NIST SPECIAL PUBLICATION 1800-17

Multifactor Authentication for E-Commerce

Risk-Based, FIDO Universal Second Factor Implementations for Purchasers

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

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The first draft of this publication is available free of charge from https://www.nccoe.nist.gov/sites/default/files/library/sp1800/cr-mfa-nist-sp1800-17.pdf

NIST
National Institute of
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NCCoE
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McLean, Virginia

July 2019

U.S. Department of Commerce
Wilbur Ross, Secretary

National Institute of Standards and Technology
Walter Copan, NIST Director and Undersecretary of Commerce for Standards and Technology

NIST SPECIAL PUBLICATION 1800-17A

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Volume A:
Executive Summary

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Executive Summary

- Retailers can implement multifactor authentication (MFA) to reduce the opportunity for a customer's online account to be used for fraudulent purchases.
- MFA is a security enhancement that allows a user to present several pieces of evidence when logging into an account. This evidence falls into three categories: something you know (e.g., password), something you have (e.g., smart card), and something you are (e.g., fingerprint). The presented evidence must come from at least two different categories to enhance security.
- The National Cybersecurity Center of Excellence (NCCoE) at the National Institute of Standards and Technology (NIST) built a laboratory environment to explore MFA options available to retailers today, and documented the example implementations that retailers can consider for their environment.
- This NIST Cybersecurity Practice Guide demonstrates how online retailers can implement MFA to help reduce electronic commerce (e-commerce) fraud.

CHALLENGE

Smart chip credit cards and terminals work together to protect in-store payments. The in-store security advances were introduced in 2015, and those have pushed malicious actors who possess stolen credit card data to perform payment card fraud online. This guide describes implementing stronger user-authentication techniques to reduce the risk of e-commerce fraud. The guide documents a system in which risk determines when to trigger MFA challenges to existing customers.

SOLUTION

This project's example implementations analyze risk to prompt returning purchasers with additional authentication requests when risk elements are exceeded during the online shopping session. Risk elements may include contextual data related to the returning purchaser and the current shopping transaction. The example implementations will prompt a returning purchaser to present another distinct authentication factor—something the purchaser has—in addition to the username and password, when automated risk assessments indicate an increased likelihood of fraudulent activity.

The MFA capabilities for e-commerce used in this guide are based upon the Fast IDentity Online (FIDO) Universal Second Factor (U2F) authentication specification. The methods chosen in this guide provide examples that can be adopted by retailers to help reduce e-commerce fraud.

The NCCoE sought existing technologies that provide the following capabilities:

- integrate MFA into online shopping systems
- mitigate potential exposure to online fraud
- integrate into a variety of retail-information technology architectures
- provide authentication options to retailers:
  - capabilities that assess and mitigate a retailer's shopping-transaction risk factors

    - alert retailer staff to potential threats, and adjust authentication mechanisms as needed

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

BENEFITS

The NCCoE's practice guide to *Multifactor Authentication for E-Commerce* can help your organization:

- reduce online fraudulent purchases, including those resulting from the use of credential stuffing to take over accounts
- show customers that the organization is committed to its security
- protect your e-commerce systems
    - provide greater situational awareness
    - avoid system-administrator-account takeover through phishing
- implement the example solutions by using our step-by-step guide

SHARE YOUR FEEDBACK

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

To provide comments or to learn more by arranging a demonstration of this example implementation, contact the NCCoE at consumer-nccoe@nist.gov.

TECHNOLOGY PARTNERS/COLLABORATORS

Organizations participating in this project submitted their capabilities in response to an open call in the Federal Register for all sources of relevant security capabilities from academia and industry (vendors and integrators). The following respondents with relevant capabilities or product components (identified as "Technology Partners/Collaborators" herein) signed a Cooperative Research and Development Agreement (CRADA) to collaborate with NIST in a consortium to build this example solution.

RSA splunk> STRONGKEY TOKENONE yubico

Certain commercial entities, equipment, products, or materials may be identified by name or company logo or other insignia in order to acknowledge their participation in this collaboration or to describe an experimental procedure or concept adequately. Such identification is not intended to imply special status or relationship with NIST or recommendation or endorsement by NIST or NCCoE; neither is it intended to imply that the entities, equipment, products, or materials are necessarily the best available for the purpose.

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

LEARN MORE

Visit https://www.nccoe.nist.gov
nccoe@nist.gov
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NIST SPECIAL PUBLICATION 1800-17B

Multifactor Authentication for E-Commerce

Risk-Based, FIDO Universal Second Factor Implementations for Purchasers

Volume B:
Approach, Architecture, and Security Characteristics

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DISCLAIMER

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National Institute of Standards and Technology Special Publication 1800-17B, Natl. Inst. Stand. Technol. Spec. Publ. 1800-17B, 52 pages, (July 2019), CODEN: NSPUE2

FEEDBACK

As a public-private partnership, we are always seeking feedback on our practice guides. We are particularly interested in seeing how businesses apply NCCoE reference designs in the real world. If you have implemented the reference design, or have questions about applying it in your environment, please email us at consumer-nccoe@nist.gov.

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NATIONAL CYBERSECURITY CENTER OF EXCELLENCE

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

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

NIST CYBERSECURITY PRACTICE GUIDES

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

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

ABSTRACT

As retailers in the United States have adopted chip-and-signature and chip-and-PIN (personal identification number) point-of-sale (POS) security measures, there have been increases in fraudulent online card-not-present electronic commerce (e-commerce) transactions. The risk of increased fraudulent online shopping became more widely known following the adoption of chip-and-PIN technology that increased security at the POS in Europe.

The NCCoE at NIST built a laboratory environment to explore methods to implement multifactor authentication (MFA) for online retail environments for the consumer and the e-commerce platform

administrator. The NCCoE also implemented logging and reporting to display authentication-related system activity.

This NIST Cybersecurity Practice Guide demonstrates to online retailers that it is possible to implement open standards-based technologies to enable Universal Second Factor (U2F) authentication at the time of purchase when risk thresholds are exceeded.

The example implementations outlined in this guide encourage online retailers to adopt effective MFA implementations by using standard components and custom applications that are composed of open-source and commercially available components.

KEYWORDS

electronic commerce (e-commerce) security; internet shopping security; multifactor authentication (MFA)

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Lorrayne Auld	The MITRE Corporation
Lura Danley	The MITRE Corporation

Name	Organization
Sallie Edwards	The MITRE Corporation
Charles Jones, Jr.	The MITRE Corporation
Joshua Klosterman	The MITRE Corporation
Jay Vora	The MITRE Corporation
Mary Yang	The MITRE Corporation

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 these example implementations. We worked with:

Technology Partner/Collaborator	Build Involvement
RSA	RSA Adaptive Authentication (Cloud) Version 13.1
Splunk	• Splunk Enterprise Version 6.6.1 • Splunk DB Connect Version 3.1.2 • Splunk Universal Forwarder Version 7.0.1
StrongKey	• StrongKey CryptoEngine Version 2.0 Open Source Fast IDentity Online (FIDO) U2F server • MagentoFIDO (magfido) 1st Edition Module
TokenOne	TokenOne cloud-based Authentication Version 2.8.5
Yubico	Yubico YubiKey NEO Security Key

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1 Summary

Smart chip credit cards and terminals work together to protect in-store payments. The in-store security advances were introduced in 2015 [1], and those have pushed malicious actors who possess stolen credit card data to perform payment card fraud online. This guide describes implementing stronger user-authentication techniques to reduce the risk of electronic commerce (e-commerce) fraud. The guide documents a system in which risk determines when to trigger multifactor authentication (MFA) challenges to existing customers.

1.1 Challenge

Volume A of this publication described why the National Cybersecurity Center of Excellence (NCCoE) took on a retail cybersecurity challenge as a project. Here in Volume B, we shift to the challenge of building two example implementations that show online retailers some options to deploy strong authentication solutions that use open and scalable standards offering enhanced authentication security. Such modern authentication systems support the following security characteristics [2]:

- a foundation built on public key cryptography
- protection from authentication replay attacks
- options for determining when MFA should be requested
- auditing and system activity logging and display

To build the example implementations, the project collaborators reached consensus on architectures that demonstrate standards-based authentication solutions. We chose to enable the use of MFA by adding a distinct second authentication factor, recognizing that doing so can help lower the online retailer's exposure to fraudulent purchases by increasing the likelihood that the purchaser who is offering the second authentication factor is a legitimate returning customer. Continuing the focus on enhanced authentication provided an incentive for the architecture to address how system owners and administrators could use MFA when performing e-commerce platform administration activities. Additionally, situational awareness dashboards were created to visually demonstrate e-commerce authentication activity.

1.2 Implementations

The modern authentication security characteristic goals and the capabilities of the collaborators matched the open and scalable standards of the Fast IDentity Online (FIDO) Alliance [3], [4]. This project demonstrates how to prompt online purchasers to provide a second authentication factor—something they have—when risk thresholds are exceeded during an online shopping session.

The returning purchaser in our example implementations is an online shopper who has established login account credentials and has registered for MFA with a retailer. The example implementations describe and document architectures to enable a returning purchaser to complete a purchase when risk thresholds are exceeded during the transaction. The second authentication factor for returning purchasers in these example implementations is a FIDO Universal Second Factor (U2F) authenticator [3], [4]. The purchaser's U2F authenticator is unique, known to the retailer, and possessed only by the returning purchaser. The U2F used in the example implementations is a FIDO Certified product, compliant with the FIDO U2F specifications [5].

In the NCCoE example implementations, U2F authentication challenges are triggered when the total cost of the shopping-cart transaction exceeds predefined retailer thresholds. The two example implementations are referred to as the *cost threshold* and *risk engine* example implementations.

The *cost threshold* example implementation requests additional authentication when a dollar amount is exceeded. Because fraudulent activity may still occur in purchases below this threshold, the *risk engine* example implementation can examine many system and external elements related to a shopping session. In this example implementation, a shopping-cart-amount threshold input trigger was chosen to demonstrate that the *risk engine* can communicate the need for a second authentication factor. Additionally, returning-purchaser account-lockout techniques are demonstrated that can limit credential stuffing and takeovers of customer accounts.

In both the *cost threshold* and *risk engine* example implementations, MFA of the retailer's e-commerce platform system administrator is also included with onetime pad authentication principles. This increases the security of the overall system by prompting the system administrators to use their non-short message service, smartphone-based MFA capability before making changes to the e-commerce platform.

Both the returning purchaser and system administrator MFA capabilities require action to be taken by the user to prove the user's possession of an authentication factor that only the legitimate user should possess. The returning purchaser is asked to confirm their presence by pressing a contact on a registered U2F device, and the administrator is prompted to enter a code provided from a unique mobile-device application as part of the authentication process.

The example implementations also describe and document situational awareness within the overall system that tracks the important processes, including logging system functions such as authentication activity, and providing dashboard displays of this information [6] for system owners.

1.2.1 Standards and Guidance

In developing our example implementations, we were influenced by standards and guidance from the following sources, which can also provide an organization with relevant standards and best practices:

- FIDO U2F authentication specification [3], [4]

- International Organization for Standardization/International Electrotechnical Commission (ISO/IEC) 27001:2013, *Information Technology—Security Techniques—Information Security Management Systems—Requirements* [7]
- National Institute of Standards and Technology (NIST) Cybersecurity Framework [8]
- NIST Special Publication (SP) 800-30 Revision 1, *Guide for Conducting Risk Assessments* [9]
- NIST SP 800-37 Revision 1, *Guide for Applying the Risk Management Framework to Federal Information Systems: A Security Life Cycle Approach* [10]
- NIST SP 800-53 Revision 4, *Security and Privacy Controls for Federal Information Systems and Organizations* [11]
- NIST SP 800-63-3, *Digital Identity Guidelines* [12]
- NIST SP 800-63A, *Digital Identity Guidelines, Enrollment and Identity Proofing* [13]
- NIST SP 800-63B, *Digital Identity Guidelines, Authentication and Lifecycle Management* [14]
- NIST SP 800-63C, *Digital Identity Guidelines, Federation and Assertions* [15]
- NIST SP 800-73-4, *Interfaces for Personal Identity Verification* (3 Parts) [16]
- NIST SP 800-160 Volume 1, *Systems Security Engineering: Considerations for a Multidisciplinary Approach in the Engineering of Trustworthy Secure Systems* [17]
- NIST SP 800-181, *National Initiative for Cybersecurity Education (NICE) Cybersecurity Workforce Framework* [18]
- Payment Card Industry (PCI) Data Security Standard, *Requirements and Security Assessment Procedures*, Version 3.2, April 2016, PCI Security Standards Council [19]
- Identity Ecosystem Steering Group (IDESG) [20]

1.3 Benefits

The NCCoE's practice guide for *Multifactor Authentication for E-Commerce* can help your organization:

- increase the level of security and assurance for card-not-present (CNP) e-commerce transactions
- reduce the risk of account takeovers and fraudulent CNP e-commerce transactions
- reduce the risk of system-administrator-account security breaches
- understand and implement several different MFA-related capabilities
- automate processes to mitigate risks
- recognize potential fraud identifiers, and visually display them on dashboards to identify trends
- implement industry-standard security controls
- increase consumer confidence

2 How to Use This Guide

This NIST Cybersecurity Practice Guide demonstrates two standards-based reference designs and provides users with the information they need to replicate the MFA for e-commerce example implementations. These reference designs are modular and can be deployed in whole or in part.

This guide contains three volumes:

- NIST SP 1800-17A: *Executive Summary*
- NIST SP 1800-17B: *Approach, Architecture, and Security Characteristics* – what we built and why **(you are here)**
- NIST SP 1800-17C: *How-To Guides* – instructions for building the example implementations

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

Business decision makers, including chief security and technology officers, will be interested in the *Executive Summary, NIST SP 1800-17A*, which describes the following topics:

- challenges that enterprises face in implementing MFA to reduce online fraud
- example implementations built at the NCCoE
- benefits of adopting the example implementations

Technology or security program managers who are concerned with how to identify, understand, assess, and mitigate risk will be interested in this part of the guide, *NIST SP 1800-17B,* which describes what we did and why. The following sections will be of interest:

- Section 3.4, Risk Assessment, provides a description of the risk analysis we performed
- Section 3.4.4, Security Control Map, maps the security characteristics of these example implementations to cybersecurity standards and best practices

You might share the *Executive Summary, NIST SP 1800-17A*, with your leadership team members to help them understand the importance of adopting standards-based solutions when implementing MFA, increasing the assurance about who is using the purchaser’s credit card and account information.

IT professionals who want to implement an approach like this will find the whole practice guide useful. You can use the how-to portion of the guide, *NIST SP 1800-17C*, to replicate all or parts of the builds created in our lab. The how-to portion of the guide provides specific product installation, configuration, and integration instructions for installing and configuring the example implementations. We do not re-create the product manufacturers’ documentation, which is generally widely available. Rather, we show how we incorporated the products together in our environment to create these example implementations.

