in Microsoft Intune
Enrolling devices allows them to receive configuration profiles and compliance policies. Configuration profiles configure features and settings on devices. Compliance policies help devices meet an organization’s rules.

1. Get an Apple MDM push certificate and add it to Endpoint Manager. This certificate is required to enroll iOS/iPadOS devices. Then enroll iOS devices in Microsoft Intune.

2. Create an iOS enrollment profile. An enrollment profile defines the settings applied to a group of devices during enrollment.

3. Enroll Android devices in Microsoft Intune. To enable Android Enterprise, an administrative Google account needs to be connected to the Intune tenant.

4. Create an iOS compliance policy in Microsoft Intune. It will be evaluated before access is allowed from iOS devices.

5. Create an Android compliance policy in Microsoft Intune. It will be evaluated before access is allowed from Android devices.

6. Create an iOS/macOS configuration profile for iOS or Mac devices.

4.2.1.4 Configure conditional access rules
Conditional access is used to control the devices and apps that can connect to company resources. Use the information in the hyperlink to create device-based conditional access policies.

4.2.1.5 Manage applications
iOS/iPadOS: Use the instructions at Add iOS Store Apps to select apps from the iOS/iPadOS store that will be approved for installation on your managed iOS or iPadOS devices.
Android: For this build we added Managed Google Play apps. Managed Google Play is Google’s enterprise app store which serves as a source of applications for Android Enterprise in Intune. Use the instructions at Add Android Store Apps to select apps that will be approved for installation and made available to your managed devices.

Windows: Use the information provided at select approved apps to choose which apps should be added to your Windows devices.

There is more than one way to configure Windows apps in Intune. We configured the app using App suite information. For other ways, refer to the Microsoft documentation.

4.3 Microsoft Defender for Endpoint

Microsoft Defender for Endpoint provides endpoint protection, detection, and response to threats.

4.3.1 Configuration and Integration

4.3.1.1 Enable Microsoft Defender for Endpoint

Use the information at Configure Microsoft Defender for Endpoint in Microsoft Intune | Microsoft Learn to enable Defender for Endpoint.

1. Use the information in the provided hyperlink to onboard devices. Once devices are onboarded, threat signals and vulnerability information are automatically collected from them.

2. You can optionally enable supervised mode on iOS devices using information at the hyperlink. Supervised mode gives administrators greater control over corporate-owned devices.

3. Alerts and security incidents can be viewed and responded to by accessing the Defender for Endpoint cloud component. Use the information in the hyperlink to view and respond to discovered threats.

4.3.1.2 Create Endpoint Detection and Response policy (Windows 10 and later)

Endpoint detection and response (EDR) policies are used to detect advanced attacks in near real-time. Use the information in the hyperlink to create an EDR policy.

4.3.1.3 Create an antivirus policy

An antivirus policy defines the behavior of the antivirus software agent on the endpoint. Use the information in the hyperlinks to create an antivirus policy and configure antivirus policy settings.
4.3.1.4 Create Defender compliance policy

Compliance policies can help protect organizational data by requiring users and devices to meet defined security requirements. Use the information in the hyperlink to create a Defender for Endpoint compliance policy.

4.3.2 Microsoft Defender Antivirus

Microsoft Defender Antivirus is leveraged by Microsoft Defender by Endpoint. It is anti-malware software built into Windows client devices that detects threats and malware on client devices and quarantines infected files. Defender Antivirus is enabled by default.

1. Check the status of real-time protection to ensure it’s on.
2. Turn real-time protection on or off.

4.4 Microsoft Sentinel

Microsoft Sentinel is a cloud-native SIEM and SOAR system. It can be used for security analytics, threat intelligence, attack detection, and threat response.

There is no need to install Sentinel, as it is a managed service. Instead, it needs to be enabled and configured in your Azure environment. It also needs a workspace to store and correlate ingested data.

1. Enable Sentinel and configure a workspace.
2. Use the general instructions found at Connector to Data Sources to enable log forwarding to Sentinel from various devices, systems, and services. Each data source will have to be connected independently from other data sources, so you must perform this step once per data source. In this build, Azure AD, Endpoint Manager, Defender for Endpoint, Office365, and Tenable.io were configured to send logs using this method.
3. The Log Analytics Agent is a log forwarder that accepts syslog and Common Event Format (CEF) formatted logs and then forwards the logs to Sentinel. If you have a product or device without a native Sentinel integration, install and configure the Log Analytics Agent on a virtual machine. Once completed, the log forwarder will be able to receive syslog data on UDP port 514. Then configure the product or device that will be the data source to send logs via syslog to the log forwarder using the product’s instructions.

4.5 Microsoft Office 365

Microsoft Office 365 is a suite of SaaS-based productivity applications used for a variety of activities such as word processing, accounting, creating presentations, email, and others. Office 365 was enabled in the
environment and was used as a set of protected target applications. Use the information at Activate Microsoft Office 365 to activate your Office 365 subscription.

Use the Office 365 Sign-in link to log on to Microsoft Office 365. Use your email address and password. You will be required to authenticate using multi-factor authentication.

Once authentication is complete, you will see the various office applications, such as Word, Excel, PowerPoint, and Outlook in your dashboard.

4.6 F5 BIG-IP

BIG-IP is both a load balancer and an identity-aware proxy. In this phase of the build, it was primarily used as an identity-aware reverse proxy that forwarded or denied traffic to protected back-end applications.

4.6.1 Installation, Configuration, and Integration

BIG-IP was deployed into the environment using a virtual machine image or open virtual appliance (OVA) file. Once this OVA import operation is complete, log into the virtual machine console and assign an IP address to a network interface, then continue configuration by connecting to its web interface. This BIG-IP image has both the Access Policy Manager (APM) and the Local Traffic Manager modules installed.

1. Deploy BIG-IP OVA into your VMware environment.

2. Access the BIG-IP web interface by entering the IP address or DNS name into a web browser. Then complete the initial setup and configuration of BIG-IP.

3. Create virtual servers which map to back-end protected applications—in this build, to our Guacamole application server.

4. Configure BIG-IP to use Azure AD as the SAML IdP for external authentication to access back-end applications. The instructions at Configure BIG-IP Easy Button for Header Based SSO and the video at Azure AD and BIG-IP APM Integration Video provide additional references.

5. Once these instructions are completed, BIG-IP, leveraging Azure AD for external authentication, will only allow successfully authenticated and authorized users to access Guacamole. Access to the backend application is either done by connecting directly via the DNS name of the application or by going to myapps.microsoft.com and selecting the backend application icon, such as F5 Guacamole SSO as shown below.
6. For this build, configure BIG-IP to send logs to Microsoft Sentinel. Then you can observe BIG-IP logs in Sentinel, as shown below.

4.7 Lookout Mobile Endpoint Security (MES)

Lookout Mobile Endpoint Security (MES) solution is used to control mobile device access to corporate resources based on risk assessment. Risk is assessed based on information collected from devices by the
Lookout service. Lookout then communicates this risk level to the MDM (Microsoft Endpoint Manager (Intune)) which determines whether the device is compliant or not.

4.7.1 Configuration and Integration

Before configuring Lookout, collect the following information from Azure AD: **Azure AD tenant ID** and **Azure AD group object ID**.

1. Go to **Azure Active Directory > Properties** and locate **Tenant ID**. Copy and save it to the text file.
2. Go to **Azure Active Directory > Groups** to open the **Groups | All groups** pane.
3. Select the group with full access **rights** (Lookout Admin group).
4. Copy the (group) **Object Id**, and then save it in a text file.

The following steps are to be completed in the Lookout Enterprise admin console and will enable a connection to Lookout’s service for Intune enrolled devices.

1. Sign in to the Lookout for Work console and go to **System > Integrations**, and then select **Choose a product to set up**. Select **Microsoft Azure**. Copy and paste the Azure AD (AAD) tenant ID and group object ID from the text file that was created in previous steps.
2. Stay in System > Integrations, and then select Choose a product to set up. Select Microsoft Intune.

3. Configure Intune connector settings.

After Lookout MES is enabled, a connection to Lookout in Intune needs to be set up.

1. Go back to Microsoft Endpoint Manager and enable the Mobile Threat Defense connector there.
2. Select Tenant administration > Connectors and tokens > Mobile Threat Defense.
4. For Mobile Threat Defense connector to setup, select Lookout MTD solution from the drop-down list.
5. Configure the toggle options according to the organization's requirements. This screenshot shows examples.

When Lookout is integrated with Intune MTD and the connection to Intune is enabled, Intune creates a classic conditional access policy in Azure AD. To view classic conditional access policy, go to Azure Active Directory > Conditional Access > Classic policies. Classic conditional access policy is used by Intune MTD to require that devices are registered in Azure AD so that they have a device ID before communicating to Lookout MTD. The ID is required so that devices can report their status to Intune.
4.7.2 Create MTD Device Compliance Policy with Intune

Compliance policy is needed to detect threats and assess risks on mobile devices to determine if a device is compliant or not.

1. Open the Microsoft Endpoint Manager admin center.
2. Select Endpoint security > Device Compliance > Create Policy.
3. Select the Platform, and then Create.
4. On Basics, provide Name and Description. Select Next to continue.
5. On Compliance settings, expand and configure Device Health. Choose the Mobile Threat Level from the drop-down list for Require the device to be at or under the Device Threat Level.
6. Select Next to go to Assignments. Select the groups or users to which this policy should be assigned.

