Mobile Device Security:
Bring Your Own Device (BYOD)

Volume C:
How-To Guides

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

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NATIONAL CYBERSECURITY CENTER OF EXCELLENCE

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

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NIST Cybersecurity Practice Guides (Special Publication Series 1800) target specific cybersecurity challenges in the public and private sectors. They are practical, user-friendly guides that facilitate the adoption of standards-based approaches to cybersecurity. They show members of the information security community how to implement example solutions that help them align 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.

This Practice Guide demonstrates a standards-based reference design and provides users with the information they need to replicate enhancing the security of bring your own device (BYOD) solutions. This reference design is modular and can be deployed in whole or in part.

This guide contains four volumes:

- NIST SP 1800-22A: Executive Summary
- NIST SP 1800-22 Supplement: Example Scenario: Putting Guidance into Practice – how organizations can implement this example solution’s guidance
- NIST SP 1800-22C: How-To Guides – instructions for building the example solution
ABSTRACT

Bring Your Own Device (BYOD) refers to the practice of performing work-related activities on personally owned devices. This practice guide provides an example solution demonstrating how to enhance security and privacy in Android and Apple phones and tablets used in BYOD deployments.

Incorporating BYOD deployments into an organization can increase the opportunities and methods available to access organizational resources. For some organizations, the combination of traditional in-office processes with mobile device technologies enables portable communication approaches and adaptive workflows. For others, it fosters a mobile-first approach in which their employees communicate and collaborate primarily using their mobile devices.

However, some of the features that make BYOD mobile devices increasingly flexible and functional also present unique security and privacy challenges to both organizations and device owners. The unique nature of these challenges is driven by the differing risks posed by the type, age, operating system (OS), and other variances in mobile devices.

Enabling BYOD capabilities in the enterprise introduces new cybersecurity risks. Solutions that are designed to secure corporate devices and on-premises data do not provide an effective cybersecurity solution for BYOD. Finding an effective solution can be challenging due to the unique risks that BYOD deployments impose. Additionally, enabling BYOD capabilities introduces new privacy risks to employees by providing their employer a degree of access to their personal devices, opening up the possibility of observation and control that would not otherwise exist.

To help organizations benefit from BYOD’s flexibility while protecting themselves from critical security and privacy challenges, this practice guide provides an example solution using standards-based, commercially available products and step-by-step implementation guidance.

KEYWORDS

Bring your own device; BYOD; mobile device management; mobile device security.

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<td>Qualcomm</td>
<td>Trusted Execution Environment</td>
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<tr>
<td>Zimperium</td>
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1 Introduction

The following volumes of this guide show information technology (IT) professionals and security engineers how we implemented this example solution. We cover all of the products employed in this reference design. We do not re-create the product manufacturers’ documentation, which is presumed to be widely available. Rather, these volumes show how we incorporated the products together in our environment.

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

1.1 Practice Guide Structure

This National Institute of Standards and Technology (NIST) Cybersecurity Practice Guide demonstrates a standards-based reference design and provides users with the information they need to replicate enhancing the security of bring your own device (BYOD) solutions. This reference design is modular and can be deployed in whole or in part.

This guide contains four volumes:

- NIST SP 1800-22A: Executive Summary
- NIST SP 1800-22 Supplement: Example Scenario: Putting Guidance into Practice – how organizations can implement this example solution’s guidance
- NIST SP 1800-22C: How-To Guides – instructions for building the example solution *(you are here)*

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

**Business decision makers, including chief security and technology officers**, will be interested in the Executive Summary, NIST SP 1800-22A, which describes the following topics:

- challenges that enterprises face in managing the security of BYOD deployments
- the example solution built at the 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 NIST SP 1800-22B, which describes what we did and why. The following sections will be of particular interest:

- Section 3.4, Risk Assessment, describes the risk analysis we performed.
- Appendix E in Volume B, Example Security Subcategory and Control Map, maps the security characteristics of this example solution to cybersecurity standards and best practices.

You might share the Executive Summary, NIST SP 1800-22A, with your leadership team members to help them understand the importance of adopting standards-based BYOD solutions.
IT professionals who want to implement an approach like this will find this whole practice guide useful. You can use this How-To portion of the guide, NIST SP 1800-22C, to replicate all or parts of the build created in our lab. This How-To portion of the guide provides specific product installation, configuration, and integration instructions for implementing the example solution. We do not recreate 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.

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 BYOD solution. 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. Volume B, Section 4.3, Technologies that Support the Security and Privacy Objectives of the Example Solution, lists the products that we used and maps them to the cybersecurity controls provided by this reference solution.

For those who would like to see how the example solution can be implemented, this practice guide contains an example scenario about a fictional company called Great Seneca Accounting. The example scenario shows how BYOD objectives can align with an organization’s priority security and privacy capabilities through NIST risk management standards, guidance, and tools. It is provided in this practice guide’s supplement, NIST SP 1800-22 Example Scenario: Putting Guidance into Practice.

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

1.2 Build Overview

In our lab at the National Cybersecurity Center of Excellence (NCCoE), NIST engineers built an environment that contains an example solution for managing the security of BYOD deployments. In this guide, we show how an enterprise can leverage this example solution’s concepts to implement Enterprise Mobility Management (EMM), mobile threat defense, application vetting, secure boot/image authentication, and virtual private network (VPN) services in support of a BYOD solution.

These technologies were configured to protect organizational assets and end-user privacy, providing methodologies to enhance the data protection posture of the adopting organization. The standards, best practices, and certification programs that this example solution is based upon help ensure the confidentiality, integrity, and availability of enterprise data on mobile systems.
1.3 Typographic Conventions

The following table presents typographic conventions used in this volume.

<table>
<thead>
<tr>
<th>Typeface/Symbol</th>
<th>Meaning</th>
<th>Example</th>
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<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 NCCoE Style Guide.</td>
</tr>
<tr>
<td><strong>Bold</strong></td>
<td>names of menus, options, command buttons, and fields</td>
<td>Choose File &gt; Edit.</td>
</tr>
<tr>
<td>Monospace</td>
<td>command-line input, onscreen computer output, sample code examples, and status codes</td>
<td>mkdir</td>
</tr>
<tr>
<td>Monospace Bold</td>
<td>command-line user input contrasted with computer output</td>
<td>service sshd start</td>
</tr>
<tr>
<td><em>blue text</em></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>
</tr>
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</table>

Acronyms can be found in Appendix A.

1.4 Logical Architecture Summary

*Figure 1-1* shows the components of the build architecture and how they interact on a high level.
Figure 1-1 High-Level Build Architecture

2 Product Installation Guides

This section of the practice guide contains detailed instructions for installing and configuring all the products used to build an instance of the example solution.

This guide assumes that a basic active directory (AD) infrastructure has been configured. The domain controller (DC) is used to authenticate users when enrolling devices as well as when connecting to the virtual private network (VPN). In this implementation, the domain enterprise.mds.local was used.

2.1 Network Device Enrollment Services Server

A Network Device Enrollment Service (NDES)/Simple Certificate Enrollment Protocol (SCEP) server was used to issue client certificates to new devices that were enrolled by using MaaS360. This guide assumes that a basic AD and certificate authority (CA) are in place, containing a root and subordinate CA, and that their certificates have been exported.

2.1.1 NDES Configuration

This section outlines configuration of an NDES that resides on its own server. Alternatively, the NDES can be installed on the SUB-CA. This section assumes a new domain-attached Windows Server is running.
1. From the Server Manager, select Manage > Add Roles and Features.

2. Click Next three times until Server Roles is highlighted.

3. Check the box next to Active Directory Certificate Services.

4. Click Next three times until Role Services is highlighted.

5. Uncheck Certification Authority. Check Network Device Enrollment Service.

6. Click Add Features on the pop-up.

7. Click Next three times.

8. Click Install.

9. When the installation completes, click the flag in the upper right-hand corner, and click Configure Active Directory Certificate Services.

Figure 2-1 Post-Deployment Configuration

10. Specify the credentials of a Domain Administrator. Click Next.

Note: The domain administrator credentials are required only to configure the NDES. Once the service is configured, the service is executed as the NDES service account, which does not require domain administrator permissions, created in step 12 below.

11. Check Network Device Enrollment Service. Click Next.

12. Configure an NDES service account by performing the following actions:

   a. On the active directory server, open Active Directory Users and Computers.
b. Click **Users** and create a new user for the service. For this example, it will be named NDES. Be sure the password never expires.

c. On the NDES server, open **Edit local users and groups**.

d. Click **Groups**. Right-click **IIS_IUSRS**, click **Add to Group**, and click **Add**.

e. Search for the service account name—in this case, NDES. Click **Check Names**, then click **OK** if no errors were displayed.

f. Click **Apply** and click **OK**.

g. Close all windows except the NDES configuration window.

13. Click **Select** next to the box and enter the service account credentials. Click **Next**.

14. Because the NDES runs on its own server, we will target it at the SUB-CA. Select **Computer name** and click **Select**. Type in the computer name—in this case, SUB-CA. Click **Check Names**, and if no errors occurred, click **OK**.

15. Click **Next** three times.

16. Click **Configure**.

17. On the SUB-CA, open the Certification Authority application.

18. Expand the SUB-CA node, right-click on **Certificate Templates**, and click **Manage**.

19. Right-click on **IPSec (Offline Request)** and click **Duplicate Template**.

20. Under the General tab, set the template display name to **NDES**.

21. Under the **Security** tab, click **Add**.

22. Select the previously configured NDES service account.

23. Click **OK**. Ensure the NDES service account is highlighted, and check **Read** and **Enroll**.

24. Click **Apply**.

25. In the Certification Authority program, right-click on **Certificate Templates**, and select **New > Certificate Template to Issue**.