This guide assumes that IT professionals have experience implementing security products within the enterprise. While we have used a suite of commercial products to address this challenge, this guide does not endorse these particular products. Your organization can adopt these example implementations or one that adheres to these guidelines in whole, or you can use this guide as a starting point for tailoring and implementing parts of these e-commerce security enhancing capabilities. Your organization's security experts should identify the products that will best integrate with your existing tools and IT system infrastructure. We hope that you will seek products that are congruent with applicable standards and best practices. Section 3.5, Technologies, lists the products we used and maps them to the cybersecurity controls provided by these reference implementations. For additional information regarding cybersecurity control mappings, see Appendix A for the Cybersecurity Framework Components Mapping table (Table A-1).

2.1 Typographic Conventions

The following table presents typographic conventions used in this volume.

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

3 Approach

This practice guide highlights the approach used to develop the NCCoE example implementations. Our approach includes risk assessment and analysis; logical design; example build development, test, and evaluation; and security control mapping. This guide is intended to provide practical guidance to retailers interested in implementing an MFA solution to reduce e-commerce fraud.

In developing the example implementations, the NCCoE:

- worked with retail organizations and other e-commerce payment stakeholders, including the Retail and Hospitality Information Sharing and Analysis Center [21], to identify the potential need and benefits of MFA for e-commerce. The need came from recognizing that malicious actors are increasingly targeting CNP online retail transactions in response to the adoption of chip credit cards in the U.S.
- participated in workshops to identify key issues that affect MFA for e-commerce. The conversations and the insight derived from those workshops have informed the direction of this project and this practice guide
- regularly interacted with members of the NCCoE Retail Community of Interest (COI) to discuss current cybersecurity trends and online retail needs
- received input from the participating technology vendors referenced in this guide who contributed to developing the architecture and reference design. They provided technologies to address the project's requirements and assisted in installing and configuring those technologies in an architecture design that reflected their customer's online retail environments

3.1 Audience

This guide is intended for individuals responsible for implementing IT security solutions and for individuals involved in reducing fraudulent purchases on retail shopping websites. The platforms demonstrated by this project, and the implementation information provided in this practice guide, permit the integration of products to implement MFA for an e-commerce system. While the example implementations' primary audience is those who support online e-commerce retailers, the capabilities may appeal to the broader audience of administrators, IT managers, IT security managers, risk-mitigation personnel, and others involved in the security of managing registered users for an organization's internet resources.

3.2 Scope

The project focuses on the need for MFA during e-commerce transactions with increased risk, and during system administration activities. The NCCoE drafted desired security solution characteristics that would be used by an online retailer. After an open call in the Federal Register for vendors to help develop a solution, we scoped the project to create the following high-level architectural elements and desired outcomes:

- provide consumers with an open standards-based MFA capability based upon FIDO
- provide a solution leveraging Universal Serial Bus (USB) Type A hardware multifactor devices used with desktop/laptop personal-computer form factors for returning purchasers
- demonstrate a system where MFA is required by e-commerce platform administration personnel before they perform system administration activities. Implementing MFA for administrative accounts can help limit the risk of compromising the information system that hosts the e-commerce solution
- demonstrate MFA device registration
- show protections to help mitigate password-guessing account takeover and credential stuffing scenarios by using account lockout protections after a certain number of incorrect logins are attempted
- enable system-activity situational awareness by providing dashboards that display account lockout and authentication activity

To maintain the project’s focus on e-commerce MFA, the following areas are **out of scope** for these example implementations:

- purchasers who check out as guests, returning purchasers who do not possess U2F authenticators, and purchasers leveraging a mobile application to shop online
- MFA device registration security and lost token replacement that would help secure the device registration workflow (recommendations are provided in Section 5.3 regarding registration workflows that organizations may use)
- customer interaction and help-desk-related functions, such as the distribution and procurement of U2F authenticators, identity proofing, or account creation of the customer identification (ID), as well as recovery processes if the account becomes locked out

While the areas noted above can be important to implementing an MFA system, they were not included in the example implementations’ design decisions. Additional system architectural elements, such as the separation of functionality and components, high availability, network or application firewalls, and intrusion detection/prevention capabilities, were out of scope for our builds.

3.3 Assumptions

Organizations should review the assumptions underlying the example builds before implementing the capabilities described in this practice guide. Before implementing these capabilities, organizations should consider whether the same assumptions apply to their environment. Appendix B provides implementation guidance for the following assumptions:

- availability of skills
- uniqueness of lab environment
- MFA decreases account takeover opportunities
- web browser (not mobile application) and returning purchaser accounts
- support of MFA devices
- customer-support mechanisms for lost tokens

Additionally, the scenarios associated with the example implementations assume that the returning purchaser has already completed these actions:

- registered their multifactor authenticator
- logged into the retailer e-commerce platform's website
- shopped and filled their shopping cart

3.4 Risk Assessment

NIST SP 800-30 Revision 1, *Guide for Conducting Risk Assessments*, states that risk is "a measure of the extent to which an entity is threatened by a potential circumstance or event, and typically a function of: (i) the adverse impacts that would arise if the circumstance or event occurs; and (ii) the likelihood of occurrence." The guide further defines risk assessment as "the process of identifying, estimating, and prioritizing risks to organizational operations (including mission, functions, image, reputation), organizational assets, individuals, other organizations, and the Nation, resulting from the operation of an information system. Part of risk management incorporates threat and vulnerability analyses, and considers mitigations provided by security controls planned or in place."

The NCCoE recommends that any discussion of risk management, particularly at the enterprise level, begins with a comprehensive review of NIST SP 800-37 Revision 2, *Risk Management Framework for Information Systems and Organizations*—material that is available to the public. The Risk Management Framework (RMF) guidance, as a whole, proved to be invaluable in giving us a baseline to assess risks, from which we developed the project, the security characteristics of the build, and this guide.

3.4.1 Threats

A threat is "an event or condition that has the potential for causing asset loss and the undesirable consequences or impact from such loss" [17]. The following subsections describe the authentication-based threats to e-commerce retail environments that were considered when developing this practice guide.

3.4.1.1 *Credential Stuffing*

Credential stuffing is a type of brute-force attack [22]. In credential stuffing, large-scale account username and password theft is used against online retailers. Common scenarios include stealing accounts from a different website, and then a credential stuffing capability tests the logins to find accounts that have identical customer IDs and passwords on both the website from which the account credentials were stolen and the website that is being targeted for theft.

An outcome or result of credential stuffing can be account takeover. A 2017 study reported that credential stuffing attacks accounted for "more than 90% of login traffic on many of the world's largest websites and mobile applications" [23]. The accounts that have been compromised in credential stuffing attacks are then used in account takeover scenarios like those described below.

3.4.1.2 *Account Takeover*

In account takeover scenarios, where account theft and reuse occur, compromised or captured e-commerce customer accounts can be used for fraudulent purchases, gift card purchase and redemption, or customer loyalty program misappropriation.

Account takeover of e-commerce platform system administrator accounts can lead to the information system, and the data contained in it, being compromised.

3.4.2 Vulnerabilities

A vulnerability is a "weakness in a system, system security procedures, internal controls, or implementation that could be exploited or triggered by a threat" [17]. Authentication-based vulnerabilities for e-commerce retail environments include the characteristics listed below.

Systems with these characteristics are especially susceptible to credential stuffing:

- allow multiple incorrect logins without account lockouts
- purchasers have reused the same password on multiple systems

Systems with these characteristics are especially susceptible to account takeover:

- accept weak passwords
- allow multiple incorrect logins without account lockouts
- account password-reset options are easily circumvented

3.4.3 Risk

Risks include the fraudulent use of account customer IDs and passwords to perform e-commerce fraud. This fraud impacts the e-commerce ecosystem by decreasing purchaser confidence in the security of their payment and account information and by increasing costs to offset the e-commerce fraud.

Additionally, through the potential compromise of administrative accounts, risk exists to the data contained within the e-commerce information-system infrastructure. Implementing MFA for these accounts can limit risk exposure in this area.

3.4.4 Security Control Map

The NIST Cybersecurity Framework security Functions and Subcategories that the reference designs support were identified through a risk analysis process. Additionally, work roles in the NICE Cybersecurity Workforce Framework [18] that perform the tasks necessary to implement those cybersecurity Functions and Subcategories were identified. See Appendix A for the Cybersecurity Framework Components Mapping table (Table A-1).

3.5 Technologies

Table 3-1 lists all of the technologies used in this project and provides a mapping among the generic product component term, the specific product used, the function of the product, and the NIST Cybersecurity Framework Subcategory outcomes that the product provides for the example implementations. Refer to Table A-1 for an explanation of the NIST Cybersecurity Framework Subcategory codes, a mapping to ISO/IEC 27001:2013 [7], NIST SP 800-53 Revision 4 controls [11], and NIST SP 800-181 [18] work roles. Many of the products have additional capabilities that were not used for the purposes of the example implementation builds.

Table 3-1 Products and Technologies

Component	Specific Product	Function	Cybersecurity Framework Subcategories
Retailer E-Commerce Platform	Magento Open Source Version 2.1.8 [24]	The landing point for the returning purchaser as they shop in the online store. The retailer e-commerce platform serves as the interaction point for the returning purchaser's e-commerce transaction. The retailer e-commerce platform also serves as the communication point between the returning purchaser and the back-office services that the website interacts with to obtain authentication, inventory information, etc.	**PR.AC-1, PR.AC-7, RS.AN-1**

Component	Specific Product	Function	Cybersecurity Framework Subcategories
U2F/Risk Assessment Module	magfido risk assessment policy rules and process module [25]	Provides purchaser account U2F registration and authentication capabilities, assesses information about the purchase and the returning purchaser's profile, and determines if MFA is required from the purchaser to complete shopping-cart checkout. These policies and processes are accomplished by Magento and StrongKey CryptoEngine (SKCE) Version 2.0 Open Source FIDO U2F server interaction [26].	**ID.RA-4, ID.RA-5**
Risk Engine	RSA Adaptive Authentication (Cloud) Version 13.1 [27]	Uses data science to provide transaction analysis and response, prompting the returning purchaser to use U2F when the organization's risk threshold is exceeded during a transaction, providing a low-friction experience for the consumer to reduce fraud while minimizing the interruptions and denials that a consumer may encounter.	**ID.RA-4, ID.RA-5**
MFA Mechanism	SKCE Version 2.0 Open Source FIDO U2F server [26] and TokenOne cloud-based Authentication Version 2.8.5 [28]	Provides a server-based enhanced-authentication capability as required by the risk assessment module (magfido) or for the e-commerce platform administrator (TokenOne).	**PR.AC-1, PR.AC-7**

Component	Specific Product	Function	Cybersecurity Framework Subcategories
Multifactor Authenticator	Yubico YubiKey NEO Security Key USB Type A ports and near-field communication device [29]; TokenOne smartphone application authenticator [28]	MFA device that the purchaser possesses and presents when requested (Yubico) or that the e-commerce administrator uses (TokenOne).	**PR.AC-1, PR.AC-7**
Logging/Reporting Dashboard	Splunk Enterprise Version 6.6.1 [6]	Provides logging and reporting data for use by MFA for e-commerce system owners.	**DE.CM-1**

3.6 NIST SP 800-63-3 Alignment

NIST SP 800-63-3, *Digital Identity Guidelines* [12], identifies three components of digital identity:

- Identity Assurance Level (IAL), which discusses the identity proofing process
- Authenticator Assurance Level (AAL), which discusses the authentication process
- Federation Assurance Level (FAL), which discusses the strength of an assertion in a federated environment

The example implementations presented in this guide align with NIST SP 800-63-3 assurance concepts in the following ways:

- IAL: demonstrates a returning purchaser’s self-asserted identity. For the e-commerce platform administrator’s use of MFA, the identity levels will depend upon organizational requirements and processes (reference Section 2.2 in NIST SP 800-63A, *Digital Identity Guidelines*, *Enrollment and Identity Proofing* [13]).
- AAL: demonstrates a single-factor cryptographic device used by the returning purchaser in conjunction with memorized secret (reference Sections 4.2.1, 5.1.1, and 5.1.7 in NIST SP 800-63B, *Digital Identity Guidelines*, *Authentication and Lifecycle Management* [14])
- FAL: Federated identity is not part of the example implementations. However, federation concepts can be further explored in NIST SP 800-63C, *Digital Identity Guidelines*, *Federation and Assertions* [15].

4 Architecture

The NCCoE worked with project collaborators to develop two open, standards-based, commercially available example implementations demonstrating the following capabilities:

- MFA for e-commerce returning purchasers who use FIDO U2F
- MFA for administrators of the e-commerce system who use onetime pad principles
- *cost threshold*- or *risk engine*-initiated MFA request
- authentication log aggregation and display

While these capabilities are implemented as integrated example implementations in this guide, subsets of these capabilities could be deployed as organizational requirements may dictate. The modular design of the two example implementations is made to support such use cases.

The two example implementations include online e-commerce platform capabilities, risk assessment and MFA, and logging and display capabilities. The high-level reference architectures shown in Figure 4-1 and Figure 4-2 illustrate the two example implementations that are also known as the *cost threshold* and *risk engine* example implementations, respectively.

The example implementations were constructed on the NCCoE's VMware vSphere virtualization operating environment. Internet access was used to connect to remote cloud-based components, while software components were installed as virtual servers within the vSphere environment.

4.1 Architecture Description

The architecture that was used to create the example implementations is described in this section. The example implementations were designed and built in the NCCoE lab environment. The lab network is not connected to the NIST enterprise network. Table 3-1 lists the MFA software and hardware components used, as well as the specific function of each component. Hardware components, such as the U2F, were used with laptops.

4.1.1 MFA for E-Commerce Returning Purchasers Who Use FIDO U2F

The example implementations demonstrated MFA by using FIDO protocols for the returning purchasers. The retailer e-commerce platform was built on Magento. StrongKey, a technology collaborator in this project, created a Magento module, magfido, to support the FIDO U2F protocol to enable strong authentication.

FIDO protocols have been designed to provide strong authentication by using a challenge-response-based protocol with strong cryptographic keys and algorithms. FIDO U2F authenticators in the example implementations are hardware-based devices on which cryptographic keys are generated and used. FIDO protocols include a test-of-human-presence requirement to confirm that a real human is in possession of the U2F. The U2F was used in the USB Type A port of a laptop that used a current version of a graphical user interface operating system that did not require additional software drivers to be installed.

4.1.2 Cost Threshold- or Risk Engine-Initiated MFA Request

In both example implementations, the FIDO capability is supported by StrongKey's SKCE FIDO Server, which is integrated with the Magento e-commerce platform and Yubico's YubiKey NEO Security Key. Magento allows extension of its base code through modules. In the first example implementation, also known as the *cost threshold* example implementation, the magfido risk assessment module is used to override Magento's default checkout process to require FIDO-based strong authentication on purchases that exceed $25—the dollar threshold used to simulate a riskier transaction.

In the second example implementation, also known as the *risk engine* example implementation, the RSA Adaptive Authentication product provides risk engine analysis capabilities that can interact with the example implementation's Magento web server and that leverage the magfido module to require FIDO-based authentication from the returning purchaser.