4.8 PC Matic Pro

PC Matic Pro is an endpoint protection system that consists of a server for centralized management and agents installed on endpoints. In addition to scanning for malware, it uses a default-deny approach for preventing malicious and unauthorized programs and processes from executing. To configure PC Matic Pro, you will need to install the server, install the agents, and configure a list of allowed software.

PC Matic Pro Server needs to be installed on a server with Windows 2019 Server and SQL Server preinstalled.

1. Obtain the OnPremInstallerRun.ps1 installation script from the vendor and open an elevated PowerShell window.
2. Execute the OnPremInstallerRun.ps1 script by entering .\OnPremInstallerRun.ps1 registryUser pcmatic -registryPwd <insert_password_here> -localDBUser pcm-app to install docker, pull down the container images, and deploy the container instances that make up the PC Matic Pro server.
3. Navigate to the PC Matic web server and verify that it is operational by opening a web browser and going to https://<pcmaticDNSName>/web_portal. In this build, the DNS name is nist.pcmaticfederal.com; as such, to access the server’s web interface, we would go to https://nist.pcmaticfederal.com/web_portal.
Follow these steps to install PC Matic Endpoint Agents:

1. Open a web browser on a Windows or macOS client device. Navigate to the PC Matic Server web interface by browsing to https://nist.pcmaticfederal.com from the client device and log on with your credentials.

2. Click Add a Device and then click Windows Installer or Mac Installer, as appropriate, to download the PC Matic Endpoint Agent.

3. Install the agent.

4. Once installed, the agent will establish communications with the server and show up on the list of managed devices once you log on to the server as previously described.

5. Devices with an agent will register and come online.

### 4.9 Tenable.io

For installation, configuration, and integration instructions, refer to Section 2.10.

#### 4.9.1 Integration with Microsoft Sentinel

1. In Tenable.io, click the hamburger menu (☰) in the top left corner and navigate to Settings > Access Control > Users.

2. (Optional) Click Create User and create a new API user for Microsoft Sentinel. In this implementation, a standard administrator account was used.

3. Click the user who needs API keys generated. Then click API KEYS > Generate > Continue. Save the Access and Secret Keys, as they will not be shown again.

4. In Microsoft Sentinel, navigate to Data Connectors. Search tenable and click Tenable.io Vulnerability Management (Preview) > Open Connector Page.

5. Scroll down in the Instructions panel and save the Workspace ID and Primary Key.

6. Click Deploy to Azure.
7. Select the appropriate resource group.

8. In the Workspace ID and Workspace Key fields, enter the values obtained in step 5.

9. In the Tenable Access Key and Tenable Secret Key fields, enter the values obtained in step 3.

10. Click Review + create.

11. Click Create. Function deployment will begin. Once deployment is complete, it will take some time before Sentinel begins making calls to Tenable.io.

### 4.10 Tenable.ad

For installation, configuration, and integration instructions, refer to Section 2.11.

### 4.11 Tenable NNM

For installation, configuration, and integration instructions, refer to Section 2.12.

### 4.12 Mandiant Security Validation (MSV)

For installation, configuration, and integration instructions, refer to Section 2.13.

### 4.13 Forescout eyeSight

Forescout eyeSight provides asset discovery with both active and passive techniques, and through integrations with network and security infrastructure. In this build, Forescout was deployed on-premises in two virtual hosts: an Enterprise Manager and Forescout Appliance.

For Forescout installation instructions, visit the Forescout Installation Overview.

#### 4.13.1 Integration with AD

1. In AD, create a domain administrator service account for Forescout and save the credentials.

2. In the Forescout console, navigate to Tools > Options > HPS Inspection Engine.

3. In the Domain Credentials section, click the Add button.

4. Enter the domain information and credentials you saved earlier. Click OK.

5. Click Apply. After the new configuration is saved, click Test to verify that the credentials are working as expected.
4.13.2 Integration with Cisco Switch
For Cisco Switch integration instructions, visit the Switch Plugin Configuration Guide.

4.13.3 Integration with Cisco Wireless Controller
For Cisco Wireless Controller integration instructions, visit the Wireless Plugin Configuration Guide.

4.13.4 Integration with Microsoft Sentinel
1. In the Forescout console, navigate to Tools > Options > CEF.
2. Click Add.
3. In the Add Server dialog, enter a Name, select Use UDP for Connection, and enter the IP address of the Sentinel Log Forwarder. Click Next.
4. Click the Assign CounterACT Devices radio button, and check all of the checkboxes next to the listed devices.
5. Click Finish. Verify that logs are being received by the Sentinel Log Forwarder.

4.13.5 Integration with Palo Alto Networks NGFW
For Palo Alto Networks NGFW integration instructions, visit the eyeExtend for Palo Alto Networks Next-Generation Firewall Configuration Guide.

4.13.6 Integration with Tenable.io
For Tenable.io integration instructions, visit the eyeExtend for Tenable.io Vulnerability Management Configuration Guide.

4.14 Palo Alto Networks Next Generation Firewall
For installation, configuration, and integration instructions, refer to 3.5.

4.15 DigiCert CertCentral
For setup and usage instructions, refer to Section 2.14.

5 Enterprise 1 Build 2 (E1B2) Product Guides
This section of the practice guide contains detailed instructions for installing, configuring, and integrating all of the products used to implement E1B2. For additional details on E1B2’s logical and physical architectures, please refer to Volume B.
5.1 Zscaler

Zscaler provides secure user access to public-facing sites and on- or off-premises private applications via the Zscaler Zero Trust Exchange, a cloud-delivered security service edge technology. The Zscaler Internet Access (ZIA) manages user access to the internet. Zscaler Private Access (ZPA) manages user access to applications within an enterprise. Zscaler integrates with Okta for authentication and authorization of users.

To begin, contact Zscaler to create an instance of ZIA and ZPA. To do this, Zscaler will need the FQDN of the enterprise using ZIA and ZPA. Admin user information will need to be provided to Zscaler to create admin accounts. Refer to documents for ZIA and ZPA.

5.1.1 Zscaler ZPA Configuration and Integration

Once admin access is available, log in to ZPA to perform the following:

1. Create additional admin accounts as needed.

2. Create a Zscaler App Connector Group and Zscaler App Connector in the ZPA portal. Note: App Connector Groups are recommended by Zscaler for availability and scaling. Note: This build has two App Connector Groups, one for on-prem applications and one for cloud applications in AWS.

3. Once the App Connector is configured in the ZPA portal, install the actual Zscaler App connector. Refer to the Zscaler Application Connector section below. Note: This build has two App Connectors, one for on-prem applications and one for cloud applications in AWS.

4. Create integration with Okta. All users accessing resources within the enterprise will use two-factor authentication when logging into the Zscaler Client Connector. Note: Step 1 of configuration is completed in the Okta cloud. Refer to Section 5.2. Step 2 of configuration is completed on the ZPA admin portal.

5. Deploy Zscaler Client Connectors (ZCCs) for various endpoints, including configuring ZCC policies to control the settings and behavior of ZCC. Refer to the Zscaler Client Connector section below.

6. Set up ZPA Application configuration for access to resources. In this step, applications are defined and applied to segments so that the proper App Connector can perform PEP functions.

7. Configure Access Policies to control user access to various applications. For our policies, we defined specific App Segments, configured specific IDP authentication parameters, and configured client posture checks.

8. Configure a log receiver for the IBM QRadar SIEM tool to receive logs for ZPA.
5.1.2 Zscaler ZIA Configuration

Once admin access is available, log in to ZIA to perform the following:

1. Create additional admin accounts as needed.
2. Set up IdP integration with Okta.
3. Create policies to manage user access to various resources on the internet. For this build, we used many of the defaults built into ZIA. We created policies to allow certain users access to a resource on the internet and to block certain users based on their role and time of day.
4. Integrate ZIA Nanolog Streaming Service with IBM QRadar SIEM tool to receive ZIA logs.

5.1.3 Zscaler Client Connector

Zscaler Client Connectors (ZCCs) are available for Windows, macOS, Linux, iOS, and Android endpoints. Deployment of ZCC includes configuring ZCC policies to control the settings and behavior of ZCC. For all these endpoints, a device manager can be leveraged to push the ZCC. For this build, we tested the use of Ivanti to push ZCC to Windows, iOS, and Android endpoints. For other devices we manually installed ZCC. Once ZCC is installed, users are prompted to log in, which allows the user and device to be managed by ZPA and ZIA, depending on the type of resource the user is accessing.

5.1.4 Zscaler Application Connector

The Zscaler Application Connector is installed and configured on the same subnet where the resource will be protected. For this build, we use the documentation for Linux OS to install the App Connector. Zscaler supports other operating systems. Repeat steps 1 and 2 in the configuration section if an application residing in a different subnet segment needs to be protected. If that application is in the same subnet, then only one App Connector is needed to protect both applications.

5.2 Okta Identity Cloud

For this build, the integration between Okta and Ivanti was disabled in Okta Identity Cloud. Users logging into a resource are authenticated via Okta with a password for the first factor and Okta Verify for the second factor. Use the link for integration with Zscaler to configure Okta.

No changes were made from Build 1 in Sections 2.1.2 and 2.1.3 (Okta Access Gateway). Refer to those sections for configuration details.

5.3 Radiant Logic RadiantOne

No changes were made from Build 1. Refer to Section 2.2.
5.4 SailPoint IdentityIQ
No changes were made from Build 1. Refer to Section 2.3.