26. Select the NDES template created in step 24.

27. Click **OK**.

28. On the NDES server, open the Registry Editor (**regedit**).

29. Expand the following key: **HKLM\SOFTWARE\Microsoft\Cryptography**.

30. Select the **MSCEP** key and update all entries besides (Default) to be **NDES**.

31. Expand the following key: **HKLM\SOFTWARE\Microsoft\Cryptography\MSCEP**.
32. Right-click on MSCEP and select New > Key. Name it PasswordMax.

33. Right-click on the newly created key and select New > DWORD (32-bit) Value.

34. Name it PasswordMax and give it a value of \texttt{0x00003e8}. This increases the NDES password cache to 1,000 entries instead of the default 5. This value can be further adjusted based on NDES demands.

Figure 2-2 PasswordMax Registry Configuration

![Registry Editor]

\textbf{Note:} The PasswordMax key governs the maximum number of NDES passwords that can reside in the cache. A password is cached when a valid certificate request is received, and it is removed from the cache when the password is used or when 60 minutes have elapsed, whichever occurs first. If the PasswordMax key is not present, the default value of 5 is used.

35. In an elevated command prompt, execute \\
\texttt{%windir\%\system32\inetsrv\appcmd set config /section:requestFiltering /requestLimits.maxQueryString:8192} to increase the maximum query string. This prevents requests longer than 2,048 bytes from being dropped.

36. Open the Internet Information Services (IIS) Manager.

37. On the left, expand NDES > Sites, and select Default Web Site.

38. On the right, click Bindings…

39. Click Add.

40. Below Host Name, enter the host name of the server. For this implementation, \texttt{ndes.enterprise.mds.local} was used.

41. Click OK.
42. Click Close and close the IIS Manager.

43. In an elevated command prompt, execute `iisreset`, or reboot the NDES server.

2.2 International Business Machines MaaS360

International Business Machines (IBM) contributed an instance of MaaS360 to deploy as the mobile device management (MDM) solution.

2.2.1 Cloud Extender

The IBM MaaS360 Cloud Extender is installed within the AD domain to provide AD and lightweight directory access protocol (LDAP) authentication methods for the MaaS360 web portal, as well as corporate VPN capabilities. The cloud extender architecture [1], as shown in Figure 2-4, gives a visual overview of how information flows between the web portal and the MaaS360 Cloud Extender.
2.2.1.1 Cloud Extender Download

1. Log in to the MaaS360 web portal.

2. Click Setup > Cloud Extender.

3. Click the link that says Click here to get your License Key. The license key will be emailed to the currently logged-in user’s email address.

4. Click the link that says Click here to download the Cloud Extender. Save the binary.

5. Move the binary to a machine behind the corporate firewall that is always online. Recommendation: Install it while logged in as a domain user on a machine that is not the domain controller.

6. Install .NET 3.5 Features in the Server Manager on the machine where the MaaS360 Cloud Extender will run.

2.2.1.2 Cloud Extender Active Directory Configuration

1. On the target machine, run the installation binary.

2. Enter the license key when prompted.

3. Proceed through the setup until the Cloud Extender Configuration Utility opens.
4. If using the old cloud extender interface, click **Switch to Modern**.

Figure 2-5 Old Cloud Extender Interface

5. Enable the toggle below **User Authentication**.

6. Create a new authentication profile by entering the username, password, and domain of the created service account.
7. Click Next.

8. (optional) Use the next page to test the active directory integration.

9. Click Save.

10. In MaaS360, navigate to Setup > Cloud Extender. Ensure that configuration information is displayed, indicating that the MaaS360 Cloud Extender is running.

2.2.1.3 MaaS360 Portal Active Directory Authentication Configuration

1. Log in to the MaaS360 web portal as an administrator.

2. Go to Setup > Settings.

3. Expand Administrator Settings and click Advanced.
4. Select **Configure Federated Single Sign-on**.

5. Select **Authenticate against Corporate User Directory**.

6. Next to **Default Domain**, enter the active directory domain. In this implementation, `enterprise.mds.local` was used.

7. Check the box next to **Allow existing Administrators to use portal credentials as well**.

8. Check the box next to **Automatically create new Administrator accounts and update roles based on user groups**.

9. Under **User Groups**, enter the distinguished name of the group(s) that should be allowed to log in. In this implementation, CN=Domain Admins, CN=Users, DC=enterprise, DC=mds, DC=local was used.

10. Next to the box, select **Administrator–Level 2**. This allows domain admins to log in as MaaS360 administrators.
11. Click **Save**.

### 2.2.1.4 Cloud Extender NDES Integration

To properly generate device certificates, MaaS360 must be integrated with the on-premises public key infrastructure (PKI).

1. Log in to the server running the MaaS360 Cloud Extender.
2. Launch the Cloud Extender Configuration Tool.
3. Toggle the button below Certificate Integration.
4. Click **Add New Template**.
5. Ensure **Microsoft CA** and **Device Identity Certificates** are selected.
6. Click **Next**.
7. Enter **NDES** for the Template Name and SCEP Default Template.
8. Enter the uniform resource locator (URL) of the NDES server next to **SCEP Server**.
9. Enter credentials of a user with enroll permissions on the template for **Challenge Username** and **Challenge Password**. For this demo implementation, we use the NDES service account.
10. Click Next.

11. (optional) Check the box next to Cache certs on Cloud Extender and specify a cache path on the machine.
12. Click **Next**.

13. (optional) Enter values for uname and email and generate a test certificate to test the configuration.

14. Click **Save**.

*Note: If a file access message appears, delete the file, and re-save the file.*

### 2.2.2 Android Enterprise Configuration

A Google account was used to provision Android Enterprise on the mobile devices. A managed domain can be used, but in this use case it was not necessary. A managed domain is necessary only if the corporation already has data stored in Google’s cloud.

1. Create a Google account if you do not have one you wish to bind with.
2. From the MaaS360 portal, navigate to **Setup > Services**.
3. Click **Mobile Device Management**.
4. Check the box next to **Enable Android Enterprise Solution Set**.
5. Enter your password and click **Enable**.
6. Click **Mobile Device Management**.
7. Click the radio button next to **Enable via Managed Google Play Accounts (no G Suite)**.
8. Ensure all pop-up blockers are disabled. Click the link on the word **here**.
9. Enter your password and click **Enable**.
10. In the new page that opens, ensure you are signed into the Google account you wish to bind.
11. Click **Get started**.
12. Enter your business name and click **Next**.
13. If General Data Protection Regulation compliance is not required, scroll to the bottom, check the **I agree** box, and click **Confirm**. If compliance is required, fill out the requested information first.
14. Click **Complete Registration**.
15. Confirm binding on the **Setup** page under **Mobile Device Management**. The settings should look like Figure 2-11, where the blurred-out portion is the Google email address used to bind.

*Figure 2-11 Enterprise Binding Settings Confirmation*
2.2.3 iOS APNs Certificate Configuration
For the iOS Apple Push Notification services (APNs) certificate configuration, the build team followed the IBM documentation.

2.2.4 Apple User Enrollment (UE) Configuration
The following sections detail the configuration process for Apple User Enrollment, which enables BYOD on iOS devices.

2.2.4.1 Apple Business Manager (ABM) Configuration
1. In MaaS360, navigate to Setup > Settings > Enrollment Programs, and click Configure next to Apple Device Enrollment Program.
2. In the popup, click Continue.
3. Click Tokens > Add Token.
4. In the popup, give the token a name and click on the here link in step 2 of the popup to download the public key file.

Figure 2-12 Where to Click to Download the Public Key

5. In Apple Business Manager, sign in with an administrator account.
6. Click the user’s name in the bottom left corner > Settings.
7. Click Add next to “Your MDM Servers” and enter a unique name for the server.
8. Upload the public key certificate file downloaded in step (4), then click Save.
9. Click Download Token to save the server token.
10. In MaaS360, click **Browse** and select the token downloaded in step (9).

11. Click **Add**.

**Figure 2-14 Creating the DEP token**

12. In Apple Business Manager, click the user’s name in the bottom left corner and click **Payments and Billing**.

13. Under Server Tokens, click the token that corresponds to the Apple Business Manager tenant and save the token.

14. In MaaS360, navigate to **Apps > Catalogue**. Click **More > Apple VPP Licenses**.

15. Click **Add Token** and give the token a name. Click **Browse** and select the token file downloaded in step (13).
16. Click **Policies** and configure the VPP token policy based on organizational requirements.

17. Click **Distribution** and configure based on organizational requirements.

18. Click **Submit**.

Figure 2-15 VPP token in MaaS360

<table>
<thead>
<tr>
<th>Token Name</th>
<th>Users</th>
<th>Country Name</th>
<th>User Groups</th>
<th>Last Sync Time</th>
<th>Update Time</th>
<th>Expiry Date</th>
<th>Status</th>
<th>App Addition St...</th>
</tr>
</thead>
<tbody>
<tr>
<td>VPP Token</td>
<td></td>
<td>United States</td>
<td>All Users</td>
<td>04/27/2022 13:15 EDT</td>
<td>04/26/2023 20:00 EDT</td>
<td>Active</td>
<td>NA</td>
<td></td>
</tr>
</tbody>
</table>

### 2.2.4.2 MaaS360 Configuration

1. In the MaaS360 web portal, navigate to **Setup > Settings**.

2. Navigate to **Device Enrollment Settings > Advanced**.

3. Under **Advanced Management for Apple Devices > Select default enrollment mode for managing employee owned (BYOD) devices**, select the radio button next to **User enrollment mode**.

