NIST SPECIAL PUBLICATION 1800-22 Supplement

Mobile Device Security:

Bring Your Own Device (BYOD)

Supplement:
Example Scenario: Putting Guidance into Practice

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

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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 1800-22B: *Approach, Architecture, and Security Characteristics* – what we built and why
- 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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The Technology Partners/Collaborators who participated in this build submitted their capabilities in response to a notice in the Federal Register. Respondents with relevant capabilities or product components were invited to sign a Cooperative Research and Development Agreement (CRADA) with NIST, allowing them to participate in a consortium to build this example solution. We worked with:

Technology Partner/Collaborator	Build Involvement
IBM	Mobile Device Management
Kryptowire (now known as Quokka)	Application Vetting
Palo Alto Networks	Firewall; Virtual Private Network
Qualcomm	Trusted Execution Environment
Zimperium	Mobile Threat Defense

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1 Applying This Build: Example Scenario

This document provides guidance for leveraging standards and tools to reduce cybersecurity and privacy risks in a Bring Your Own Device (BYOD) implementation. This document uses an example scenario - using a fictional company named Great Seneca Accounting—to outline specific steps an organization could take. The example shows how BYOD objectives can align with a fictional organization's security and privacy priorities using risk management standards, guidance, and tools.

To demonstrate how an organization may use this National Institute of Standards and Technology (NIST) Special Publication (SP) and other NIST tools to implement a BYOD use case, the National Cybersecurity Center of Excellence created an example scenario that centers around a fictional, small-to-mid-size organization called Great Seneca Accounting. This scenario exemplifies the issues that an organization may face when addressing common enterprise BYOD security challenges.

1.1 Standards and Guidance Used in this Example Scenario

In addition to the Executive Summary contained in Volume A, and the architecture description in Volume B, this practice guide also includes a series of how-to instructions in Volume C. The how-to instructions in Volume C provide step-by-step instructions covering the initial setup (installation or provisioning) and configuration for each component of the architecture. These step-by-step instructions can help security engineers rapidly deploy and evaluate the example solution in their test environment.

The example solution uses standards-based, commercially available products that can be used by an organization interested in deploying a BYOD solution. The example solution provides recommendations for enhancing security and privacy infrastructure by integrating on-premises and cloud-hosted mobile security technologies. This practice guide provides an example solution that an organization may use in whole or in part as the basis for creating a custom solution that best supports their unique needs.

The fictional Great Seneca Accounting organization illustrates how this guide may be applied by an organization, starting with a mobile device infrastructure that lacked mobile device security architecture concepts. Great Seneca employed multiple NIST cybersecurity and privacy risk management tools to understand the gaps in its architecture and methods to enhance security of its systems and privacy for its employees.

This example scenario provides useful context for using the following NIST Frameworks and other relevant tools to help mitigate some of the security and privacy challenges that organizations may encounter when deploying BYOD capabilities:

- NIST *Framework for Improving Critical Infrastructure Cybersecurity*, Version 1.1 (Cybersecurity Framework) [1]
- NIST *Privacy Framework: A Tool for Improving Privacy Through Enterprise Risk Management*, Version 1.0 (Privacy Framework) [2]
- NIST Special Publication (SP) 800-181 *National Initiative for Cybersecurity Education (NICE) Cybersecurity Workforce Framework* [3]
- NIST Risk Management Framework [4]

- NIST Mobile Threat Catalogue [5]

For additional information, see Volume B’s Appendix D.

2 About Great Seneca Accounting

In the example scenario, Great Seneca Accounting is a fictional accounting firm that grew from a single office location into a larger firm with a regional presence. Great Seneca Accounting performs accounting functions related to capturing, communicating, processing, transmitting, and analyzing financial data and accounting services for its customers.

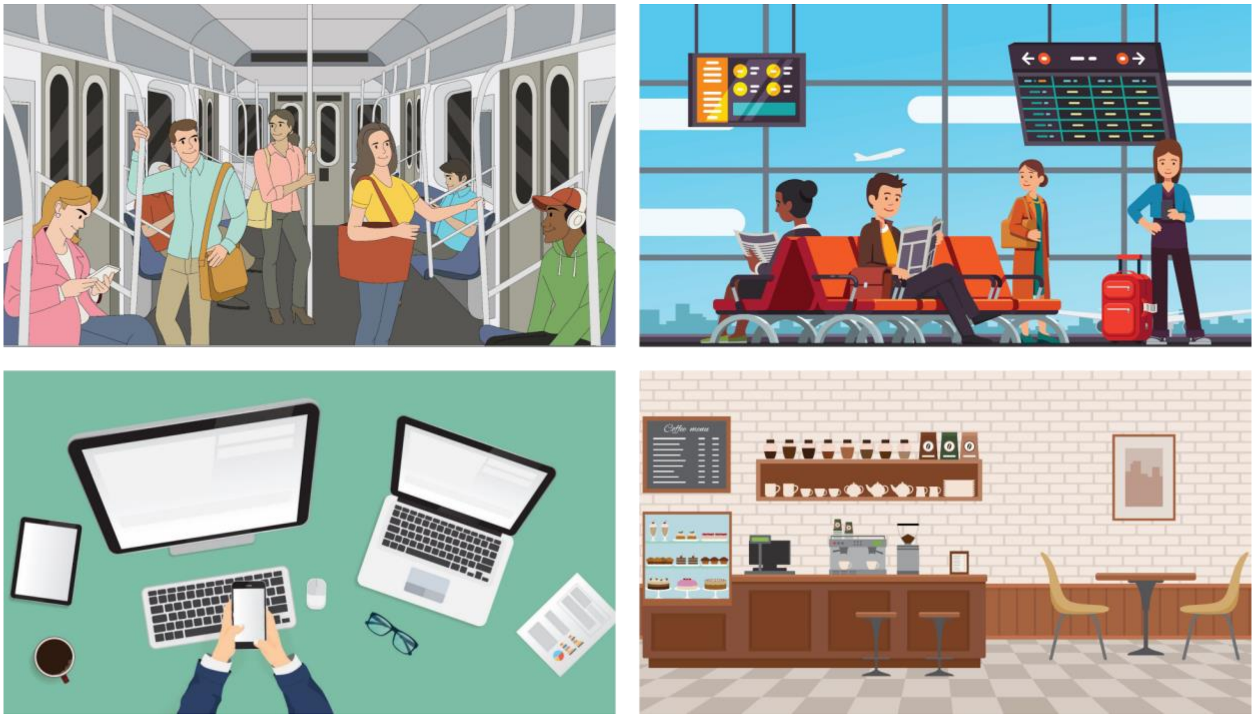
When the firm was first created, most of its employees worked from the Great Seneca Accounting office, with minimal use of mobile devices. They were able to do this without actively embracing mobile device usage because most of the employees worked at their desks at the company’s single location.

Over the years, the Great Seneca Accounting company grew from a local company, where all its employees performed work at their desks by using desktop computers provided by the organization, into a regional firm with employees who work remotely and who support regional customers.

Now, many of the employees spend part of their week traveling and working from customer or other remote locations. This has prompted the organization to specify, the need to support employees to work remotely as a strategic priority, while both traveling and working from a customer location. Consequently, the company wants to embrace BYOD solutions to support its remote work.

Figure 2-1 shows an overview of the typical work environments for a Great Seneca Accounting employee. Many employees work remotely while using their own mobile phones and tablets to perform both work and personal activities throughout the day.

Figure 2-1 Great Seneca Accounting’s Work Environments



Great Seneca Accounting’s corporate management initiated a complete review of all policies, procedures, and technology relating to its mobile deployment to ensure that the company is well protected against attacks involving personal mobile devices. This includes mitigating risks against its devices, custom applications, and corporate infrastructure supporting mobile services. Management identified NIST’s Risk Management Framework (RMF) [4] and Privacy Risk Assessment Methodology (PRAM) [6] as useful tools for supporting this analysis. The company developed Cybersecurity Framework and Privacy Framework Target Profiles to guide Great Seneca Accounting’s decision-making because the target profiles link Great Seneca Accounting’s mission and business priorities with supporting cybersecurity and privacy activities.

Great Seneca Accounting identified the scope of their mobile solution to be both Android and Apple personally owned mobile phones and tablets. While this example scenario intends to provide an exemplar of organization guidance with a description of BYOD concepts and how to apply those concepts, this example scenario should not suggest a limit on BYOD uses.

Great Seneca Accounting plans to use NIST SP 1800-22 (this practice guide) to inform its updated BYOD architecture as well as NIST’s Mobile Threat Catalogue to identify threats to mobile deployment. These NIST frameworks and tools used are described further in Appendix E.

As shown in Figure 2-2, this example solution applied multiple mobile device security technologies. These included a cloud-based Enterprise Mobility Management solution integrated with cloud- and agent-based mobile security technologies to help deploy a set of security and privacy capabilities that support the example solution.

Figure 2-2 Example Solution Architecture

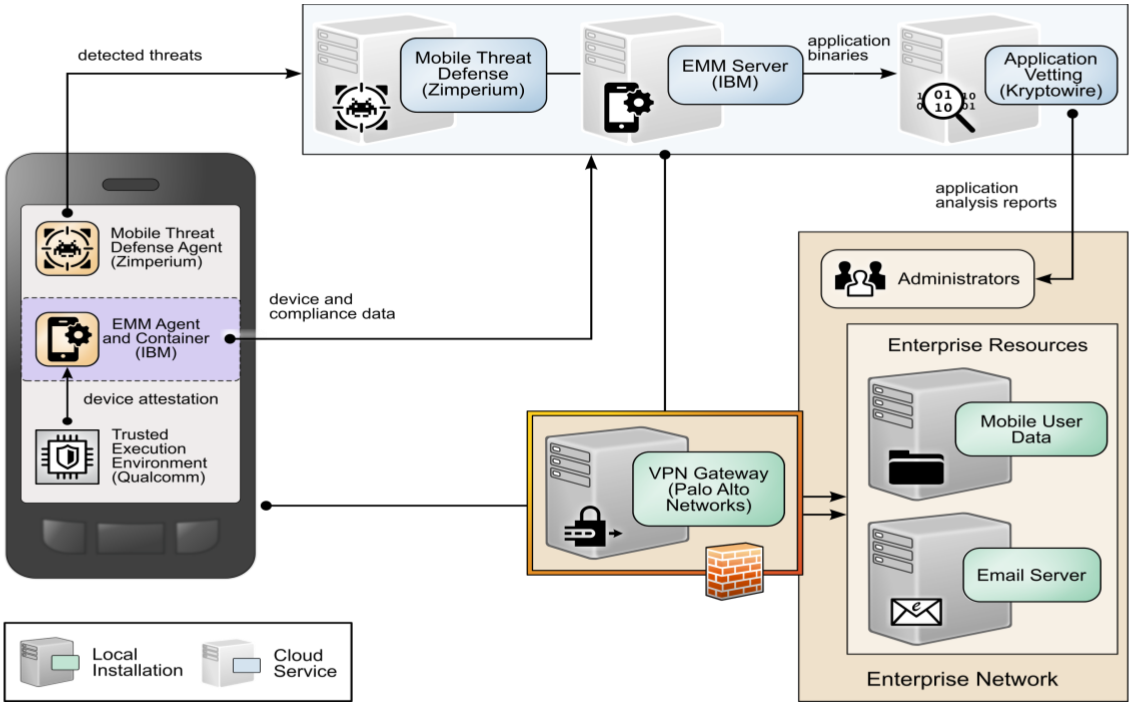
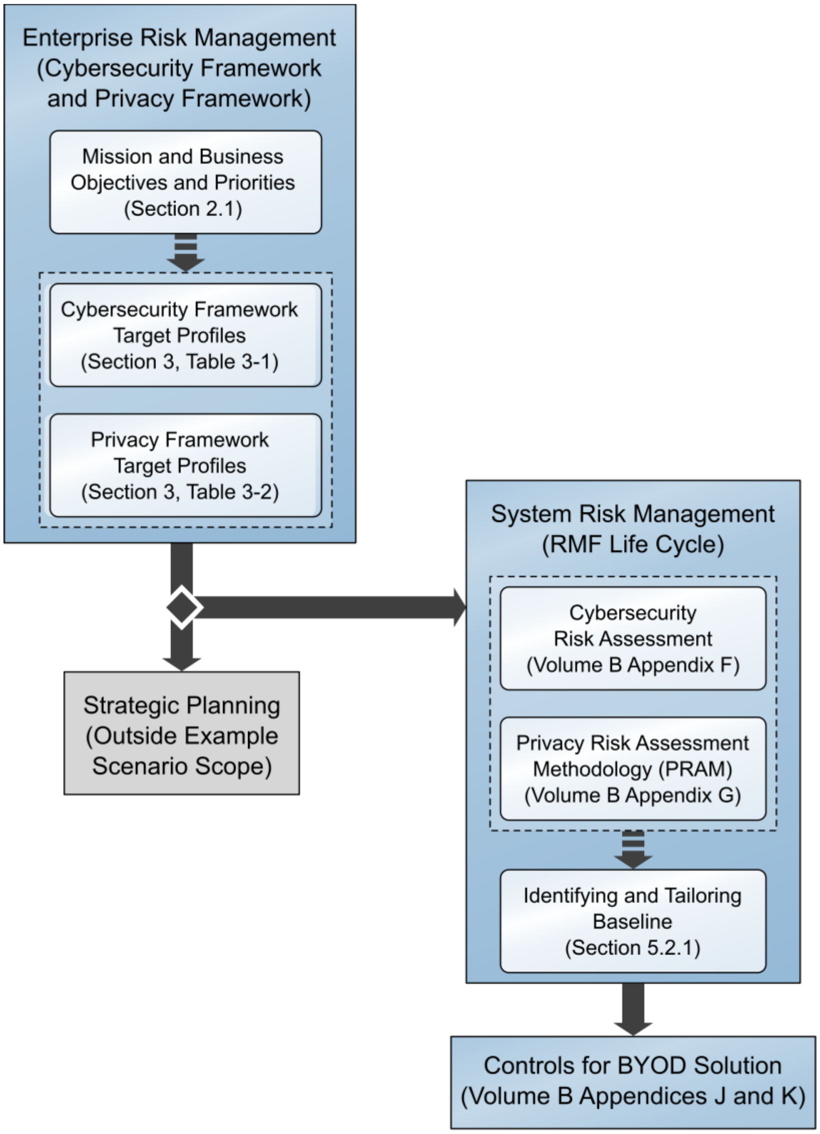

detected threats
Mobile Threat Defense (Zimperium)
EMM Server (IBM)
application binaries
Application Vetting (Kryptowire)
application analysis reports
Mobile Threat Defense Agent (Zimperium)
EMM Agent and Container (IBM)
device and compliance data
device attestation
Trusted Execution Environment (Qualcomm)
Administrators
Enterprise Resources
Mobile User Data
VPN Gateway (Palo Alto Networks)
Email Server
Enterprise Network
Local Installation
Cloud Service

Figure 2-3 shows the overall process that Great Seneca Accounting plans to follow. It highlights key activities from various NIST guidance documents related to security and privacy risk management, each of which is discussed in the sections identified in Figure 2-3. Please note that this process is an abbreviated version of steps provided in NIST SP 800-37 Revision 2 [7], which shows how some available resources may be used by any organization.