5.5 Ivanti Neurons for UEM
No significant changes were made from Build 1. Ivanti Neurons for UEM was configured to deploy the Zscaler Client Connector to managed devices. For information, configuration, and integration instructions, refer to Section 2.4.

5.6 IBM Security QRadar XDR
For installation, configuration, and integration instructions, refer to Section 2.9.

5.7 Tenable.io
For installation, configuration, and integration instructions, refer to Section 2.10.

5.8 Tenable.ad
For installation, configuration, and integration instructions, refer to Section 2.11.

5.9 Tenable NNM
For installation, configuration, and integration instructions, refer to Section 2.12.

5.10 Mandiant Security Validation (MSV)
For installation, configuration, and integration instructions, refer to Section 2.13.

5.11 DigiCert CertCentral
For setup and usage instructions, refer to Section 2.14.

5.12 AWS IaaS
Amazon Web Services is a cloud computing platform provided by Amazon that includes a mixture of IaaS, platform as a service (PaaS), and SaaS offerings. The following section describes the setup of AWS IaaS resources to serve as a public/private cloud host.
For details on the logical architecture of the AWS environment, please refer to Volume B, Section 4.4.9.1.
5.12.1 Configuration

The purpose of this subsection is to outline how to set up a cloud infrastructure to provide a platform to host public and private resources which integrate with products from E1B2. AWS CloudFormation templates were used during the build of the AWS IaaS environment but are considered outside of the scope of this document. More information about CloudFormation may be found here.

1. Create and activate an AWS account. Use the root account to create administrative accounts with rights to create necessary resources for the project.

2. Create a Production and Management Virtual Private Cloud (VPC). Configure ingress and egress Security Group rules for each VPC.

3. Create Transit gateways to attach on-prem networks to the AWS environment. Create Internet gateways for access to the internet.

4. Within the Prod VPC, configure redundant public subnets in different Availability Zones for fault tolerance. Configure redundant private subnets for Web, Application, and Database tiers.

5. Set up resources for testing in the Prod VPC. For demonstration purposes, a private WordPress and GitLab server pair and a public WordPress server were built. Configure auto scaling and Elastic Load Balancing for servers/services set up on the Web, Application, and Database tiers.


7. Set up AWS Session Manager access for remote admins.

8. For shared AWS services, configure VPC endpoints with ICAM policies to control access.

6 Enterprise 3 Build 2 (E3B2) Product Guides

This section of the practice guide contains detailed instructions for installing, configuring, and integrating all the products used to implement E3B2. For additional details on E3B2’s logical and physical architectures, please refer to Volume B. Build 2 was built on top of Build 1 and all the components in Build 1 were used in this build. For E3B1’s configuration please refer to Section 4. Below are the additional components added to Build 2.

6.1 Microsoft Azure AD Identity Protection

This section offers a guide for setting up the various components that make up Azure AD Identity Protection in your environment.
1. To ensure that all users register for multifactor authentication, configure Azure AD Multifactor
Authentication registration policy using the information found at Configure MFA Registration Policy.

2. Sign-in risk policy enables detection of and response to suspicious logon sessions and unusual
logon activity. Use the information found at Configure Sign-in Risk Policy to configure the sign-in
risk policy.

3. User-risk policy enables detection of and response to compromised user accounts. To configure
this policy, use the information found at Configure User-Risk Policy.

6.2 Microsoft Azure AD Identity Governance
Azure AD Identity Governance enables organizations to manage access to resources applying access
request and approval workflows, access assignments and removals, access expiration, and access
reviews.

1. Create an access package to encapsulate the target resources in a single object.
2. Create policies to define approvers and eligible requestors.
3. Requesting access to the access package can be done using the information found at Request access.
4. To approve or deny access requests, use the information found at Approve or deny request.

6.3 Microsoft Defender for Cloud Apps
Microsoft Defender for Cloud Apps is a cloud access broker solution that protects cloud applications and
on-premises web applications by monitoring session activity to those applications, ensuring compliance
to defined policy and mitigating detected threats.

1. Login to the portal and activate your Defender for Cloud Apps tenant.
2. Connect your apps to Defender for Cloud Apps. For custom web applications including on-premises web applications, use the information on connecting a custom app to Defender for Cloud Apps to integrate your custom web applications.
3. Use the information on creating and assigning policies to provide security controls to apps, ensuring compliance and mitigating threats.
4. Deploy Conditional Access App Control, which leverages Azure AD conditional access policies and enforcement for connected apps.
6.4 Microsoft Azure AD Application Proxy

Azure AD Application Proxy enables users to securely connect to internal applications via the Internet. It has two components, Application Proxy service and Application Proxy connector, which work together to provide access to the internal application.

1. Configure Application Proxy deployment prerequisites.
2. Install and register the Application Proxy connectors. Once the application proxy connectors are successfully installed and registered, the Application Proxy service will be enabled automatically.
3. Add your application to Application Proxy.

6.5 Microsoft Defender for Cloud

Defender for Cloud is a SaaS-based cloud security posture management and cloud workload protection platform. It enables organizations to monitor their cloud and on-premises resources, determine differences and security issues based on benchmarks and regulations, and provide recommendations to help remediate the issues. Within Defender for Cloud, benchmarks and regulations encapsulate policies that are used as baselines to measure how compliant your environment is. This leads to the generation of a secure score.

1. Enable Defender for Cloud for your subscription.
2. To receive a secure score, which provides a numeric value indicating your point-in-time security posture, you must ensure that the Azure Security Benchmark initiative or at least one other listed regulation is selected and applied to your subscription. Azure Security Benchmark should automatically apply to your subscription. Examples of regulations include PCI DSS, HIPAA, and NIST SP 800-53. Azure Security Benchmark is comprised of a set of controls that detect security misconfigurations based on best practices from common compliance frameworks.
3. Apply regulations to your subscription.
4. Defender for Cloud will list recommendations for your environment to improve the security posture. Apply the listed security recommendations.

6.6 Forescout eyeSight

Forescout eyeSight provides asset discovery with both active and passive techniques, and through integrations with network and security infrastructure.

For installation, configuration, and integration instructions, refer to Section 4.13.
6.7 **Forescout eyeControl**

Forescout eyeControl enforces and automates network policies across the enterprise.

For Forescout eyeControl installation instructions, visit the [Forescout Installation Overview](#).

6.7.1 **Configuring a policy**

1. In the Forescout Console, choose a policy.
2. Select the network segment to which the policy will be applied.
3. Add **Conditions** to select the attributes of the hosts that the policy will be applied to.
4. Add **Actions** that will be applied to the selected hosts.
5. Add any additional rules that will be used in the policy.
6. Run the policy.

6.8 **Forescout eyeSegment**

Forescout eyeSegment accelerates zero trust segmentation through visibility into traffic and transaction flows.

For Forescout eyeSegment installation instructions, visit the [Forescout Installation Overview](#). After installation has been completed, visit the [eyeSegment Application How-to Guide](#) to configure and use eyeSegment to analyze your network traffic from a dynamic zone perspective, simplify segmentation planning, and automate access control list (ACL)/VLAN assignment.

6.8.1 **Access the eyeSegment Dashboard**

1. From the Forescout Console, click **Dashboards**. This will launch a web browser and authenticate to the Forescout Web Client.
2. At the top of the Forescout Web Client, click **Segmentation**.
3. The initial dashboard is the eyeSegment Matrix. This dashboard can be used to analyze traffic and transaction flows between different network hosts, segments, and groups.
4. Open the eyeSegment Policy dashboard, which can be used to apply proposed zero trust rules. The effect of these rules can be seen in the eyeSegment Matrix.
5. Open the eyeSegment Health dashboard, which provides information about Reporting Appliances, Traffic Sensors, Endpoint Coverage, and the connection to the eyeSegment cloud.
6.9 Forescout eyeExtend

Forescout eyeExtend automates security workflows across disparate products through integration with other security technologies.

For Forescout eyeExtend installation instructions, visit the Forescout Installation Overview. Once installation has been completed, visit the Connect Plugin Configuration Guide, which provides the capability to build custom integrations with products that are not already provided. However, Forescout also provides a wide range of integrations at the official Forescout eyeExtend repository.

6.9.1 Integration with Microsoft Endpoint Manager

Integration instructions for Microsoft Endpoint Manager can be found at Forescout’s official GitHub repository: https://github.com/Forescout/eyeExtend-Connect/tree/master/Intune.

6.10 Microsoft Azure IaaS

Azure IaaS provides compute, networking, and storage services that enable the creation of an enterprise IT infrastructure by subscribers. The following section describes the Azure IaaS components that were deployed in this build.

1. Virtual Networks (VNETs) are isolated customer networks. They contain subnets and are built in Azure. We have three VNETs: a hub VNET, which provides central connectivity for other VNETs, and a GitLab VNET and a WordPress VNET, which are both designed to protect individual apps and their associated resources. Use the information at Create a VNET to create and configure a virtual network. To enable communication between the hub and other VNETs, establish peering between them.

2. Public VNETs are regular VNETs that have hosts with public IP addresses. The GitLab VNET is configured as a public subnet with a public IP address attached to the Application Gateway which was configured to provide load balancing and protection against common web attacks.

3. Private VNETs are regular VNETs that have hosts with only private IP addresses and are reachable only by internal users by default. WordPress VNET was configured as a private VNET.

4. Configure Azure Bastion to enable web-based SSH and remote desktop-based access to servers and virtual machines.

5. Instantiate and configure Azure Firewall in the hub VNET to provide protection for incoming traffic from both the Internet and the VPN traffic from on-prem clients.