4.1.3 MFA for E-Commerce System Administrators Using Onetime Pad Principles

TokenOne's authentication capability authenticates the Magento e-commerce platform administrator before any administrative modifications are made to the e-commerce platform. It is based upon TokenOne's cloud-based authentication infrastructure and a smartphone application on either an Android or iPhone device. This helps secure the e-commerce organization's overall infrastructure.

4.1.4 Authentication Log Aggregation and Display

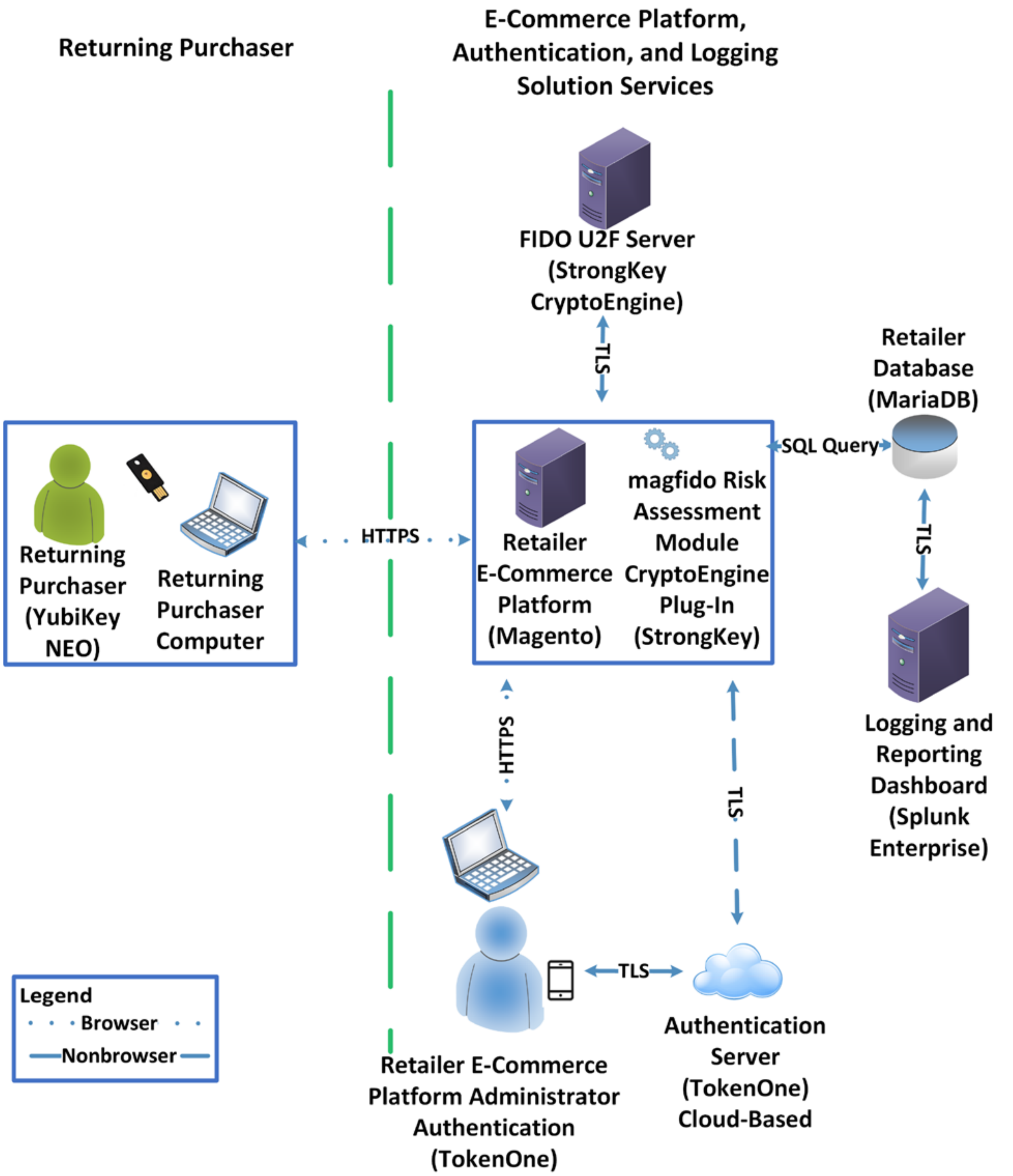
Splunk Enterprise provides authentication-related logging and dashboard capabilities.

4.2 Cost Threshold Architecture Details

The *cost threshold* example implementation is described in this section, and the *risk engine* example implementation is described in Section 4.3. The *cost threshold* architecture depicted in Figure 4-1 includes the following elements:

- returning purchaser
- retailer e-commerce platform
- magfido risk assessment module
- FIDO U2F server
- e-commerce platform administrator authentication
- logging and reporting dashboard

Figure 4-1 High-Level Cost Threshold Reference Architecture


Returning Purchaser
E-Commerce Platform, Authentication, and Logging Solution Services
FIDO U2F Server (StrongKey CryptoEngine)
TLS
Retailer Database (MariaDB)
SQL Query
TLS
Returning Purchaser (YubiKey NEO)
Returning Purchaser Computer
HTTPS
Retailer E-Commerce Platform (Magento)
magfido Risk Assessment Module CryptoEngine Plug-In (StrongKey)
Logging and Reporting Dashboard (Splunk Enterprise)
HTTPS
TLS
TLS
Legend
Browser
Nonbrowser
Retailer E-Commerce Platform Administrator Authentication (TokenOne)
Authentication Server (TokenOne) Cloud-Based

The high-level *cost threshold* architecture components are described in the following subsections.

4.2.1 Returning Purchaser

The returning purchaser initiates an e-commerce purchase from their returning-purchaser computer, logging in with their customer ID and password to complete the purchase. The returning purchaser can present their U2F authenticator, if requested by the e-commerce retailer, when the risk threshold has been exceeded. The user's U2F authenticator leveraged in the example implementations is the Yubico YubiKey NEO Security Key [29].

4.2.2 Retailer E-Commerce Platform

The returning purchaser uses a FIDO-supported web browser for accessing the retailer e-commerce platform. The retailer e-commerce platform allows the returning purchaser to browse the retailer's products and services. The e-commerce platform provides the returning purchaser with the ability to select items for eventual purchase and to check out to complete the purchase. The checkout process includes authentication requests presented to the purchaser. The information conveyed to the returning purchaser is provided by or through the retailer e-commerce platform's website.

The retailer e-commerce platform serves as a conduit with the back-office components of the e-commerce retailer's information systems, such as product inventory, shopping-cart information, customer identity management, authentication information, as well as the retailer database.

The specific product that we leveraged in our example implementations for the retailer e-commerce platform is an open-source version of Magento [24] that integrates with third-party modules like the magfido module developed for the example implementations and described in this guide.

4.2.3 magfido Risk Assessment Module

The magfido risk assessment module identifies when a risk threshold has been exceeded and then requires the purchaser to provide their U2F authenticator to complete a purchase. It also allows a returning purchaser to register the U2F authenticator needed when the risk threshold has been exceeded. The magfido risk assessment module was developed by StrongKey and is publicly available [25]. The magfido module is explained in greater detail in Section 2.3 of Volume C of this guide.

4.2.4 FIDO U2F Server

The FIDO U2F server provides server-based enhanced authentication capabilities. SKCE Version 2.0 performs cryptographic functions through web services and, among other capabilities, includes a FIDO engine to support FIDO U2F authenticator registration and authentication [30].

4.2.5 Retailer E-Commerce Platform Administrator Authentication

In our example implementations, MFA is required to perform management functions on the retailer e-commerce platform. This MFA capability is provided by TokenOne's cloud-based and smartphone-based application [28]. Implementing this feature is consistent with PCI Data Security Standards 3.2, Requirement 8.3 [31].

4.2.6 Logging and Reporting Dashboard Server

The logging and reporting dashboard aggregates log data from the different components in the e-commerce system. It then provides the system operator with a visual display of the authentication events. The product leveraged for the example implementations is Splunk Enterprise [6].

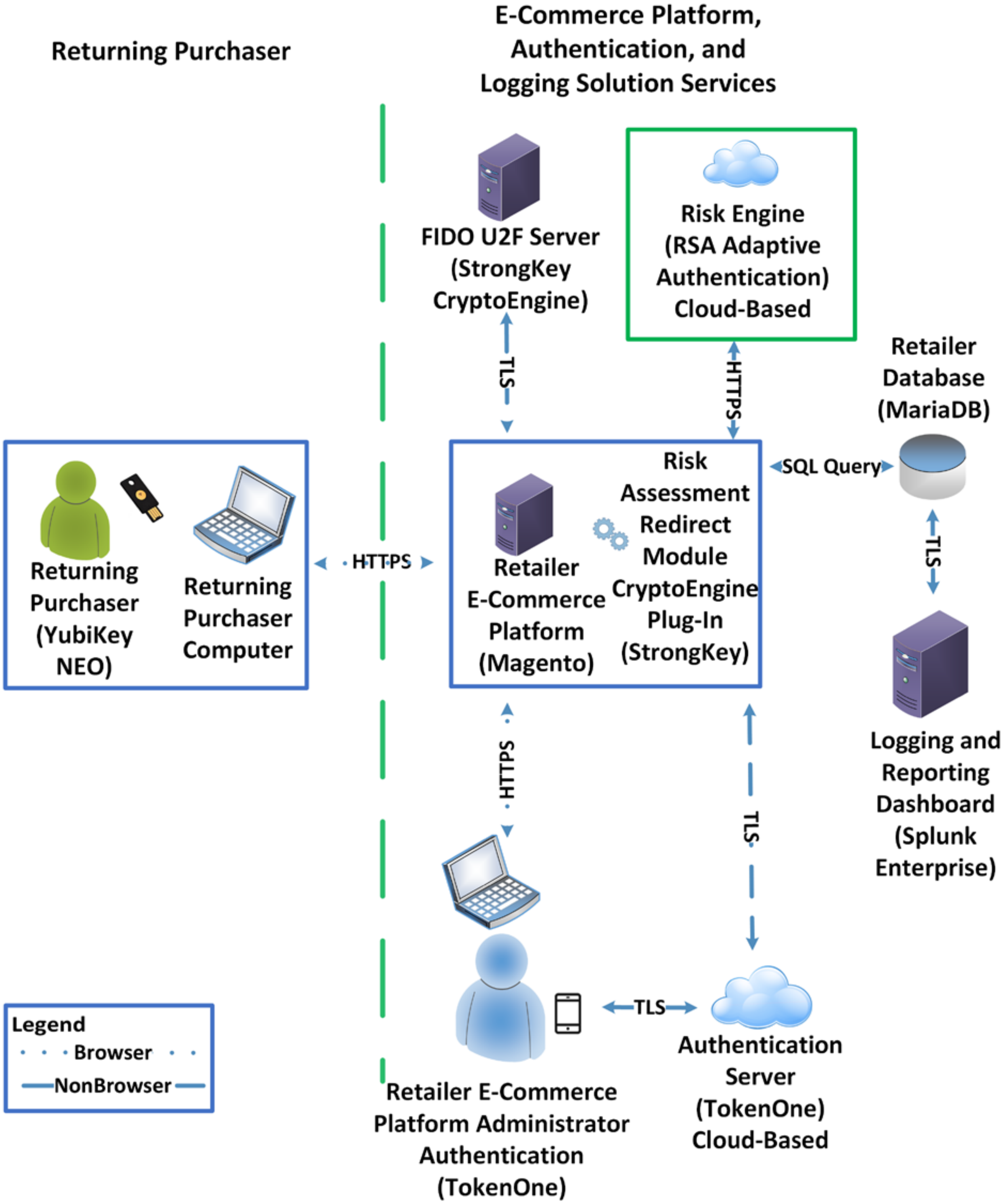
4.3 Risk Engine Architecture Details

The *risk engine* architecture depicted in Figure 4-2 includes the following elements:

- returning purchaser
- retailer e-commerce platform
- risk assessment redirect module
- adaptive authentication capability
- FIDO U2F server
- e-commerce platform administrator authentication
- logging and reporting dashboard

The *risk engine* architecture depicted in Figure 4-2 leverages the magfido module, replacing the *cost threshold* capability with the RSA Adaptive Authentication Risk Engine displayed in the figure's green box. This example implementation build focuses on risk engine-based MFA capabilities. This uses an analytic engine to leverage additional capabilities for detecting increased risks. The RSA Adaptive Authentication Risk Engine examines details of the transaction and requires the returning purchaser to use MFA only when the transaction is deemed to be higher risk.

Figure 4-2 High-Level Risk Engine Reference Architecture


Returning Purchaser
E-Commerce Platform, Authentication, and Logging Solution Services
FIDO U2F Server (StrongKey CryptoEngine)
Risk Engine (RSA Adaptive Authentication) Cloud-Based
TLS
HTTPS
Retailer Database (MariaDB)
SQL Query
TLS
Returning Purchaser (YubiKey NEO)
Returning Purchaser Computer
HTTPS
Retailer E-Commerce Platform (Magento)
Risk Assessment Redirect Module CryptoEngine Plug-In (StrongKey)
Logging and Reporting Dashboard (Splunk Enterprise)
HTTPS
TLS
TLS
Retailer E-Commerce Platform Administrator Authentication (TokenOne)
Authentication Server (TokenOne) Cloud-Based
Legend
Browser
NonBrowser

4.3.1 Risk Engine

In addition to the components described in Section 4.2, the *risk engine* example implementation modifies the magfido module to add an additional capability by using the RSA Adaptive Authentication Risk Engine highlighted in the green box in Figure 4-2 [27]. The risk engine leverages machine learning and risk-based authentication, and the example implementation will prompt users for FIDO-based authentication only when the risk engine deems the transaction to be higher risk.

For this purpose, we refer to the updated magfido module as the risk assessment redirect module.

In our example implementation, the risk engine suspends the transactions when it identifies the transaction as exceeding risk thresholds. Leveraging machine learning, the risk engine computes a score that focuses on each consumer's normal activity, the activity of the merchant's population, and global fraudulent device metrics (an outside service contributes the latter). In an online retail setting, the system would prompt the consumer to contact customer service for assistance in completing the transaction, a possible scenario where the risk engine would intercede.

4.3.2 Risk Assessment Redirect Module

The risk assessment redirect module is hosted by the Magento server and provides risk and authentication analysis information related to the returning purchaser's shopping-transaction activities to the risk engine. Risk engine decisions are then communicated back to the Magento server through the risk assessment redirect module.

Based upon an analysis performed by the risk engine, the risk assessment redirect module then directs the Magento server to allow the returning purchaser to use their customer ID and password for lower-risk transactions, and then requires the returning purchaser to also successfully present their FIDO U2F authenticator to complete their shopping transaction.

Optionally at the retailer's discretion, and with additional programming of the risk assessment redirect module, the transaction can be suspended when the risk engine identifies the transaction as exceeding particular risk thresholds.

4.4 Process Flows

The following process flows show the sequence of events taking place as a returning purchaser completes an online purchase by using the *cost threshold* or *risk engine* example implementation.