Figure 2-3 Great Seneca Accounting's Security and Privacy Risk Management Steps


Enterprise Risk Management (Cybersecurity Framework and Privacy Framework)
Mission and Business Objectives and Priorities (Section 2.1)
Cybersecurity Framework Target Profiles (Section 3, Table 3-1)
Privacy Framework Target Profiles (Section 3, Table 3-2)
Strategic Planning (Outside Example Scenario Scope)
System Risk Management (RMF Life Cycle)
Cybersecurity Risk Assessment (Volume B Appendix F)
Privacy Risk Assessment Methodology (PRAM) (Volume B Appendix G)
Identifying and Tailoring Baseline (Section 5.2.1)
Controls for BYOD Solution (Volume B Appendices J and K)

2.1 Great Seneca Accounting's Business/Mission Objectives

Great Seneca Accounting developed a mission statement and a set of supporting business/mission objectives to ensure that its activities align with its core purpose. The company has had the same mission since it was founded:

Mission Statement

Provide financial services with integrity and responsiveness

While Great Seneca Accounting has a number of business/mission objectives, those below relate to its interest in BYOD, listed in priority order:

- Mission Objective 1—Provide good data stewardship

- Mission Objective 2—Enable timely communication with clients
- Mission Objective 3—Provide innovative financial services
- Mission Objective 4—Enable workforce flexibility

3 Great Seneca Accounting's Target Profiles

Great Seneca Accounting used the NIST Cybersecurity Framework and NIST Privacy Framework as key strategic planning tools to improve its security and privacy programs. It followed the processes outlined in the frameworks, and as part of that effort, created *two* target profiles—one for cybersecurity and one for privacy.

These Target Profiles describe the desired or aspirational state of Great Seneca Accounting by identifying and prioritizing the cybersecurity and privacy activities and outcomes needed to support its enterprise business/mission objectives. The Subcategories in each Framework Core articulate those cybersecurity and privacy activities and outcomes.

Note: See Appendix E for a high-level description of the Cybersecurity Framework and Privacy Framework.

To understand what Subcategories to prioritize implementing in each framework, Great Seneca Accounting considered the importance of the Subcategories for accomplishing each business/mission objective. The Target Profiles reflect that discussion by designating prioritized Subcategories as low, moderate, or high.

Subcategory improvements important for BYOD deployment also became part of its Target Profiles because Great Seneca Accounting was upgrading its existing information technology infrastructure as part of its BYOD implementation.

The Cybersecurity Framework Target Profile in Table 3-1 and the Privacy Framework Target Profile in Table 3-2 are included as examples of Great Seneca Accounting's identification of the business/mission objectives that are relevant to their BYOD deployment.

Great Seneca Accounting chose to address the Subcategories that are prioritized as moderate and high for multiple business/mission objectives in its Target Profiles for this year's BYOD deployment with plans to address the low Subcategories in the future.

Table 3-1 and Table 3-2 include only those Subcategories that are prioritized as moderate or high for the business/mission objectives. Any subcategory designated as low is included in Table 3-1 and Table 3-2 only because it is high or moderate for another business/mission objective.

Great Seneca Accounting used the Target Profiles to help guide risk management decisions throughout the organization's activities, including making decisions regarding budget allocation, technology design, and staffing for its programs and technology deployments. Discussions for developing and using the Target Profiles include stakeholders in various parts of the organization, such as business/mission program owners, data stewards, cybersecurity practitioners, privacy practitioners, legal and compliance experts, and technology experts.

Note: Low, moderate, and high designations indicate the level of relative importance among Subcategories for Great Seneca to accomplish a business/mission objective.

Table 3-1 Great Seneca Accounting's Cybersecurity Framework Target Profile

Function	Category	Subcategory	Mission Objective 1	Mission Objective 2	Mission Objective 3	Mission Objective 4
IDENTIFY	**Asset Management**	**ID.AM-1:** Physical devices and systems within the organization are inventoried.	moderate	moderate	moderate	low
		ID.AM-2: Software platforms and applications within the organization are inventoried.	moderate	moderate	moderate	low
	Risk Assessment	**ID.RA-1:** Asset vulnerabilities are identified and documented.	moderate	moderate	moderate	moderate
		ID.RA-3: Threats, both internal and external, are identified and documented.	moderate	moderate	moderate	moderate
PROTECT	**Identity Management and Access Control**	**PR.AC-1:** Identities and credentials are issued, managed, verified, revoked, and audited for authorized devices, users, and processes.	moderate	high	moderate	high
		PR.AC-3: Remote access is managed.	moderate	high	high	high
		PR.AC-5: Network integrity is protected (e.g., network segregation, network segmentation).	high	high	high	high
		PR.AC-6: Identities are proofed and bound to credentials and asserted in interactions.	moderate	high	high	high
	Data Security	**PR.DS-1:** Data-at-rest is protected.	high	moderate	moderate	high
		PR.DS-2: Data-in-transit is protected.	moderate	high	moderate	high
		PR.DS-6: Integrity-checking mechanisms are used to verify software, firmware, and information integrity.	high	moderate	moderate	high

Function	Category	Subcategory	Mission Objective 1	Mission Objective 2	Mission Objective 3	Mission Objective 4
		PR.DS-8: Integrity checking mechanisms are used to verify hardware integrity.	moderate	moderate	moderate	low
	Information Protection Processes and Procedures	**PR.IP-1:** A baseline configuration of information technology/industrial control systems is created and maintained incorporating security principles.	moderate	moderate	moderate	low
	Protective Technology	**PR.PT-4:** Communications and control networks are protected.	low	moderate	moderate	low
DETECT	**Anomalies and Events**	**DE.AE-5:** Incident alert thresholds are established.	high	high	high	high
	Security Continuous Monitoring	**DE.CM-4:** Malicious code is detected.	high	high	high	high
		DE.CM-5: Unauthorized mobile code is detected.	moderate	moderate	moderate	low
		DE.CM-8: Vulnerability scans are performed.	high	high	high	high

Table 3-2 Great Seneca Accounting’s Privacy Target Profile

Function	Category	Subcategory	Mission Objective 1	Mission Objective 2	Mission Objective 3	Mission Objective 4
IDENTIFY-P	**Inventory and Mapping**	**ID.IM-P7:** The data processing environment is identified (e.g., geographic location, internal, cloud, third parties).	high	high	high	high
GOVERN-P	**Governance Policies, Processes, and Procedures**	**GV.PO-P1:** Organizational privacy values and policies (e.g., conditions on data processing, individuals’ prerogatives with respect to data processing) are established and communicated.	high	high	high	high
		GV.PO-P5: Legal, regulatory, and contractual requirements regarding privacy are understood and managed.	high	high	high	high
	Monitoring and Review	**GV.MT-P3:** Policies, processes, and procedures for assessing compliance with legal requirements and privacy policies are established and in place.	high	high	high	high
		GV.MT-P5: Policies, processes, and procedures are established and in place to receive, analyze, and respond to problematic data actions disclosed to the organization from internal and external sources (e.g., internal discovery, privacy researchers, professional events).	high	high	high	high

Function	Category	Subcategory	Mission Objective 1	Mission Objective 2	Mission Objective 3	Mission Objective 4
CONTROL-P	**Data Management**	**CT.DM-P1:** Data elements can be accessed for review.	high	moderate	high	moderate
		CT.DM-P3: Data elements can be accessed for alteration.	high	moderate	high	moderate
		CT.DM-P4: Data elements can be accessed for deletion.	high	moderate	high	moderate
		CT.DM-P5: Data are destroyed according to policy.	high	moderate	high	moderate
	Disassociated Processing	**CT.DP-P4:** System or device configurations permit selective collection or disclosure of data elements.	high	high	high	high
COMMUNICATE-P	**Data Processing Awareness**	**CM.AW-P5:** Data corrections or deletions can be communicated to individuals or organizations (e.g., data sources) in the data processing ecosystem.	high	moderate	moderate	moderate
PROTECT-P	**Data Protection Policies, Processes, and Procedures**	**PR.PO-P3:** Backups of information are conducted, maintained, and tested.	high	moderate	high	moderate
		PR.AC-P1: Identities and credentials are issued, managed, verified, revoked, and audited for authorized individuals, processes, and devices.	moderate	high	moderate	high
	Identity Management,	**PR.AC-P2:** Physical access to data and devices is managed.	high	moderate	high	moderate

Function	Category	Subcategory	Mission Objective 1	Mission Objective 2	Mission Objective 3	Mission Objective 4
	Authentication, and Access Control	**PR.AC-P4:** Access permissions and authorizations are managed, incorporating the principles of least privilege and separation of duties.	high	moderate	high	moderate
		PR.AC-P5: Network integrity is protected (e.g., network segregation, network segmentation).	high	high	high	high
		PR.DS-P1: Data-at-rest is protected.	high	moderate	moderate	high
	Data Security	**PR.DS-P2:** Data-in-transit is protected.	moderate	high	moderate	high
		PR.DS-P5: Protections against data leaks are implemented.	high	moderate	high	moderate
		PR.DS-P6: Integrity checking mechanisms are used to verify software, firmware, and information integrity.	high	moderate	moderate	high
		PR.PT-P3: Communications and control networks are protected.	moderate	high	moderate	high

4 Great Seneca Accounting Embraces BYOD

Great Seneca Accounting now allows its staff to use their personal mobile devices to perform their daily work duties on an as-needed basis. Accountants use the devices for various tasks including communicating with client organizations and other employees, collecting confidential client information, analyzing financial transactions, generating reports, accessing tax and payroll information, and creating and reviewing comprehensive financial statements.

Great Seneca accountants work from many locations including their corporate office building, their homes, their customers' offices, and other locations. In order to be able to work in all these locations, they require the use of mobile devices to perform their job functions.

Great Seneca Accounting's current mobile infrastructure enables accountants to perform their job duties by using their personally owned devices, despite minimal security installed and enforced on these devices. Examples of security concerns with the use of personally owned devices are:

- Employees can connect to any Wi-Fi network to perform work-related activities when they are working on the road, including at a client's site.
- Custom mobile applications being sideloaded onto devices that employees use.
- The personally owned devices allow users to install applications on an as-needed basis without separation of enterprise and personal data.

While not affecting Great Seneca Accounting, a string of well-publicized cybersecurity attacks was recently reported in the news, and this prompted Great Seneca to review its mobile device security and privacy deployment strategy. When making BYOD deployment decisions, Great Seneca Accounting plans to prioritize implementing cybersecurity and privacy capabilities that would enable it to accomplish its business/mission objectives (i.e., its reasons for deploying BYOD capabilities).

To do this, Great Seneca Accounting conducted a technical assessment of its current BYOD architecture to help it understand ways to improve the confidentiality, integrity, availability, and privacy of data and devices associated with its BYOD deployment. The company identified several vulnerabilities based on its current mobile device deployment. Figure 4-1 below presents a subset of those vulnerabilities.

Figure 4-1 Great Seneca Accounting's Current Mobile Deployment Architecture (Before Security and Privacy Enhancements)

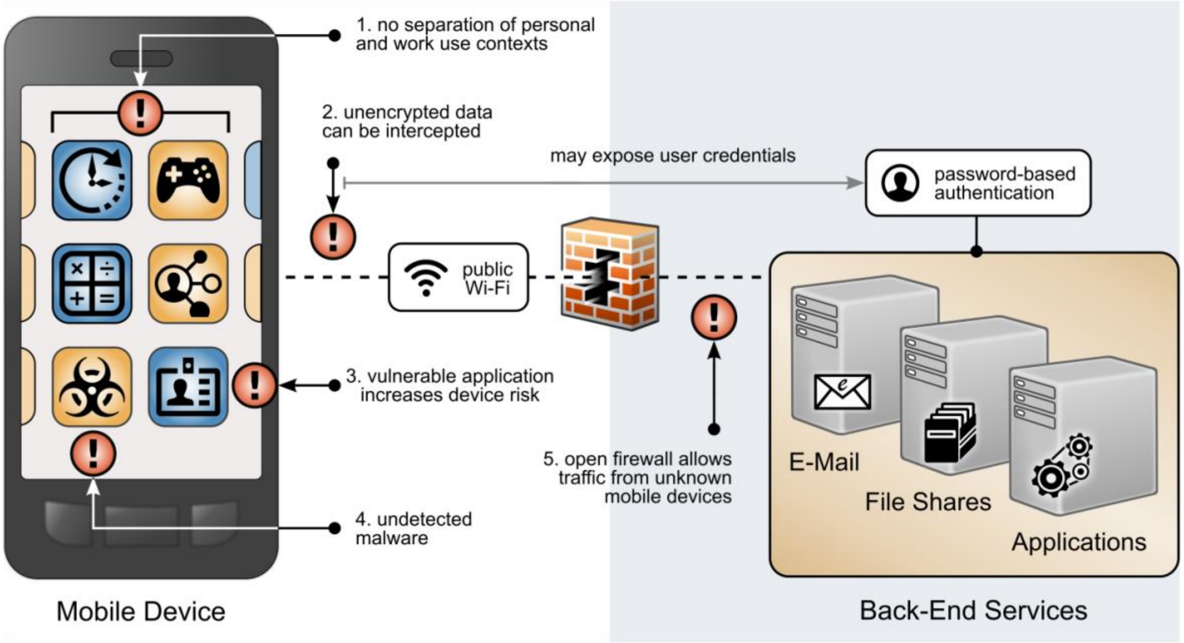

1. no separation of personal and work use contexts
2. unencrypted data can be intercepted
may expose user credentials
password-based authentication
public Wi-Fi
3. vulnerable application increases device risk
5. open firewall allows traffic from unknown mobile devices
4. undetected malware
E-Mail
File Shares
Applications
Mobile Device
Back-End Services

Figure 4-1 highlights the following vulnerabilities with a red exclamation mark:

1. BYOD deployments can place organizational and personal data, as well as employees' privacy, at risk. Organizational and personal data can become commingled if either the same application is used in both contexts or if multiple applications access shared device resources (e.g., contacts or calendar) as applications for both personal and work usage are installed. This also puts employees' privacy at risk, as the organization can have visibility into their personal life outside work.