6. Use network security groups (NSGs) to filter inbound or outbound traffic to or from Azure resources. Enable only ports that are necessary for appropriate access.
7. Azure App Gateway is a web traffic load balancer that can detect and stop common web attacks. The Azure App Gateway was configured to protect the GitLab application servers, and the WordPress servers. Use the information at Application Gateway Quickstart to configure the Application Gateway.

7  Enterprise 1 Build 3 (E1B3) Product Guides

E1B3 uses all of the same products and technologies as E1B2. (See Section 5.)

8  Enterprise 2 Build 3 (E2B3) Product Guides

This section of the practice guide contains detailed instructions for installing, configuring, and integrating all of the products used to implement Microsegmentation (Network) E2B3. For additional details on E2B3’s logical and physical architectures, please refer to Volume B.

8.1  Ping Identity PingOne

Ping Identity PingOne is a SaaS solution that provides ICAM capabilities to an enterprise. The following sections describe the setup of PingOne and its PingFederate service, and various integrations to other products. Ping Identity integrates with Radiant Logic for identity information, and with Cisco Duo to delegate the second authentication factor for users accessing resources.

8.1.1  Configuration: PingOne and PingFederate

Refer to Section 3.1.1.

8.1.2  Integrations

Refer to Sections 3.1.2 and 3.1.3 for integrations of Ping Identity with Radiant Logic and Cisco Duo.

VMware Workspace ONE Access’s Integration with PingFederate was achieved using a SAML redirect (Workspace ONE Access is configured as a third-party SAML IdP in PING). When users on mobile devices attempt to authenticate through PingFederate, they will be redirected to Workspace ONE Access. Workspace ONE Access performs seamless passwordless user and device authentication using certificates, as well as checking the device’s compliance status in Workspace ONE UEM. The result of the compliance check and authentication is passed back to PING as a SAML Assertion.

1. To integrate with VMware Workspace ONE Access, navigate to the Authentication -> IdP Connections menu and click Create Connection to create an IdP connection. The steps below describe the information needed to configure this IdP connection.
2. For the IDP Connection settings, the connection role is IdP using SAML 2.0. General information needed is Partner’s Entity ID, Connection Name, and Base URL. All this information is provided by Workspace ONE Access.

3. Browser SSO properties include IdP-Initiated SSO and SP-Initiated SSO.

4. For User-Session Creation information, leverage the contract that was created in Section 3.1.

5. For Protocol Settings, SSO Service URLs need to include a Redirect URL and a POST URL.

6. Lastly, a certificate that is provided by Workspace ONE Access is needed for Credentials.

Refer to the PingFederate Administrator’s Reference Guide for detailed configuration steps.

### 8.2 Radiant Logic RadiantOne

#### 8.2.1 Installation and Configuration

Refer to Section 2.2.1 and Section 2.2.2.

Additional attributes were added to the RadiantOne solution. These attributes allow other ZT tools to create more granular policies for access. Within the Directory Namespace, we created namespaces (HDAP) for Clearance, Data Governance, Risk, and Training. Information pertaining to these categories was imported via flat files for the purpose of this build. For configuration instructions, refer to RadiantOne v7.4.4 Namespace Configuration Guide. We also updated RadiantOne’s configuration with a global identity view of users combining these attributes with the AD directory and HR database. We leveraged the Global Identity Builder to perform this.

#### 8.2.2 Integrations

Refer to Section 2.2.3 for integration of Radiant Logic with SailPoint.

To integrate with Cisco ISE and VMware Workspace ONE Access, follow the instructions in the Integration sub-section of Section 2.2 to create unique service accounts for the integration.

### 8.3 SailPoint IdentityIQ

#### 8.3.1 Installation and Configuration

Refer to Section 2.3.1.

#### 8.3.2 Integration with Radiant Logic

Refer to Section 2.3.2.
8.3.3 Integration with AD

Refer to Section 2.3.3.

8.3.4 Integration with Ping Identity

There is no integration with Ping Identity. For this build, SailPoint provides AD user information and Duo pulls from AD.

8.4 VMware Workspace ONE

VMware Workspace ONE Access is a cloud-based service that provides a variety of management functions to support enterprise operations. For this build, two VMware services were utilized to support endpoint management functionality: Workspace ONE Access and Workspace ONE UEM.

8.4.1 VMware Workspace ONE Access

Workspace ONE Access can serve as an IdP and integrate with a large range of enterprise identity components. For this build, Workspace ONE Access was integrated with PingFederate and RadiantOne to provide certificate-based authentication for endpoints.

8.4.2 Setup

Each instance of Workspace ONE Access must be provisioned by VMware. After this has been completed, VMware provides access and setup instructions.

8.4.3 Integration with RadiantOne

To integrate with RadiantOne, an on-premises agent was installed on a Microsoft Windows Server 2019 system and connected to Workspace ONE Access. After this, Workspace ONE Access was configured to pull user, group, and attribute information.

1. The step-by-step guide to adding the on-prem connector can be triggered in the Workspace ONE Access console by navigating to Integrations -> Connectors and clicking New.
2. After the on-prem agent is installed and connected to Workspace ONE Access, follow the official VMware documentation to add a new LDAP Directory and point Workspace ONE Access to your RadiantOne installation.

Once these two steps are completed, RadiantOne’s users, groups, and attributes are available for use within Workspace ONE.
8.4.4 Integration with PingFederate

Integration with PingFederate was achieved using a SAML redirect. When users with mobile devices attempt to authenticate through PingFederate, they will be redirected to Workspace ONE Access if certificate authentication is available.

1. In the Workspace ONE Access console, navigate to **Integrations** -> **Identity Providers** and click **Add** -> **SAML IdP**.
2. Fill out details in the form pertaining to your installation. For the binding protocol, select **HTTP Redirect**.
3. Under **Users**, select the directory that you created in your previous integration with RadiantOne.
5. Click **Save** in the bottom right corner.

Now that the configuration on the Workspace ONE Access side has been completed, navigate to the PingFederate console.

1. Navigate to **Authentication** -> **IdP Connections** and click **Create Connection**.
2. Check the **BROWSER SSO Profiles** checkbox and select **SAML 2.0** from the dropdown menu that appears. Click **Next**.
3. Select the **Browser SSO** checkbox and click **Next**.
4. On the **Metadata URL** page, click **Next**.
5. Under the **Partner’s Entity ID (Connection ID)** section, paste your Workspace ONE Access metadata URL. It should look something like https://<WorkspaceONEAccessURL>/SAAS/API/1.0/GET/metadata/idp.xml.
6. Under **BASE URL**, add the base URL for your Workspace ONE Access instance. Click **Save**.

Workspace ONE Access can also be configured as a Service Provider (SP) for PingFederate. This process is very similar to the IdP configuration.

1. In the PingFederate console, navigate to **Applications** -> **SP Connections** and click **Create Connection**.
2. Check the **BROWSER SSO Profiles** checkbox and select **SAML 2.0** from the dropdown menu that appears. Click **Next**.
3. Select the **Browser SSO** checkbox and click **Next**.
4. On the Metadata URL page, click **Next**.

5. Under the **Partner’s Entity ID (Connection ID)** section, paste your Workspace ONE Access metadata URL. It should look something like https://<WorkspaceONEAccessURL>/SAAS/API/1.0/GET/metadata/idp.xml.

6. Under **BASE URL**, add the base URL for your Workspace ONE Access instance. Click **Next**.

7. Under **Browser SSO**, select the checkboxes next to **IdP-Initiated SSO** and **SP-Initiated SSO**.

8. For **Assertion Creation**, select the checkbox next to **Enable Standard Identifier**. Select the PingFederate contract to use for this connection.

9. Under **Protocol Settings**, set the **Assertion Consumer Service URL** to /SAAS/auth/saml/response. Click **Save**.

Initial setup for this integration has now been completed. To utilize this integration, you can set policies on either Workspace ONE Access or PingFederate to point to the other IdP or SP. In PingFederate, this can be found under **Authentication -> Policies**. In Workspace ONE Access, this can be found under **Resources -> Policies**.

### 8.4.5 VMware Workspace ONE UEM

Workspace ONE UEM provides endpoint management capabilities for this build and allows certificates to be provisioned for user authentication.

### 8.4.6 Setup

The cloud-based Workspace ONE UEM instance must be provisioned by VMware. After this has been completed, follow the [official Workspace ONE UEM documentation](#) to deploy agents to each of your managed endpoints. Instructions for deploying profiles and compliance requirements to devices can also be found in the link above.

### 8.4.7 Integration with Certificate Authority

To provide certificates with custom attributes, Workspace ONE UEM was integrated with the on-prem Certificate Authority hosted in Enterprise 4. Instructions on how to complete this process can be found in the [official Workspace ONE UEM documentation](#).

### 8.5 Cisco Duo

Cisco Duo is a SaaS solution that implements and enforces security policies and processes, using strong authentication to reduce the risk of data breaches due to compromised credentials and access from unauthorized devices. For this build, we use Cisco Duo as the second authentication factor for resources.
8.5.1  Configuration
Refer to Section 3.4.1.

8.5.2  Integration
Refer to Section 3.4.2.

8.6  Palo Alto Networks Next Generation Firewall
For installation, configuration, and integration instructions, refer to Section 3.5.