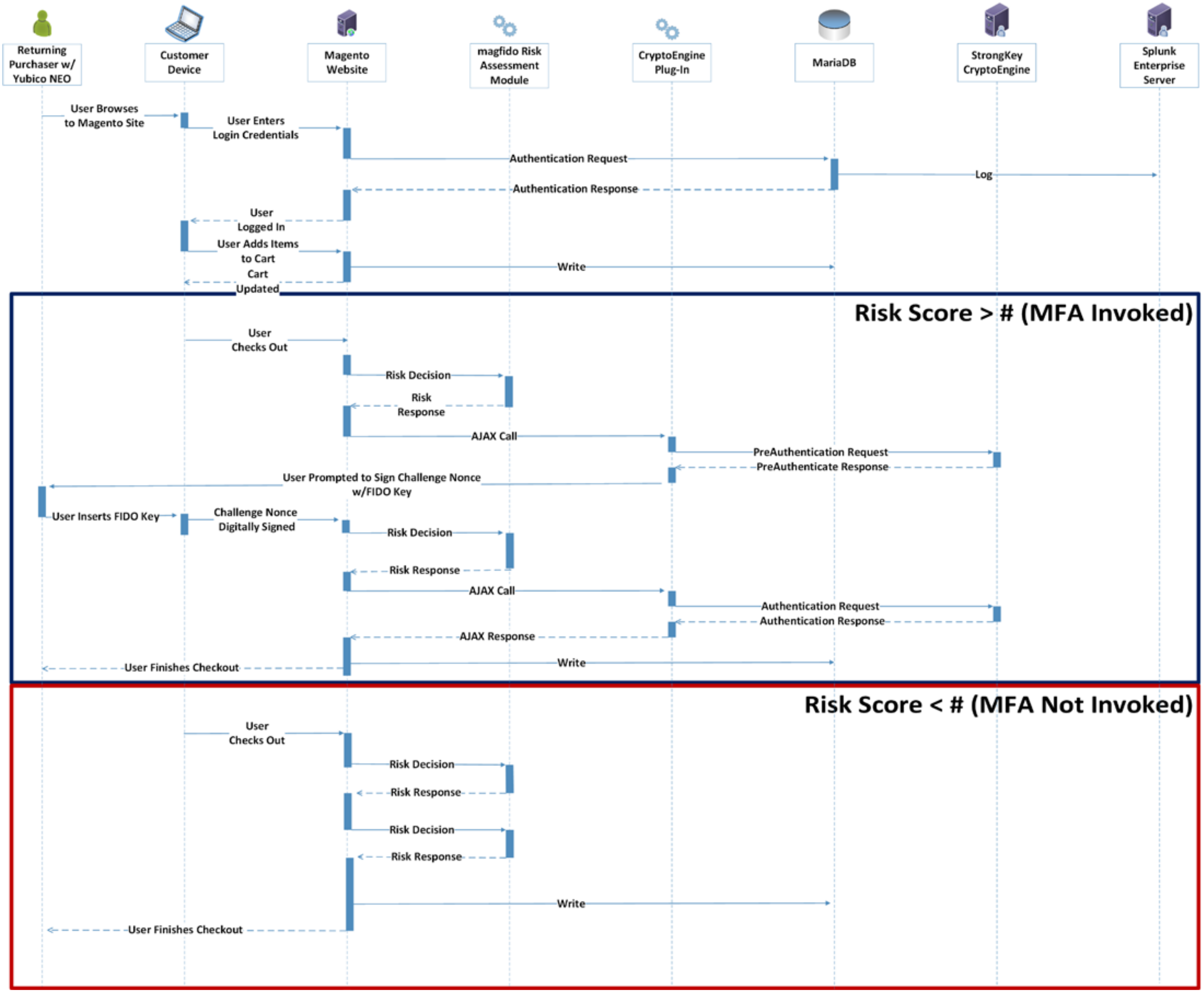
4.4.1 Cost Threshold Process Flow

Figure 4-3 shows the process flow as a returning purchaser browses to the shopping site and enters their customer ID and password, and as, upon checkout, the risk assessment module makes a decision to either require (box surrounded in blue) or not require (box surrounded in red) use of the U2F authenticator. If the returning purchaser's U2F authenticator is requested, then the shopping transaction will complete only upon successful use of the U2F.

The process flow of Figure 4-3 is described below.

- The returning purchaser uses their laptop (customer device) to shop on the Magento e-commerce platform website.
- The returning purchaser authenticates to the Magento e-commerce platform's MariaDB with their customer ID and password.
- As the checkout process begins, the risk assessment module makes a risk decision and then either allows the transaction to complete with no further authentication requirements (as shown within the red box) or, in the case of a transaction with increased risk, transmits its risk assessment need to use MFA to the SKCE Plug-In (as shown within the blue box).
- The returning purchaser then inserts their FIDO key into their customer device, and their authentication is approved or denied based upon the validity of their security key.

Figure 4-3 Cost Threshold Process Flow



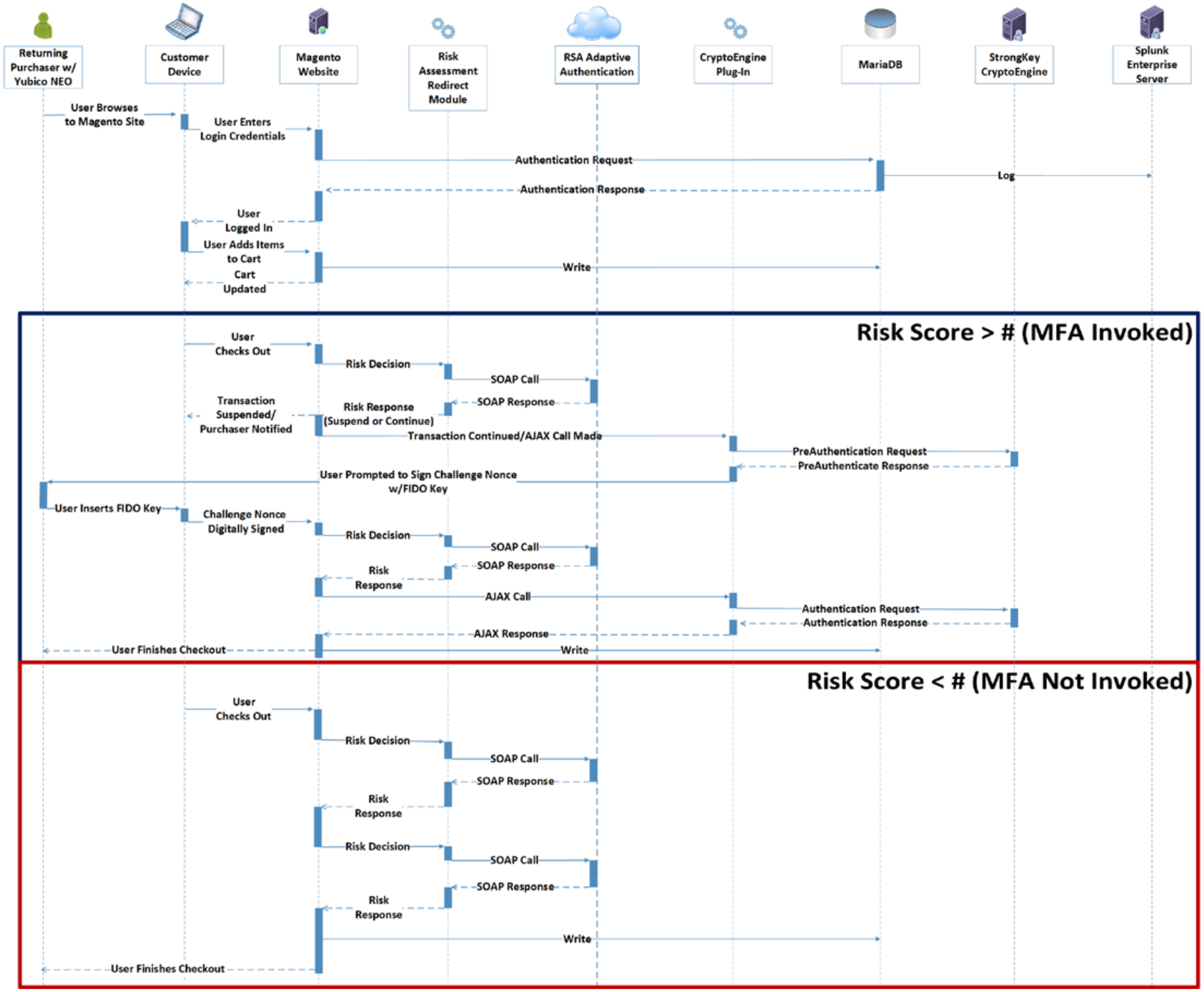
4.4.2 Risk Engine Process Flow

Figure 4-4 shows the process flow as a returning purchaser browses to the shopping site and enters their customer ID and password, and as, upon checkout, the risk engine makes a decision to either require (box surrounded in blue) or not require (box surrounded in red) use of the U2F authenticator. If the returning purchaser's U2F authenticator is requested, then the shopping transaction will complete only upon successful use of the U2F.

The process flow of Figure 4-4 is described below.

- The returning purchaser uses their laptop (customer device) to shop on the Magento e-commerce platform's website.
- The returning purchaser authenticates to the Magento e-commerce platform's MariaDB with their customer ID and password.
- As the checkout process begins, the risk engine makes a risk decision and then allows the transaction to complete with no further authentication requirements (as shown within the red box) or, in the case of a transaction with increased risk, allows the transaction to continue with the use of MFA or suspends the transaction if it exceeds organizational risk tolerances (as shown within the blue box).
- The returning purchaser then inserts their FIDO key into their customer device, and their authentication is approved or denied based upon the validity of their security key.

Figure 4-4 Risk Engine Process Flow



5 Solution Scoping for the Example Implementations

This section provides information about the scope and the use cases that apply to the example implementations, as well as customization options for the *cost threshold* example implementation.

5.1 Scoping Context of the Returning Purchaser Processes

Real-world extension modules to Magento could include additional criteria to identify risk. While there is also a multishipping workflow in Magento, this architecture modifies only the default single-address checkout process flow. In environments using the multishipping workflow to enable shipping a single order to multiple addresses, appropriate changes within that workflow will be needed to incorporate FIDO as described within this practice guide.

5.1.1 Securing the FIDO Security Key Registration Process

The FIDO registration workflow's level of security should be considered. The example implementations prompt the returning purchaser to use a registered U2F only when the shopping session exceeds a predetermined level of risk—in this case, the dollar amount. With this example, strong authentication is used only when a transaction exceeds the predetermined level of risk, and not for all purchaser-related activities. This implies that if an attacker compromised a legitimate purchaser's password, then the attacker could register a new FIDO Security Key under that account.

Once registered, the attacker could use their registered key to authorize any checkout that requires FIDO-based strong authentication. Reference Section 8 for information regarding how to help mitigate this threat.

5.1.2 Lost U2F or Registration of a New U2F

The following areas are outside this project's scope and were identified as options that could help mitigate risks related to lost or new U2F Security Key registration risks:

- The purchaser is required to register a key when an account is created. When any subsequent FIDO keys are registered, a previously existing FIDO key is required for authentication before registering those subsequent FIDO keys.
- Configure Magento to always require FIDO-based strong authentication for any changes to an account's U2F Security Key registration settings, once a FIDO Security Key is registered. This will help inhibit a malicious actor from registering a second FIDO key into the account and from using that FIDO key to perform cart checkout activities and to circumvent the security measures of the checkout process.
- As detailed in Section 8, workflow that enables existing purchasers to confirm their identity by other means (e.g., by confirming receipt of an email sent to their account, by entering a

personal identification number (PIN) before being able to register their FIDO key, or via other contact methods) could also be employed in cases where existing purchasers will be registering a new FIDO key.

5.2 Example Implementation Use Cases

The example implementations were designed and built to support the following e-commerce use cases that were developed with input from the NCCoE Retail COI. The first use case involved the U2F not being requested, and the second use case shows the U2F being requested when the returning purchaser attempts to make an online purchase. A third use case applies to both the *cost threshold* and *risk engine* example implementations when a system administrator is managing the e-commerce platform.

5.2.1 Use Case 1: Risk Threshold Not Exceeded—MFA Not Requested

In use case 1, a returning purchaser shops for items and places them into their shopping cart, and then, upon checkout, either a predetermined purchase amount is not exceeded (in the *cost threshold* example implementation) or the risk engine determines that the transaction is lower risk (in the *risk engine* example implementation). The purchaser continues through their checkout activities and completes the shopping experience without invoking the U2F.

5.2.2 Use Case 2: Risk Threshold Exceeded—MFA Requested

In use case 2, a returning purchaser shops for items and places them into their shopping cart, and then, upon checkout, either a predetermined purchase amount is exceeded *(cost threshold)* or the risk engine determines that the transaction is higher risk *(risk engine).* The returning purchaser is prompted to use U2F confirmation and, upon doing so, completes the shopping experience after successfully using their U2F.

The Adaptive Authentication Risk Engine leverages machine learning for device identification, assessment of the consumer's purchase activity, the merchant population's purchase activity, and global fraud indicators to determine if a transaction appears risky enough to warrant an MFA challenge.

In scenarios where the U2F is not successfully used, the purchase is declined. This could take place if the returning purchaser did not successfully use their U2F or if the purchaser's customer ID and password are being used by someone who does not possess the U2F.

5.2.3 Use Case 3: System Administrator Prompted for MFA

In use case 3, MFA is required by e-commerce platform administration personnel before they perform system administration activities. Implementing MFA for administrative accounts can help limit the risk of compromising the information system that hosts the e-commerce solution. This applies to both example implementations *(cost threshold* and *risk engine).* This helps limit the risk of the e-commerce platform administrator's authentication credentials being compromised and provides assurance that they are being used by an authorized person.

5.3 Cost Threshold Example Implementation Customization Options

Leveraging the concepts from this practice guide's example implementations, retail organizations can customize their risk mitigation scenarios beyond those described above. For example, if the MFA login was not successfully used, then customized risk mitigation scenarios could include these actions:

- Identify the transaction for follow-up and review by the retailer fraud-detection team. Direct the person attempting to complete the transaction to the online retailer's customer service department, where review of the shopping transaction could take place.
- Notify the returning purchaser via email if a purchase is declined because their MFA device is not used successfully (potentially by another person not authorized to shop on their account).

In addition to the above scenarios, the retailer can review their organizational risk thresholds and explore additional risk-based decision options beyond the shopping-cart purchase exceeding a predetermined dollar amount. These options could include requesting MFA from the purchaser when the following situations take place:

- The purchaser provides a new or updated ship-to address.
- The purchaser's billing and ship-to address do not match.
- The machine internet protocol (IP) address differs from those previously used or is from a certain IP address range.
- The purchaser uses a new credit card.
- The purchaser purchases specific items or categories that are often included in fraudulent purchases.
- The purchaser purchases items from a new location.
- a combination of any of the above risk factors, for example, an order with a high transaction amount that is shipping to a new or updated ship-to address or transactions where billing and ship-to addresses do not match and a prespecified transaction amount is exceeded
- other scenarios whose logic could be predetermined, such as additional combinations from the list above or other risk-based decision options could also be used

6 Security Characteristic Analysis

The purpose of the security characteristic analysis is to understand the extent to which the project meets its objective of demonstrating the use of MFA in an e-commerce environment. In addition, it seeks to understand the security benefits and drawbacks of the example solutions.