2. BYOD deployments can leverage nonsecure networks. As employees use nonsecure Wi-Fi hotspots, mobile devices that are connecting to Great Seneca Accounting from those unencrypted networks place data transmitted prior to a secure connection at risk of discovery and eavesdropping, including passwords.

3. As employees install applications on their personally owned devices, the applications can have unidentified vulnerabilities or weaknesses that increase the risk of device compromise (e.g., applications that access contacts may now have access to the organization's client contact information). Further, legitimate, privacy-intrusive applications can legally collect data through terms and conditions and requested permissions.

4. On personally owned devices without restriction policies in place, employees may inadvertently download applications outside official application stores, which are malware in disguise.

5. Because personally owned mobile devices can connect from unknown locations, firewall rules must allow inbound connections from unrecognized, potentially malicious Internet Protocol addresses.

In addition to identifying the technical assets and the vulnerabilities, Great Seneca Accounting identified the scope of the mobile solution (i.e., both Android and Apple personally owned mobile phones and tablets) and the regulatory requirements or guidance that will apply to their deployment and solution (e.g., encryption will be Federal Information Processing Standards [FIPS]-validated to protect sensitive accounting information).

5 Applying NIST Risk Management Methodologies to Great Seneca Accounting's BYOD Architecture

Section 2 and Section 3 above describe Great Seneca Accounting, their business mission, and what security and privacy areas they consider most important. Great Seneca created Target Profiles that mapped their BYOD-related mission/business objectives and priorities with the Functions, Categories, and Subcategories of both the Cybersecurity Framework and the Privacy Framework. Those Cybersecurity Framework and Privacy Framework Target Profiles are provided in Table 3-1 and Table 3-2 in Section 3 of this document.

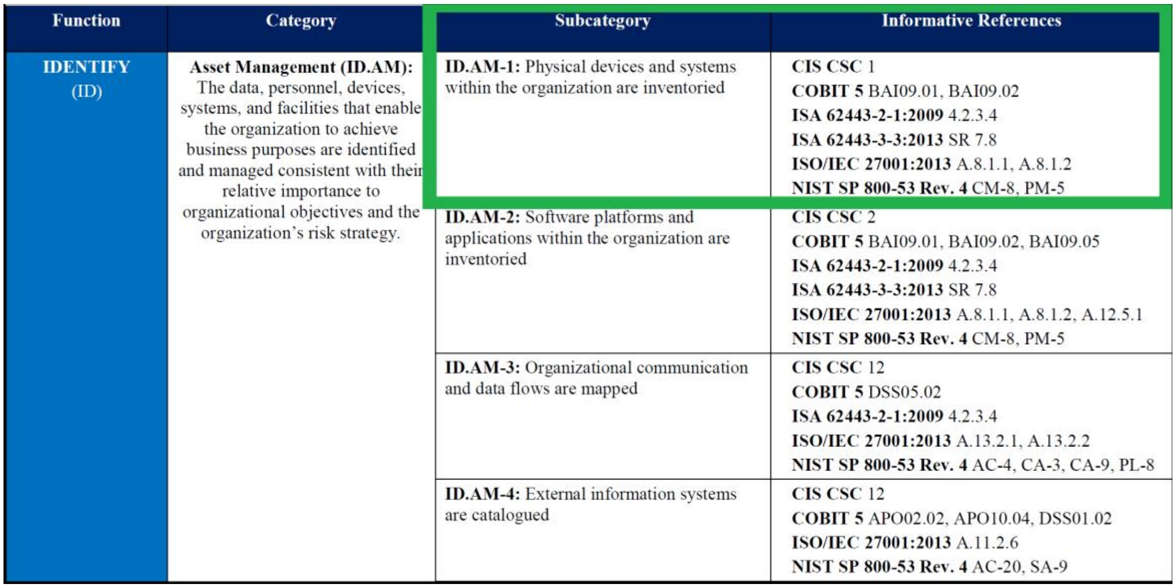
Now, the Target Profiles provided in Section 3 will demonstrate the role they play in identifying and prioritizing the implementation of the security and privacy controls, as well as the capabilities that Great Seneca would like to include in its new BYOD security and privacy-enhanced architecture.

5.1 Using Great Seneca Accounting's Target Profiles

The Cybersecurity Framework maps its Subcategories to Informative References. The Informative References contained in the Framework Core provide examples of methods that Great Seneca can use to achieve its desired outcomes. The Cybersecurity Framework's Subcategory and Informative References mappings include NIST SP 800-53 controls.

An illustrative segment of the Cybersecurity Framework's Framework Core is shown in Figure 5-1. Highlighted in the green box is an example of how the Cybersecurity Framework provides a mapping of Subcategories to Informative References.

Figure 5-1 Cybersecurity Framework Subcategory to Informative Reference Mapping



Function	Category	Subcategory	Informative References
IDENTIFY (ID)	**Asset Management (ID.AM):** The data, personnel, devices, systems, and facilities that enable the organization to achieve business purposes are identified and managed consistent with their relative importance to organizational objectives and the organization's risk strategy.	**ID.AM-1:** Physical devices and systems within the organization are inventoried	**CIS CSC** 1 **COBIT 5** BAI09.01, BAI09.02 **ISA 62443-2-1:2009** 4.2.3.4 **ISA 62443-3-3:2013** SR 7.8 **ISO/IEC 27001:2013** A.8.1.1, A.8.1.2 **NIST SP 800-53 Rev. 4** CM-8, PM-5
		ID.AM-2: Software platforms and applications within the organization are inventoried	**CIS CSC** 2 **COBIT 5** BAI09.01, BAI09.02, BAI09.05 **ISA 62443-2-1:2009** 4.2.3.4 **ISA 62443-3-3:2013** SR 7.8 **ISO/IEC 27001:2013** A.8.1.1, A.8.1.2, A.12.5.1 **NIST SP 800-53 Rev. 4** CM-8, PM-5
		ID.AM-3: Organizational communication and data flows are mapped	**CIS CSC** 12 **COBIT 5** DSS05.02 **ISA 62443-2-1:2009** 4.2.3.4 **ISO/IEC 27001:2013** A.13.2.1, A.13.2.2 **NIST SP 800-53 Rev. 4** AC-4, CA-3, CA-9, PL-8
		ID.AM-4: External information systems are catalogued	**CIS CSC** 12 **COBIT 5** APO02.02, APO10.04, DSS01.02 **ISO/IEC 27001:2013** A.11.2.6 **NIST SP 800-53 Rev. 4** AC-20, SA-9

To provide a starting point for Great Seneca's mapping of their Cybersecurity Framework and Privacy Framework Target Profiles to the NIST SP 800-53 security and privacy controls and capabilities, Great Seneca leveraged the mapping provided in the Cybersecurity Framework. An example of the Cybersecurity Framework's mapping is provided in Figure 5-1.

See Volume B's Appendices E and F for additional information on the security and privacy outcomes that this document's example solution supports. Appendices E and F provide a mapping of this document's example solution capabilities with the related Subcategories in the Cybersecurity Framework and Privacy Framework.

Volume B's Appendix E provides the Cybersecurity Framework Subcategory mappings, and Volume B's Appendix F provides the Privacy Framework Subcategory mappings.

5.2 Great Seneca Uses the Target Profiles to Help Prioritize Security and Privacy Control Deployment

Due to budget constraints, Great Seneca Accounting will focus on implementing the higher priority security and privacy controls that were identified in the organization's two Target Profiles first. The company will then focus on implementing lower priority controls when more funding becomes available. This is accomplished by Great Seneca Accounting comparing the prioritized Subcategories contained in Section 3's Table 3-1 and Table 3-2 with the outcomes that the example solution supports.

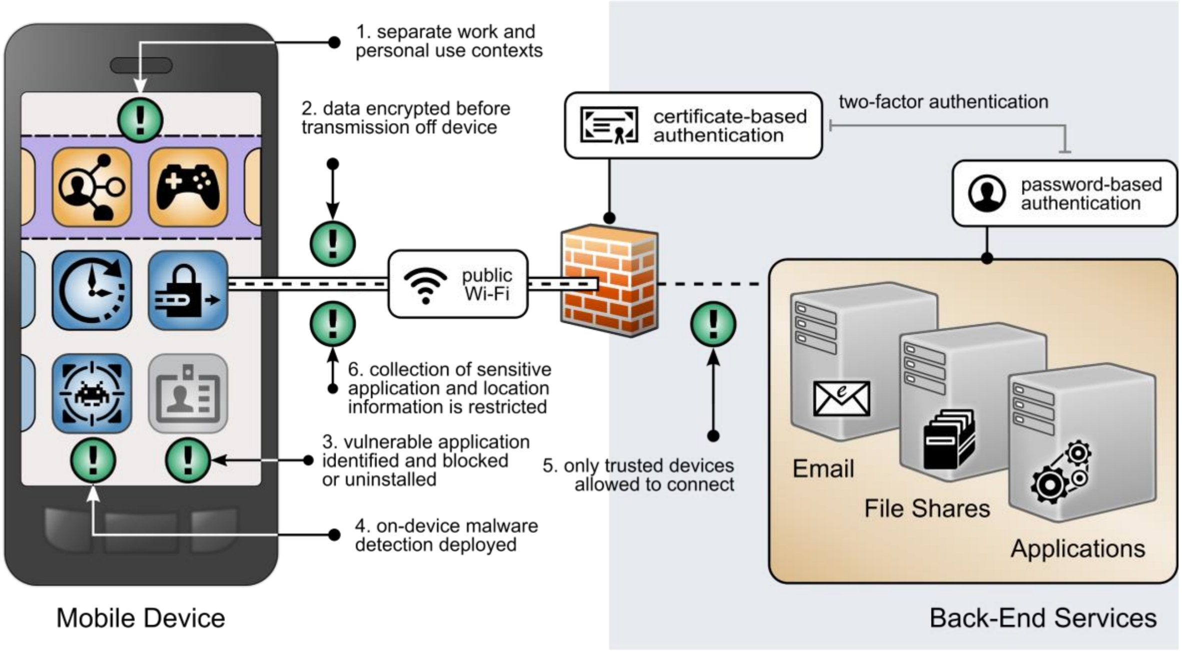
By comparing its Cybersecurity Framework Target Profile (Table 3-1) with the Subcategories supported by the example solution that are shown in Volume B's Appendix F, Great Seneca Accounting determines that the example solution will help it achieve its desired Cybersecurity Framework Target Profile outcomes.

Great Seneca performs a similar comparison of the Privacy Framework Target Profile in Table 3-2 with the Subcategories supported by the example solution that are shown in Volume B's Appendix H. From that comparison of the example solution's capabilities and Great Seneca's privacy-related objectives, Great Seneca determines that the example solution provided in this practice guide will help it to achieve the privacy-related outcomes that were identified in Table 3-2's Privacy Framework Target Profile.

5.2.1 Identifying and Tailoring the Baseline Controls

Now that Great Seneca Accounting understands how the Target Profiles will help prioritize the implementation of the high-level security and privacy objectives shown in Figure 5-2, they would like to look more closely at the NIST SP 800-53 controls it will initially implement in its new BYOD architecture. This will help Great Seneca identify the capabilities it will deploy first to meet its architecture needs.

Figure 5-2 Security and Privacy Objectives


1. separate work and personal use contexts
2. data encrypted before transmission off device
certificate-based authentication
two-factor authentication
password-based authentication
public Wi-Fi
6. collection of sensitive application and location information is restricted
3. vulnerable application identified and blocked or uninstalled
5. only trusted devices allowed to connect
4. on-device malware detection deployed
Email
File Shares
Applications
Mobile Device
Back-End Services

Volume B's Appendices E and F provide a list of the controls that the example solution implements, including how the controls in the example solution align to the Subcategories in both the Cybersecurity Framework and Privacy Framework. Because these controls only focus on the example solution, Great Seneca will need to implement additional controls that address the unique risks associated with its environment.

To help identify the specific controls Great Seneca Accounting will be implementing to support the new BYOD architecture, it uses the NIST RMF process to manage security and privacy risk for its systems. The organization decides to follow the RMF guidance in NIST SP 800-37 [7] to conduct security and privacy risk assessments as it continues preparing to design its new solution.

5.3 Great Seneca Accounting Performs a Risk Assessment

Great Seneca Accounting completes a security risk assessment by using the guidance in NIST SP 800-30 [8] and the Mobile Threat Catalogue [5] to identify cybersecurity threats to the organization. The company then uses the NIST PRAM [6] to perform a privacy risk assessment. Appendix F and Appendix G in this document describe these risk assessments in more detail. These risk assessments produce two significant conclusions:

1. Great Seneca Accounting finds similar cybersecurity threats in its environment and problematic data actions for employee privacy as those discussed in NIST SP 1800-22, validating that the controls discussed in the example solution are relevant to their environment.