8.7  IBM Security QRadar XDR
For installation, configuration, and integration instructions, refer to Section 2.9.

8.8  Tenable.io
For installation, configuration, and integration instructions, refer to Section 2.10.

8.9  Tenable.ad
For installation, configuration, and integration instructions, refer to Section 2.11.

8.10  Tenable NNM
For installation, configuration, and integration instructions, refer to Section 2.12.

8.11  Mandiant Security Validation (MSV)
For installation, configuration, and integration instructions, refer to Section 2.13.

8.12  DigiCert CertCentral
For installation, configuration, and integration instructions, refer to Section 2.14.

8.13  Cisco Identity Services Engine (ISE)
Cisco ISE is a network central PDP that includes both PE and PA to help organizations provide secure access to users, their devices, and the other resources in their network environment. It simplifies the delivery of consistent and secure access control to PEPs across wired and wireless multi-vendor networks, as well as remote VPN connections.
To deploy ISE, use the following steps:

1. Install Cisco ISE ADE-OS-Version 3.1.0.010 Patch 5 using **Cisco ISE Installation Guide**.
2. Continue configuration using **Cisco ISE configuration information**.
3. Key configuration features used at the NCCoE lab are as follows:
   a. Basic setup: Cisco ISE Deployment model used is the “Stand Alone” as shown [here](#).
   b. Maintain and Monitor: System recovery, syslog settings, backups/recovery, advance filtering, and reporting, including endpoint purging and quarantining used as shown [here](#).
   c. Secure Access: Cisco ISE User Identity is supported by Integration with Microsoft Active Directory as the user identity source as shown [here](#).
   d. Profiling and Compliance: Configuration of posture policies to mandate allowance of specific applications is shown [here](#). For NCCoE lab configuration, AnyConnect is enabled on endpoints in order to achieve accurate posture on enterprise-supplied endpoints.
   e. Segmentation: Cisco ISE supports configuration for segmentations as shown [here](#).
   f. BYOD: Cisco ISE is used as a tool that allow employees to securely use either employer-provided or personal devices on the enterprise network. Cisco ISE is used to protect network services and enterprise data by authenticating and authorizing users (employees and contractors) and their devices. The BYOD configuration is shown [here](#).

### 8.13.1 Integrations

Cisco ISE was provisioned with a service account to pull user and device attributes from Workspace ONE UEM for use in policy decisions. Configure this integration in **Administration/Network Resources/External MDM** using the **ISE Admin Guide**.

Cisco ISE and Cisco Secure Network Analytics (SNA) are integrated to allow SNA to provide network visibility information to ISE to enforce policies. Integration configuration was completed by creating a client for SNA under **Administration/pxGrid Services/Client Management**.

### 8.14 Cisco Secure Workload (CSW – Formerly Tetration)

Cisco Secure Workload (formerly known as Cisco Tetration) is designed to address application security challenges by providing comprehensive workload protection and bringing security closer to applications and tailoring the security posture based on the application behavior. For configuration, this document references specific sections of the **Cisco Secure Workload User Guide**.
8.14.1 Configuration

For this build, the NCCoE used the SaaS-based version of CSW. To start, contact a Cisco representative to procure an instance of CSW.

1. A prerequisite for CSW is to gather and document the organizational layout of your enterprise in the form of security boundaries. Leverage the Cisco Secure Workload Quick Start Guide to familiarize the CSW design using scopes and labels.

2. Once a basic understanding of CSW is achieved, a CSW administrator can leverage labels to develop the scope tree. These labels can be uploaded to CSW so that CSW maintains these additional metadata tags within the inventory database in CSW.

3. Once logged into CSW, leverage the first-time user-experience (FTUE) wizard to define the scope and inventory. Note: This step was not necessary, but it was leveraged to have a baseline understanding of how scopes and inventory function.

4. In parallel to a scope tree being defined in CSW, users can begin installing software agents on all workloads (resources) to be managed by CSW. Once in the “Software Agents Installer” page, the user will be guided through the process of selecting the OS platform to download. See the Deploying Software Agents page for support platforms, requirements, and install instructions.

5. With agent installations completed on the workloads, CSW will begin collecting network flow data along with OS information about these resources. Ensure a minimum of at least a week or so if you want to take advantage of CSW’s ability to auto-generate microsegmentation policies using the solution’s built-in machine learning algorithms.

6. Once agents are installed and your scope tree is set up properly, create policies. The policy analysis phase is intended to be an iterative process that allows a CSW user to adjust policies as necessary.

7. Once you feel the policies are good enough to enforce, enable enforcement of those policies. Alerts should be created for escaped policies. CSW can, at a minimum, generate internal alerts, but best practice suggests that these alerts should also be sent to a northbound platform like a SIEM.

8.15 Cisco Secure Network Analytics (SNA – Formerly Stealthwatch)

Cisco Secure Network Analytics (SNA) uses machine learning, behavioral modeling, and threat intelligence to provide network visibility. For this build, we mainly leverage NetFlow data collected from network devices to feed to SNA.
8.15.1 Installation

The components of SNA are installed on-premises in the virtual environment for Enterprise 2. Installation is completed using the Virtual Edition Appliance Installation Guide 7.4.1. Specific sections from that guide are noted below.

1. Prior to installing SNA, check all resource requirements and prerequisites (General Deployment Requirements and Section 1).

2. Install the virtual edition for VMware vCenter (Section 3a).

3. Configure the SNA manager and the Flow Sensor (Section 4).

8.15.2 Configuration

Use the Cisco Secure Network Analytics System Configuration Guide to configure the SNA.

1. Configure SNA to retrieve information for network appliances. This is performed by the Flow Sensor, which is a separate appliance managed by the SNA manager.

2. Configure network components to send NetFlow data to the SNA Flow Sensor. Note: There are tools that can build the configuration for network devices.

3. Configure hosts and host groups to be used by policies and response management.

4. Configure policies to monitor various host groups.

5. Configure response management to perform specific actions based on policies. Response management configuration provides information to Cisco ISE to act on those policies.

8.15.3 Integration

Integrate with Cisco ISE to inform ISE of actions it needs to take to allow or deny communications based on the policies. To integrate with ISE, follow the configuration instructions shown here.

8.16 Cisco Secure Endpoint (CSE – Formerly AMP)

Cisco Secure Endpoint (CSE) is a cloud-based solution that leverages connectors that are deployed on endpoints to protect against vulnerabilities. The configuration steps below leverage the Cisco Secure Endpoint User Guide.

1. Work with your Cisco representative to procure an instance of Cisco Secure Endpoint.

2. Ensure administrator accounts are created and users have access to the AMP portal.
3. Develop policies for all your different endpoints. For this build, endpoints include Windows, macOS, Linux, iOS, and Android devices. By default, CSE has various default policies that can be applied to endpoints once these endpoints are configured. For this build, we began by leveraging the Audit mode to allow CSE to gather information and learn about the endpoints. After several weeks, we enabled the Enforce mode to block malicious traffic. Refer to Chapter 5 of the User Guide.

4. Note that Groups can be configured to apply policies for different types of endpoints. Refer to Chapter 6.

5. Exclusions for the types of applications that you want to exclude from policies can be configured. You can create custom exclusions or view the Cisco-maintained exclusions list. Refer to Chapter 4.

6. Download connectors from CSE and deploy them to endpoints. Once in the Management/Download Connector page, links will be available for download or for a URL for the various endpoints that CSE supports. The URL can be provided to the user to download, or it can be downloaded and deployed via an enterprise tool. Refer to Chapters 8-12 for connector installation.

8.16.1 Integrations

CSE integrates with ISE to provide endpoint threat detection information to ISE to act on. The process for integration begins with Cisco ISE. From the ISE Administration menu, click on the Third Party Vendors link. Click Add and click Cisco AMP as the vendor. Input all information. Once added, there will be a status link stating “Ready to configure.” Click on it and follow instructions to configure CSE.

8.17 Palo Alto Networks - Panorama

Palo Alto Networks’ Panorama provides centralized management and monitoring of the Palo Alto Networks NGFWs. For this build, it was leveraged to integrate with Cisco ISE in addition to managing the NGFWs.

1. Deploy Panorama in the virtual environment using Palo Alto Networks’ prerequisite recommendations. Follow each step of the deployment to install the VM, register Panorama and install licenses, perform updates, add firewalls as managed devices, and create templates and device groups.

2. Complete all configuration of the firewalls on Panorama’s console.

3. For remote access, the NGFW is leveraged to check compliance of user devices. Create the configuration for compliance checks and add it to the VPN policy created for users. Note: Integration with ISE needs to be completed prior to this step.
8.17.1 Integration with Cisco ISE

For this integration, the user logging onto the Palo Alto Networks VPN will leverage ISE for authentication. The Palo Alto Networks NGFW will perform device compliance checks prior to completing the authentication. To integrate with Cisco ISE, leverage the instructions to enable delivery of vendor-specific attributes to RADIUS server.

9 Enterprise 3 Build 3 (E3B3) Product Guides

This section of the practice guide contains detailed instructions for installing, configuring, and integrating all the products used to implement E3B3. For additional details on E3B3’s logical and physical architectures, please refer to Volume B. Build 3 was built on top of Build 2 and all the components in Build 2 were used in this build. For E3B2’s configuration, please refer to Section 6. Below are the additional components added to Build 3.

9.1 Microsoft Defender for Identity

Microsoft Defender for Identity is a cloud-based solution that detects identity-based threats in hybrid environments. Using signals collected from AD, it will discover compromised identities and alert on suspicious user actions. To deploy Defender for Identity, use the following steps:

1. Review the prerequisites before deploying Defender for Identity.
2. Configure the necessary Windows event logs to enable appropriate detections.
3. Create a directory service account that will be used by Defender for Identity in the domain.
4. Download and install the Defender for Identity sensor.
5. Configure sensor settings and validate installation.