6.1 Assumptions and Limitations

The security characteristic analysis has the following limitations:

- It is neither a comprehensive test of all security components nor a red-team exercise.
- It cannot identify all weaknesses.
- It does not include the lab infrastructure. It is assumed that devices are hardened. Testing these devices would reveal only weaknesses in implementation that would not be relevant to those adopting these reference architectures.

As a best-practice recommendation to help keep the organization's Magento product current, visit the Resources section of the Magento website to sign up for updates on the most recent security patches and best practices [32].

6.2 Build Testing

The purpose of the security characteristic analysis is to understand the extent to which the project meets its objective of demonstrating the use of MFA in an e-commerce environment. In addition, it seeks to understand the security benefits and drawbacks of the reference designs. Also, Appendix C provides information regarding research into the products used for architecture components.

6.3 Scenarios and Findings

One aspect of our security evaluation involved assessing how well the reference designs address the security characteristics that they were intended to support. The Cybersecurity Framework Subcategories were used to provide structure to the security assessment by consulting the specific sections of each standard that are cited in reference to that Subcategory. The cited sections provide validation points that the example implementations would be expected to exhibit. Using the Cybersecurity Framework Subcategories as a basis for organizing our analysis allowed us to systematically consider how well the reference designs support the intended security characteristics.

6.4 Analysis of the Reference Designs' Support for Cybersecurity Framework Subcategories

This section analyzes the example implementations in terms of the specific Subcategories of the Cybersecurity Framework that they support. This enables an understanding of how the example implementations achieved the goals of the design when compared against a standardized framework. This section identifies the security benefits provided by each component of the example implementations and how those components support specific cybersecurity activities, as specified in terms of Cybersecurity Framework Subcategories.

The Cybersecurity Framework includes Functions, Categories, and Subcategories that define the capabilities and processes needed to implement a cybersecurity program. In Table A-1, the NCCoE has identified the Subcategories that are desirable to implement when deploying the example implementations. This section discusses how the example implementations support each of the Subcategories listed in Table A-1. Using the Subcategories as a basis for organizing our analysis allowed us to systematically consider how well the example implementations support specific security activities and provides structure to our security analysis.

6.4.1 DE.CM-1: The Network Is Monitored to Detect Potential Cybersecurity Events

The reference designs support monitoring network activity, with a focus on monitoring authentication attempts. Event log information is correlated with the reference designs' network architectures to make the following determinations:

- total authentication attempts
- successful login attempts
- unsuccessful login attempts

6.4.2 ID.RA-4: Potential Business Impacts and Likelihoods Are Identified

The example implementations track the transaction dollar-purchase amount to determine whether U2F authentication is needed. If the purchase amount meets or exceeds the threshold dollar amount, then U2F authentication is activated.

The risk assessment function of the example implementations enables the online retailer to identify shopping experience attributes that are likely to create business impact. These attributes include the cost of items in the shopping cart and could also use the attributes and potential workflow discussed in Section 5.3 or the capabilities that the risk engine provides.

The information gained from the shopping cart's dollar-amount attribute is used to determine when an organization would elect to employ a U2F authentication device request for a shopping session.

6.4.3 ID.RA-5: Threats, Vulnerabilities, Likelihoods, and Impacts Are Used to Determine Risk

The impact to the implementing organization of a potentially fraudulent transaction is used to determine risk. In the example implementations, the risk engine or the total cost of the items in the shopping cart could be used to help determine the financial risk to which the implementing e-commerce retailer might be subject. Section 5.3 describes additional attributes that could be used to help determine and mitigate the online shopping session's risk.

6.4.4 PR.AC-1: Identities and Credentials Are Issued, Managed, Verified, Revoked, and Audited for Authorized Devices, Users, and Processes

The example implementations use U2F authentication to authorize purchasers and their devices. Specifically, the Yubico YubiKey NEO Security Key was used as the purchaser's second factor authentication mechanism. The Yubico YubiKey NEO Security Key is a hardware FIDO Ready U2F authenticator. It uses public key cryptography, which includes a private key that never leaves the NEO. When a purchaser registers an account on the e-commerce platform, the Yubico YubiKey NEO Security Key uses the private key to generate another cryptographic key that is unique for the e-commerce platform.

In the example implementations, the unique key is used to develop a public key that is sent and stored on the StrongKey FIDO server. After the registration process is completed, logging into the e-commerce platform's website continues to use the unique generated cryptographic key and the public key stored on the StrongKey FIDO server to authenticate the purchaser. The StrongKey FIDO server provides the U2F registration, authentication, and storage of purchaser registration data. The TokenOne cloud-based infrastructure provides an administration interface and services for authentication credential life-cycle management.

6.4.5 PR.AC-7: Users, Devices, and Other Assets Are Authenticated (e.g., Single Factor, Multifactor), Commensurate with the Risk of the Transaction (e.g., Individuals' Security and Privacy Risks and Other Organizational Risks)

Authentication that is commensurate with the risk of the transaction is an intrinsic part of the example implementations. Users are authenticated based upon the shopping transaction's level of risk. For transactions deemed to be lower risk, customer ID and password are used. For transactions with increased risk, U2F MFA is used.

For the *cost threshold* example implementation, acceptable shopping cart dollar-amount risk levels are made by the implementing organization. For the *risk engine* example implementation, risk engine analysis determines when additional authentication will be prompted. In both example implementations, when the risk threshold is exceeded, an MFA request is then activated and communicated to the returning purchaser.

In both example implementations, MFA is required by e-commerce administration personnel before they perform system administration activities. Implementing MFA for administrative accounts can help limit the risk of compromise of the information system that hosts the e-commerce solution.

6.4.6 RS.AN-1: Notifications from Detection Systems Are Investigated

The example implementations leverage Splunk Enterprise displays to provide logging information in a dashboard format that can be investigated by system operators.

6.5 Systems Engineering

Some organizations use a systems-engineering-based approach to plan and implement their IT projects. Organizations wishing to implement IT systems should conduct robust requirements development, considering the operational needs of each system stakeholder. Standards, such as ISO/IEC 15288:2015 [33] and NIST SP 800-160 [17], provide guidance for applying security in systems development. With each of these standards, organizations can choose to adopt only those sections of the standard that are relevant to their development approach, environment, and business context. NIST SP 800-160 recommends thoroughly analyzing alternative solution classes accounting for security objectives, considerations, concerns, limitations, and constraints. This advice applies to both new system developments and integration of components into existing systems, which would be required to deploy the example implementations described in this practice guide.

6.5.1 Example Implementation Code Analysis

In support of systems engineering best practices, code developed to support the example implementations was analyzed by using manual and automated code analysis methods. As part of an overall systems engineering process, organizations can use systematic procedures and code-checking tools that will help find vulnerabilities or weaknesses that can be improved upon.

7 Functional Evaluation

Functional evaluations of the MFA example implementations, as constructed in our lab, were conducted to verify that they meet their objective of enabling a returning purchaser to use enhanced authentication capabilities for e-commerce transactions.

Section 7.1 describes the format and components of the functional test cases. Each functional test case was designed to assess the capability of the example implementations.

7.1 MFA Functional Tests

This section includes the test cases necessary to conduct the functional evaluation of the MFA example implementations. Refer to Section 4 for descriptions of the tested example implementations.

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

Table 7-1 Test Case Fields

Test Case Field	Description
Parent Requirement	Identifies the top-level requirement, or the series of top-level requirements, leading to the testable requirement.
Testable Requirement	Guides the definition of the remainder of the test case fields. Specifies the capability to be evaluated.
Description	Describes the objective of the test case.
Associated Test Cases	In some instances, a test case may be based on the outcome of (an)other test case(s). For example, analysis-based test cases produce a result that is verifiable through various means (e.g., log entries, reports, alerts).
Associated Cybersecurity Framework Subcategories	Lists the Cybersecurity Framework Subcategories addressed by the test case.
Preconditions	The starting state of the test case. Preconditions indicate various starting state items, such as a specific capability configuration required or specific protocol and content.
Procedure	The step-by-step actions required to implement the test case. A procedure may consist of a single sequence of steps or multiple sequences of steps (with delineation) to indicate variations in the test procedure.
Expected Results	the expected results for each variation in the test procedure

Test Case Field	Description
Actual Results	the observed results
Overall Results	The overall result of the test as pass/fail. In some test case instances, determination of the overall result may be more involved, such as determining pass/fail based on a percentage of errors identified.

7.1.1 MFA Use Case Requirements

Table 7-2 identifies the MFA functional analysis requirements that are addressed in the associated requirements and test cases.

Table 7-2 Functional Analysis Requirements

Capability Requirement (CR) ID	Parent Requirement	Subrequirement 1	Subrequirement 2	Test Case
CR 1	The MFA example implementations shall determine if a purchase does not require U2F authentication for the *cost threshold* and *risk engine* example lab builds.			MFA-1
CR 1.a		RSA, StrongKey, and Magento, with the authenticator contained in CR 1.a.1		MFA-1
CR 1.a.1			Customer ID and password	MFA-1
CR 2	The MFA example implementations shall determine if a purchase requires U2F authentication for			MFA-2

Capability Requirement (CR) ID	Parent Requirement	Subrequirement 1	Subrequirement 2	Test Case
	the *cost threshold* and *risk engine* example lab builds.			
CR 2.a		RSA, StrongKey, and Magento, with the authenticator contained in CR 2.a.1		MFA-2
CR 2.a.1			Yubico	MFA-2
CR 3	The MFA example implementations shall detect failed login attempts by a purchaser's account for the *cost threshold* and *risk engine* example lab builds.			MFA-3
CR 3.a		Splunk Enterprise and Magento, with the authenticator contained in CR 3.a.1		MFA-3
CR 3.a.1			Customer ID and password	MFA-3
CR 4	The MFA example implementations shall lock a purchaser's account upon detection of that account exceeding a predetermined number of failed login attempts for the *cost threshold* and *risk engine* example lab builds.			MFA-4

Capability Requirement (CR) ID	Parent Requirement	Subrequirement 1	Subrequirement 2	Test Case
CR 4.a		Magento, with the authenticator contained in CR 4.a.1		MFA-4
CR 4.a.1			Customer ID and password	MFA-4
CR 5	The MFA example implementations shall strongly authenticate retailer e-commerce platform administrators before the administrators perform administration activities.			MFA-5
CR 5.a		Magento and TokenOne, with the authenticator contained in CR 5.a.1		MFA-5
CR 5.a.1			TokenOne Authenticator	MFA-5

7.1.2 Test Case MFA-1 (MFA Not Required)

Table 7-3 contains test case requirements, associated test cases, and descriptions of the test scenarios for the MFA capabilities of the example implementations.

Table 7-3 Test Case MFA-1 (MFA Not Required)

Test Case Field	Description
Parent Requirement	(CR 1) The MFA example implementations shall determine if a purchase does not require a U2F mechanism for the *cost threshold* and *risk engine* example lab builds.

Test Case Field	Description
Testable Requirement	(CR 1.a) RSA, StrongKey, and Magento (CR 1.a.1) Using customer ID and password
Description	Show that the MFA example implementation can determine that a purchase is lower risk and therefore does not require additional U2F authentication.
Associated Test Cases	CR 1
Associated Cybersecurity Framework Subcategories	ID.RA-4, ID.RA-5, PR.AC-7
Preconditions	(CR 1.a) RSA, StrongKey, and Magento capabilities are implemented and operational in the lab environment. Yubico FIDO U2F authenticator is registered to a purchaser account on the e-commerce platform. The purchase dollar-amount threshold has been set to determine when U2F authentication is activated.
Procedure	The returning purchaser logs into the e-commerce platform's website with their customer ID and password and initiates and completes a lower-risk purchase that does not require U2F use by the returning purchaser.
Expected Results	(CR 1) The MFA example implementation determines that U2F authentication is not needed. (CR 1.a) U2F authentication with Yubico (CR 1.a.1) is not activated because the purchase dollar-amount is below the set threshold.
Actual Results	The returning purchaser logged into their account by using their customer ID and password, placed items totaling $25 or less (for the *cost threshold* build) or $50 or less (for the *risk engine* build) into the shopping cart, and then completed their shopping purchase.

Test Case Field	Description
Overall Results	The returning purchaser was able to complete their lower-risk purchase with only their customer ID and password.

7.1.3 Test Case MFA-2 (MFA Required)

Table 7-4 contains test case requirements, associated test cases, and descriptions of the test scenarios for the MFA capabilities of the example implementations.

Table 7-4 Test Case MFA-2 (MFA Required)

Test Case Field	Description
Parent Requirement	(CR 2) The MFA example implementations shall determine if a purchase requires U2F authentication for the *cost threshold* and *risk engine* example lab builds.
Testable Requirement	(CR 2.a) RSA, StrongKey, and Magento (CR 2.a.1) Yubico
Description	Show that the MFA example implementation can determine that a shopping session exceeds organizational risk tolerance, and therefore the transaction requires the successful use of U2F authentication for the shopping transaction to be completed.
Associated Test Cases	CR 2
Associated Cybersecurity Framework Subcategories	ID.RA-4, ID.RA-5, PR.AC-7
Preconditions	(CR 2.a) Reuse RSA, StrongKey, and Magento capabilities in the state after MFA-1 is completed
Procedure	The returning purchaser logs onto the website and initiates and completes an increased-risk purchase that would require the returning purchaser to use U2F.

Test Case Field	Description
Expected Results	(CR 2) The MFA example implementation determines that U2F authentication is needed. (CR 2.a) U2F authentication with Yubico (CR 2.a.1) is activated because the purchase dollar-amount is above the thresholds that trigger an MFA response. The online shopping transaction does not proceed to completion without the returning purchaser's successful use of the U2F authenticator.
Actual Results	The returning purchaser logged into their account with their customer ID and password, placed items greater than $25 (for the *cost threshold* build) or greater than $50 (for the *risk engine* build) into the shopping cart, and then completed the shopping purchase by using the U2F authenticator when prompted. The shopping session would not continue without the U2F authenticator being successfully activated.
Overall Results	The returning purchaser was able to complete their increased-risk purchase with U2F.

7.1.4 Test Case MFA-3 (Failed Login Attempts Detected)

Table 7-5 contains test case requirements, associated test cases, and descriptions of the test scenarios for the failed-login-attempt detection capabilities of the example implementations.

Table 7-5 Test Case MFA-3 (Failed Login Attempts Detected)

Test Case Field	Description
Parent Requirement	(CR 3) The MFA example implementation shall detect failed login attempts by a purchaser's account for the *cost threshold* and *risk engine* example lab builds.
Testable Requirement	(CR 3.a) Splunk Enterprise and Magento
Description	Show that the MFA example implementation can detect and demonstrate in a dashboard the customer ID and password's failed login attempts.