2. The organization determines that it has a high-impact system, based on the impact guidance in NIST FIPS 200, *Minimum Security Requirements for Federal Information and Information Systems* [9], and needs to implement more controls beyond those identified in NIST SP 1800-22 and its Target Profiles to support the additional system components in its own solution (e.g., underlying OS, the data center where the equipment will reside).

5.4 Great Seneca Accounting Tailors Their Security and Privacy Control Baselines

As part of their review of NIST FIPS 200 [9], Great Seneca Accounting selects the high controls baseline in NIST SP 800-53 [10] for their BYOD architecture implementation. They then tailor the control baselines based on the needs identified through the priority Subcategories in its cybersecurity and privacy Target Profiles.

Control baselines are tailored to meet their organization’s needs. NIST SP 800-53 [10] defines tailoring as “The process by which security control baselines are modified by: (i) identifying and designating common controls; (ii) applying scoping considerations on the applicability and implementation of baseline controls; (iii) selecting compensating security controls; (iv) assigning specific values to organization-defined security control parameters; (v) supplementing baselines with additional security controls or control enhancements; and (vi) providing additional specification information for control implementation.”

While not discussed in this example scenario, Great Seneca also plans to make tailoring decisions based on other unique needs in its environment (e.g., legal, and regulatory requirements).

5.4.1 An Example Tailoring of the System and Communications Protection Security Control Family

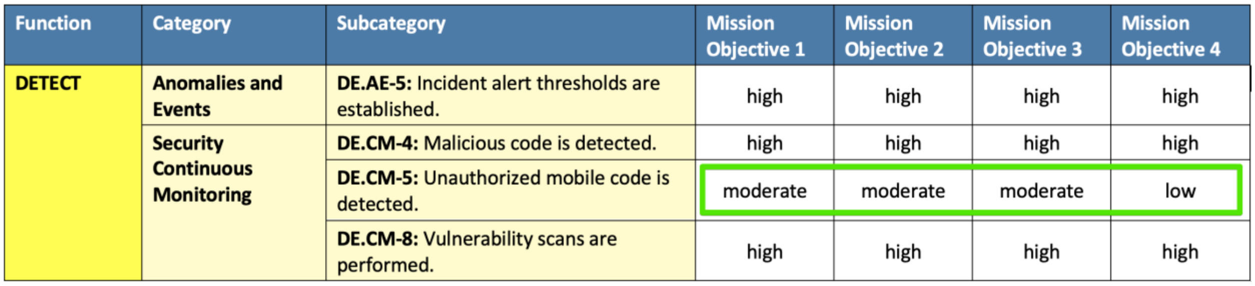
As Great Seneca Accounting reviews the System and Communications Protection (SC) control family in NIST SP 800-53 [10], it notes there are opportunities for tailoring.

For example, the NIST SP 800-53 baseline includes control enhancements, whereas the Cybersecurity Framework Informative References contain only base controls. Great Seneca Accounting decides to implement the enhancements that are applicable to a high-impact system for the SC controls they have selected.

Using this decision as a guide, Great Seneca Accounting also makes the following tailoring decisions related to the NIST SP 800-53 SC control family:

- NIST SP 800-53 provides recommendations regarding implementation priorities for controls. The implementation priorities of controls related to some Cybersecurity Framework Subcategories were adjusted to be higher or lower based on their alignment with Subcategory prioritization in the Target Profile.
- For example, the implementation priority for Cybersecurity Framework Subcategory DE.CM-5 was identified as having low or moderate importance for accomplishing all four BYOD-related Business/Mission Objectives. NIST SP 800-53 designates control SC-18, which supports the implementation of Cybersecurity Framework Subcategory DE.CM-5, as high priority. However, since Cybersecurity Framework Subcategory DE.CM-5 is moderate or low priority in this context, Great Seneca makes a tailoring decision to lower the implementation priority for the SC-18 NIST SP 800-53 control to moderate.
    - DE.CM-5’s importance designations for accomplishing the BYOD-Related Business/Mission Objectives are highlighted using a green box in Figure 5-3.

Figure 5-3 Subcategory DE.CM-5 Mapping to BYOD-Related Business/Mission Objectives

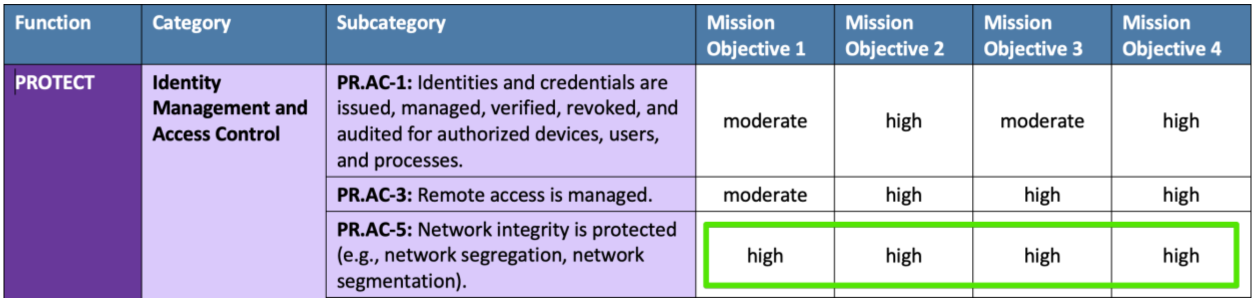


Function	Category	Subcategory	Mission Objective 1	Mission Objective 2	Mission Objective 3	Mission Objective 4
DETECT	**Anomalies and Events**	**DE.AE-5:** Incident alert thresholds are established.	high	high	high	high
	Security Continuous Monitoring	**DE.CM-4:** Malicious code is detected.	high	high	high	high
		DE.CM-5: Unauthorized mobile code is detected.	moderate	moderate	moderate	low
		DE.CM-8: Vulnerability scans are performed.	high	high	high	high

- Conversely, just as the implementation priority for the NIST SP 800-53 control that supports implementation of Subcategory DC.CM-5 was lowered based on the Target Profile, the implementation priority for the NIST SP 800-53 controls that support implementation of Cybersecurity Framework Subcategory PR.AC-5 was raised. This is because Subcategory PR.AC-5 was identified as having high importance for accomplishing all four BYOD-Related Business/Mission Objectives.
    - The NIST SP 800-53 SC Family security control related to the Cybersecurity Framework Subcategory PR.AC-5 is SC-7. NIST SP 800-53 prioritizes control SC-7 as low. Since control SC-7 supports the implementation of a Cybersecurity Framework Subcategory that is designated as high priority in Great Seneca’s Target Profile (Cybersecurity Framework Subcategory PR.AC-5), Great Seneca makes a tailoring decision to increase the priority of NIST SP 800-53 control SC-7 to high.
    - PR.AC-5’s high importance designation for accomplishing the BYOD-Related Business/Mission Objectives is highlighted using a green box in Figure 5-4. All

Subcategory prioritizations (including PR.AC-5's shown below) can be found in Table 3-1.

Figure 5-4 Subcategory PR.AC-5 Mapping to BYOD-Related Business/Mission Objectives



Function	Category	Subcategory	Mission Objective 1	Mission Objective 2	Mission Objective 3	Mission Objective 4
PROTECT	**Identity Management and Access Control**	**PR.AC-1:** Identities and credentials are issued, managed, verified, revoked, and audited for authorized devices, users, and processes.	moderate	high	moderate	high
		PR.AC-3: Remote access is managed.	moderate	high	high	high
		PR.AC-5: Network integrity is protected (e.g., network segregation, network segmentation).	high	high	high	high

Great Seneca Accounting follows the same approach for the privacy controls in NIST SP 800-53, using the Privacy Framework Target Profile and controls identified through its PRAM analysis (for more information reference Appendix G).

Great Seneca Accounting will evaluate the security controls as they come up for review under its continuous monitoring program to determine whether there are enhancements to the implemented security controls that can be made over time.

In addition to identifying controls to select, the priorities articulated in Target Profiles will also help Great Seneca Accounting decide how to align financial resources for control implementations (e.g., buying a tool to automate a control as opposed to relying on policy and procedures alone). The Target Profiles will help Great Seneca identify how robustly to reassess the efficacy of implemented controls before new system components or capabilities are enabled in a production environment. Great Seneca will also be able to use the Target Profiles to help evaluate the residual risks of the architecture in the context of Great Seneca Accounting's business/mission objectives, and the frequency and depth of continued monitoring requirements over time.

Note: All the tailoring decisions discussed above are for example purposes only. An organization's actual tailoring decision will be based upon their own unique business/mission objectives, risk assessment results, and organizational needs that may significantly vary from these examples.

Appendix A List of Acronyms

BYOD	Bring Your Own Device
CRADA	Cooperative Research and Development Agreement
EMM	Enterprise Mobility Management
FIPS	Federal Information Processing Standards
IBM	International Business Machines
ICS	Industrial Control System
iOS	iPhone Operating System
IP	Internet Protocol
ITL	Information Technology Laboratory
MDM	Mobile Device Management
NCCoE	National Cybersecurity Center of Excellence
NICE	National Initiative for Cybersecurity Education
NIST	National Institute of Standards and Technology
NISTIR	NIST Interagency Report
OS	Operating System
PII	Personally Identifiable Information
PIN	Personal Identification Number
PRAM	Privacy Risk Assessment Methodology
RMF	Risk Management Framework
SC	Systems and Communications Protection
SMS	Short Message Service
SP	Special Publication
URL	Uniform Resource Locator
VPN	Virtual Private Network

Appendix B Glossary

Access Management Access Management is the set of practices that enables only those permitted the ability to perform an action on a particular resource. The three most common Access Management services you encounter every day perhaps without realizing it are: Policy Administration, Authentication, and Authorization [11].

Availability Ensure that users can access resources through remote access whenever needed [12].

Bring Your Own Device (BYOD) A non-organization-controlled telework client device [12].

Confidentiality Ensure that remote access communications and stored user data cannot be read by unauthorized parties [12].

Data Actions System operations that process PII [13].

Disassociability Enabling the processing of PII or events without association to individuals or devices beyond the operational requirements of the system [13].

Eavesdropping An attack in which an attacker listens passively to the authentication protocol to capture information which can be used in a subsequent active attack to masquerade as the claimant [14] (definition located under eavesdropping attack).

Firewall Firewalls are devices or programs that control the flow of network traffic between networks or hosts that employ differing security postures [15].

Integrity Detect any intentional or unintentional changes to remote access communications that occur in transit [12].

Manageability Providing the capability for granular administration of PII including alteration, deletion, and selective disclosure [13].

Mobile Device A portable computing device that: (i) has a small form factor such that it can easily be carried by a single individual; (ii) is designed to operate without a physical connection (e.g., wirelessly transmit or receive information); (iii) possesses local, non-removable or removable data storage; and (iv) includes a self-contained power source. Mobile devices may also include voice communication capabilities, on-board sensors that allow the devices to capture information, and/or built-in features for synchronizing local data with remote locations. Examples include smart phones, tablets, and E-readers [10].

Personally Identifiable Information (PII) Any information about an individual maintained by an agency, including any information that can be used to distinguish or trace an individual‘s identity, such as name, Social Security number, date and place of birth, mother‘s maiden name, or biometric records; and any other information that is linked or linkable to an individual, such as medical, educational, financial, and employment information [16] (adapted from Government Accountability Office Report 08-536).

Problematic Data Action A data action that could cause an adverse effect for individuals [2].

Threat Any circumstance or event with the potential to adversely impact organizational operations (including mission, functions, image, or reputation), organizational assets, individuals, other organizations, or the Nation through an information system via unauthorized access, destruction, disclosure, or modification of information, and/or denial of service [8].

Vulnerability Weakness in an information system, system security procedures, internal controls, or implementation that could be exploited by a threat source [8].

Appendix C References

[1] National Institute of Standards and Technology (NIST). NIST *Framework for Improving Critical Infrastructure Cybersecurity,* Version 1.1 (Cybersecurity Framework). Apr. 16, 2018. [Online]. Available: https://www.nist.gov/cyberframework.

[2] NIST. *NIST Privacy Framework: A Tool for Improving Privacy Through Enterprise Risk Management,* Version 1.0 (Privacy Framework). Jan. 16, 2020. [Online]. Available: https://www.nist.gov/privacy-framework.

[3] W. Newhouse et al., *National Initiative for Cybersecurity Education (NICE) Cybersecurity Workforce Framework,* NIST Special Publication (SP) 800-181 rev. 1, NIST, Gaithersburg, Md., Nov. 2020. Available: https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.800-181r1.pdf.

[4] NIST. Risk Management Framework (RMF) Overview. [Online]. Available: https://csrc.nist.gov/projects/risk-management/risk-management-framework-(rmf)-overview.

[5] NIST. Mobile Threat Catalogue. [Online]. Available: https://pages.nist.gov/mobile-threat-catalogue/.

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[7] Joint Task Force, *Risk Management Framework for Information Systems and Organizations: A System Life Cycle Approach for Security and Privacy,* NIST SP 800-37 Revision 2, NIST, Gaithersburg, Md., Dec. 2018. Available: https://csrc.nist.gov/publications/detail/sp/800-37/rev-2/final.

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[12] M. Souppaya and K. Scarfone, *Guide to Enterprise Telework, Remote Access, and Bring Your Own Device (BYOD) Security,* NIST SP 800-46 Revision 2, NIST, Gaithersburg, Md., July 2016. Available: https://csrc.nist.gov/publications/detail/sp/800-46/rev-2/final.

[13] S. Brooks et al., *An Introduction to Privacy Engineering and Risk Management in Federal Systems,* NIST Interagency or Internal Report 8062, Gaithersburg, Md., Jan. 2017. Available: https://nvlpubs.nist.gov/nistpubs/ir/2017/NIST.IR.8062.pdf.

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[16] E. McCallister et al., *Guide to Protecting the Confidentiality of Personally Identifiable Information (PII),* NIST SP 800-122, NIST, Gaithersburg, Md., Apr. 2010. Available: https://nvlpubs.nist.gov/nistpubs/Legacy/SP/nistspecialpublication800-122.pdf.