4. Scroll to the top of the page and click **Save**.

Figure 2-16 iOS Enrollment Configuration

### 2.2.5 Android Configuration

The following sections detail the configuration policies applied to enrolled Android devices.

#### 2.2.5.1 Policy Configuration

1. Navigate to **Security > Policies**.

2. Click the appropriate deployed Android policy.

3. Click **Edit**.

4. Navigate to **Android Enterprise Settings > Passcode**.

5. Check the box next to **Configure Passcode Policy**.

6. Configure the passcode settings based on corporate requirements.

7. Navigate to **Android Enterprise Settings > Restrictions**.

8. Check the box next to **Configure Restrictions**.
9. Configure restrictions based on corporate requirements.
10. Click Save.

2.2.5.2 VPN Configuration

2. Click the currently deployed Android device policy.
3. Click Edit.
4. Navigate to Android Enterprise Settings > Certificates.
5. Check the box next to Configure CA Certificates.
6. Click Add New.
7. Give the certificate a name, such as Internal Root.
8. Click Browse and navigate to the exported root CA certificate from earlier in the document.
9. Click Save.
10. Select Internal Root from the drop-down next to CA Certificate.
11. Click the + icon on the far right.
12. Repeat steps 6–10 with the internal sub-CA certificate.
13. Check the box next to Configure Identity Certificates.
14. From the drop-down next to Identity Certificate, select the profile that matches the name configured on the MaaS360 Cloud Extender—for this example, NDES.
15. Click Save and Publish and follow the prompts to publish the updated policy. Click Apps.
17. Select the radio button next to Add via Public Google Play Store.
18. Search for GlobalProtect.
19. Select the matching result.
20. Click I Agree when prompted to accept the permissions.
21. Check the three boxes next to Remove App on.
22. Check the box next to Instant Install.
23. Select All Devices next to Distribute to.
24. Click Add.
25. Next to the newly added GlobalProtect application, select More > Edit App Configurations.
26. Click **Check for Settings**.

27. Next to **Portal**, enter the GlobalProtect portal address. In this implementation, `vpn.ent.mdse.nccoe.org` was used.

28. Next to **Username**, enter `%username%`.

29. Next to **Connection Method**, enter **user-logon**. *(Note: This will enable an always-on VPN connection for the work profile. The user will always see the VPN key icon, but it will apply only to applications contained within the work profile.)*

30. Click **Save** and follow the prompts to update the application configuration.

31. Navigate to **Security > Policies**.

32. Click the used Android policy.

33. Select **Android Enterprise Settings > App Compliance**.

34. Click **Edit**.

35. Click the + on the row below **Configure Required Apps**.

36. Enter the App Name, **GlobalProtect**.

37. Enter the App ID, `com.paloaltonetworks.globalprotect`.

38. Click **Save And Publish** and follow the prompts to publish the policy.

**Figure 2-17 Android GlobalProtect Application Compliance**

2.2.6 **iOS Configuration**

The following sections detail the configuration policies applied to enrolled iOS devices.
2.2.6.1 Policy Configuration

2. Click the deployed iOS policy.
3. Click Edit.
4. Check the box next to Configure Passcode Policy.
5. Check the box next to Enforce Passcode on Mobile Device.
6. Configure the rest of the displayed options based on corporate requirements.
7. Click Restrictions.
8. Check the box next to Configure Device Restrictions.
9. Configure restrictions based on corporate requirements.
10. Click Save.

2.2.6.2 VPN Configuration

1. Click Device Settings > VPN.
2. Click Edit.
3. Next to Configure for Type, select Custom SSL.
4. Enter a name next to VPN Connection Name. In this sample implementation, Great Seneca VPN was used.
5. Next to Identifier, enter com.paloaltonetworks.globalprotect.vpn.
6. Next to Host name of the VPN Server, enter the URL of the VPN endpoint without http or https.
7. Next to VPN User Account, enter %username%.
8. Next to User Authentication Type, select Certificate.
9. Next to Identity Certificate, select the name of the certificate profile created during the NDES configuration steps. In this sample implementation, NDES was used.
10. Next to Custom Data 1, enter allowPortalProfile=0.
11. Next to Custom Data 2, enter fromAspen=1.
12. Next to Apps to use this VPN, enter the application identifications (IDs) of applications to go through the VPN. This will be the applications deployed to the devices as work applications.
13. Next to Provider Type, select Packet Tunnel.
15. Search for GlobalProtect.
16. Select the non-legacy search result.

17. Select the business’s location and enter the desired number of licenses (installations) and click Get.

18. In MaaS360, navigate to Apps > Catalog.


20. In the VPP line, select More > Sync. Follow the confirmation pop-ups to confirm the sync with Apple Business Manager.

21. Navigate to Apps > Catalog.

22. Click Add > iOS > iTunes App Store App.

23. Search for GlobalProtect.


25. Click Policies and Distribution.

26. Check all three boxes next to Remove App on.

27. Select All Devices next to Distribute to.

28. Check the box next to Instant Install.

29. Click Add.


31. Click the used iOS policy.

32. Click Application Compliance.

33. Click Edit.

34. Click the + next to the first row under Configure Required Applications.

35. Search for GlobalProtect.

36. Select the non-Legacy result.

37. Navigate to Advanced Settings > Certificate Credentials.

38. Check the box next to Configure Credentials for Adding Certificates on the Device.

39. Click Add New.

40. Give the certificate a name, such as Internal Root.

41. Click Browse and navigate to the exported root CA certificate from earlier in the document.

42. Click Save.
43. Select **Internal Root** from the drop-down next to **CA Certificate**.

44. Click the + icon on the far right.

45. Repeat steps 33–35 with the internal sub-CA certificate.

46. From the drop-down next to **Identity Certificate**, select the profile that matches the name configured on the MaaS360 Cloud Extender—for this example, **NDES**.

47. Click **Save And Publish** and follow the prompts to publish the policy.

2.3 **Zimperium**

Zimperium was used as a mobile threat defense service via a MaaS360 integration.

*Note: For Zimperium automatic enrollment to function properly, users must have an email address associated with their MaaS360 user account.*

2.3.1 **Zimperium and MaaS360 Integration**

This section assumes that IBM has provisioned an application programming interface (API) key for Zimperium within MaaS360.

1. Log in to the zConsole.

2. Navigate to **Manage > MDM**.

3. Select **Add MDM > MaaS360**.

4. Fill out the MDM URL, MDM username, MDM password, and API key.

*Note: For the MDM URL, append the account ID to the end. For example, if the account ID is 12345, the MDM URL would be https://services.fiberlink.com/12345.*

5. Check the box next to **Sync users**.
6. Click **Next**.

7. Select the MaaS360 groups to synchronize with Zimperium. In this case, **All Devices** was selected.

8. Click **Finish**. Click **Sync Now** to synchronize all current MaaS360 users and devices.

### 2.3.2 Automatic Device Activation

*Note: This requires contacting Zimperium support to get required application configuration values.*

1. In Apple Business Manager, click **Apps and Books**.

2. Search for **Zimperium zIPS**.

3. Select the non-legacy search result.

4. Select the business’s location and enter the desired number of licenses (installations) and click **Get**.
5. In MaaS360, navigate to Apps > Catalog.
7. In the VPP line, select More > Sync. Follow the confirmation pop-ups to confirm the sync with Apple Business Manager.
8. Click Apps on the navigation bar.
10. Search for Zimperium zIPS. Click the result that matches the name.
11. Click Policies and Distribution.
12. Check the three checkboxes next to Remove App on.
13. Next to Distribute to, select All Devices.
14. Click Configuration.
15. Set App Config Source to Key/Value.
16. The configuration requires three parameters: uuid, defaultchannel, and tenantid. uuid can be set to %csn%, but defaultchannel and tenantid must come from Zimperium support.

Figure 2-19 Zimperium zIPS iOS Configuration

<table>
<thead>
<tr>
<th>MDMDeviceID</th>
<th>%csn%</th>
</tr>
</thead>
<tbody>
<tr>
<td>defaultchannel</td>
<td></td>
</tr>
<tr>
<td>tenantid</td>
<td></td>
</tr>
</tbody>
</table>

17. Click Add.
19. Select the radio button next to Add via Public Google Play Store.
20. Search for Zimperium Mobile IPS (zIPS).
21. Click the matching result.
22. Click I Agree when prompted to accept permissions.
23. Click Policies and Distribution.
24. Check all three boxes next to Remove App on.
25. Check Instant Install.
26. Select All Devices next to Distribute to.
27. Click App Configurations.
28. Check Configure App Settings.
29. Enter the values provided by Zimperium next to Default Acceptor and Tenant.
30. Next to MDM Device ID, insert %deviceid%.
31. Adjust any other configuration parameters as appropriate for your deployment scenario.

Figure 2-20 Zimperium zIPS Android Configuration

![Zimperium zIPS Android Configuration](image)

32. Click Add.

### 2.3.3 Enforce Application Compliance

From the IBM MaaS360 web portal:

2. Select the default Android policy.
4. Click Edit.
5. Check the box next to Configure Required Apps if not checked already. If it is, click the + icon.
6. Enter com.zimperium.zips as the App ID.
7. Click Save And Publish. This will prevent the user from uninstalling zIPS once it is installed.
9. Select the default iOS policy.
10. Click **Application Compliance**.