Test Case Field	Description
Associated Test Cases	CR 2
Associated Cybersecurity Framework Subcategories	DE.CM-1, PR.AC-1, PR.AC-7, RS.AN-1
Preconditions	Reuse MFA example implementation in the state after MFA-2 is completed.
Procedure	An automated logging and reporting dashboard capability is built. It identifies and displays failed purchaser-authentication attempts.
Expected Results	(CR 3, CR 3.a) The logging and reporting dashboard capability identifies and displays failed purchaser-account-authentication attempts. (CR 3.a.1) The account is identified by the customer ID and password.
Actual Results	The automated logging and reporting dashboard displayed failed purchaser-authentication attempts.
Overall Results	The automated logging and reporting dashboard displayed a historical display of failed purchaser-authentication attempts.

7.1.5 Test Case MFA-4 (Accounts Automatically Locked After Failed Login Attempts)

Table 7-6 contains test case requirements, associated test cases, and descriptions of the test scenarios for the automatic account lockout capabilities of the example implementations.

Table 7-6 Test Case MFA-4 (Accounts Automatically Locked After Failed Login Attempts)

Test Case Field	Description
Parent Requirement	(CR 4) The MFA example implementation shall lock a purchaser's account upon detection of that account exceeding a predetermined number of failed login attempts for the *cost threshold* and *risk engine* example lab builds.

Test Case Field	Description
Testable Requirement	(CR 4.a) Magento
Description	Show that the MFA example implementation can lock a purchaser account if the allowed number of customer ID and password-authentication attempts is exceeded.
Associated Test Cases	CR 3
Associated Cybersecurity Framework Subcategories	DE.CM-1, PR.AC-1
Preconditions	Reuse MFA example implementation in the state after MFA-3 is completed.
Procedure	After the failed authentication limit has been met, the purchaser account is locked out.
Expected Results	(CR 4, CR 4.a, CR 4.a.1) The returning purchaser account is locked, and the purchaser is unable to log into the account after the threshold limit for failed authentications is met for an amount of time determined by the organization.
Actual Results	The failed authentication attempts were made until the previously identified threshold was met, at which time the account was locked for a previously identified amount of time (in this case, 20 minutes).
Overall Results	The returning purchaser's account was locked out for a previously determined amount of time before the account could be used again.

7.1.6 Test Case MFA-5 (System Administrator MFA)

Table 7-7 contains test case requirements, associated test cases, and descriptions of the test scenarios for the e-commerce platform system administrator MFA capabilities of the example implementations.

Table 7-7 Test Case MFA-5 (System Administrator MFA)

Test Case Field	Description
Parent Requirement	(CR 5) The MFA example implementations shall strongly authenticate e-commerce platform administrators before the administrators perform administration activities.
Testable Requirement	(CR 5.a) Magento and TokenOne
Description	Show that the MFA example implementation requires the e-commerce platform administrator to authenticate with TokenOne before logging in and performing administration.
Associated Test Cases	None applicable
Associated Cybersecurity Framework Subcategories	ID.RA-4, PR.AC-7
Preconditions	Reuse MFA example implementation in the state after MFA-1 is completed.
Procedure	Attach to the Magento e-commerce platform and attempt to log in. Provide account and authentication information as prompted.
Expected Results	(CR 5, CR 5.a, CR 5.a.1) The e-commerce platform administrator must authenticate by using their TokenOne authenticator before administering the platform.
Actual Results	The e-commerce platform administrator was prompted for their TokenOne multifactor authenticator before being able to manage the platform.
Overall Results	When the e-commerce platform administrator used their TokenOne authenticator, they were able to manage the Magento e-commerce platform. When the e-commerce administrator did not provide their TokenOne credentials, their account was denied access to the Magento e-commerce platform.

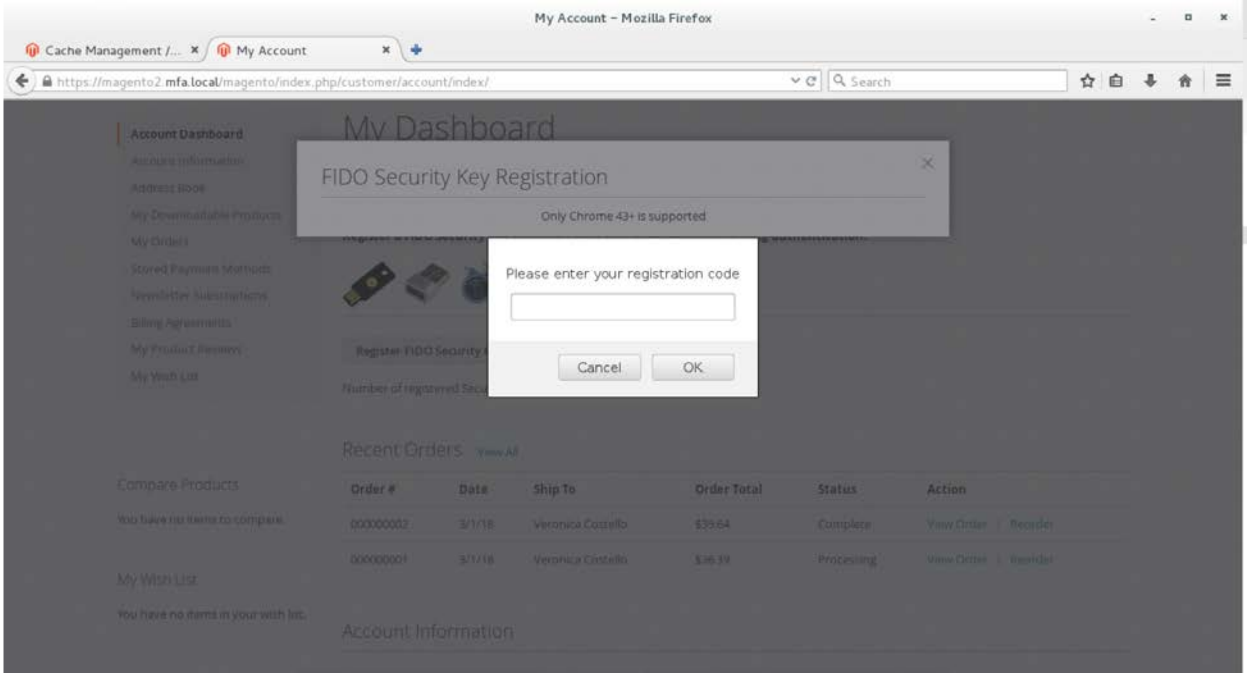
8 Future Build Considerations

Authentication technologies, such as MFA, are continuously evolving. Additional future build considerations may include the topics described in this section.

8.1 FIDO Key Registration Enhancements

Additional future build considerations include securing the FIDO key registration process with a PIN. The PIN would be sent to the customer's registered email account. The customer would then enter the registration-code PIN received in the email, as displayed on the screen shown in Figure 8-1, before being allowed to register a FIDO authenticator.

Figure 8-1 FIDO Authenticator Registration Confirmation PIN



My Account – Mozilla Firefox

https://magento2.mfa.local/magento/index.php/customer/account/index/

My Dashboard

FIDO Security Key Registration

Only Chrome 43+ is supported

Please enter your registration code

Cancel OK

8.2 IP Address as a Risk Factor

Another future build consideration would be to add the IP address as a factor that is analyzed to trigger the need for MFA in the *cost threshold* example implementation. Currently, the *cost threshold* example implementation examines the dollar amount in the shopping cart when determining whether MFA is needed. An e-commerce transaction's originating IP address can be an indicator of increased risk [34]. Adding the IP address as a factor that is analyzed during an e-commerce transaction might appeal to those who are considering the *cost threshold* example implementation and who require more risk factors to be addressed.

Appendix A Mapping to Cybersecurity Framework

Table A-1 maps National Institute of Standards and Technology (NIST) and consensus security references to the NIST Cybersecurity Framework Subcategories and International Organization for Standardization (ISO), International Electrotechnical Commission (IEC) 27001:2013 mappings that are addressed in this practice guide. Additionally, from NIST Special Publication (SP) 800-181, *National Initiative for Cybersecurity Education (NICE) Cybersecurity Workforce Framework* [18], work roles are identified so that organizations may understand the work roles that are typically used by those implementing the capabilities contained in this practice guide.

Table A-1 Multifactor Authentication for E-Commerce Cybersecurity Framework Components Mapping

Cybersecurity Framework v1.1			Standards and Best Practices Alignment		
Function	**Category**	**Subcategory**	**NIST SP 800-53 Rev. 4 Security and Privacy Controls**	**ISO/IEC 27001:2013**	**NIST SP 800-181, NICE Framework Work Roles**
IDENTIFY (ID)	Risk Assessment (ID.RA)	ID.RA-4: Potential business impacts and likelihoods are identified.	RA-2: Security Categorization RA-3: Risk Assessment PM-9: Risk Management Strategy PM-11: Mission/Business Process Definition SA-14: Criticality Analysis	ISO/IEC N/A	AN-TWA-001 Threat/Warning Analyst OM-ANA-001 Systems Security Analyst PR-CDA-001 Cyber Defense Analyst OV-MGT-001 Information Systems Security Manager
		ID.RA-5: Threats, vulnerabilities, likelihoods, and impacts are used to determine risk.	RA-2: Security Categorization RA-3: Risk Assessment PM-16: Threat Awareness Program	A.12.6.1	AN-TWA-001 Threat/Warning Analyst PR-CDA-001 Cyber Defense Analyst OV-MGT-001 Information Systems Security Manager

Cybersecurity Framework v1.1			Standards and Best Practices Alignment		
Function	Category	Subcategory	NIST SP 800-53 Rev. 4 Security and Privacy Controls	ISO/IEC 27001:2013	NIST SP 800-181, NICE Framework Work Roles
PROTECT (PR)	Identity Management, Authentication, and Access Control (PR.AC)	PR.AC-1: Identities and credentials are issued, managed, verified, revoked, and audited for authorized devices, users, and processes.	AC-1: Access Control Policy and Procedures AC-2: Account Management IA-1: Identification and Authentication Policy and Procedures IA-2: Identification and Authentication (Organizational Users) IA-3: Device Identification and Authentication IA-4: Identifier Management IA-5: Authenticator Management IA-6: Authenticator Feedback IA-7: Cryptographic Module Authentication IA-8: Identification and Authentication (Nonorganizational Users) IA-9: Service Identification and Authentication IA-10: Adaptive Identification and Authentication	A.9.2.1, A.9.2.2, A.9.2.3, A.9.2.4, A.9.2.6, A.9.3.1, A.9.4.2, A.9.4.3	OM-ANA-001 Systems Security Analyst PR-CDA-001 Cyber Defense Analyst OM-ADM-001 System Administrator OV-PMA-003 Product Support Manager SP-DEV-001 Software Developer

Cybersecurity Framework v1.1			Standards and Best Practices Alignment		
Function	**Category**	**Subcategory**	**NIST SP 800-53 Rev. 4 Security and Privacy Controls**	**ISO/IEC 27001:2013**	**NIST SP 800-181, NICE Framework Work Roles**
			IA-11: Reauthentication		
		PR.AC-7: Users, devices, and other assets are authenticated (e.g., single factor, multifactor) commensurate with the risk of the transaction (e.g., individuals' security and privacy risks and other organizational risks).	AC-7: Unsuccessful Logon Attempts AC-8: System Use Notification AC-9: Previous Logon (Access) Notification AC-11: Session Lock AC-12: Session Termination AC-14: Permitted Actions Without Identification or Authentication IA-1: Identification and Authentication Policy and Procedures IA-2: Identification and Authentication (Organizational Users) IA-3: Device Identification and Authentication IA-4: Identifier Management IA-5: Authenticator Management IA-8: Identification and Authentication	A.9.2.1, A.9.2.4, A.9.3.1, A.9.4.2, A.9.4.3, A.18.1.4	OM-ANA-001 Systems Security Analyst PR-CDA-001 Cyber Defense Analyst OM-ADM-001 System Administrator OV-PMA-003 Product Support Manager SP-DEV-001 Software Developer

Cybersecurity Framework v1.1			Standards and Best Practices Alignment		
Function	Category	Subcategory	NIST SP 800-53 Rev. 4 Security and Privacy Controls	ISO/IEC 27001:2013	NIST SP 800-181, NICE Framework Work Roles
			(Nonorganizational Users) IA-9: Service Identification and Authentication IA-10: Adaptive Identification and Authentication IA-11: Reauthentication		
DETECT (DE)	Security Continuous Monitoring (DE.CM)	DE.CM-1: The network is monitored to detect potential cybersecurity events.	AC-2: Account Management AU-12: Audit Generation CA-7: Continuous Monitoring CM-3: Configuration Change Control SC-5: Denial of Service Protection SC-7: Boundary Protection SI-4: Information System Monitoring	ISO/IEC N/A	PR-CDA-001 Cyber Defense Analyst

Cybersecurity Framework v1.1			Standards and Best Practices Alignment		
Function	**Category**	**Subcategory**	**NIST SP 800-53 Rev. 4 Security and Privacy Controls**	**ISO/IEC 27001:2013**	**NIST SP 800-181, NICE Framework Work Roles**
RESPOND (RS)	Analysis (RS.AN)	RS.AN-1: Notifications from detection systems are investigated.	AU-6: Audit Review, Analysis, and Reporting CA-7: Continuous Monitoring IR-4: Incident Handling IR-5: Incident Reporting PE-6: Monitoring Physical Access SI-4: Information System Monitoring	A.12.4.1, A.12.4.3, A.16.1.5	PR-CDA-001 Cyber Defense Analyst PR-CIR-001 Cyber Defense Incident Responder IN-FOR-002 Cyber Defense Forensics Analyst

Appendix B Assumptions

This project is guided by the assumptions described in the following subsections. Implementers are advised to consider whether the same assumptions can be made based on current policy, process, and information-technology infrastructure. Where applicable, appropriate guidance is provided to assist implementation.

B.1 Availability of Skills

An organization has a workforce able to implement the multifactor authentication (MFA) capabilities described in this practice guide. Work roles in the National Initiative for Cybersecurity Education (NICE) Cybersecurity Workforce Framework [18] are identified in Appendix A to assist organizations to see which work roles perform the tasks necessary to implement the capabilities contained in this practice guide. A NICE Framework work role is composed of specific knowledge, skills, and abilities required to perform tasks in that work role.

B.2 Uniqueness of Lab Environment

The example implementations were developed in a lab environment. They do not reflect the complexity of a production environment, and production deployment processes were not used. Before production deployment, it should be confirmed that the example implementation capabilities meet the organization’s architecture, reliability, and scalability requirements.

B.3 MFA Decreases Account Takeover Opportunities

Using customer identification (ID) and password alone for authentication provides increased opportunities for account takeover, compared with the additional use of MFA.

B.4 Web Browser and Returning Purchaser Accounts

A web browser, not a mobile application, was used to make the purchase from the electronic commerce (e-commerce) platform’s website. A returning purchaser had an account with the online retailer.

B.5 Support of MFA Devices

The purchaser expects the retailer to be committed to the continued use and support of Universal Second Factor (U2F) because the returning purchaser has invested time and/or expense in obtaining the authenticator device.