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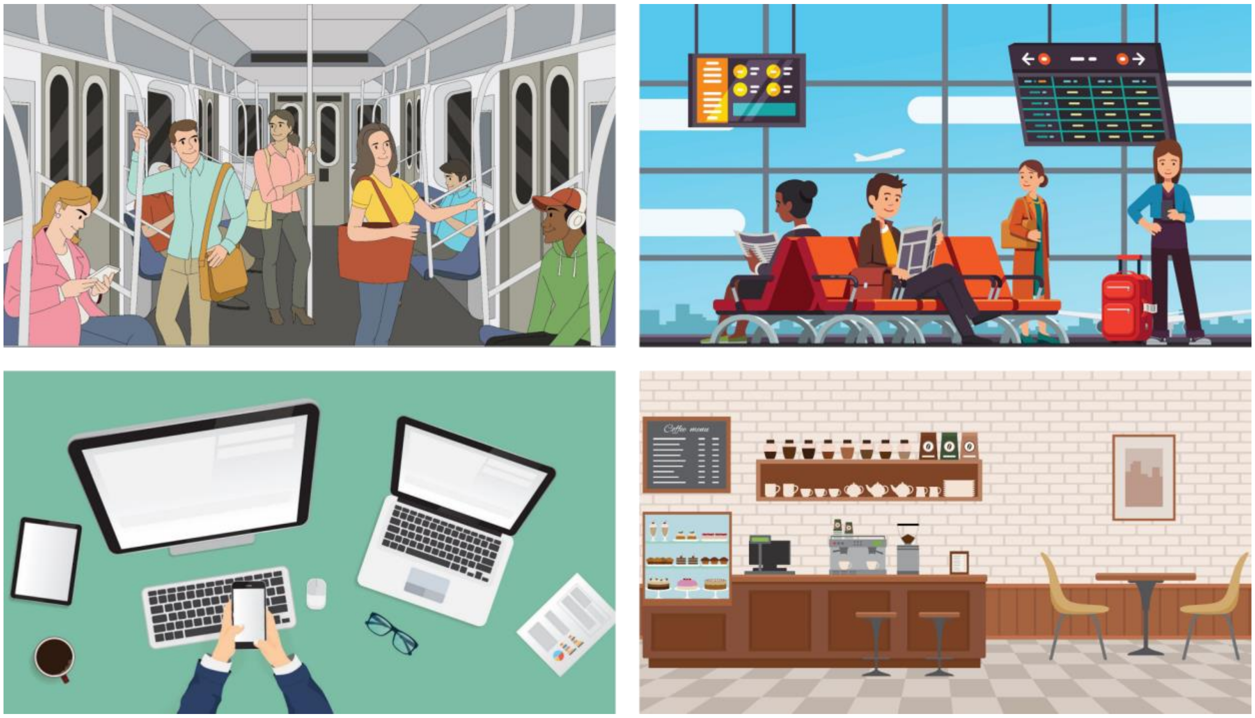
Appendix D A Note Regarding Great Seneca Accounting

A description of a fictional organization, Great Seneca Accounting, was included in the National Institute of Standards and Technology (NIST) Special Publication (SP) 1800-22 Mobile Device Security: Bring Your Own Device (BYOD) Practice Guide.

This fictional organization demonstrates how a small-to-medium sized, regional organization implemented the example solution in this practice guide to assess and protect their mobile-device-specific security and privacy needs. It illustrates how organizations with office-based, remote-working, and travelling personnel can be supported in their use of personally owned devices that enable their employees to work while on the road, in the office, at customer locations, and at home.

Figure D-1 Great Seneca Accounting's Work Environments



Appendix E How Great Seneca Accounting Applied NIST Risk Management Methodologies

This practice guide contains an example scenario about a fictional organization called Great Seneca Accounting. The example scenario shows how to deploy a Bring Your Own Device (BYOD) solution to be in alignment with an organization's security and privacy capabilities and objectives.

The example scenario uses National Institute of Standards and Technology (NIST) standards, guidance, and tools. It is provided in the *Example Scenario: Putting Guidance into Practice* supplement of this practice guide.

This appendix provides a brief description of some of the key NIST tools referenced in the example scenario supplement of this practice guide.

Section E.1 below provides descriptions of the risk frameworks and tools, along with a high-level discussion of how Great Seneca Accounting applied each framework or tool in the example scenario. Section E.2 describes how the *NIST Cybersecurity Framework* and *NIST Privacy Framework* can be used to establish or improve cybersecurity and privacy programs.

E.1 Overview of Risk Frameworks and Tools That Great Seneca Used

Great Seneca used NIST frameworks and tools to identify common security and privacy risks related to BYOD solutions and to guide approaches to how they were addressed in the architecture described in Volume B Section 4. Great Seneca used additional standards and guidance, listed in Appendix D of Volume B, to complement these frameworks and tools when designing their BYOD architecture.

Both the Cybersecurity Framework and Privacy Framework include the concept of framework profiles, which identify the organization's existing activities (contained in a Current Profile) and articulate the desired outcomes that support its mission and business objectives within its risk tolerance (that are contained in the Target Profile). When considered together, Current and Target Profiles are useful tools for identifying gaps and for strategic planning.

E.1.1 Overview of the NIST Cybersecurity Framework

Description: The NIST Cybersecurity Framework "is voluntary guidance, based on existing standards, guidelines, and practices for organizations to better manage and reduce cybersecurity risk. In addition to helping organizations manage and reduce risks, it was designed to foster risk and cybersecurity management communications amongst both internal and external organizational stakeholders." [17]

Application: This guide refers to two of the main components of the Cybersecurity Framework: The Framework Core and the Framework Profiles. As described in Section 2.1 of the Cybersecurity Framework, the Framework Core provides a set of activities to achieve specific cybersecurity outcomes, and reference examples of guidance to achieve those outcomes (e.g., controls found in NIST Special Publication [SP] 800-53). Section 2.3 of the Cybersecurity Framework identifies Framework Profiles as the alignment of the Functions, Categories, and Subcategories (i.e., the Framework Core) with the business requirements, risk tolerance, and resources of the organization.

The Great Seneca Accounting example scenario assumed that the organization used the Cybersecurity Framework Core and Framework Profiles, specifically the Target Profiles, to align cybersecurity outcomes and activities with its overall business/mission objectives for the organization. In the case of Great Seneca Accounting, its Cybersecurity Framework Target Profile helps program owners and system architects understand business and mission-driven priorities and the types of cybersecurity capabilities needed to achieve them. Great Seneca Accounting also used the NIST Interagency Report (NISTIR) 8170, *The Cybersecurity Framework, Implementation Guidance for Federal Agencies* [18], for guidance in using the NIST Cybersecurity Framework.

E.1.2 Overview of the NIST Privacy Framework

Description: The *NIST Privacy Framework* is a voluntary enterprise risk management tool intended to help organizations identify and manage privacy risk and build beneficial systems, products, and services while protecting individuals' privacy. It follows the structure of the NIST Cybersecurity Framework to facilitate using both frameworks together [2].

Application: This guide refers to two of the main components of the Privacy Framework: The Framework Core and Framework Profiles. As described in Section 2.1 of the Privacy Framework, the Framework Core provides an increasingly granular set of activities and outcomes that enable dialog about managing privacy risk as well as resources to achieve those outcomes (e.g., guidance in NISTIR 8062, *An Introduction to Privacy Engineering and Risk Management in Federal Systems* [13]). Section 2.2 of the Privacy Framework identifies Framework Profiles as the selection of specific Functions, Categories, and Subcategories from the core that an organization has prioritized to help it manage privacy risk.

Great Seneca Accounting used the Privacy Framework as a strategic planning tool for its privacy program as well as its system, product, and service teams. The Great Seneca Accounting example scenario assumed that the organization used the Privacy Framework Core and Framework Profiles, specifically Target Profiles, to align privacy outcomes and activities with its overall business/mission objectives for the organization. Its Privacy Framework Target Profile helped program owners and system architects to understand business and mission-driven priorities and the types of privacy capabilities needed to achieve them.

E.1.3 Overview of the NIST Risk Management Framework

Description: The NIST Risk Management Framework (RMF) "provides a process that integrates security and risk management activities into the system development life cycle. The risk-based approach to security control selection and specification considers effectiveness, efficiency, and constraints due to applicable laws, directives, Executive Orders, policies, standards, or regulations" [19]. Two of the key documents that describe the RMF are NIST SP 800-37 Revision 2, *Risk Management Framework for Information Systems and Organizations: A System Life Cycle Approach for Security and Privacy;* and NIST SP 800-30, *Guide for Conducting Risk Assessments*.

Application: The RMF has seven steps: Prepare, Categorize, Select, Implement, Assess, Authorize, and Monitor. These steps provide a method for organizations to characterize the risk posture of their information and systems and identify controls that are commensurate with the risks in the system's environment. They also support organizations with selecting beneficial implementation and assessment approaches, reasoning through the process to understand residual risks, and monitoring the efficacy of implemented controls over time.

The Great Seneca Accounting example solution touches on the risk assessment activities conducted under the *Prepare* step, identifying the overall risk level of the BYOD system architecture in the *Categorize* step, and, consistent with example approach 8 in NISTIR 8170, reasoning through the controls that are necessary in the *Select* step. The influence of the priorities provided in Great Seneca Accounting's Cybersecurity Framework Target Profile is also briefly mentioned regarding making decisions for how to apply controls during *Implement* (e.g., policy versus tools), how robustly to verify and validate controls during *Assess* (e.g., document review versus "hands on the keyboard" system testing), and the degree of evaluation required over time as part of the *Monitor* step.

E.1.4 Overview of the NIST Privacy Risk Assessment Methodology

Description: The NIST Privacy Risk Assessment Methodology (PRAM) is a tool for analyzing, assessing, and prioritizing privacy risks to help organizations determine how to respond and select appropriate solutions. A blank version of the PRAM is available for download on NIST's website.

Application: The PRAM uses the privacy risk model and privacy engineering objectives described in NISTIR 8062 to analyze for potential problematic data actions. Data actions are any system operations that process data. Processing can include collection, retention, logging, analysis, generation, transformation or merging, disclosure, transfer, and disposal of data. A problematic data action is one that could cause an adverse effect, or problem, for individuals. The occurrence or potential occurrence of problematic data actions is a privacy event. While there is a growing body of technical privacy controls, including those found in NIST SP 800-53, applying the PRAM may result in identifying controls that are not yet available in common standards. This makes it an especially useful tool for managing risks that may otherwise go unaddressed.

The Great Seneca Accounting example solution assumed that a PRAM was used to identify problematic data actions and mitigating controls for employees. The controls in this build include some technical controls, such as controls that can be handled by security capabilities, as well as policy and procedure-level controls that need to be implemented outside yet are supported by the system.

E.2 Using Frameworks to Establish or Improve Cybersecurity and Privacy Programs

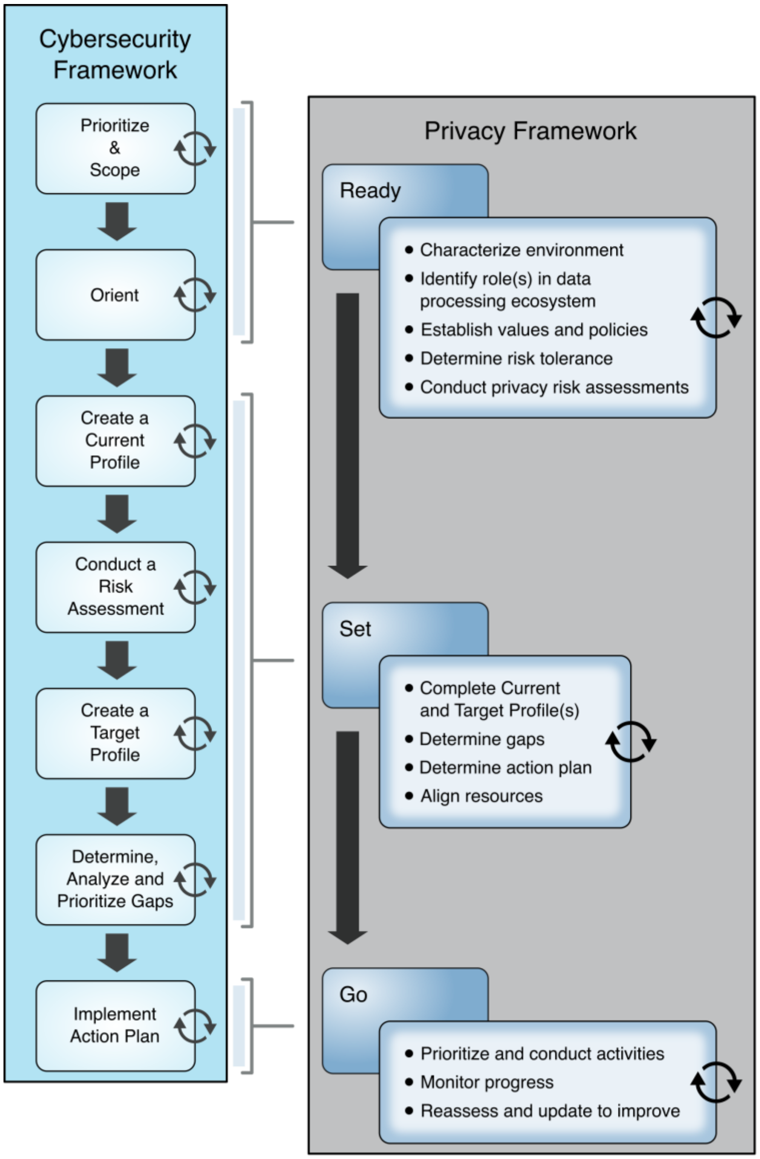
While their presentation differs, the NIST Cybersecurity Framework and NIST Privacy Framework also both provide complementary guidance for establishing and improving cybersecurity and privacy programs. The NIST Cybersecurity Framework's process for establishing or improving programs provides seven steps that an organization could use iteratively and as necessary throughout the program's life cycle to continually improve its cybersecurity posture:

- Step 1: Prioritize and scope the organization's mission.
- Step 2: Orient its cybersecurity program activities to focus efforts on applicable areas.
- Step 3: Create a current profile of what security areas it currently supports.
- Step 4: Conduct a risk assessment.