9.2 Microsoft Defender for Office

Microsoft Defender for Office 365 provides protection from malware, phishing, spam, unsafe links and attachments, and other related threats. To configure Defender for Office 365, use the following steps:

2. Configure anti-phishing policies.
3. Configure anti-malware policies.
4. Configure safe attachment protections in Office 365.
5. Set up safe links protections.
9.3 Purview Information Protection

Purview Information Protection discovers, labels, classifies, and protects data in the cloud and on-premises. It aims to provide data governance and protection throughout the enterprise.

Discover your sensitive data using the examples shown here. To discover sensitive data on-premises, you will need to deploy the Information Protection Scanner.

9.3.1 Information Protection Scanner

Information Protection Scanner is used to discover sensitive data in an on-premises environment.

Use the information here to install and configure the Information Protection Scanner.

9.3.2 Purview DLP

Purview Data Loss Prevention (DLP) reduces the risk of unauthorized information disclosure and reduces the likelihood that sensitive data will be shared inappropriately. Data loss prevention policies specify the category of data to protect and the type of restrictions that are applicable.

Use the information here to create and deploy DLP policies.

9.4 Entra Permissions Management

Entra Permissions Management provides visibility and control of an identity’s permissions in Amazon Web Services (AWS), Microsoft Azure, and Google Cloud Platform (GCP). It identifies a user’s permissions across all three cloud platforms, determines which permissions are not required based on usage, and can be configured to reduce the permissions to only those being used.

1. Enable Entra Permissions Management.
2. Onboard an AWS Account.
3. Onboard an Azure Subscription.
4. Onboard a GCP Project.
5. Add an AWS Account, Azure Subscription, and GCP Project after onboarding is complete.
6. To view inactive users or users with overprovisioned permissions, click here.
7. To revoke unused permissions, click here.
9.5 Azure Virtual Desktop

Azure Virtual Desktop is a desktop and application virtualization service that delivers the full Windows experience over HTTPS to a connecting client. Use the following steps to set up Azure Virtual Desktop:

1. Understand prerequisites prior to deployment.
2. Create and connect to an Azure Virtual Desktop.

9.6 Intune VPN Tunnel

The Intune VPN Tunnel is a VPN solution that provides access to internal network resources from iOS/iPad and Android devices using modern authentication and conditional access. Use the following steps to set up the Intune VPN Tunnel:

1. Understand the prerequisites prior to deployment.
2. Install and configure Intune VPN Tunnel.

9.7 Azure Arc

Azure Arc is an Azure cloud platform that provides governance and management of on-premises servers, containers, and other related infrastructure components using Azure policies and management tools. It essentially extends governance to resources existing in on-premises environments. Use the following steps to set up Azure Arc:

1. Understand network requirements.
2. Understand Azure Arc-enabled servers.
3. Onboard a Windows server.
4. Onboard a Linux server.

9.8 Azure Automanage

Azure Automanage automatically configures onboarded servers with Azure best practices, monitors those servers, and Remediated them when any configuration drift occurs. With Automanage, you must create a configuration profile for the server.

Enable Azure Automanage for VMs in Azure portal.

9.9 Microsoft Sentinel Playbooks

Playbooks in SOAR systems enable automated responses to address detected threats in an environment. In this build, a Sentinel playbook was created to revoke or terminate sessions of users when the risk
evaluated for that session was deemed high. You can create playbooks with the information found at the create a playbook link.

9.10 Microsoft Privileged Access Workstation

A privileged access workstation is a hardened workstation that includes security controls that lock down local administrative access and tools to only what is required for performing sensitive tasks. Use the information at configure a privileged access workstation to do so.

10 Enterprise 4 Build 3 (E4B3) Product Guides

This section of the practice guide contains detailed instructions for installing, configuring, and integrating all the products used to implement E4B3. For additional details on E4B3’s logical and physical architectures, please refer to Volume B.

10.1 IBM Security Verify

IBM Security Verify is a cloud-based SaaS that operates as the Policy Engine and ICAM for Enterprise 4 and provides a variety of services including SSO, multifactor and passwordless authentication, adaptive access, identity lifecycle management, and identity analytics.

10.1.1 Setup

IBM provisioned a new instance of IBM Security Verify for this build.

10.1.2 Integration with Active Directory

To integrate with Active Directory, an IBM Security Verify Bridge agent was installed on an on-premises server running Microsoft Windows Server 2019. To replicate this process, follow the instructions in the official IBM documentation. Completing this integration will add AD as an available identity source in IBM Security Verify.

10.1.3 Configuration

For this build, configuration focused on several areas. First, the integration with applications/resources needed to be configured. With the AD integration completed, users, groups, and attributes can now be managed, and authentication methods can be set up. Finally, access policies can be defined and implemented.

1. Add/configure connected applications.
   a. Begin the application configuration using the official IBM documentation.
b. In this build, SAML was configured to allow for user authentication. Follow the official IBM documentation for instructions on this step.

2. Users, groups, and attributes were managed using the official IBM documentation. This allowed the configured policies to make decisions using user and group attributes.

3. Create security policies. There are a variety of pre-built policies available that can be utilized in different scenarios. For example, one of the pre-built policies will deny access to any device that is not in compliance with MaaS360 policy. Custom policies can also be built based on a range of criteria, including user and group attributes. Additional information on creating/editing policies can be found in the official IBM documentation.

10.2 IBM Security Trusteer

IBM Security Trusteer is a cloud-based SaaS that integrates with IBM Security Verify and uses cloud-based intelligence, AI, and machine learning (ML) to holistically identify new and existing users while improving the overall user experience by reducing the friction created with traditional forms of MFA. Within a ZTA, Trusteer acts as a risk engine that improves the efficacy of policy decisions enforced by various identity and access management solutions.

10.2.1 Integration with IBM Security Verify

To act as a risk engine in this build, IBM provisioned a new Trusteer instance and linked it with IBM Security Verify. This action must be completed by an IBM representative.

10.3 IBM Security MaaS360

IBM Security MaaS360 cloud-based SaaS provides endpoint management capabilities for both user workstations and user mobile devices through agents installed on each endpoint, supporting both BYOD and corporate-owned device usage.

10.3.1 Setup

IBM provisioned a new cloud-based instance of IBM Security MaaS360 for this build.

10.3.2 Configuration

The majority of MaaS360 configuration for this build was completed by building policies to apply to user or device groups.

1. Configure user and device groups. Group configuration instructions can be found in the official IBM documentation.
2. Build and apply policies to groups. Instructions for building these policies can be found in the official IBM documentation.

3. Once these groups have been built and policies have been applied, policy enforcement can begin.

10.4 IBM Security QRadar XDR

For installation, configuration, and integration instructions, refer to Section 2.9.

10.4.1 Integration with IBM Security MaaS360
QRadar was integrated with MaaS360 using the official IBM documentation.

10.4.2 Integration with IBM Security Verify
QRadar was integrated with Verify using the official IBM documentation.

10.5 IBM Security Guardium
IBM Security Guardium is a data security platform that protects sensitive and regulated data across with compliance enforcement, sensitive data discovery, data encryption, and risk reduction. This build utilized two Security Guardium products: Guardium Data Protection and Guardium Data Encryption.

10.5.1 IBM Security Guardium Data Protection
Guardium Data Protection is a unified data security solution that provides data discovery and classification, data activity monitoring and analytics, real-time response to threats, and automated compliance auditing and reporting. For this build, a single Guardium Data Protection appliance was deployed in VMware to serve as a data collector.

10.5.1.1 Appliance Installation and Configuration
1. Create a new virtual machine using IBM’s recommended requirements.
2. Boot from the IBM-provided Guardium Data Protection ISO using the IBM Guardium installation guide.
3. Choose standard installation at the boot prompt. Once the install completes, on first boot the appliance will ask the user to choose Collector or Aggregator mode. Choose Collector.
4. After the installer finishes, log into the appliance console using the default credentials.
5. Complete the initial setup and configuration for the appliance using the IBM Guardium setup guide. Reboot the appliance when configuration changes are complete.
6. Log into the appliance command line and add a QRadar instance as a remote logger with the command.

7. Log into the Guardium Data Protection web console at https://<ip address>:8443

8. Confirm remote log forwarders are configured by clicking on Tools | Tools and Views | Remote Loggers. Each daemon should have a green checkmark.

10.5.2 IBM Security Guardium Data Encryption

Guardium Data Encryption is a data encryption suite that can safeguard files and databases, provide in-application encryption, manage encryption keys, and enforce access policies for data.

10.5.2.1 Appliance Installation & Configuration

The Guardium Data Encryption platform for this build requires a local appliance installation on the Enterprise 4 VM ware farm.

1. Obtain the latest .ova image from IBM for the IBM Security CipherTrust Manager software.

2. Follow the install guide to deploy the IBM Security CipherTrust Manager on a new virtual machine with the cloud-init configuration enabled to set the static IP address.

3. On boot, access the assigned IP address of the CipherTrust Manager with a web browser and enter a user’s public SSH key for administrator access. The CipherTrust Manager is not functional until this key is entered.

4. Change the default administrator password.

5. Under Admin Settings | Licensing, enter a license key or click on Start CipherTrust Evaluation to license the appliance.