11. Click **Edit**.

12. Check the box next to **Configure Required Applications** if not checked already. If it is, click the + icon.

13. Enter **Zimperium zIPS** for the Application Name.

14. Click **Save And Publish** and follow the prompts to publish the policy.

### 2.3.4 MaaS360 Risk Posture Alerts

1. From the MaaS360 home screen, click the + button that says **Add Alert**.

   ![Figure 2-21 Add Alert Button](image)

2. Next to **Available for** select **All Administrators**.

3. For Name, enter **Zimperium Risk Posture Elevated**.

4. Under **Condition 1**, select **Custom Attributes** for the Category.

5. Select **zimperium_risk_posture** for Attribute.

6. Select **Equal To** for Criteria.

7. For Value, select **Elevated** for the count of risk posture elevated devices or **Critical** for risk posture critical devices.
2.4 Palo Alto Networks Virtual Firewall

Palo Alto Networks contributed an instance of its VM-100 series firewall for use on the project.

2.4.1 Network Configuration

1. Ensure that all Ethernet cables are connected or assigned to the virtual machine and that the management web user interface is accessible. Setup will require four Ethernet connections: one for management, one for wide area network (WAN), one for local area network, and one for the demilitarized zone (DMZ).

2. Reboot the machine if cables were attached while running.

3. Navigate to **Network > Interfaces > Ethernet**.

4. Click **ethernet1/1** and set the Interface Type to be **Layer3**.

5. Click **IPv4**, ensure that **Static** is selected under Type, and click **Add** to add a new static address.

6. If the appropriate address does not exist yet, click **New Address** at the bottom of the prompt.

7. Once the appropriate interfaces are configured, commit the changes. The Link State icon should turn green for the configured interfaces. The commit dialogue will warn about unconfigured zones. That is an expected dialogue warning.

8. Navigate to **Network > Zones**.

9. Click **Add**. Give the zone an appropriate name, set the Type to **Layer3**, and assign it an interface.

10. Commit the changes.
11. Navigate to **Network > Virtual Routers**.

12. Click **Add**.

13. Give the router an appropriate name and add the internal and external interfaces.

14. Click **Static Routes > Add**. Give the static route an appropriate name, e.g., WAN. Set the destination to be **0.0.0.0/0**, set the interface to be the WAN interface, and set the next hop internet protocol (IP) address to be the upstream gateway's IP address.

15. (optional) Delete the default router by clicking the checkbox next to it and clicking **Delete** at the bottom of the page.

16. Commit the changes. The commit window should not display any more warnings.

17. Navigate to **Network > DNS Proxy**.

18. Click **Add**.

19. Give the proxy an appropriate name. Under **Primary**, enter the primary domain name system (DNS) IP address.

20. (optional) Enter the secondary DNS IP address.

21. Add the interfaces under **Interface**. Click **OK**.

Figure 2-23 DNS Proxy Object Configuration
22. Navigate to **Device > Services**.
23. Click the **gear** in the top-right corner of the Services panel.
24. Under **DNS settings**, click the radio button next to **DNS Proxy Object**. Select the created DNS proxy object from the drop-down.
25. Click **OK** and commit the changes. This is where static DNS entries will be added in the future.
26. Navigate to **Objects > Addresses**.
27. For each device on the network, click **Add**. Give the device an appropriate name, enter an optional description, and enter the IP address.
28. Click **OK**.
29. Once all devices are added, commit the changes.
30. Navigate to **Policies > NAT**.
31. Click **Add**.
32. Give the network address translation rule a meaningful name, such as **External Internet Access**.
33. Click **Original Packet**.
34. Click **Add** and add the zone representing the intranet—in this case, **Enterprise_Intranet**.
35. Repeat step 34 for the secure sockets layer (SSL) VPN zone.
36. Under **Source Address**, click **Add**.
37. Enter the subnet corresponding to the intranet segment.
38. Repeat step 37 for the SSL VPN segment.
39. Click **Translated Packet**. Set the translation type to **Dynamic IP and Port**. Set Address Type to be **Interface Address**. Set Interface to be the WAN interface and set the IP address to be the WAN IP of the firewall.
40. Click **OK** and commit the changes.
2.4.2 Demilitarized Zone Configuration

1. Navigate to Network > Interfaces.
2. Click the interface that has the DMZ connection.
3. Add a comment, set the Interface Type to Layer3, and assign it to the virtual router created earlier.
4. Click IPv4 > Add > New Address. Assign it an IP block and give it a meaningful name. Click OK.
5. Navigate to Network > Zones.
6. Click Add. Give it a meaningful name, such as Enterprise_DMZ.
7. Set the Type to Layer3 and assign it the new interface that was configured—in this case, ethernet1/3.
8. Click OK.
9. Navigate to Network > DNS Proxy. Click Add under Interface and add the newly created interface. Click OK.
10. Commit the changes.
11. Navigate to Network > Interfaces, and the configured interfaces should be green.

2.4.3 Firewall Configuration

2. Click Add.
3. Give the rule a meaningful name, such as Intranet Outbound.

4. Click Source. Click Add under Source Zone and set the source zone to be the internal network.

5. Click Destination. Click Add under Destination Zone and set the destination zone to be the WAN zone.


7. Click OK.

8. Click Add.

9. Click Destination. Add the IP address of the Simple Mail Transfer Protocol (SMTP) server.

10. Click Application. Click Add.

11. Search for smtp. Select it.

12. Click OK.

13. Commit the changes.

14. Internal hosts should now be able to communicate on the internet.

2.4.4 Certificate Configuration


2. Click Add.

3. Give the profile a meaningful name, such as Enterprise_Certificate_Profile.

4. Select Subject under Username Field.

5. Select the radio button next to Principal Name.

6. Enter the domain under User Domain—in this case, enterprise.

7. Click Add under CA Certificates. Select the internal root CA certificate.

8. Click Add under CA Certificates. Select the internal sub-CA certificate. (Note: The entire certificate chain must be included in the certificate profile.)

9. Click OK.

10. Commit the changes.
2.4.5 Website Filtering Configuration

The following sections detail the configuration of website blocking on the Palo Alto firewall.

2.4.5.1 Configure Basic Website Blocking

1. Navigate to Objects > URL Category.

2. Click Add.

3. Enter a name for the URL Category. Click Add on the bottom.

4. Add websites that should be blocked. Use the form *.example.com for all subdomains and example.com for the root domain.
5. Click **OK**.

6. Navigate to **Objects > URL Filtering**.

7. Click **Add**.

8. Give the filtering profile a name.

9. Scroll to the bottom of the categories table. The profile created in step 4 should be the last item in the list, with an asterisk next to it. Click where it says **allow** and change the value to **block**.

10. Configure any additional categories to allow, alert, continue, block, or override.
11. Click OK.


13. Select a policy to apply the URL filtering to.


15. Next to Profile Type, select Profiles.

16. Next to URL Filtering, select the created URL filtering profile.
17. Click **OK**.

18. Repeat steps 13–17 for any policies that need the filtering profile applied.

19. Commit the changes.

**2.4.5.2 Configure SSL Website Blocking**

*Note: This section is optional. Section 2.4.5.1 outlines how to configure basic URL filtering, which will serve a URL blocked page for unencrypted (http [hypertext transfer protocol]) connections, and it will send a transmission control protocol reset for encrypted (https [hypertext transfer protocol secure]) connections, which will show a default browser error page. This section outlines how to configure the firewall so that it can serve the same error page for https connections as it does for http connections. This is purely for user experience and has no impact on blocking functionality.*

1. Navigate to **Device > Certificates**.

2. Click **Generate** on the bottom of the page.

3. Give the root certificate a name, such as SSL Decryption Root; and a common name (CN) such as PA Root.

4. Check the box next to **Certificate Authority**.
Figure 2-29 Generating the Root CA

5. Click **Generate**.

6. Click **Generate** at the bottom of the page.

7. Give the certificate a name, such as SSL Decryption Intermediate.

8. Give the certificate a CN, such as PA Intermediate.

9. Next to **Signed By**, select the generated root CA. In this case, SSL Decryption Root was selected.

10. Check the box next to **Certificate Authority**.

11. Click **Generate**.

12. Click the newly created certificate.

13. Check the boxes next to **Forward Trust Certificate** and **Forward Untrust Certificate**.

14. Click **OK**.

15. Navigate to **Policies > Decryption**.

16. Click **Add**.

17. Give the policy a name and description.
18. Click **Source**.

19. Under **Source Zone**, click **Add**.

20. Select the source zone(s) that matches the security policy that uses URL filtering. In this implementation, the Intranet and SSL VPN zones were selected.

21. Click **Destination**.

22. Under **Destination Zone**, click **Add**.

23. Select the destination zone that matches the security policy that uses URL filtering. Most likely it is the WAN zone.

24. Click **Service/URL Category**.

25. Under **URL Category**, click **Add**.

26. Select the created block list. This ensures that only sites matching the block list are decrypted.

27. Click **Options**.

28. Next to **Action**, select **Decrypt**.

29. Next to **Type**, select **SSL Forward Proxy**.

30. Next to **Decryption Profile**, select **None**.

31. Click **OK**.

32. Commit the changes.
2.4.6 User Authentication Configuration

1. Navigate to Device > Setup > Services > Service Route Configuration.
2. Click Destination.
3. Click Add.
4. Enter the IP address of the internal LDAP server for Destination.
5. Select the internal network adapter for Source Interface.
6. Select the firewall’s internal IP address for Source Address.
7. Click OK twice and commit the changes.
8. Navigate to Device > Server Profiles > LDAP.