- Step 5: Create a Target Profile for the security areas that the organization would like to improve in the future.
- Step 6: Determine, analyze, and prioritize cybersecurity gaps.
- Step 7: Implement an action plan to close those gaps.

The *NIST Privacy Framework* includes the same types of activities for establishing and improving privacy programs, described in a three-stage Ready, Set, Go model. Figure E-1 below shows a comparison of these two approaches, demonstrating their close alignment.

Figure E-1 Comparing Framework Processes to Establish or Improve Programs


Cybersecurity Framework
Prioritize & Scope
Orient
Create a Current Profile
Conduct a Risk Assessment
Create a Target Profile
Determine, Analyze and Prioritize Gaps
Implement Action Plan
Privacy Framework
Ready
• Characterize environment
• Identify role(s) in data processing ecosystem
• Establish values and policies
• Determine risk tolerance
• Conduct privacy risk assessments
Set
• Complete Current and Target Profile(s)
• Determine gaps
• Determine action plan
• Align resources
Go
• Prioritize and conduct activities
• Monitor progress
• Reassess and update to improve

Both approaches are equally effective. Regardless of the approach selected, an organization begins with orienting around its business/mission objectives and high-level organizational priorities and carry out the remaining activities in a way that makes the most sense for the organization. The organization repeats these steps as necessary throughout the program's life cycle to continually improve its risk posture.

Appendix F How Great Seneca Accounting Used the NIST Risk Management Framework

This practice guide contains an example scenario about a fictional organization called Great Seneca Accounting. The example scenario shows how to deploy a Bring Your Own Device (BYOD) solution to be in alignment with an organization's security and privacy capabilities and objectives.

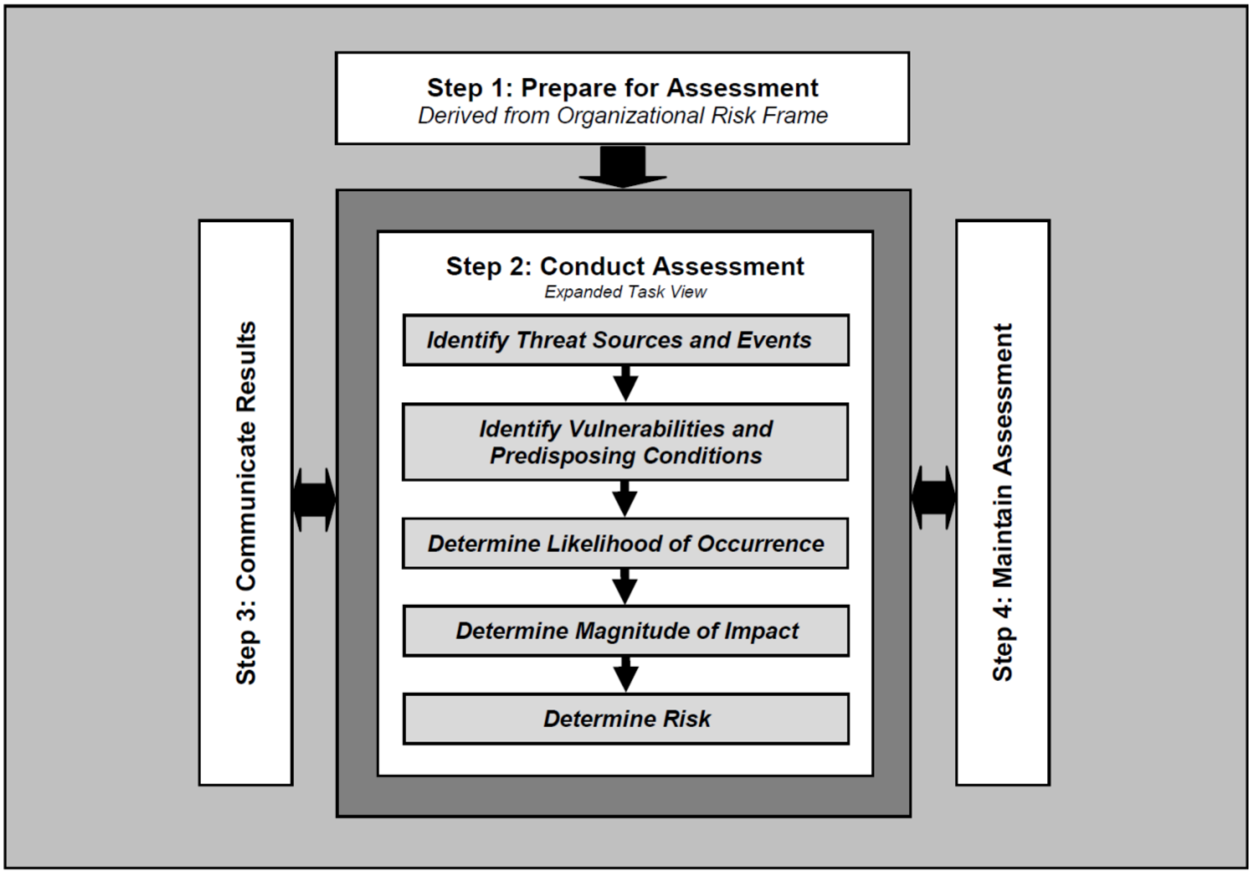
The example scenario uses National Institute of Standards and Technology (NIST) standards, guidance, and tools. It is provided in the *Example Scenario: Putting Guidance into Practice* supplement of this practice guide.

In the example scenario supplement of this practice guide, Great Seneca Accounting decided to use the NIST Cybersecurity Framework, the *NIST Privacy Framework,* and the NIST Risk Management Framework to help improve its mobile device architecture. The following material provides information about how Great Seneca Accounting used the NIST Risk Management Framework to improve its BYOD deployment.

F.1 Understanding the Risk Assessment Process

This section provides information on the risk assessment process employed to improve the mobile security posture of Great Seneca Accounting. Typically, a risk assessment based on NIST SP 800-30 Revision 1 follows a four-step process as shown in Figure F-1: prepare for assessment, conduct assessment, communicate results, and maintain assessment.

Figure F-1 Risk Assessment Process


Step 1: Prepare for Assessment
Derived from Organizational Risk Frame
Step 2: Conduct Assessment
Expanded Task View
Identify Threat Sources and Events
Identify Vulnerabilities and Predisposing Conditions
Determine Likelihood of Occurrence
Determine Magnitude of Impact
Determine Risk
Step 3: Communicate Results
Step 4: Maintain Assessment

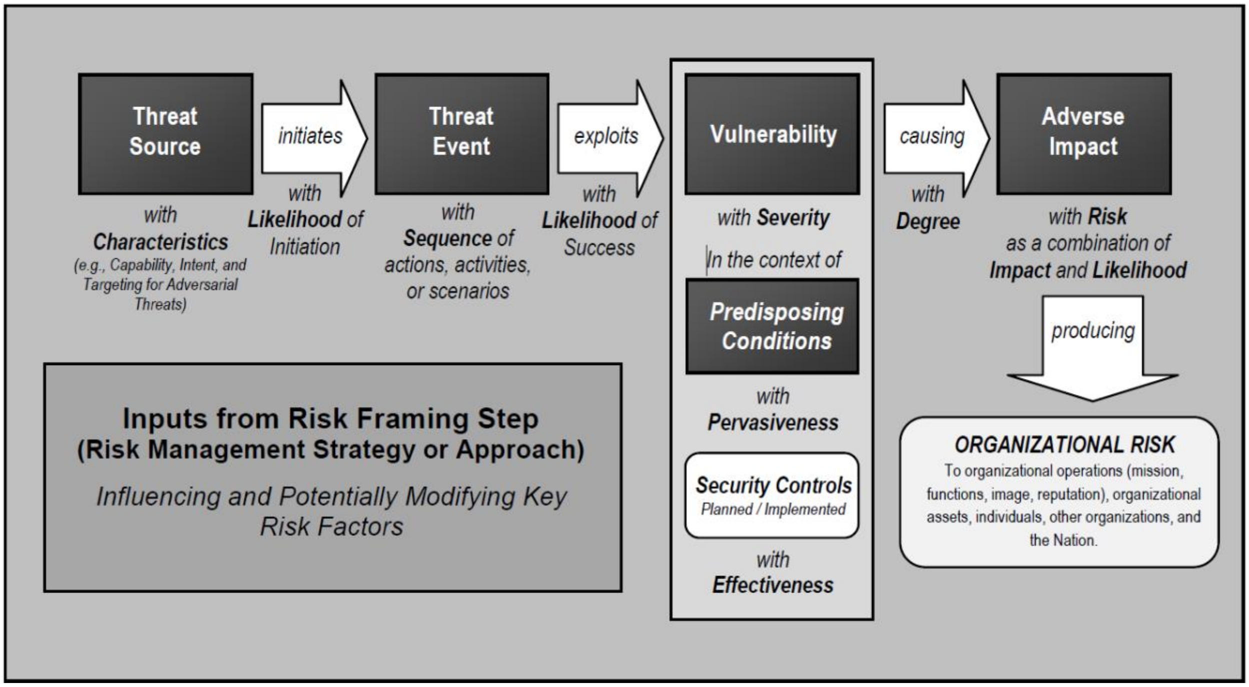
F.2 Risk Assessment of Great Seneca Accounting's BYOD Program

This risk assessment is scoped to Great Seneca Accounting's mobile deployment, which includes the mobile devices used to access Great Seneca Accounting's enterprise resources, along with any information technology components used to manage or provide services to those mobile devices.

Risk assessment assumptions and constraints were developed by using a NIST SP 800-30 Revision 1 generic risk model as shown in Figure F-2 to identify the following components of the risk assessment:

- threat sources
- threat events
- vulnerabilities
- predisposing conditions
- security controls
- adverse impacts
- organizational risks

Figure F-2 NIST SP 800-30 Generic Risk Model


Threat Source
initiates
with Likelihood of Initiation
Threat Event
exploits
with Likelihood of Success
Vulnerability
causing
with Degree
Adverse Impact
with Characteristics
(e.g., Capability, Intent, and Targeting for Adversarial Threats)
with Sequence of actions, activities, or scenarios
with Severity
In the context of
Predisposing Conditions
with Pervasiveness
Security Controls
Planned / Implemented
with Effectiveness
with Risk as a combination of Impact and Likelihood
producing
ORGANIZATIONAL RISK
To organizational operations (mission, functions, image, reputation), organizational assets, individuals, other organizations, and the Nation.
Inputs from Risk Framing Step
(Risk Management Strategy or Approach)
Influencing and Potentially Modifying Key Risk Factors

F.3 Development of Threat Event Descriptions

Great Seneca Accounting developed threat event tables based on NIST SP 800-30 Revision 1 and used those to help analyze the sources of mobile threats. Using this process, Great Seneca Accounting leadership identified the following potential mobile device threat events that are described in the following subsections.

A note about selection of the threat events:

This practice guide's example solution helps protect organizations from the threat events shown in Table F-1. A mapping of these threat events to the NIST Mobile Threat Catalogue is provided in Table F-2.

Table F-1 Great Seneca Accounting's BYOD Deployment Threats

Great Seneca Accounting's Threat Event Identification Number	Threat Event Description
TE-1	privacy-intrusive applications
TE-2	account credential theft through phishing
TE-3	malicious applications
TE-4	outdated phones
TE-5	camera and microphone remote access
TE-6	sensitive data transmissions
TE-7	brute-force attacks to unlock a phone

Great Seneca Accounting’s Threat Event Identification Number	Threat Event Description
TE-8	protection against weak password practices
TE-9	protection against unmanaged devices
TE-10	protection against lost or stolen data
TE-11	protecting data from being inadvertently backed up to a cloud service
TE-12	protection against sharing personal identification number (PIN) or password

Great Seneca Accounting’s 12 threat events and their mapping to the NIST Mobile Threat Catalogue [5] are shown in Table F-2.

Table F-2 Threat Event Mapping to the Mobile Threat Catalogue

Great Seneca Accounting’s Threat Event Identification Number	NIST Mobile Threat Catalogue Threat ID
TE-1	APP-2, APP-12
TE-2	AUT-9
TE-3	APP-2, APP-5, APP-31, APP-40, APP-32, AUT-10
TE-4	APP-4, APP-26, STA-0, STA-9, STA-16
TE-5	APP-32, APP-36
TE-6	APP-0, CEL-18, LPN-2
TE-7	AUT-2, AUT-4
TE-8	APP-9, AUT-0
TE-9	EMM-5
TE-10	PHY-0
TE-11	EMM-9
TE-12	AUT-0, AUT-2, AUT-4, AUT-5

F.4 Great Seneca Accounting’s Leadership and Technical Teams Discuss BYOD’s Potential Threats to Their Organization

Great Seneca Accounting’s leadership team wanted to understand real-world examples of each threat event and what the risk was for each. Great Seneca Accounting’s leadership and technical teams then discussed those possible threats that BYOD could introduce to their organization.

The analysis performed by Great Seneca Accounting’s technical team included analyzing the likelihood of each threat, the level of impact, and the threat level that the BYOD deployment would pose. The following are leadership’s questions and the technical team’s responses regarding BYOD threats during that discussion using real-world examples. One goal of the example solution contained within this practice guide is to mitigate the impact of these threat events. Reference Table 5-1 in Volume B for a listing of the technology that addresses each of the following threat events.

F.4.1 Threat Event 1

What happens if an employee installs risky applications?

A mobile application can attempt to collect and exfiltrate any information to which it has been granted access. This includes any information generated during use of the application (e.g., user input), user-granted permissions (e.g., contacts, calendar, call logs, photos), and general device data available to any application (e.g., International Mobile Equipment Identity, device make and model, serial number). Further, if a malicious application exploits a vulnerability in other applications, the operating system (OS), or device firmware to achieve privilege escalation, it may gain unauthorized access to any data stored on or otherwise accessible through the device.

Risk assessment analysis:

Overall likelihood: very high

Justification: Employees have access to download any application at any time. If an employee requires an application that provides a desired function, the employee can download that application from any available source (trusted or untrusted) that provides a desired function. If an application performs an employee's desired function, the employee may download an application from an untrusted source and/or disregard granted privacy permissions.