10.5.2.2 S-TAP Installation and Configuration

1. Install the appropriate S-TAP agent on any client machines that require monitoring. For this build the Windows S-TAP agent was deployed on the Microsoft SQL Server Express 2019 using IBM’s install guide. The S-TAP agent appliance IP address used during setup is from the IBM Guardium Data Protection Collector configured in the previous section.

2. Confirm S-TAP control from the IBM Guardium Data Protection Collector web console by accessing the S-TAP control menu and verifying the client machine appears with a green checkmark.

10.5.2.3 Client Machine Setup and Configuration

The client machine for this build is a Windows 2019 Server running Microsoft SQL Server Express 2019.
1. From the Guardium Data Encryption web console, create a registration token for the client machine following the steps in the CipherTrust Manager Administration Guide.

2. Copy and save the registration token created in step 1.

3. From the Guardium Data Encryption web console, manually create a new client entry for the client machine following the steps in the CipherTrust Data Encryption Guide. For this build, password registration was used to register the client with a user-generated password.

4. Install the CipherTrust Transparent Encryption client software on the client machine. Choose Register CipherTrust Transparent Encryption Now at the end of the installation. These parameters were used for this build:
   a. Components: File System
   b. Host name of key manager: IP/DNS of the Guardium Data Encryption Appliance
   c. Enable hardware association and LDT feature.
   d. On the host screen, paste the ASCII token from Step 2 into the Registration Token field. Leave the remaining fields blank.
   e. Click Next and then Finish once the client is registered. Restart the client machine.

10.5.2.4 GuardPoint Configuration

A GuardPoint specifies the list of folders that contain paths to be protected. Access to files and encryption of files under the GuardPoint are controlled by security policies. More information on Guardpoints can be found in the Guardium Data Encryption GuardPoint Guide.

1. Create two user sets, one for full and one for limited/no access using the CipherTrust Transparent Encryption Guide. For this build, the Admins User Set will have no access to a protected directory while the AppUsers User Set will have full access.


3. Follow the CipherTrust Transparent Encryption Guide using Step 2 to create a new Key Rule and a new encryption key.

4. Once the policy is created, check the order of the Key Rules from the Policies Menu on the web console. If they are out of order, reorder them according to Step 2.

5. Create “encrypted” and “unencrypted” folders on the client machine to test access policies.
6. From the web console, create an AutoDirectory GuardPoint using the CipherTrust Transparent Encryption Guide. Use the Policy created in Step 2 and point the GuardPoint to the “encrypted” folder created in Step 5.

7. Confirm access is restricted by logging into the client machine with a user from each UserSet.

10.6 IBM Cloud Pak for Security (CP4S)

The IBM Cloud Pak for Security (CP4S) platform enables the integration of existing security tools and provides understanding and management of threats in the environment.

10.6.1 Installation

Refer to Section 2.8 for CP4S installation instructions.

10.6.2 CP4S and QRadar Integration

For this build, QRadar was integrated into CP4S as a data source for events from other resources.

1. Install the QRadar SOAR app plugin on the QRadar instance.

2. Configure the QRadar SOAR app plugin to connect to the CP4S instance using an API key. Follow the instructions in the IBM QRadar SOAR app plugin Configuration Guide.

3. An IBM Edge Application Gateway must be installed first to connect CP4S to QRadar. Install the Edge Gateway appliance in your virtual environment following the IBM installation guide.

4. Pair the IBM Cloud Pak for Security account with the Edge Gateway appliance.

5. Finish creating the Edge Gateway with the pairing information from Step 4.

6. Follow the IBM guide to add QRadar as a data source to CP4S.

10.6.3 CP4S Playbooks

A CP4S Playbook is a set of rules, conditions, business logic, workflows, and tasks used to respond to a case/incident. For this build, IBM provided a test playbook to disable accounts in IBM Security Verify when multiple failed logins were detected in QRadar. Playbook design suggestions and instructions can be found in the IBM Cloud Pak for Security SOAR Guide.

10.7 IBM Cloud

IBM Cloud provides compute, networking, and storage services that enable the creation of an enterprise IT infrastructure by subscribers.
1. Start with setting up the IPsec tunnel between IBM Cloud and the on-prem data center as shown [here](#).

2. Build the components in the IBM Cloud using the architecture and configuration guide.

### 10.8 Tenable.io

For installation, configuration, and integration instructions, refer to Section 2.10.

### 10.9 Tenable.ad

For installation, configuration, and integration instructions, refer to [Section 2.11](#).

### 10.10 Tenable NNM

For installation, configuration, and integration instructions, refer to [Section 2.12](#).

### 10.11 Mandiant Security Validation (MSV)

For installation, configuration, and integration instructions, refer to [Section 2.13](#).

### 10.12 DigiCert CertCentral

For installation, configuration, and integration instructions, refer to [Section 2.14](#).

### 10.13 Palo Alto Networks Next Generation Firewall

For installation, configuration, and integration instructions, refer to [Section 3.5](#).

### 10.14 VMware

The VMware environment was used for on-premises virtualized infrastructure hosting enterprise resources and consisted of three vSAN clusters. The VMware vSAN installation and configuration guide can be found [here](#).

### 11 Enterprise 1 Build 4 (E1B4) Product Guides

This section of the practice guide contains detailed instructions for installing, configuring, and integrating all the products used to implement E1B4. For additional details on E1B4’s logical and physical architectures, please refer to Volume B.
11.1 Appgate

The Appgate SDP solution has been designed with the intent to provide all the critical elements of zero trust. The Appgate SDP has a controller that offers PA and PE functionality, and gateways that offer PEP functionality. By providing highly performant, scalable, secure, integrated, and cloaked zero trust access, Appgate SDP is able to ensure that the correct device and user (under the appropriate conditions at that moment in time) are connected.

11.1.1 Appgate Installation and Configuration

Appgate components for deployment are the controller and gateway. Prior to installation, admins should understand the pre-installation considerations to deploy Appgate. These considerations include browser compatibility, network setup, identity providers, and DNS.

For this build, an Appgate controller and gateway are deployed on-prem as well as in the AWS IaaS cloud. Both the controller and gateway are deployed on the same server on-prem and in AWS.

For the on-prem installation, we used the instructions in the Appgate SDP Installation from ISO into VMware guide.

For the Appgate install in AWS, we used the Appgate SDP for AWS Deployment Guide.

After installation, the initial configuration is completed via CLI (command-line interface) on the controller. Note: Gather various information about the network and IP addresses that are needed to configure the controller. Once the configuration is completed, an administrator can gain access to the GUI via https://“controller-ip-address”:8443 on a browser.

Gateway configuration: As mentioned earlier, the gateway is deployed on the same server as the controller. Once logged into the controller, deploy the gateway.

For this build, policies were created to allow users to access various resources on-premises and in the AWS IaaS environment for Enterprise 1. We leveraged the following tags, conditions, entitlements, and policies to allow employees access to all resources and contractors to certain resources.

- Tags were used to differentiate which users were allowed access. Tags were created for employees, contractors, and mobile devices. Tags can be created when configuring a policy.
  - Conditions were created for employees and contractors.
    - Check endpoints and resources for compliance
    - Appgate delegates to Ivanti to validate compliance for mobile devices
    - Do a 10-minute reauthentication for high-value resources
    - Validate user attributes pulled from Radiant Logic
An **entitlement** was created for four resources and applied with the appropriate tags. Resource1 and Resource2 were on-premises. Resource3 and Resource4 were in AWS. The employee tag was applied to all four resources. The contractor tag was applied to Resource2 and Resource4. Contractors did not have access to Resource1 and Resource3.

**Policies** were created for employees and contractors.

- The employee policy leveraged an identity provider for authentication, and validated that the user was an employee based on information retrieved from Radiant Logic. The employee tag was applied to this policy. Therefore, any entitlements and conditions applied with the same tag were applied to this policy.

- The same logic was applied to the contractor policy.

### 11.1.2 Appgate Clients

Appgate has clients for end users logging to desktop, laptop, and mobile devices for different OSes including Windows, Linux, macOS, iOS, and Android. [Installing clients](#) require downloads for all clients’ software, which are available [here](#).

Headless clients were also installed to protect resources. From the same download page above, the Windows client is the same for both workstations/laptops and servers. For Linux clients, use the “Ubuntu Headless Client v6.x.x” instead of the full client. Instructions for installing Windows and Linux both use the command line.

### 11.1.3 Appgate Integrations

For this build, Appgate integrates with Okta, Radiant Logic, Ivanti, and IBM.

For integration with Okta, which is used for authentication and authorization of the user to log in to the Appgate client, follow the [SAML configuration](#) instructions to create an identity provider in Appgate. Note: Certain information will be provided by Okta, so the integration configuration within Okta should be completed prior to this configuration.

For [integration configuration with Radiant Logic](#), the purpose is to identify users and additional attributes to verify compliance of a user. One attribute being leveraged is the groups attribute so Appgate can identify whether the user is an employee or contractor. We also leveraged several attributes such as BreakGlassScore, ClearanceValue, RiskLevel, and BehavioralRiskScore. A **User Claim Script** was leveraged to pull these attributes from Radiant Logic. If the user does not meet certain scores for these attributes, the user is denied entitlements to resources.

For integration with Ivanti, Appgate is trusting Ivanti’s claim of whether a device is complaint or not. To perform this integration, a **User Claim Script** was created. Note: Knowledge of JavaScript is required for this configuration.
To manage Appgate logs for large deployments, Appgate recommends using a LogForwarder to send logs to your log server or SIEM. For integration with IBM QRadar, we configured the LogForwarder to send logs to IBM QRadar.