9. Click Add.

10. Give the profile a meaningful name, such as Enterprise_LDAP_Server.

11. Click Add in the server list. Enter the name for the server and the IP.

12. Under Server Settings, set the Type drop-down to active-directory.

13. Enter the Bind DN and the password for the Bind DN.

Note: In this implementation, a new user, palo-auth, was created in Active Directory. This user does not require any special permissions or groups beyond the standard Domain Users group.

14. Ensure that Require SSL/TLS secured connection is checked.

15. Click the down arrow next to Base DN. If the connection is successful, the Base DN (Distinguished Name) should display.

16. Click OK.
17. Navigate to **Device > User Identification > Group Mapping Settings**.

18. Click **Add**.

19. Give the mapping a name, such as Enterprise_LDAP_Usermap.

20. Select the **server profile**, and enter the **user domain**—in this case, Enterprise.

21. Click **Group Include List**.

22. Expand the arrow next to the **base DN** and then again next to **cn=users**.

23. For each group that should be allowed to connect to the VPN, click the proper **entry** and then the **+ button**. In this example implementation, mobile users, domain users, and domain admins were used.
24. Click **OK**.

25. Navigate to **Device > Authentication Profile**.

26. Click **Add**.

27. Give the profile a meaningful name, such as **Enterprise_Auth**.

28. For the Type, select **LDAP**.

29. Select the newly created LDAP profile next to **Server Profile**.

30. Set the Login Attribute to be **sAMAccountName**.

31. Set the User Domain to be the **LDAP domain name**—in this case, **enterprise**.
32. Click on Advanced.

33. Click Add. Select enterprise\domain users.

34. Repeat step 33 for mobile users and domain admins.

35. Click OK.

36. Commit the changes.

2.4.7 VPN Configuration

1. Navigate to Network > Interfaces > Tunnel.

2. Click Add.

3. Enter a tunnel number. Assign it to the main virtual router. Click OK.

Figure 2-35 Configured Tunnel Interfaces

<table>
<thead>
<tr>
<th>Interface</th>
<th>Management Profile</th>
<th>IP Address</th>
<th>Virtual Router</th>
<th>Security Zone</th>
<th>Features</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>tunnel</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td></td>
<td></td>
</tr>
<tr>
<td>tunnel.1</td>
<td>none</td>
<td>none</td>
<td>Enterprise_Main_Ro...</td>
<td>Enterprise_VPN</td>
<td>🌐</td>
<td>SSL VPN</td>
</tr>
</tbody>
</table>

4. Click the newly created tunnel.

5. Click the drop-down next to Security Zone. Select New Zone.

6. Give it a name and assign it to the newly created tunnel. Click OK twice.
7. Commit the changes.


9. Click Add.

10. Give the policy a descriptive name. For this example, the rule was named VPN_Auth.

11. Click Source.

12. Click Add and add the VPN and WAN zones.

13. Click Destination.

14. Check the Any box above Destination Zone.

15. Click Service/URL Category.

16. Click Add under Service and add service-https.

17. Click Actions.

18. Next to Authentication Enforcement, select default-web-form.

19. Click OK.

2.4.7.1 Configure the GlobalProtect Gateway

1. Navigate to Network > GlobalProtect > Gateways.

2. Click Add.

3. Give the gateway a meaningful name. For this implementation, the name Enterprise_VPN_Gateway was used.
4. Under **Interface**, select the **WAN Ethernet interface**.

5. Ensure that **IPv4 Only** is selected next to **IP Address Type**.

6. Select the **WAN IP of the firewall** next to **IPv4 Address**. Ensure that end clients can resolve it.

7. Click **Authentication**.

8. Select the created **SSL/TLS service profile** next to **SSL/TLS Service Profile**.

9. Click **Add** under **Client Authentication**.

10. Give the object a meaningful name, such as iOS Auth.

11. Next to **OS**, select **iOS**.

12. Next to **Authentication Profile**, select the created **Authentication Profile**.

13. Next to **Allow Authentication with User Credentials OR Client Certificate**, select Yes.

14. Click **OK**.

15. Click **Add** under **Client Authentication**.

16. Give the object a meaningful name, such as Android Auth.

17. Next to **OS**, select **Android**.

18. Next to **Authentication Profile**, select the created **Authentication Profile**.


20. Click **Agent**.

21. Check the box next to **Tunnel Mode**.

Figure 2-37 GlobalProtect iOS Authentication Profile
22. Select the created tunnel interface next to Tunnel Interface.

23. Uncheck Enable IPSec.

24. Click Timeout Settings.

25. Set Disconnect On Idle to an organization defined time.

26. Click Client IP Pool.

27. Click Add and assign an IP subnet to the clients—in this case, 10.3.3.0/24.

28. Click Client Settings.

29. Click Add.

30. Give the config a meaningful name, such as Enterprise_Remote_Access.


32. Click Add under Source User.

33. Enter the LDAP information of the group allowed to use this rule. In this example, implementation, domain users, and mobile users were used.

Figure 2-38 LDAP Authentication Group Configuration

34. Click Split Tunnel.

35. Click Add under Include.

36. Enter 0.0.0.0/0 to enable full tunneling.

37. Click OK.
38. Click **Network Services**.
39. Set **Primary DNS** to be the internal domain controller/DNS server—in this case, **192.168.8.10**.
40. Click **OK**.
41. Navigate to **Network > Zones**.
42. Click the created **VPN zone**.
43. Check the box next to **Enable User Identification**.

Figure 2-39 VPN Zone Configuration

44. Click **OK**.
45. Commit the changes.

### 2.4.7.2 Configure the GlobalProtect Portal

1. Navigate to **Network > GlobalProtect > Portals**.
2. Click **Add**.
3. Give the profile a meaningful name, such as Enterprise_VPN_Portal.
4. For Interface, assign it the firewall’s **WAN interface**.

5. Set IP Address Type to **IPv4 Only**.

6. Set the IPv4 address to the firewall’s **WAN address**.

7. Set all three appearance options to be **factory-default**.

Figure 2-40 GlobalProtect Portal General Configuration

8. Click **Authentication**.

9. Select the **created SSL/TLS service profile**.

10. Click **Add** under **Client Authentication**.

11. Give the profile a meaningful name, such as Enterprise_Auth.

12. Select the created **authentication profile** next to **Authentication Profile**.

13. Click **OK**.
14. Click **Agent** and click **Add** under **Agent**.
15. Give the agent configuration a name.
16. Ensure that the **Client Certificate** is set to **None**, and **Save User Credentials** is set to **No**.
17. Check the box next to **External gateways-manual only**.
18. Click **External**.

19. Click **Add** under **External Gateways**.

20. Give the gateway a name and enter the fully qualified domain name (FQDN) of the VPN end point.

21. Click **Add** under **Source Region** and select **Any**.

22. Check the box next to **Manual**.

23. Click **OK**.

24. Click **App**.


26. Next to **Welcome Page**, select **factory-default**.

27. Click **OK**.

28. Click **Add** under **Trusted Root CA**.

29. Select the internal root certificate used to generate device certificates.

30. Click **Add** again. Select the root certificate used to create the VPN end-point SSL certificate. For this implementation, it is a DigiCert root certificate.

---

**Figure 2-42 GlobalProtect Portal Agent Authentication Configuration**
31. Click **Add** again. Select the **root certificate** used for SSL URL filtering, created in a previous section.

32. Check the box next to **Install in Local Root Certificate Store** for all three certificates.

Figure 2-43 GlobalProtect Portal Agent Configuration

33. Click **OK**.

### 2.4.7.3 Activate Captive Portal

1. Navigate to **Device > User Identification > Captive Portal Settings**.
2. Click the gear icon on the top right of the Captive Portal box.
3. Select the **created SSL/TLS service profile and authentication profile**.
4. Click the radio button next to **Redirect**.
5. Next to **Redirect Host**, enter the **IP address** of the firewall’s WAN interface—in this case, **10.8.1.2**.
6. Click **OK**.

7. Commit the changes.

### 2.4.7.4 Activate the GlobalProtect Client

1. Navigate to **Device > GlobalProtect Client**.
2. Acknowledge pop up messages.
3. Click **Check Now** at the bottom of the page.
4. Click **Download** next to the **first release** that comes up. In this implementation, version 5.0.2atewas used.
5. Click **Activate** next to the **downloaded release**.
6. Navigate to the FQDN of the VPN. You should see the Palo Alto Networks logo and the GlobalProtect portal login prompt, potentially with a message indicating that a required certificate cannot be found. This is expected on desktops because there is nothing in place to seamlessly deploy client certificates.
Note: If you intend to use the GlobalProtect agent with a self-signed certificate (e.g., internal PKI), be sure to download the SSL certificate from the VPN website and install it in the trusted root CA store.

2.4.8 Enable Automatic Application and Threat Updates

1. In the PAN-OS portal, navigate to Device > Dynamic Updates.

2. Install the latest updates.
   a. At the bottom of the page, click Check Now.
   b. Under Applications and Threats, click Download next to the last item in the list with the latest Release Date. This will take a few minutes.
   c. When the download completes click Close.