Level of impact: high

Justification: Employees may download an application from an untrusted source and/or disregard granted privacy permissions. This poses a threat for sensitive corporate data, as some applications may include features that could access corporate data, unbeknownst to the user.

BYOD-specific threat: In a BYOD scenario, users are still able to download and install applications at their leisure. This capability allows users to unintentionally side-load or install a malicious application that may harm the device or the enterprise information on the device.

F.4.2 Threat Event 2

Can account information be stolen through phishing?

Malicious actors may create fraudulent websites that mimic the appearance and behavior of legitimate ones and entice users to authenticate to them by distributing phishing messages over short message service (SMS) or email. Effective social engineering techniques such as impersonating an authority figure or creating a sense of urgency may compel users to forgo scrutinizing the message and proceed to authenticate to the fraudulent website; it then captures and stores the user's credentials before (usually) forwarding them to the legitimate website to allay suspicion.

Risk assessment analysis:

Overall likelihood: very high

Justification: Phishing campaigns are a very common threat that occurs almost every day.

Level of impact: high

Justification: A successful phishing campaign could provide the malicious actor with corporate credentials, allowing access to sensitive corporate data, or personal credentials that could lead to compromise of corporate data or infrastructure via other means.

BYOD-specific threat: The device-level controls applied to personal devices do not inhibit a user's activities. This allows the user to access personal/work messages and emails on their device that could be susceptible to phishing attempts. If the proper controls are not applied to a user's enterprise messages and email, successful phishing attempts could allow an attacker unauthorized access to enterprise data.

F.4.3 Threat Event 3

How much risk do malicious applications pose to Great Seneca Accounting?

Malicious actors may send users SMS or email messages that contain a uniform resource locator (URL) where a malicious application is hosted. Generally, such messages are crafted using social engineering techniques designed to dissuade recipients from scrutinizing the nature of the message, thereby increasing the likelihood that they access the URL using their mobile device. If they do, it will attempt to download and install the application. Effective use of social engineering by the attacker will further compel an otherwise suspicious user to grant any trust required by the developer and all permissions requested by the application. Granting the former facilitates installation of other malicious applications by the same developer, and granting the latter increases the potential for the application to do direct harm.

Risk assessment analysis:

Overall likelihood: high

Justification: Installation of malicious applications via URLs is less common than other phishing attempts. The process for side-loading applications requires much more user input and consideration (e.g., trusting the developer certificate) than standard phishing, which solely requests a username and password. A user may proceed through sideloading an application to acquire a desired capability from an application.

Level of impact: high

Justification: Once a user installs a malicious side-loaded application, an adversary could gain full access to a mobile device and, therefore, access to corporate data and credentials, without the user's knowledge.

BYOD-specific threat: Like threat event 1, BYOD deployments may have fewer restrictions to avoid preventing the user from performing desired personal functions. This increases the attack surface for malicious actors to take advantage.

F.4.4 Threat Event 4

What happens when outdated phones access Great Seneca Accounting's network?

When malware successfully exploits a code execution vulnerability in the mobile OS or device drivers, the delivered code generally executes with elevated privileges and issues commands in the context of the root user or the OS kernel. This may be enough for some malicious actors to accomplish their goal, but those that are advanced will usually attempt to install additional malicious tools and to establish a persistent presence. If successful, the attacker will be able to launch further attacks against the user, the device, or any other systems to which the device connects. As a result, any data stored on, generated by, or accessible to the device at that time or in the future may be compromised.

Risk assessment analysis:

Overall likelihood: high

Justification: Many public vulnerabilities specific to mobile devices have been seen over the years. In these, users can jailbreak iOS devices and root Android devices to download third-party applications and apply unique settings/configurations that the device would not typically be able to apply/access.

Level of impact: high

Justification: Exploiting a vulnerability allows circumventing security controls and modifying protected device data that should not be modified. Jailbroken and rooted devices exploit kernel vulnerabilities and allow third-party applications/services root access that can also be used to bypass security controls that are built in or applied to a mobile device.

BYOD-specific threat: As with any device, personal devices are susceptible to device exploitation if not properly used or updated.

F.4.5 Threat Event 5

Can Great Seneca Accounting stop someone from turning on a camera or microphone?

Malicious actors with access (authorized or unauthorized) to device sensors (microphone, camera, gyroscope, Global Positioning System receiver, and radios) can use them to conduct surveillance. It may be directed at the user, as when tracking the device location, or it may be applied more generally, as when recording any nearby sounds. Captured sensor data may be immediately useful to a malicious actor, such as a recording of an executive meeting. Alternatively, the attacker may analyze the data in isolation or in combination with other data to yield sensitive information. For example, a malicious actor can use audio recordings of on-device or proximate activity to probabilistically determine user inputs to touchscreens and keyboards, essentially turning the device into a remote keylogger.

Risk assessment analysis:

Overall likelihood: very high

Justification: This has been seen on public application stores, with applications allegedly being used for data-collection. As mentioned in threat event 1, unbeknownst to the user, a downloaded application may be granted privacy-intrusive permissions that allow access to device sensors.

Level of impact: high

Justification: When the sensors are being misused, the user is typically not alerted. This allows collection of sensitive enterprise data, such as location, without knowledge of the user.

BYOD-specific threat: Applications commonly request access to these sensors. In a BYOD deployment, the enterprise does not have control over what personal applications the user installs on their device. These personal applications may access sensors on the device and eavesdrop on a user's enterprise-related activities (e.g., calls and meetings).

F.4.6 Threat Event 6

Is sensitive information protected when the data travels between the employee's mobile device and Great Seneca Accounting's network?

Malicious actors can readily eavesdrop on communication over unencrypted, wireless networks such as public Wi-Fi access points, which coffee shops and hotels commonly provide. While a device is connected to such a network, a malicious actor could gain unauthorized access to any data sent or received by the device for any session that has not already been protected by encryption at either the transport or application layers. Even if the transmitted data were encrypted, an attacker would be privy to the domains, internet protocol (IP) addresses, and services (as indicated by port numbers) to which the device connects; an attacker could use such information in future watering hole or person-in-the-middle attacks against the device user.

Additionally, visibility into network-layer traffic enables a malicious actor to conduct side-channel attacks against the network's encrypted messages, which can still result in a loss of confidentiality. Further, eavesdropping on unencrypted messages during a handshake to establish an encrypted session with another host or endpoint may facilitate attacks that ultimately compromise the security of the session.

Risk assessment analysis:

Overall likelihood: moderate

Justification: Unlike installation of an application, installations of enterprise mobility management (EMM)/mobile device management (MDM), network, virtual private network (VPN) profiles, and certificates require additional effort and understanding from the user to properly implement.

Level of impact: very high

Justification: If a malicious actor can install malicious configuration profiles or certificates, they would be able to perform actions such as decrypting network traffic and possibly even control the device.

BYOD-specific threat: Like threat event 2, personal devices may not have the benefit of an always-on device-wide VPN. This leaves application communications at the discretion of the developer.

F.4.7 Threat Event 7

Is Great Seneca Accounting's data protected from brute-force PIN attacks?

A malicious actor may be able to obtain a user's device unlock code by direct observation, side-channel attacks, or brute-force attacks. Both the first and second can be attempted with at least proximity to the device; only the third technique requires physical access. However, applications with access to any peripherals that detect sound or motion (microphone, gyroscope, or accelerometer) can attempt side-channel attacks that infer the unlock code by detecting taps and swipes to the screen. Once the device unlock code has been obtained, a malicious actor with physical access to the device will gain immediate access to any data or functionality not already protected by additional access control mechanisms. Additionally, if the user employs the device unlock code as a credential to any other systems, the malicious actor may further gain unauthorized access to those systems.

Risk assessment analysis:

Overall likelihood: moderate

Justification: Unlike shoulder-surfing to observe a user's passcode, brute-force attacks are not as common or successful due to the built-in deterrent mechanisms. These mechanisms include exponential back-off/lockout period and device wipes after a certain number of failed unlock attempts.

Level of impact: very high

Justification: If a malicious actor can successfully unlock a device without the user's permission, they could have full control over the user's corporate account and, thus, gain unauthorized access to corporate data.

BYOD-specific threat: Because BYODs are prone to travel (e.g., vacations, restaurants, and other nonwork locations), the risk that the device's passcode is obtained increases due to the heightened exposure to threats in different environments.

F.4.8 Threat Event 8

Can Great Seneca Accounting protect its data from poor application development practices?

If a malicious actor gains unauthorized access to a mobile device, they also have access to the data and applications on that mobile device. The mobile device may contain an organization's in-house applications that a malicious actor can subsequently use to gain access to sensitive data or backend services. This could result from weaknesses or vulnerabilities present in the authentication or credential storage mechanisms implemented within an in-house application.

Risk assessment analysis:

Overall likelihood: moderate

Justification: Often applications include hardcoded credentials for the default password of the admin account. Default passwords are readily available online. The user might not change these passwords to allow access and eliminate the need to remember a password.

Level of impact: high

Justification: Successful extraction of the credentials allows an attacker to gain unauthorized access to enterprise data.

BYOD-specific threat: The risk of hardcoded credentials residing in an application on the device is the same for any mobile device deployment scenario.

F.4.9 Threat Event 9

Can unmanaged devices connect to Great Seneca Accounting?

An employee who accesses enterprise resources from an unmanaged mobile device may expose the enterprise to vulnerabilities that may compromise enterprise data. Unmanaged devices do not benefit from any security mechanisms deployed by the organization such as mobile threat defense, mobile threat intelligence, application vetting services, and mobile security policies. These unmanaged devices limit an organization's visibility into the state of a mobile device, including if a malicious actor compromises the device. Therefore, users who violate security policies to gain unauthorized access to enterprise resources from such devices risk providing malicious actors with access to sensitive organizational data, services, and systems.

Risk assessment analysis:

Overall likelihood: very high

Justification: This may occur accidentally when an employee attempts to access their email or other corporate resources.

Level of impact: high

Justification: Unmanaged devices pose a sizable security risk because the enterprise has no visibility into their security or risk postures of the mobile devices. Due to this lack of visibility, a compromised device may allow an attacker to attempt to exfiltrate sensitive enterprise data.

BYOD-specific threat: The risk of an unmanaged mobile device accessing the enterprise is the same for any mobile deployment scenario.

F.4.10 Threat Event 10

Can Great Seneca Accounting protect its data when a phone is lost or stolen?

Due to the nature of the small form factor of mobile devices, they can be misplaced or stolen. A malicious actor who gains physical custody of a device with inadequate security controls may be able to gain unauthorized access to sensitive data or resources accessible to the device.

Risk assessment analysis:

Overall likelihood: very high

Justification: Mobile devices are small and can be misplaced. Enterprise devices may be lost or stolen at the same frequency as personally owned devices.

Level of impact: high

Justification: Similar to threat event 9, if a malicious actor can gain access to the device, they could access sensitive corporate data.

BYOD-specific threat: Due to the heightened mobility of BYODs, they are more prone to being accidentally lost or stolen.

F.4.11 Threat Event 11

Can data be protected from unauthorized cloud services?

If employees violate data management policies by using unmanaged services to store sensitive organizational data, the data will be placed outside organizational control, where the organization can no longer protect its confidentiality, integrity, or availability. Malicious actors who compromise the unauthorized service account or any system hosting that account may gain unauthorized access to the data.

Further, storage of sensitive data in an unmanaged service may subject the user or the organization to prosecution for violation of any applicable laws (e.g., exportation of encryption) and may complicate efforts by the organization to achieve remediation or recovery from any future losses, such as those resulting from public disclosure of trade secrets.

Risk assessment analysis:

Overall likelihood: high

Justification: This could occur either intentionally or accidentally (e.g., taking a screenshot and having pictures backed up to an unmanaged cloud service).

Level of impact: high

Justification: Storage in unmanaged services presents a risk to the confidentiality and availability of corporate data because the corporation would no longer control it.

BYOD-specific threat: In a BYOD deployment, employees are more likely to have some backup or automated cloud storage solution configured on their device, which may lead to unintentional backup of enterprise data.

F.4.12 Threat Event 12

Can Great Seneca Accounting protect its data from PIN or password sharing?

Many individuals choose to share the PIN or password to unlock their personal device with family members. This creates a scenario where a non-employee can access the device, the work applications, and, therefore, the work data.

Risk assessment analysis:

Overall likelihood: moderate

Justification: Even though employees are conditioned almost constantly to protect their work passwords, personal device PINs and passwords are not always protected with that same level of security. Anytime individuals share a password or PIN, there is an increased risk that it might be exposed or compromised.

Level of impact: very high

Justification: If a malicious actor can bypass a device lock and gain access to the device, they can potentially access sensitive corporate data.

BYOD-specific threat: The passcode of an individual's personal mobile device is more likely to be shared among family and/or friends to provide access to applications (e.g., games). Although sharing passcodes may be convenient for personal reasons, this increases the risk of an unauthorized individual gaining access to enterprise data through a personal device.

F.5 Identification of Vulnerabilities and Predisposing Conditions

In this section we identify vulnerabilities and predisposing conditions that increase the likelihood that identified threat events will result in adverse impacts for Great Seneca Accounting. We list each vulnerability or predisposing condition in Table F-3, along with the corresponding threat events and ratings of threat pervasiveness. More details on threat event ratings can be found in Appendix Section F-3.

Table F-3 Identify Vulnerabilities and Predisposing Conditions

Vulnerability ID	Vulnerability or Predisposing Condition	Resulting Threat Events	Pervasiveness
VULN-1	Email and other enterprise resources can be accessed from anywhere, and only username/password authentication is required.	TE-2, TE-9, TE-10	very high
VULN-2	Public Wi-Fi networks are regularly used by employees for remote connectivity from their mobile devices.	TE-6	very high
VULN-3	No EMM/MDM deployment exists to enforce and monitor compliance with security-relevant policies on mobile devices.	TE-1, TE-3, TE-4, TE-5, TE-6, TE-7, TE-8, TE-9, TE-10, TE-11, TE-12	very high

F.6 Summary of Risk Assessment Findings

Table F-4 summarizes the risk assessment findings. More detail about the methodology used to rate overall likelihood, level of impact, and risk is in the Appendix Section F.3.