B.6 Customer Support Mechanisms for Lost Tokens

The retailer has established customer support mechanisms for lost U2F authenticators. This could include the ability to determine that the person calling their customer assistance line is the actual returning purchaser.

Appendix C Common Vulnerabilities and Exposures

To understand and mitigate security issues associated with architecture components, the Common Vulnerabilities and Exposures (CVE) database [35] was searched for security issues associated with the example build components.

A search of the collaborating vendors' products used in the example implementations was performed on March 15, 2018, which led to discovery of a single CVE vulnerability that applied to the example implementations. As reported in the online CVE database, the product has since been patched in an update. The example implementations froze version numbers in the example lab builds before the product patch was released.

Automated alerts can be subscribed to via the United States Computer Emergency Readiness Team to keep up-to-date on current security issues and vulnerabilities [36].

Appendix D List of Acronyms

AAL	Authenticator Assurance Level
CNP	Card Not Present
COI	Community of Interest
CR	Capability Requirement
CVE	Common Vulnerabilities and Exposures
e-commerce	Electronic Commerce
FAL	Federation Assurance Level
FIDO	Fast IDentity Online
IAL	Identity Assurance Level
ID	Identification
IDESG	Identity Ecosystem Steering Group
IP	Internet Protocol
ISO/IEC	International Organization for Standardization/International Electrotechnical Commission
IT	Information Technology
MFA	Multifactor Authentication
NCCoE	National Cybersecurity Center of Excellence
NICE	National Initiative for Cybersecurity Education
NIST	National Institute of Standards and Technology
PCI	Payment Card Industry
PIN	Personal Identification Number
SKCE	StrongKey CryptoEngine
SP	Special Publication
U.S.	United States
U2F	Universal Second Factor

USB	Universal Serial Bus
US-CERT	United States Computer Emergency Readiness Team

Appendix E Glossary

Authentication

Verifying the identity of a user, process, or device, often as a prerequisite to allowing access to a system's resources [12]

Authentication Factor

The three types of authentication factors are *something you know*, *something you have*, and *something you are*. Every authenticator has one or more authentication factors [12].

Authenticator

Something the claimant possesses and controls (typically a cryptographic module or password) that is used to authenticate the claimant's identity [12]

Authenticator Assurance Level (AAL)

A category describing the strength of the authentication process [12]

Credential

An object or data structure that authoritatively binds an identity—via an identifier or identifiers–and (optionally) additional attributes to at least one authenticator possessed and controlled by a subscriber

While common usage often assumes that the subscriber maintains the credential, these guidelines also use the term to refer to electronic records maintained by the Credential Service Providers that establish binding between the subscriber's authenticator(s) and identity [12].

Federation Assurance Level (FAL)

A category describing the assertion protocol used by the federation to communicate authentication and attribute information (if applicable) to a relying party [12]

Identity

An attribute or set of attributes that uniquely describe a subject within a given context [12]

Identity Assurance Level (IAL)

A category that conveys the degree of confidence that the applicant's claimed identity is their real identity [12]

Identity Fraud and Identity Theft

Identity theft and identity fraud are terms used to refer to all types of crime in which someone wrongfully obtains and uses another person's personal data in some way that involves fraud or deception, typically for economic gain [37]

Multifactor

A characteristic of an authentication system or an authenticator that requires more than one distinct authentication factor for successful authentication. MFA can be performed using a single authenticator that provides more than one factor or by a combination of authenticators that provide different factors. The three authentication factors are something you know, something you have, and something you are [12].

Multifactor Authentication (MFA)

An authentication system that requires more than one distinct authentication factor for successful authentication. Multifactor authentication can be performed using a multifactor authenticator or by a combination of authenticators that provide different factors. The three authentication factors are something you know, something you have, and something you are [12].

Multifactor Authenticator

An authenticator that provides more than one distinct authentication factor, such as a cryptographic authentication device with an integrated biometric sensor that is required to activate the device [12]

Personal Identification Number (PIN)

A memorized secret typically consisting of only decimal digits [12]

Phishing

An attack in which the subscriber is lured (usually through an email) to interact with a counterfeit verifier or relying party and tricked into revealing information that can be used to masquerade as that subscriber to the real verifier or relying party [12]

Private Key

The secret part of an asymmetric key pair that is used to digitally sign or decrypt data [12]

Public Key

The public part of an asymmetric key pair that is used to verify signatures or encrypt data [12]

Public Key Certificate

A digital document issued and digitally signed by the private key of a certificate authority that binds an identifier to a subscriber to a public key. The certificate indicates that the subscriber identified in the certificate has sole control and access to the private key. See also Request for Comment 5280 [12].

Relying Party

An entity that relies upon the subscriber’s authenticator(s) and credentials or a verifier’s assertion of a claimant’s identity, typically to process a transaction or grant access to information or a system [12]

Risk

A measure of the extent to which an entity is threatened by a potential circumstance or event, and typically a function of (i) the adverse impacts that would arise if the circumstance or event occurs and (ii) the likelihood of occurrence [9]

Session

A persistent interaction between a subscriber and an end point, either a relying party or a Credential Service Provider. A session begins with an authentication event and ends with a session termination event. A session is bound by use of a session secret that the subscriber's software (a browser, application, or operating system) can present to the relying party or the Credential Service Provider in lieu of the subscriber's authentication credentials [12].

Single Factor

A characteristic of an authentication system or an authenticator that requires only one authentication factor (something you know, something you have, or something you are) for successful authentication [12]

Subscriber

A party who has received a credential or authenticator from a Credential Service Provider [12]

Threat

An event or condition that has the potential for causing asset loss and the undesirable consequences or impact from such loss [17]

Token

See Authenticator [12]

Transaction

A discrete event between a user and a system that supports a business or programmatic purpose. A government digital system may have multiple categories or types of transactions, which may require separate analysis within the overall digital identity risk assessment [12].

Verifier

An entity that verifies the claimant's identity by verifying the claimant's possession and control of one or two authenticators using an authentication protocol. To do this, the verifier may also need to validate credentials that link the authenticator(s) to the subscriber's identifier and check their status [12].

Vulnerability

Weakness in a system, system security procedures, internal controls, or implementation that could be exploited or triggered by a threat [17]

Appendix F References

[1] U.S. Department of Treasury, Bureau of the Fiscal Service. Europay, Mastercard & Visa (EMV) [Online]. Available: https://fiscal.treasury.gov/cas/europay-mastercard-and-visa.html.

[2] FIDO Alliance. (n.d.). *What is FIDO?* [Online]. Available: https://fidoalliance.org/about/what-is-fido/.

[3] FIDO Alliance. (n.d.). *Specifications Overview* [Online]. Available: https://fidoalliance.org/specifications/overview/.

[4] FIDO Alliance. (n.d.). [Online]. Available: https://fidoalliance.org/.

[5] FIDO Alliance. (n.d.). *FIDO® Certified* [Online]. Available: https://fidoalliance.org/certification/fido-certified-products/.

[6] Splunk Inc. (n.d.). [Online]. Available: https://www.splunk.com/.

[7] International Organization for Standardization (ISO)/International Electrotechnical Commission (IEC). (Oct. 2013). *ISO/IEC 27001:2013: Information technology–Security techniques–Information security management systems–Requirements* [Online]. Available: https://www.iso.org/standard/54534.html.

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

[9] NIST Special Publication (SP) 800-30 Rev. 1, *Guide for Conducting Risk Assessments.* (Sept. 2012). [Online]. Available: https://csrc.nist.gov/publications/detail/sp/800-30/rev-1/final.

[10] NIST SP 800-37 Rev. 1, *Guide for Applying the Risk Management Framework to Federal Information Systems: a Security Life Cycle Approach.* (June 5, 2014). [Online]. Available: https://csrc.nist.gov/publications/detail/sp/800-37/rev-1/final.

[11] NIST SP 800-53 Rev. 4, *Security and Privacy Controls for Federal Information Systems and Organizations.* (Apr. 2013). [Online]. Available: https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.800-53r4.pdf.

[12] NIST SP 800-63-3, *Digital Identity Guidelines.* (June 2017). [Online]. Available: https://pages.nist.gov/800-63-3/.

[13] NIST SP 800-63A, *Digital Identity Guidelines, Enrollment and Identity Proofing.* (June 2017). [Online]. Available: https://pages.nist.gov/800-63-3/.

[14] NIST SP 800-63B, *Digital Identity Guidelines, Authentication and Lifecycle Management.* (June 2017). [Online]. Available: https://pages.nist.gov/800-63-3/.

[15] NIST SP 800-63C, *Digital Identity Guidelines, Federation and Assertions.* (June 2017). [Online]. Available: https://pages.nist.gov/800-63-3/.

[16] NIST SP 800-73-4, *Interfaces for Personal Identity Verification–Part 1: PIV Card Application Namespace, Data Model and Representation.* (May 2015). [Online]. Available: https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.800-73-4.pdf.

[17] NIST SP 800-160 Vol. 1, *Systems Security Engineering: Considerations for a Multidisciplinary Approach in the Engineering of Trustworthy Secure Systems.* (Mar. 21, 2018). [Online]. Available: https://csrc.nist.gov/publications/detail/sp/800-160/vol-1/final.

[18] NIST SP 800-181, *National Initiative for Cybersecurity Education (NICE) Cybersecurity Workforce Framework.* (Aug. 2017). [Online]. Available: https://www.nist.gov/itl/applied-cybersecurity/national-initiative-cybersecurity-education-nice/nice-cybersecurity.

[19] PCI Security Standards Council, LLC. (n.d.). Document Library [Online]. Available: https://www.pcisecuritystandards.org/document_library?category=pcidss&document=pci_dss.

[20] Identity Ecosystem Steering Group, Inc. (n.d.). The Identity Ecosystem Steering Group (IDESG) [Online]. Available: https://www.idesg.org/.

[21] Retail and Hospitality Information Sharing and Analysis Center (RH-ISAC). (n.d.). *RH-ISAC* [Online]. Available: https://rhisac.org/.

[22] Open Web Application Security Project. (Feb. 23, 2015). *Credential stuffing* [Online]. Available: https://www.owasp.org/index.php/Credential_stuffing.

[23] Shape Security, Inc. (Jan. 2017). *2017 Credential Spill Report* [Online]. Available: http://info.shapesecurity.com/2017-Credential-Spill-Report.html.

[24] Magento, Inc. (n.d.). *eCommerce Platform|Best eCommerce Software for Selling Online* [Online]. Available: https://magento.com/.

[25] A. Noor and A. de Leon. SourceForge. (Feb. 20, 2018). *FIDO U2F Integration for Magento 2* [Online]. Available: https://sourceforge.net/projects/magfido/?source=navbar.

[26] StrongKey. (n.d.). Home–StrongKey [Online]. Available: https://www.strongkey.com/.

[27] RSA Security LLC. (n.d.). *Adaptive Authentication|Fraud Detection–RSA* [Online]. Available: https://www.rsa.com/en-us/products/fraud-prevention/secure-consumer-access.

[28] TokenOne. (n.d.). *TokenOne|Secure Authentication|Sydney* [Online]. Available: https://www.tokenone.com.

[29] Yubico. (n.d.). *Yubico|YubiKey Strong Two Factor Authentication for Business and Individual Use* [Online]. Available: https://www.yubico.com/.

[30] A. Noor et al. (July 3, 2018). SourceForge. *FIDO strong authentication, encryption, digital signature engine* [Online]. Available: https://sourceforge.net/projects/skce/.

[31] PCI Security Standards Council, LLC. (May 2015). *PCI DSS Quick Reference Guide: Understanding the Payment Card Industry Data Security Standard version 3.2* [Online]. Available: https://www.pcisecuritystandards.org/document_library?category=pcidss&document=pci_dss.

[32] Magento, Inc. (n.d.). Security Center [Online]. Available: https://magento.com/security.

[33] ISO/IEC/Institute of Electrical and Electronics Engineers (IEEE). (May 2015). *ISO/IEC/IEEE 15288:2015: Systems and software engineering–System life cycle processes* [Online]. Available: https://www.iso.org/standard/63711.html.

[34] M. Tatham. (Apr. 13, 2018). Experian. *Russian Hackers Aren't the Only Ones to Worry About: Online Shopping Fraud Report* [Online]. Available: https://www.experian.com/blogs/ask-experian/the-state-of-online-shopping-fraud/.

[35] The MITRE Corporation. (n.d.). *CVE–Common Vulnerabilities and Exposures (CVE)* [Online]. Available: https://cve.mitre.org/.

[36] United States Computer Emergency Readiness Team (US-CERT). (n.d.). *Alerts* [Online]. Available: https://www.us-cert.gov/ncas/alerts.

[37] United States Department of Justice. (Feb. 7, 2017). *Identity Theft* [Online]. Available: https://www.justice.gov/criminal-fraud/identity-theft/identity-theft-and-identity-fraud.

NIST SPECIAL PUBLICATION 1800-17C

Multifactor Authentication for E-Commerce

Risk-Based, FIDO Universal Second Factor Implementations for Purchasers

Volume C:
How-To Guides

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National Institute of Standards and Technology
U.S. Department of Commerce

NCCoE
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FEEDBACK

As a public-private partnership, we are always seeking feedback on our practice guides. We are particularly interested in seeing how businesses apply NCCoE reference designs in the real world. If you have implemented the reference design, or have a question about applying it in your environment, please email us at consumer-nccoe@nist.gov.

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NATIONAL CYBERSECURITY CENTER OF EXCELLENCE

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

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NIST CYBERSECURITY PRACTICE GUIDES

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

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

ABSTRACT

As retailers in the United States have adopted chip-and-signature and chip-and-PIN (personal identification number) point-of-sale (POS) security measures, there have been increases in fraudulent online card-not-present electronic commerce (e-commerce) transactions. The risk of increased fraudulent online shopping became more widely known following the adoption of chip-and-PIN technology that increased security at the POS in Europe.

The NCCoE at NIST built a laboratory environment to explore methods to implement multifactor authentication (MFA) for online retail environments for the consumer and the e-commerce platform

administrator. The NCCoE also implemented logging and reporting to display authentication-related system activity.

This NIST Cybersecurity Practice Guide demonstrates to online retailers that it is possible to implement open standards-based technologies to enable Universal Second Factor (U2F) authentication at the time of purchase when risk thresholds are exceeded.

The example implementations outlined in this guide encourage online retailers to adopt effective MFA implementations by using standard components and custom applications that are composed of open-source and commercially available components.