Figure 2-46 Downloaded Threats and Applications

<table>
<thead>
<tr>
<th>Release Date</th>
<th>Downloaded</th>
<th>Currently Installed</th>
<th>Action</th>
<th>Documentation</th>
</tr>
</thead>
</table>

d. Click Install on the first row.
e. Click **Continue Installation**, leaving the displayed box unchecked. Installation will take a few minutes.

f. When the installation completes click **Close**.

3. Enable automatic threat updates. (*Note: Automatic threat updates are performed in the background and do not require a reboot of the appliance.*)

   a. At the top of the page, next to **Schedule**, click the hyperlink with the date and time, as shown in Figure 2-47.

   ![Figure 2-47 Schedule Time Hyperlink](image)

   b. Select the **desired recurrence**. For this implementation, weekly was used.

   c. Select the **desired day and time** for the update to occur. For this implementation, Saturday at 23:45 was used.

   d. Next to **Action**, select **download-and-install**.

   ![Figure 2-48 Application and Threats Update Schedule](image)

   e. Click **OK**.

   f. Commit the changes.
2.5  **Kryptowire**

Kryptowire was used as an application vetting service via a custom active directory-integrated web application.

2.5.1  **Kryptowire and MaaS360 Integration**

1. Contact IBM support to provision API credentials for Kryptowire.

2. Contact Kryptowire support to enable the MaaS360 integration, including the MaaS360 API credentials.

3. In the Kryptowire portal, click the logged-in user’s email address in the upper right-hand corner of the portal. Navigate to Settings > Analysis.

4. Set the **Threat Score Threshold** to the desired amount. In this sample implementation, 75 was used.

5. Enter an **email address** where email alerts should be delivered.

6. Click **Save Settings**. Kryptowire will now send an email to the email address configured in step 5 when an analyzed application is at or above the configured alert threshold.
# Appendix A  List of Acronyms

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABM</td>
<td>Apple Business Manager</td>
</tr>
<tr>
<td>AD</td>
<td>Active Directory</td>
</tr>
<tr>
<td>API</td>
<td>Application Programming Interface</td>
</tr>
<tr>
<td>APN</td>
<td>Apple Push Notification</td>
</tr>
<tr>
<td>BYOD</td>
<td>Bring Your Own Device</td>
</tr>
<tr>
<td>CA</td>
<td>Certificate Authority</td>
</tr>
<tr>
<td>CN</td>
<td>Common Name</td>
</tr>
<tr>
<td>CRADA</td>
<td>Cooperative Research and Development Agreement</td>
</tr>
<tr>
<td>DC</td>
<td>Domain Controller</td>
</tr>
<tr>
<td>DMZ</td>
<td>Demilitarized Zone</td>
</tr>
<tr>
<td>DN</td>
<td>Distinguished Name</td>
</tr>
<tr>
<td>DNS</td>
<td>Domain Name System</td>
</tr>
<tr>
<td>EMM</td>
<td>Enterprise Mobility Management</td>
</tr>
<tr>
<td>FQDN</td>
<td>Fully Qualified Domain Name</td>
</tr>
<tr>
<td>HKEY</td>
<td>Handle to Registry Key</td>
</tr>
<tr>
<td>HKLM</td>
<td>HKEY_LOCAL_MACHINE</td>
</tr>
<tr>
<td>HTTP</td>
<td>Hypertext Transfer Protocol</td>
</tr>
<tr>
<td>HTTPS</td>
<td>Hypertext Transfer Protocol Secure</td>
</tr>
<tr>
<td>IBM</td>
<td>International Business Machines</td>
</tr>
<tr>
<td>ID</td>
<td>Identification</td>
</tr>
<tr>
<td>IIS</td>
<td>Internet Information Services</td>
</tr>
<tr>
<td>IP</td>
<td>Internet Protocol</td>
</tr>
<tr>
<td>IPSec</td>
<td>Internet Protocol Security</td>
</tr>
<tr>
<td>IPv4</td>
<td>Internet Protocol version 4</td>
</tr>
<tr>
<td>IT</td>
<td>Information Technology</td>
</tr>
<tr>
<td>ITL</td>
<td>Information Technology Laboratory</td>
</tr>
<tr>
<td>LDAP</td>
<td>Lightweight Directory Access Protocol</td>
</tr>
<tr>
<td>MDM</td>
<td>Mobile Device Management</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Description</td>
</tr>
<tr>
<td>--------------</td>
<td>-------------</td>
</tr>
<tr>
<td>NCCoE</td>
<td>National Cybersecurity Center of Excellence</td>
</tr>
<tr>
<td>NDES</td>
<td>Network Device Enrollment Service</td>
</tr>
<tr>
<td>NIST</td>
<td>National Institute of Standards and Technology</td>
</tr>
<tr>
<td>OS</td>
<td>Operating System</td>
</tr>
<tr>
<td>PII</td>
<td>Personally Identifiable Information</td>
</tr>
<tr>
<td>PIN</td>
<td>Personal Identification Number</td>
</tr>
<tr>
<td>PKI</td>
<td>Public Key Infrastructure</td>
</tr>
<tr>
<td>SCEP</td>
<td>Simple Certificate Enrollment Protocol</td>
</tr>
<tr>
<td>SMTP</td>
<td>Simple Mail Transport Protocol</td>
</tr>
<tr>
<td>SP</td>
<td>Special Publication</td>
</tr>
<tr>
<td>SSID</td>
<td>Service Set Identifier</td>
</tr>
<tr>
<td>SSL</td>
<td>Secure Sockets Layer</td>
</tr>
<tr>
<td>TLS</td>
<td>Transport Layer Security</td>
</tr>
<tr>
<td>UE</td>
<td>User Enrollment</td>
</tr>
<tr>
<td>URL</td>
<td>Uniform Resource Locator</td>
</tr>
<tr>
<td>UUID</td>
<td>Universally Unique Identifier</td>
</tr>
<tr>
<td>VPN</td>
<td>Virtual Private Network</td>
</tr>
<tr>
<td>WAN</td>
<td>Wide Area Network</td>
</tr>
<tr>
<td>zIPS</td>
<td>Zimperium Mobile IPS</td>
</tr>
</tbody>
</table>
Appendix B  Glossary

Bring Your Own Device (BYOD)  A non-organization-controlled telework client device. [2]
Appendix C  References


Appendix D  Example Solution Lab Build Testing Details

This section shows the test activities performed to demonstrate how this practice guide’s example solution that was built in the National Institute of Standards and Technology (NIST) National Cybersecurity Center of Excellence (NCCoE) lab addresses the threat events and privacy risks defined from the risk assessment found in Volume B, Section 3.4.

D.1  Threat Event 1 – Unauthorized Access to Sensitive Information Via a Malicious or Intrusive Application Practices

Summary: Unauthorized access to work information via a malicious or privacy-intrusive application.

Test Activity: Place mock enterprise contacts on devices, then attempt to install and use unmanaged applications that access and back up those entries.

Desired Outcome: Built-in device mechanisms such as Apple User Enrollment functionality and Google’s Android Enterprise work profile functionality are used to separate the contact and calendar entries associated with enterprise email accounts so that they can only be accessed by enterprise applications (applications that the enterprise mobility management (EMM) authorizes and manages), not by applications manually installed by the user.

Observed Outcome: Since the test application was unmanaged, it was unable to access the enterprise contacts and calendar entries. This is due to Android Enterprise and Apple User Enrollment providing data separation and isolation capabilities between the personal and work profiles. The observed outcomes are shown in Figure D-1 and Figure D-2, which show how a contact created in a work profile cannot be seen by a personal profile. In addition, Figure D-3 and Figure D-4 show how a contact created in a managed application cannot be seen by an unmanaged application.

Figure D-1 Contact Created in Work Profile
Figure D-2 Personal Profile Can't See Work Contacts

Figure D-3 Contact Created in Managed App
Summary: A fictional phishing event was created to test protection against the theft of credentials through an email phishing campaign.

Test Activity:

- This threat event can be tested by establishing a web page with a form that impersonates an enterprise login prompt.
- The web page’s uniform resource locator (URL) is then sent via email and there is an attempt to collect and use enterprise login credentials.

Desired Outcome: The enterprise’s security architecture should block the user from browsing to known malicious websites. Additionally, the enterprise should require multifactor authentication or phishing-resistant authentication methods such as those based on public key cryptography so that either there is no password for a malicious actor to capture or capturing the password is insufficient to obtain access to enterprise resources.

Observed Outcome: The example solution used Palo Alto Networks’ next-generation firewall. The firewall includes PAN-DB, a URL filtering service that automatically blocks known malicious URLs. The URL filtering database is updated regularly to help protect users from malicious URLs. The next-generation firewall blocked the attempt to visit the phishing site when accessing it from within the work profile. However, if the malicious URL were not present in PAN-DB, or the URL was accessed in the personal profile of the device, the user would be allowed to access the website. Figure D-5 shows the observed outcome of the phishing webpage being blocked from within the work profile.
D.3 Threat Event 3 – Confidentiality and Integrity Loss Due to Exploitation of Known Vulnerability in the OS or Firmware

Summary: Confidentiality and integrity loss due to the exploitation of a known vulnerability in the operating system or firmware.

Test Activity: Attempt to access enterprise resources from a mobile device with known vulnerabilities (e.g., running an older, unpatched version of iOS or Android).

Desired Outcome: The enterprise’s security architecture should identify the presence of devices that are running an outdated version of iOS or Android susceptible to known vulnerabilities. It should be possible, when warranted by the risks, to block devices from accessing enterprise resources until system updates are installed.