Table F-4 Summary of Risk Assessment Findings

Threat Event	Vulnerabilities, Predisposing Conditions	Overall Likelihood	Level of Impact	Risk
TE-1: unauthorized access to sensitive information via a malicious or privacy-intrusive application	VULN-3	very high	high	high
TE-2: theft of credentials through an SMS or email phishing campaign	VULN-1	very high	high	high
TE-3: malicious applications installed via URLs in SMS or email messages	VULN-3	high	high	high
TE-4: confidentiality and integrity loss due to exploitation of known vulnerability in the OS or firmware	VULN-3	high	high	high
TE-5: violation of privacy via misuse of device sensors	VULN-3	very high	high	high
TE-6: loss of confidentiality of sensitive information via eavesdropping on unencrypted device communications	VULN-2, VULN-3	moderate	very high	high
TE-7: compromise of device integrity via observed, inferred, or brute-forced device unlock code	VULN-3	moderate	very high	high
TE-8: unauthorized access to backend services via authentication or credential storage vulnerabilities in internally developed applications	VULN-3	moderate	high	high
TE-9: unauthorized access of enterprise resources from an unmanaged and potentially compromised device	VULN-1, VULN-3	very high	high	high
TE-10: loss of organizational data due to a lost or stolen device	VULN-1, VULN-3	very high	high	high
TE-11: loss of confidentiality of organizational data due to its	VULN-3	high	high	high

Threat Event	Vulnerabilities, Predisposing Conditions	Overall Likelihood	Level of Impact	Risk
unauthorized storage in non-organizationally managed services				
TE-12: unauthorized access to work applications via bypassed lock screen	VULN-3	moderate	very high	high

Note 1: Risk is stated in qualitative terms based on the scale in Table I-2 of Appendix I in NIST SP 800-30 Revision 1 [8].

Note 2: The risk rating is derived from both the overall likelihood and level of impact using Table I-2 of Appendix I in NIST SP 800-30 Revision 1 [8]. Because these are modified interval scales, the combined overall risk ratings from Table I-2 do not always reflect a strict mathematical average of these two variables. The table above demonstrates this where levels of moderate weigh more heavily than other ratings.

Note 3: Ratings of risk relate to the probability and level of adverse effect on organizational operations, organizational assets, individuals, other organizations, or the nation. Per NIST SP 800-30 Revision 1, adverse effects (and the associated risks) range from negligible (i.e., very low risk), limited (i.e., low), serious (i.e., moderate), severe or catastrophic (i.e., high), to multiple severe or catastrophic (i.e., very high).

Appendix G How Great Seneca Accounting Used the NIST Privacy Risk Assessment Methodology

This practice guide contains an example scenario about a fictional organization called Great Seneca Accounting. The example scenario shows how to deploy a Bring Your Own Device (BYOD) solution to be in alignment with an organization's security and privacy capabilities and objectives.

The example scenario uses National Institute of Standards and Technology (NIST) standards, guidance, and tools.

In the example scenario, Great Seneca Accounting decided to use the NIST Privacy Risk Assessment Methodology (PRAM) to conduct a privacy risk assessment and help improve the company's mobile device architecture. The PRAM helps an organization analyze and communicate about how it conducted its data processing to achieve business/mission objectives.

At Great Seneca Accounting, the PRAM helped elucidate how enabling employees to use their personal devices for work-related functions can present privacy concerns for individuals. The PRAM also supports the risk assessment task in the Prepare step of the NIST Risk Management Framework as discussed in Appendix Section E.1. The privacy events that were identified are provided below, along with potential mitigations.

G.1 Privacy Risk 1: Wiping Activities on the User's Device May Inadvertently Delete the User's Personal Data

Privacy Risk: Removal of personal data from a device.

Potential Problem for Individuals: In a BYOD environment, employees are likely to use their devices for both personal and work-related purposes; thus, in a system that features robust security information and event management capable of wiping a device entirely, there could be an issue of employees losing personal data and employees may not even expect that this is a possibility. A hypothetical example is that a Great Seneca Accounting employee stores personal photos on their mobile device within the work container, but these photos are lost when their device is selectively wiped after anomalous activity is detected. This privacy risk is related to the Unwarranted Restriction Problematic Data Action.

Mitigations:

- **Block access to corporate resources by removing the device from mobile device management (MDM) control instead of wiping devices.**

  As an alternative to wiping data entirely, Section F.4.3, Threat Event 3, discusses blocking a device from accessing enterprise resources until an application is removed. Temporarily blocking access ensures that an individual will not lose personal data through a full wipe of a device. This approach may help bring the system's capabilities into alignment with employees' expectations about what can happen to their devices, especially if they are unaware that devices can be wiped by administrators, providing greater predictability in the system.

  Related mitigation: If this mitigation approach is taken, the organization may also wish to consider establishing and communicating these remediation processes to employees. It is important to have a clear remediation process in place to help employees regain access to resources on their devices at the appropriate time. It is also important to clearly convey this remediation process to employees. A remediation process provides greater manageability in the system supporting employees' ability to access resources. If well-communicated to employees, this also provides greater predictability as employees will know the steps to regain access.

- **Enable only selective wiping of corporate resources on the device.**

  An alternative mitigation option for wiping device data is to limit what can be wiped. International Business Machines' (IBM's) MaaS360 can be configured to selectively wipe instead of performing a full factory reset. When configured this way, a wipe preserves employees' personal configurations, applications, and data while removing only the corporate configurations, applications, and data. However, on Android, a selective wipe will preserve restrictions imposed via policy on the device. To fully remove MDM control, the Remove Work Profile action must be used.

- **Advise employees to appropriately store and back up the personal data maintained on devices.**

  If device wiping remains an option for administrators, encourage employees to perform regular backups of their personal data to ensure it remains accessible in case of a wipe and to not store personal data within the work container on their device.

- **Restrict staff access to system capabilities that permit removing device access or performing wipes.**

  Limit staff with the ability to perform a wipe to only those with that responsibility by using role-based access controls. This can help decrease the chances of accidentally removing employee data or blocking access to resources.

G.2 Privacy Risk 2: Organizational Collection of Device Data May Subject Users to Feeling or Being Surveilled

Privacy Risk: The assessed infrastructure offers Great Seneca Accounting and its employees a number of security capabilities, including reliance on comprehensive monitoring capabilities, as noted in Volume B Section 4, Architecture. Multiple parties could collect and analyze a significant amount of data relating to employees, their devices, and their activities.

Potential Problem for Individuals: Employees may not be aware that the organization has the ability to monitor their interactions with the system and may not want this monitoring to occur or understand the way these interactions are being analyzed or used. If there is awareness, employees may feel compelled to allow for monitoring to occur for the ability to use their mobile devices for corporate access. Collection and analysis of information might enable Great Seneca Accounting or other parties to craft a narrative about an employee based on the employee's interactions with the system, which could lead to a power imbalance between Great Seneca Accounting and the employee and loss of trust in the employer or loss of autonomy if the employee discovers monitoring that they did not anticipate or expect. This privacy risk is related to the Surveillance Problematic Data Action.

Mitigations:

- **Restrict staff access to system capabilities that permit reviewing data about employees and their devices.**

This may be achieved using role-based access controls. Access can be limited to any dashboard in the system containing data about employees and their devices but is most sensitive for the MaaS360 dashboard, which is the hub for data about employees, their devices, and threats. Minimizing access to sensitive information can enhance disassociability for employees using the system.

- **Limit or disable collection of specific data elements.**

  Conduct a system-specific privacy risk assessment to determine what elements can be limited. In the configuration of MaaS360, location services and application inventory collection may be disabled. iOS devices can be configured in MaaS360 to collect only an inventory of applications that have been installed through the corporate application store instead of all applications installed on the device.

  While these administrative configurations may help provide disassociability in the system, there are also some opportunities for employees to limit the data collected. Employees can choose to disable location services in their device OS to prevent collection of location data. MaaS360 can also be configured to provide employees with the ability to manage their own devices through the IBM User Portal.

  Each of these controls contributes to limiting the number of attributes regarding employees and their devices that is collected, which can impede administrators' ability to associate information with specific individuals.

- **Dispose of personally identifiable information (PII).**

  Disposing of PII after an appropriate retention period can help reduce the risk of entities building profiles of individuals. Disposal can also help bring the system's data processing into alignment with employees' expectations and reduce the security risk associated with storing a large volume of PII. Disposal may be particularly important for certain parties in the system that collect a larger volume of data or more sensitive data. Disposal may be achieved using a combination of policy and technical controls. Parties in the system may identify what happens to data, when, and how frequently.

G.3 Privacy Risk 3: Data Collection and Transmission Between Integrated Security Products May Expose User Data

Privacy Risk: The infrastructure involves several parties that serve different purposes supporting Great Seneca Accounting's security objectives. As a result, device usage information could flow across various parties.

Potential Problems for Individuals: This transmission among a variety of different parties could be confusing for employees who might not know who has access to information about them. If administrators and co-workers know which colleagues are conducting activity on their device that triggers security alerts, employees could be embarrassed by its disclosure. Information being revealed and associated with specific employees could also lead to stigmatization and even impact Great Seneca Accounting upper management in its decision-making regarding the employee. Further, clear text transmissions could leave information vulnerable to attackers and, therefore, to an unanticipated release of employee information. This privacy risk is related to the Unanticipated Revelation Problematic Data Action.

Mitigations:

- **De-identify personal and device data when that data is not necessary to meet processing objectives.**

  De-identifying data helps decrease the chances that a third party is aggregating information pertaining to one individual. While de-identification can help reduce privacy risk, there are residual risks of re-identification.

- **Encrypt data transmitted between parties.**

  Encryption reduces the risk of compromise of information transmitted between parties. MaaS360 encrypts all communications over the internet with Transport Layer Security.

- **Limit or disable access to data.**

  Conduct a system-specific privacy risk assessment to determine how access to data can be limited. Using access controls to limit staff access to compliance information, especially when associated with individuals, can be important in preventing association of specific events with specific employees.

- **Limit or disable collection of specific data elements.**

  Conduct a system-specific privacy risk assessment to determine what elements can be limited. MaaS360 can be configured to limit collection of application and location data. Further, instead of collecting a list of all the applications installed on the device, MaaS360 can collect only the list of those applications that were installed through the corporate application store (called "managed applications"). This would prevent insight into the employees' applications that employees downloaded for personal use. Zimperium provides privacy policies that can be configured to collect or not collect data items when certain events occur.

- **Use contracts to limit third-party data processing.**

  Establish contractual policies to limit data processing by third parties to only the processing that facilitates delivery of security services and to no data processing beyond those explicit purposes.

G.4 Mitigations Applicable Across Various Privacy Risks

Several mitigations benefit employees in all three privacy risks identified in the privacy risk assessment. The following training and support mitigations can help Great Seneca Accounting appropriately inform employees about the system and its data processing.

Mitigations:

- **Train employees about the system, parties involved, data processing, and actions that administrators can take.**

  Training sessions can also highlight any privacy-preserving techniques used, such as for disclosures to third parties. Training should include confirmation from employees that they understand the actions that administrators can take on their devices and their consequences—whether this is blocking access or wiping data. Employees may also be informed of data retention periods and when their data will be deleted. This can be more effective than sharing a privacy notice, which research has shown, individuals are unlikely to read. Still, MaaS360 should also be configured to provide employees with access to a visual privacy policy, which describes what device information is collected and why, as well as what actions administrators can take on the device. This enables employees to make better informed decisions while using their devices, and it enhances predictability.

- **Provide ongoing notifications or reminders about system activity.**

  This can be achieved using notifications to help directly link administrative actions on devices to relevant threats and to also help employees understand why an action is being taken. MaaS360 also notifies employees when changes are made to the privacy policy or MDM profile settings. These notifications can help increase system predictability by setting employee expectations appropriately regarding the way the system processes data and the resulting actions.

- **Provide a support point of contact.**

  By providing employees with a point of contact in the organization who can respond to inquiries and concerns regarding the system, employees can better understand how the system processes their data, which enhances predictability.

G.5 Privacy References for Example Solution Technologies

Additional privacy information on the example solution's technologies appears below.

Table G-1 Privacy References for the Example Solution Technologies

Commercially Available Product	Mobile Security Technology	Product Privacy Information Location
IBM MaaS360 Mobile Device Management (SaaS) Version 10.73 IBM MaaS360 Mobile Device Management Agent Version 3.91.5 (iOS), 6.60 (Android) IBM MaaS360 Cloud Extender / Cloud Extender Modules	mobile device management	https://www.ibm.com/docs/en/search/privacy https://www.ibm.com/support/pages/node/571227 https://www.ibm.com/support/knowledgecenter/SS8H2S/com.ibm.mc.doc/pag_source/tasks/pag_sec_privacy.htm https://www.ibm.com/support/pages/maas360-data-privacy-information
Kryptowire Cloud Service	application vetting	https://www.kryptowire.com
Palo Alto Networks PA-VM-100 Version 9.0.1 Palo Alto Networks GlobalProtect VPN Client Version 5.0.6-14 (iOS), 5.0.2-6 (Android)	virtual private network (VPN) and firewall/ filtering	https://docs.paloaltonetworks.com/globalprotect/9-1/globalprotect-admin/host-information/about-host-information/what-data-does-the-globalprotect-app-collect-on-each-operating-system https://www.paloaltonetworks.com/resources/datasheets/url-filtering-privacy-datasheet

Commercially Available Product	Mobile Security Technology	Product Privacy Information Location
Qualcomm (Version is mobile device dependent)	trusted execution environment	https://www.qualcomm.com/media/documents/files/guard-your-data-with-the-qualcomm-snapdragon-mobile-platform.pdf
Zimperium Defense Suite Zimperium Console Version vGA-4.23.1 Zimperium zIPS Agent Version 4.9.2 (Android and iOS)	mobile threat defense	https://www.zimperium.com/mobile-app-protection