11.2 Okta Identity Cloud

For this build, the integration between Okta and Ivanti was disabled in Okta Identity Cloud. Users logging into a resource are authenticated via Okta with a password for the first factor and Okta Verify for the second factor. Users logging into AppGate SDP also use Okta for authentication. Use the link for integration with AppGate to configure Okta. Note: Information such as Single Sign-on URL, Issuer, and other data created here are needed for the Appgate integration configuration.

No changes were made from Build 1 in Sections 2.1.2 and 2.1.3 (Okta Access Gateway). Refer to those sections for configuration details.

11.3 Radiant Logic RadiantOne

Additional attributes were added to the RadiantOne solution. These attributes allow other zero trust tools to create more granular policies for access. Within the Directory Namespace, we created namespaces for Clearance, Data Governance, Risk, and Training. Information pertaining to these categories was imported via flat files for the purpose of this build. For configuration instructions, refer to RadiantOne v7.4.4 Namespace Configuration Guide. We also updated RadiantOne’s configuration with a Global Database View of users combining these attributes with the AD directory and HR database. We leveraged the Global Identity Builder to perform this.

For integration with Appgate, a user ID was created in Radiant Logic as a service account for Appgate to be able to retrieve attributes. To create this, follow the instructions from Section 2.2.3.

11.4 SailPoint IdentityIQ

No changes were made from Build 1. Refer to Section 2.3.

11.5 Ivanti Neurons for UEM

No significant changes were made from Build 1. Ivanti Neurons for UEM was configured to deploy the AppGate Client to managed devices. For information, configuration, and integration instructions, refer to Section 2.4.

11.6 IBM Security QRadar XDR

For installation, configuration, and integration instructions, refer to Section 2.9.
11.7 Tenable.io
For installation, configuration, and integration instructions, refer to Section 2.10.

11.8 Tenable.ad
For installation, configuration, and integration instructions, refer to Section 2.11.

11.9 Tenable NNM
For installation, configuration, and integration instructions, refer to Section 2.12.

11.10 Mandiant Security Validation (MSV)
For installation, configuration, and integration instructions, refer to Section 2.13.

11.11 DigiCert CertCentral
For setup and usage instructions, refer to Section 2.14.

11.12 AWS IaaS
Amazon Web Services is a cloud computing platform provided by Amazon that includes a mixture of IaaS, PaaS, and SaaS offerings. This section describes the setup of AWS IaaS resources to serve as a public/private cloud host.

For details on the logical architecture of the AWS environment, please refer to Volume B, Section 4.4.9.1.

11.12.1 AppGate Controller Configuration
Ensure the on-prem controller can reach the AWS segment on which the new controller will be installed. This controller will need to communicate with the on-prem controller. To install the controller in AWS, follow the prerequisites outlined in the AWS Step by Step guide and the steps to provision AWS resource for a new appliance (up to Step 1 of the guide). Once these steps are completed, log in to the on-prem Appgate controller user interface (UI) and follow the Configuring a new appliance instructions to deploy the AWS controller.

11.13 Zimperium Mobile Threat Defense (MTD)
For installation, configuration, and integration instructions, refer to Section 2.10.
## Appendix A  List of Acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAD</td>
<td>(Microsoft) Azure Active Directory</td>
</tr>
<tr>
<td>ACL</td>
<td>Access Control List</td>
</tr>
<tr>
<td>AD</td>
<td>Active Directory</td>
</tr>
<tr>
<td>AG</td>
<td>(Okta) Access Gateway</td>
</tr>
<tr>
<td>API</td>
<td>Application Programming Interface</td>
</tr>
<tr>
<td>APM</td>
<td>(F5) Access Policy Manager</td>
</tr>
<tr>
<td>APNs</td>
<td>Apple Push Notification service</td>
</tr>
<tr>
<td>AWS</td>
<td>Amazon Web Services</td>
</tr>
<tr>
<td>BYOD</td>
<td>Bring Your Own Device</td>
</tr>
<tr>
<td>CA</td>
<td>Certificate Authority</td>
</tr>
<tr>
<td>CEF</td>
<td>Common Event Format</td>
</tr>
<tr>
<td>CLI</td>
<td>Command Line Interface</td>
</tr>
<tr>
<td>CP4S</td>
<td>(IBM) Cloud Pak for Security</td>
</tr>
<tr>
<td>CRADA</td>
<td>Cooperative Research and Development Agreement</td>
</tr>
<tr>
<td>CSE</td>
<td>Cisco Secure Endpoint</td>
</tr>
<tr>
<td>CSR</td>
<td>Certificate Signing Request</td>
</tr>
<tr>
<td>CSW</td>
<td>Cisco Secure Workload</td>
</tr>
<tr>
<td>DLP</td>
<td>Data Loss Prevention</td>
</tr>
<tr>
<td>DN</td>
<td>Domain Name</td>
</tr>
<tr>
<td>DNS</td>
<td>Domain Name System</td>
</tr>
<tr>
<td>E1B1</td>
<td>Enterprise 1 Build 1</td>
</tr>
<tr>
<td>E1B2</td>
<td>Enterprise 1 Build 2</td>
</tr>
<tr>
<td>E1B3</td>
<td>Enterprise 1 Build 3</td>
</tr>
<tr>
<td>E1B4</td>
<td>Enterprise 1 Build 4</td>
</tr>
<tr>
<td>E2B1</td>
<td>Enterprise 2 Build 1</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Full Form</td>
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<tr>
<td>-------------</td>
<td>-----------</td>
</tr>
<tr>
<td>ML</td>
<td>Machine Learning</td>
</tr>
<tr>
<td>MSV</td>
<td>Mandiant Security Validation</td>
</tr>
<tr>
<td>MTD</td>
<td>Mobile Threat Defense</td>
</tr>
<tr>
<td>NCCoE</td>
<td>National Cybersecurity Center of Excellence</td>
</tr>
<tr>
<td>NGFW</td>
<td>Next-Generation Firewall</td>
</tr>
<tr>
<td>NIST</td>
<td>National Institute of Standards and Technology</td>
</tr>
<tr>
<td>NNM</td>
<td>(Tenable) Nessus Network Monitor</td>
</tr>
<tr>
<td>NSG</td>
<td>Network Security Group</td>
</tr>
<tr>
<td>NTP</td>
<td>Network Time Protocol</td>
</tr>
<tr>
<td>OS</td>
<td>Operating System</td>
</tr>
<tr>
<td>OU</td>
<td>Organizational Unit</td>
</tr>
<tr>
<td>OVA</td>
<td>Okta Verify App, Open Virtual Appliance</td>
</tr>
<tr>
<td>PA</td>
<td>Policy Administration</td>
</tr>
<tr>
<td>PaaS</td>
<td>Platform as a Service</td>
</tr>
<tr>
<td>PDP</td>
<td>Policy Decision Point</td>
</tr>
<tr>
<td>PE</td>
<td>Policy Engine</td>
</tr>
<tr>
<td>PEP</td>
<td>Policy Enforcement Point</td>
</tr>
<tr>
<td>SaaS</td>
<td>Software as a Service</td>
</tr>
<tr>
<td>SAML</td>
<td>Security Assertion Markup Language</td>
</tr>
<tr>
<td>SDP</td>
<td>Software-Defined Perimeter</td>
</tr>
<tr>
<td>SIEM</td>
<td>Security Information and Event Management</td>
</tr>
<tr>
<td>SNA</td>
<td>(Cisco) Secure Network Analytics</td>
</tr>
<tr>
<td>SOAR</td>
<td>Security Orchestration, Automation, and Response</td>
</tr>
<tr>
<td>SP</td>
<td>Special Publication, Service Provider</td>
</tr>
<tr>
<td>SSH</td>
<td>Secure Shell</td>
</tr>
<tr>
<td>SSL</td>
<td>Secure Sockets Layer</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Full Form</td>
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</tr>
<tr>
<td>SSO</td>
<td>Single Sign-On</td>
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<tr>
<td>SSPR</td>
<td>Single Sign-On Password Reset</td>
</tr>
<tr>
<td>TCP</td>
<td>Transmission Control Protocol</td>
</tr>
<tr>
<td>TLS</td>
<td>Transport Layer Security</td>
</tr>
<tr>
<td>UAC</td>
<td>User Account Control</td>
</tr>
<tr>
<td>UDP</td>
<td>User Datagram Protocol</td>
</tr>
<tr>
<td>UI</td>
<td>User Interface</td>
</tr>
<tr>
<td>UEM</td>
<td>Unified Endpoint Management</td>
</tr>
<tr>
<td>URL</td>
<td>Uniform Resource Locator</td>
</tr>
<tr>
<td>VLAN</td>
<td>Virtual Local Area Network</td>
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<tr>
<td>VNET</td>
<td>Virtual Network</td>
</tr>
<tr>
<td>VPC</td>
<td>Virtual Private Cloud</td>
</tr>
<tr>
<td>VPN</td>
<td>Virtual Private Network</td>
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<tr>
<td>ZCC</td>
<td>Zscaler Client Connector</td>
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<tr>
<td>ZIA</td>
<td>Zscaler Internet Access</td>
</tr>
<tr>
<td>ZPA</td>
<td>Zscaler Private Access</td>
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<tr>
<td>ZSO</td>
<td>(Ivanti) Zero Sign-On</td>
</tr>
<tr>
<td>ZTA</td>
<td>Zero Trust Architecture</td>
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</tbody>
</table>