Observed Outcome: Zimperium was able to identify devices that were running an outdated version of iOS or Android, and it informed MaaS360 when a device was out of compliance. Once MaaS360 alerted the user, they had a pre-configured amount of time to remediate the risk before work data was
removed from the device, leaving the personal data unaffected. Figure D-6 and Figure D-7 show the security architecture identifying the presence of outdated operating systems.

Figure D-6 iOS MaaS360 OS Compliance Alert
D.4 Threat Event 4 – Loss of Confidentiality of Sensitive Information Via Eavesdropping on Unencrypted Device Communications

**Summary:** Loss of confidentiality of sensitive information via eavesdropping on unencrypted device communications.

**Test Activity:** Test if applications will attempt to establish a hypertext transfer protocol or unencrypted connection.

**Desired Outcome:**

- **Android:** Because all work applications are inside a work profile, a profile-wide virtual private network (VPN) policy can be applied to mitigate this threat event; all communications, both encrypted and unencrypted, will be sent through the VPN tunnel. This will prevent eavesdropping on any communication originating from a work application.
- **iOS:** Apply a per-application VPN policy that will send all data transmitted by managed applications through the VPN tunnel. This will prevent eavesdropping on any unencrypted communication originating from work applications.
- **Kryptowire** can identify if an application attempts to establish an unencrypted connection.

**Observed Outcome:** The Kryptowire report indicated that the application did not use in-transit data encryption. When the managed version of that application was launched, an SSL VPN connection was automatically established. Figure D-8 shows the analysis summary finding of no in-transit data encryption in use.
D.5 Threat Event 5 – Compromise of Device Integrity Via Observed, Inferred, or Brute-Forced Device Unlock Code

Summary: Compromise of device integrity via observed, inferred, or brute-forced device unlock code.

Test Activity:
- Attempt to completely remove the device unlock code. Observe whether the attempt succeeds.
- Attempt to set the device unlock code to “1234,” a weak four-digit personal identification number (PIN). Observe whether the attempt succeeds.

Desired Outcome: Policies set on the device by the EMM (MaaS360) should require a device unlock code to be set, prevent the device unlock code from being removed, and require a minimum complexity for the device unlock code. The VPN (GlobalProtect) should require periodic re-authentication with multi-factor authentication to prevent devices with a bypassed lock screen from accessing on-premises enterprise resources.

Additionally, the MTD (Zimperium) can identify and report iOS devices with a disabled lock screen.

Observed Outcome: MaaS360 applies a policy to the devices to enforce a mandatory PIN, Zimperium reports devices with a disabled lock screen, and GlobalProtect requires periodic re-authentication using MFA. Figure D-9 through Figure D-11 show the passcode and lock screen configuration settings.
Figure D-9 Android Passcode Configuration

Figure D-10 iOS Passcode Configuration
**D.6  Threat Event 6 – Unauthorized Access to Backend Services Via Authentication or Credential Storage Vulnerabilities in Internally Developed Applications**

**Summary:** Unauthorized access to backend services via authentication or credential storage vulnerabilities in internally developed applications.

**Test Activity:** Application was submitted to Kryptowire for analysis of credential weaknesses.

**Desired Outcome:** Discover and report credential weaknesses.

**Observed Outcome:** Kryptowire recognized that the application uses hardcoded credentials. The application’s use of hardcoded credentials could introduce vulnerabilities if unauthorized entities used the hardcoded credentials to access enterprise resources. Figure D-12 shows the discovery of hardcoded credentials.
D.7 Threat Event 7 – Unauthorized Access of Enterprise Resources From an Unmanaged and Potentially Compromised Device

**Summary:** Unauthorized access of enterprise resources from an unmanaged and potentially compromised device.

**Test Activity:** Attempt to directly access enterprise services, e.g., Exchange email server or corporate VPN, on a mobile device that is not enrolled in the EMM system.

**Desired Outcome:** Enterprise services should not be accessible from devices that are not enrolled in the EMM system. Otherwise, the enterprise is not able to effectively manage devices to prevent threats.

**Observed Outcome:** Devices that were not enrolled in MaaS360 were unable to access enterprise resources as the GlobalProtect VPN gateway prevented the devices from authenticating without proper client certificates—obtainable only through enrolling in the EMM. Figure D-13 through Figure D-15 show the desired outcome of the VPN gateway protecting the enterprise.
Figure D-13 Attempting to Access the VPN on an Unmanaged iOS Device
Figure D-14 Attempting to Access the VPN on an Unmanaged Android Device

What's your portal address?

No certificates found

GlobalProtect has requested a certificate. Agreeing to this request will allow the application to use this certificate with servers from now on. The requesting server has been recognized as vpn.ent.mdse.nccoe.org:443. Only agree to this request if you trust the application.

+ Install certificate

Cancel
D.8 Threat Event 8 – Loss of Organizational Data Due to a Lost or Stolen Device

**Summary:** Loss of organizational data due to a lost or stolen device.

**Test Activity:** Attempt to download enterprise data onto a mobile device that is not enrolled in the EMM system (may be performed in conjunction with TE-7). Attempt to remove (in conjunction with TE-5) the screen lock passcode or demonstrate that the device does not have a screen lock passcode in place. Attempt to locate and selectively wipe the device through the EMM console (will fail if the device is not enrolled in the EMM).

**Desired Outcome:** It should be possible to locate or wipe EMM enrolled devices in response to a report that they have been lost or stolen. As demonstrated by TE-7, only EMM enrolled devices should be able to access enterprise resources. As demonstrated by TE-5, EMM enrolled devices can be forced to have a screen lock with a passcode of appropriate strength, which helps resist exploitation (including loss of organizational data) if the device has been lost or stolen.

**Observed Outcome (Enrolled Devices):** Enrolled devices are protected. They have an enterprise policy requiring a PIN/lock screen, and therefore, the enterprise data on the device could not be accessed.
Additionally, the device could be remotely wiped after it was reported as lost to enterprise mobile device service management, ensuring no corporate data is left in the hands of attackers.

**Observed Outcome (Unenrolled Devices):** As shown in Threat Event 7, only enrolled devices could access enterprise resources. When the device attempted to access enterprise data, no connection to the enterprise services was available. Because the device cannot access the enterprise, the device would not contain enterprise information.

In both outcomes, both enrolled and unenrolled, it would be at the user’s discretion if they wanted to wipe all personal data as well. Because this is a Bring Your Own Device (BYOD) scenario, only corporate data (managed applications on iOS, and the work container on Android) would be deleted from a device if the device were lost or stolen. Figure D-16 through Figure D-19 show the removal of only organization data using selective wipe features.

Figure D-16 Selective Wiping a Device

**Selective Wipe - Mobile User’s iPhone**

This will remove the Mail Server account configured on the device and all Corporate settings made available to the device.

Are you sure you want to Selective Wipe Device - *Mobile User’s iPhone*?

Comments
(Max 64 chars)

![Selectiver Wipe Complete](image)

**Figure D-17 Selective Wipe Complete**

<table>
<thead>
<tr>
<th>Applied Policy</th>
<th>MDM: Default: iOS MDM Policy (192)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>WorkPlace Persona: WorkPlace Persona Policy (9)</td>
</tr>
<tr>
<td>Jailbroken/Rooted</td>
<td>No</td>
</tr>
<tr>
<td>Selective Wipe Status</td>
<td>Completed (05/23/2022 14:28 EDT)</td>
</tr>
<tr>
<td>Passcode Status</td>
<td>MDM:Compliant</td>
</tr>
<tr>
<td></td>
<td>WorkPlace: Enabled</td>
</tr>
<tr>
<td>Rules Compliance Status</td>
<td>In Compliance</td>
</tr>
<tr>
<td>Rule Set Name</td>
<td>Zimperium - Critical</td>
</tr>
</tbody>
</table>
D.9 Threat Event 9 – Loss of Confidentiality of Organizational Data Due to its Unauthorized Storage in Non-Organizationally Managed Services

**Summary:** Loss of confidentiality of organizational data due to its unauthorized storage in non-organizationally managed services.

**Test Activity:** Connect to the enterprise VPN. Open an enterprise website or application. Attempt to extract enterprise data by taking a screenshot, or copy/paste and send it via an unmanaged email account.

**Desired Outcome:** The EMM will prohibit screenshots and other data-sharing actions while using managed applications.

**Observed Outcome:** As shown in Figure D-20 through Figure D-22, MaaS360 device policies prevented the following actions on BYOD managed phones:

- **Android**
- clipboard sharing
- screen capture
- share list
- backup to Google
- Secure Digital card write
- Universal Serial Bus storage
- video recording
- Bluetooth
- background data sync
- Android Beam
- Sbeam

- iOS
  - opening, writing, and saving from managed to unmanaged applications
  - AirDrop for managed applications
  - screen capture
  - AirPlay
  - iCloud backup
  - document, photo stream, and application sync
  - print
  - importing files
## Figure D-20 iOS DLP Configuration Options

<table>
<thead>
<tr>
<th>Device Settings</th>
<th>Restriction Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Configure Device Restrictions</td>
<td>Yes</td>
</tr>
<tr>
<td>ActiveSync</td>
<td>Unencrypted backups are restricted for all APNS managed devices.</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Select this option to configure restrictions on use of device features, application and content.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Device Functionality</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Allow Open from Managed to Unmanaged apps</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Allows Content to be opened from Managed to Unmanaged apps.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Applies to Mail, Calendar events, Contacts and other types of content.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Allow Open from Unmanaged to Managed Apps</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Allows Content to be opened from Unmanaged to Managed apps.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Applies to Mail, Calendar events, Contacts and other types of content.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Allow AirDrop for Managed Apps</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Allow AirDrop to be used with managed apps.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Allow Screen Capture</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Disable to prevent screenshots, and on iOS9 devices video capture.</td>
<td></td>
</tr>
</tbody>
</table>

**Default iOS MDM Policy**

Last Published: 03/28/2022 11:29 EDT  [Version: 192]  Current Status: Needs
Figure D-21 Android DLP Configuration

<table>
<thead>
<tr>
<th>Device Features</th>
<th>Android Version Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allow camera</td>
<td>Android 1.0+ (PO &amp; DQ)</td>
</tr>
<tr>
<td>Allow camera on personal profile</td>
<td>Android 11+ (MPOS)</td>
</tr>
<tr>
<td>Mute Master Volume</td>
<td>Android 5.0+ (DO)</td>
</tr>
<tr>
<td>Allow unmuting of microphone</td>
<td>Android 3.0+ (DO)</td>
</tr>
<tr>
<td>Allow volume adjustments</td>
<td>Android 5.0+ (DO)</td>
</tr>
<tr>
<td>Allow bluetooth configuration</td>
<td>Android 5.0+ (DO)</td>
</tr>
<tr>
<td>Allow outgoing beam</td>
<td>Android 5.1+ (PO &amp; DO)</td>
</tr>
<tr>
<td>Allow sharing of locations</td>
<td>Android 5.0+ (PO &amp; DO)</td>
</tr>
</tbody>
</table>

To enable camera on device, camera app needs to be allowed in native app compliance apart from enabling this.

Camera app also needs to be allowed in native app compliance apart from enabling this.

This policy controls location permission availability for apps. Keep this policy enabled if you are configuring WiFi policies. Trustee policies or WiFi or Bluetooth settings within kiosk. Location permission is required for discovering list of configured networks, current connected network and discovering other bluetooth networks.
D.10 Privacy Risk 1 – Wiping Activities on the Employee’s Device May Inadvertently Delete the Employee’s Personal Data

Summary: Personal data on the phone could be lost during a device wipe.

Test Activity: Selectively wipe a device using MaaS360; restrict staff access to only allow wiping of work profile data.

Desired Outcome: The user will no longer be able to access work applications and data on the device and retains all access to their personal applications and data. The restricted administrator accounts will only be able to remove work profile data.

Observed Outcome: Corporate data and applications are removed while personal data is untouched. The EMM console removes staff access to performing full device wiping. Figure D-23 shows initiation of a selective wipe. The selective wipe will remove the Mail Server account and all corporate settings available to the device.
Additional Potential Mitigations:

- Notify users of use-policy regarding corporate applications.
- Disallow configuration of work applications by users where possible to prevent comingling of personal and work data.
- Restrict staff access to system capabilities that permit removing device access or performing wipes.

D.11 Privacy Risk 2 – Organizational Collection of Device Data May Subject Employees to Feeling or Being Surveilled

Summary: The user may experience surveillance from the organization collecting device application and location data.

Test Activity: Disable location tracking and verify that applications outside of the organizationally controlled portions of the phone are not inventoried by the EMM.

Desired Outcome: Collection of application and location data is restricted by the EMM. The EMM does not collect an inventory of personal applications on the device and does not collect location information, including physical address, geographic coordinates and history, internet protocol (IP) address, and service set identifier (SSID).

Observed Outcome: When inspecting a device, location and application inventory information are not collected by an EMM, and application inventory information is not transmitted to Kryptowire. Collection of the installed personal apps is restricted by OS-level controls.
Figure D-24 shows inventory information for installed applications. When privacy restrictions are configured, only corporate application inventory information is collected. No personal applications are found in the EMM’s installed applications list.

Figure D-24 Application Inventory Information

![Application Inventory Information](image)

Figure D-25 shows that privacy settings have been enabled to restrict collection of location information.

Figure D-25 Location Information Restricted

![Location Information Restricted](image)

**Additional Potential Mitigations:**

-_restrict staff access to system capabilities that permit reviewing data about employees and their devices.
- Limit or disable collection of specific data elements.
- Dispose of personally identifiable information (PII).

D.12 Privacy Risk 3 – Data Collection and Transmission Between Integrated Security Products May Expose Employee Data

Summary: Access to monitoring data from the device is not restricted to administrators. Application and location data are shared with third parties that support monitoring, data analytics, and other functions for operating the BYOD solution.

Test Activity: Attempt to log in to the MaaS360 admin portal without domain administrator permissions.

Desired Outcome: System provides access controls to monitoring functions and logs. Data flow between the organization and third parties does not contain location information, including physical address, geographic coordinates and history, IP address, and SSID.

Observed Outcome: Domain administrators were allowed to log in, but non-administrator users were not.

Figure D-26 demonstrates how a non-administrator account will be prevented from logging into the MaaS360 portal.

Figure D-26 Non-Administrator Failed Portal Login

Log into IBM MaaS360

The credentials entered were incorrect or this account is not provisioned.
Contact your Administrator to request that your Login account be provisioned.

testuser

Password

Log In

Forgot Username or Password?
Potential Mitigations:

- De-identify personal and device data when such data is not necessary to meet processing objectives.
- Encrypt data transmitted between parties.
- Limit or disable access to data.
▪ Limit or disable collection of specific data elements.
▪ Use policy controls such as contracts to limit third-party data processing.

D.13 Privacy Risk 4 – Employees Might Feel Compelled to Participate in Data Processing Practices Inconsistent with Expectations

Summary: Users may not have knowledge of what information is collected and monitored by the organization.

Test Activity: Test to ensure that MDM provides custom notification to users detailing collected device information.

Desired Outcome: MDM provides details of what information is collected during device enrollment.

Observed Outcome: Device data collection information is displayed to users.

Figure D-29 demonstrates how users will be notified of what device information is collected by mobile security products during the device enrollment process.
Additional Potential Mitigations:

- Provide notification to the user.
- Train users on mobile-device collection policy.
- Provide a point of contact for user questions regarding organizational data collection and use policies.
- Train system administrators regarding the privacy requirements for operating the BYOD systems.
D.14 Privacy Risk 5 – Unauthorized or Invasive Application Processing of Information Exposes Employee Data

Summary: The employee or organization installs third-party applications that access data on the device without fully understanding the nature of the applications data processing practices, creating opportunities for invasive or malicious activity or installation of malware. An application may over-collect information or conduct analysis that may result in embarrassment to the employee or create opportunities for surveillance that extend beyond the level of monitoring needed for an organization.

Test Activity: Log in to an Application Vetting solution to automatically analyze all new applications installed on enrolled devices, then run the reports to see threat details.

The administrator configures a threat score alert threshold and an email address to receive alerts when an application’s threat score is at or above the threshold.

Desired Outcome: After application analysis the risk posture of the devices, and therefore, the enterprise stays at an acceptable level. If the work application did not pass the App Vetting process it should not be used by the enterprise.

Observed Outcome: App vetting solution recognized that the application exceeded the configured security threshold and over-collected personal information. The application’s collection of contacts, calendars and device sensors could introduce vulnerabilities. Figure D-30 through Figure D-32 demonstrate the app vetting findings.

Figure D-30 Mobile Device Information Collection Notification
Figure D-31 Privacy and Information Access of the Application

<table>
<thead>
<tr>
<th>Privacy &amp; Information Access</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tracks user behaviour</td>
<td>Low</td>
</tr>
<tr>
<td>Integrates with an ad network</td>
<td>Low</td>
</tr>
<tr>
<td>Integrates with a cloud storage service</td>
<td>Low</td>
</tr>
<tr>
<td>Integrates with a social network</td>
<td>Low</td>
</tr>
<tr>
<td>Access to accounts from Account Manager</td>
<td>Low</td>
</tr>
<tr>
<td>User password exposed</td>
<td>High</td>
</tr>
<tr>
<td>Accesses subscriber ID of the user</td>
<td>Low</td>
</tr>
<tr>
<td>Accesses unique ID of the device</td>
<td>Low</td>
</tr>
<tr>
<td>Accesses SIM serial number of the device</td>
<td>Low</td>
</tr>
<tr>
<td>Accesses phone number of the device</td>
<td>Low</td>
</tr>
<tr>
<td>Has in app purchases</td>
<td>Medium</td>
</tr>
<tr>
<td>Exposes sensitive information</td>
<td>High</td>
</tr>
<tr>
<td>Creates resources accessible from outside parties</td>
<td>Medium</td>
</tr>
<tr>
<td>Connection to foreign country</td>
<td>Medium</td>
</tr>
<tr>
<td>Exposes low risk sensitive information</td>
<td>Medium</td>
</tr>
<tr>
<td>App communicates with high risk locations</td>
<td>Critical</td>
</tr>
<tr>
<td>Accesses calendar</td>
<td>Low</td>
</tr>
<tr>
<td>Accesses contacts</td>
<td>Medium</td>
</tr>
</tbody>
</table>
Figure D-32 Application Analysis

Additional Potential Mitigations:

- EMM leverages OS related separation between enterprise and personal data.
- Train users on safe practices for downloading files and installing applications of their devices.
- Scan downloaded applications for malware.
- Institute procedures for conducting a privacy risk assessment for applications installed by the organization.