KEYWORDS

electronic commerce (e-commerce) security; internet shopping security; multifactor authentication (MFA)

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Adam Cohn	Splunk
Arshad Noor	StrongKey
Kamil Kreiser	TokenOne
Derek Hanson	Yubico
David Coley	Dominion Tea
Brian Abe	The MITRE Corporation
Lorrayne Auld	The MITRE Corporation

Name	Organization
Lura Danley	The MITRE Corporation
Sallie Edwards	The MITRE Corporation
Charles Jones, Jr.	The MITRE Corporation
Joshua Klosterman	The MITRE Corporation
Jay Vora	The MITRE Corporation
Mary Yang	The MITRE Corporation

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 these example implementations. We worked with:

Technology Partner/Collaborator	Build Involvement
RSA	RSA Adaptive Authentication (Cloud) Version 13.1
Splunk	• Splunk Enterprise Version 6.6.1 • Splunk DB Connect Version 3.1.2 • Splunk Universal Forwarder Version 7.0.1
StrongKey	• StrongKey CryptoEngine Version 2.0 Open Source Fast IDentity Online (FIDO) U2F server • MagentoFIDO (magfido) 1st Edition Module
TokenOne	TokenOne cloud-based Authentication Version 2.8.5
Yubico	Yubico YubiKey NEO Security Key

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1 Introduction

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

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

1.1 Practice Guide Structure

This National Institute of Standards and Technology (NIST) Cybersecurity Practice Guide demonstrates standards-based reference designs and provides retailers with the information they need to replicate the multifactor authentication (MFA) for electronic commerce (e-commerce) example implementations. These reference designs are modular and can be deployed in whole or in parts.

This guide contains three volumes:

- NIST SP 1800-17A: *Executive Summary*
- NIST SP 1800-17B: *Approach, Architecture, and Security Characteristics* – what we built and why
- NIST SP 1800-17C: *How-To Guides* – instructions for building the example implementations **(you are here)**

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

Business decision makers, including chief security and technology officers, will be interested in the *Executive Summary*, *NIST SP 1800-17A*, which describes the following topics:

- challenges that enterprises face in implementing MFA to reduce online fraud
- example implementations built at the NCCoE
- benefits of adopting one or more of these example implementations

Technology or security program managers who are concerned with how to identify, understand, assess, and mitigate risk will be interested in *NIST SP 1800-17B*, which describes what we did and why. The following sections of Volume B will be of particular interest:

- Section 3.4, Risk Assessment, provides a description of the risk analysis we performed.
- Appendix A, Mapping to Cybersecurity Framework, maps NIST and consensus security references to the Cybersecurity Framework Subcategories that are addressed in this practice guide. Additionally, work roles in NIST SP 800-181, *National Initiative for Cybersecurity Education*

(NICE) Cybersecurity Workforce Framework that perform the tasks necessary to implement those cybersecurity Functions and Subcategories were identified.

You might share the *Executive Summary, NIST SP 1800-17A*, with your leadership team members to help them understand the importance of adopting standards-based solutions when implementing MFA that can increase assurance of who is using the purchaser’s credit card and account information.

IT professionals who want to implement approaches like these will find the whole practice guide useful. You can use the How-To portion of the guide, *NIST SP 1800-17C*, to replicate all or parts of the build created in our lab. This How-To portion of the guide provides specific product installation, configuration, and integration instructions for deploying the example implementations. We do not recreate the product manufacturers’ documentation, which is generally widely available. Rather, we show how we incorporated the products together in our environment to create example implementations.

This guide assumes that IT professionals have experience implementing security products within the enterprise. While we have used a suite of commercial products to address this challenge, this guide does not endorse these particular products. Your organization can adopt these example implementations or one that adheres to these guidelines in whole, or you can use this guide as a starting point for tailoring and implementing parts of these e-commerce fraud-reducing capabilities. Your organization’s security experts should identify the products that will best integrate with your existing tools and IT system infrastructure. We hope that you will seek products that are congruent with applicable standards and best practices. Volume B, Section 3.5, Technologies, lists the products that we used and maps them to the cybersecurity controls provided by the reference implementations.

1.2 Example Builds Overview

The NCCoE at NIST built two example laboratory environments to explore MFA options available to online retailers, which are described in this section.

1.2.1 Usage Scenarios

The example implementations fulfill the use cases of a returning purchaser with established login account credentials with the retailer, and who possesses a Fast IDentity Online (FIDO) Universal Second Factor (U2F) authenticator [1], [2]. The purchaser’s U2F authenticator is used when the retailer system requests additional authentication. This gives the retailer additional assurance that the purchaser is a returning customer when the checkout process occurs in circumstances that exceed the retailer’s risk thresholds. In these NCCoE reference architectures, the risk thresholds that initiate MFA requests are based on the total cost of the shopping-cart transaction or upon input received from the risk engine.

The NCCoE worked with members of the NCCoE Retail Community of Interest to develop a set of use case scenarios to help design and test the reference implementations. For a detailed description of the example builds' architectures and the use cases that they are based upon, reference Sections 4 and 5 in Volume B.

1.2.2 Architectural Overview

The MFA for e-commerce high-level reference architectures illustrated in Figure 1-1 and Figure 1-2 show the *cost threshold* and *risk engine* example implementations, respectively. The high-level reference architectures display the data communication among the returning purchaser, retailer e-commerce platform, risk assessment/MFA module and risk engine, MFA mechanisms, and logging and reporting dashboard.

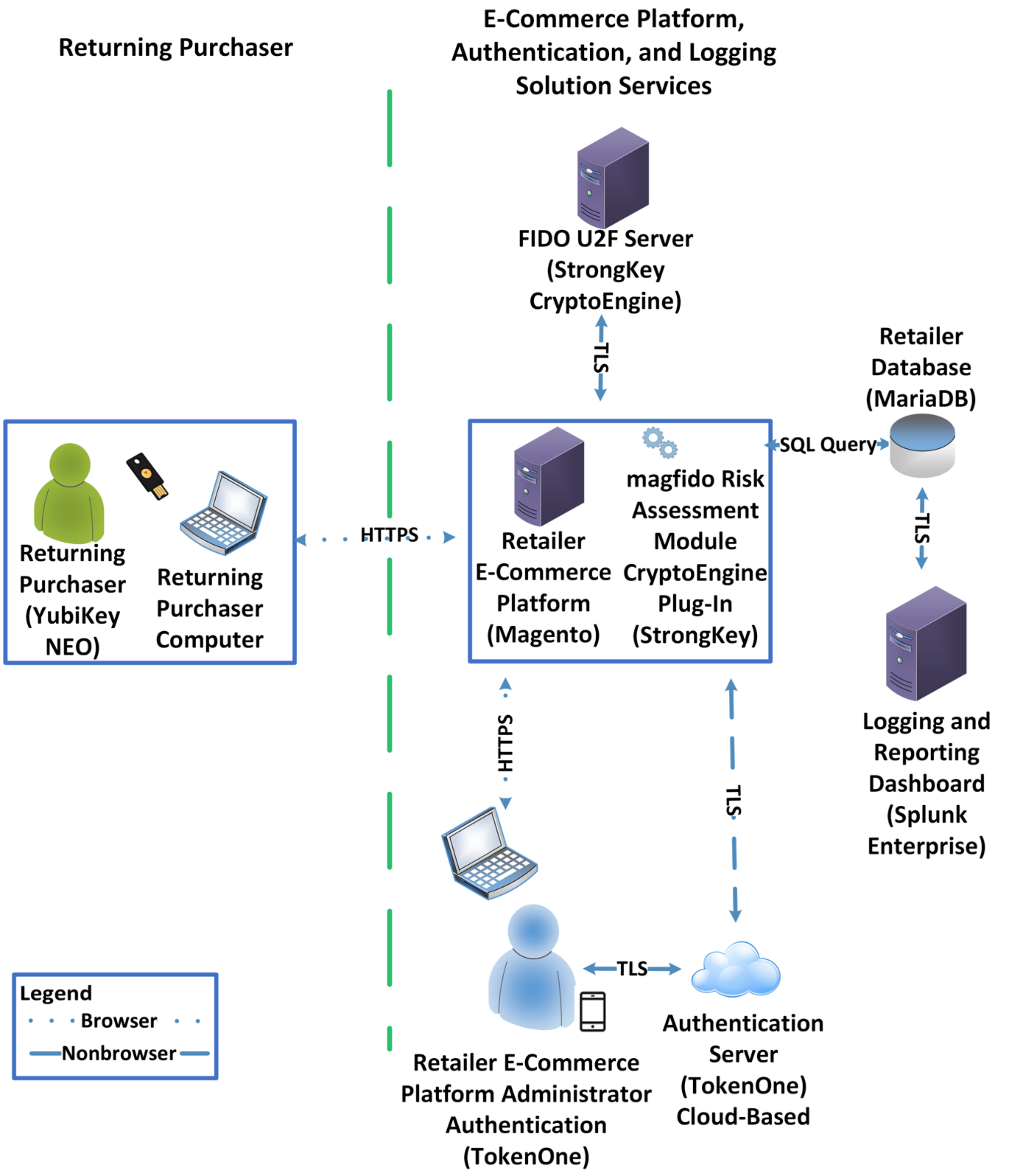
The *cost threshold* example implementation uses a predetermined shopping-cart price threshold to require use of MFA by the returning purchaser. The *risk engine* example implementation uses analytics to determine when MFA is required by the returning purchaser. The two example implementations include e-commerce platform capabilities, risk assessment and MFA, and logging and display capabilities.

The example implementations were constructed on the NCCoE's VMware vSphere virtualization operating environment. Internet access was used to connect to remote cloud-based components, while software components were installed as virtual servers within the vSphere environment.

TokenOne's authentication capability authenticates the Magento e-commerce platform administrator before any administration modifications are made to the e-commerce platform. It is based upon TokenOne's cloud-based authentication infrastructure and a smartphone application on either an Android or iPhone device. This helps secure the overall e-commerce organization's infrastructure.

The lab network that was used to build and configure the example implementations is not connected to the NIST enterprise network.

Figure 1-1 MFA for E-Commerce High-Level Cost Threshold Reference Architecture

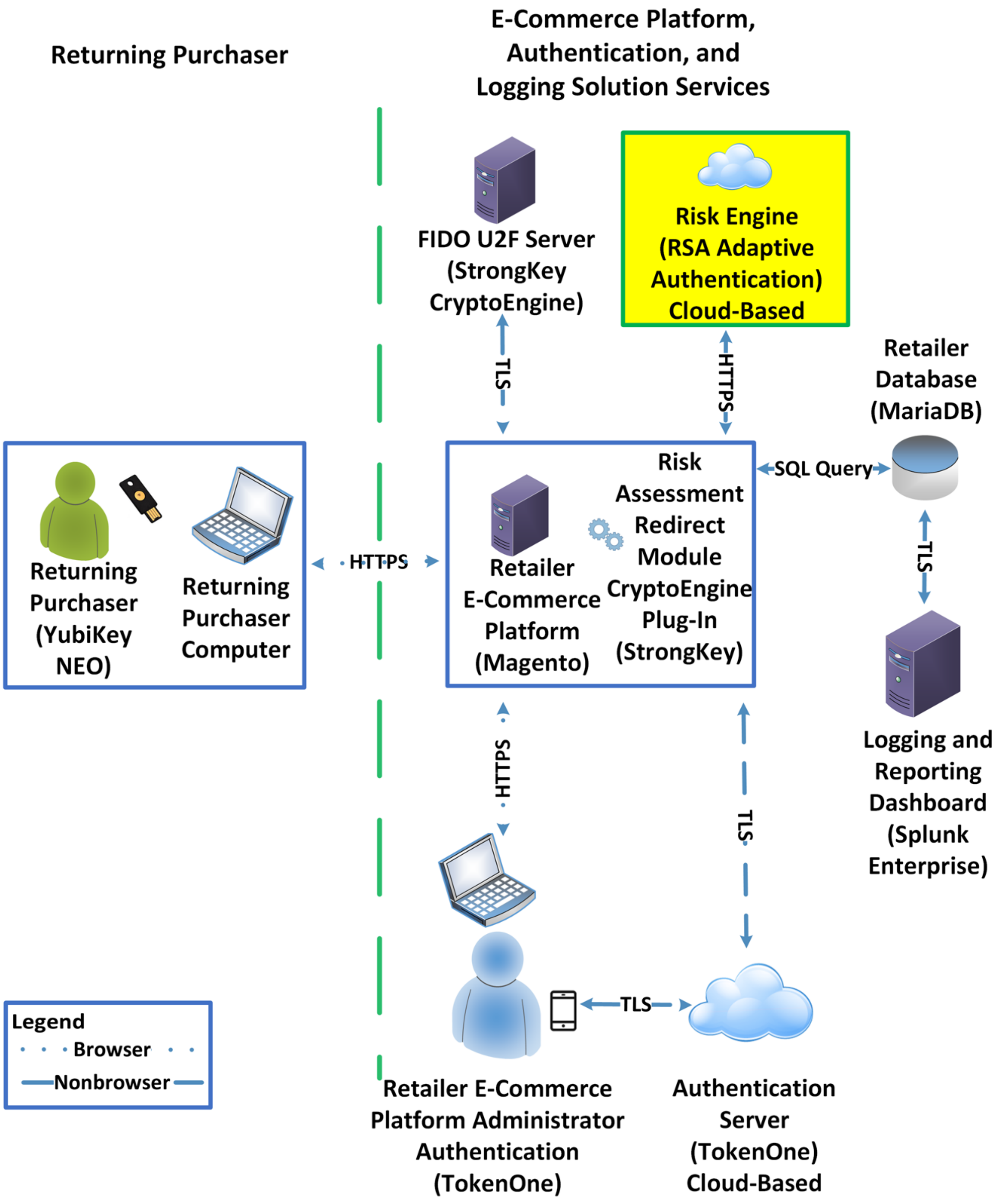

Returning Purchaser
E-Commerce Platform, Authentication, and Logging Solution Services
FIDO U2F Server (StrongKey CryptoEngine)
TLS
Retailer Database (MariaDB)
SQL Query
TLS
Returning Purchaser (YubiKey NEO)
Returning Purchaser Computer
HTTPS
Retailer E-Commerce Platform (Magento)
magfido Risk Assessment Module CryptoEngine Plug-In (StrongKey)
Logging and Reporting Dashboard (Splunk Enterprise)
HTTPS
TLS
TLS
Legend
Browser
Nonbrowser
Retailer E-Commerce Platform Administrator Authentication (TokenOne)
Authentication Server (TokenOne) Cloud-Based

The *cost threshold* example build illustrated in Figure 1-1 uses the components listed in Table 1-1.

Table 1-1 Cost Threshold Architecture List of Components

Components	Installation Guidance
StrongKey CryptoEngine (SKCE) FIDO U2F server and CryptoEngine plug-in	Section 2.1
Magento Open Source e-commerce platform	Section 2.2
StrongKey Magento magfido risk assessment module	Section 2.3
TokenOne Authentication	Section 2.5
Splunk Enterprise logging/reporting dashboard	Section 2.6
Yubico YubiKey NEO Security Key	Section 2.7

Figure 1-2 MFA for E-Commerce High-Level Risk Engine Reference Architecture


Returning Purchaser
E-Commerce Platform, Authentication, and Logging Solution Services
FIDO U2F Server (StrongKey CryptoEngine)
Risk Engine (RSA Adaptive Authentication) Cloud-Based
TLS
HTTPS
Retailer Database (MariaDB)
SQL Query
TLS
Returning Purchaser (YubiKey NEO)
Returning Purchaser Computer
HTTPS
Retailer E-Commerce Platform (Magento)
Risk Assessment Redirect Module CryptoEngine Plug-In (StrongKey)
Logging and Reporting Dashboard (Splunk Enterprise)
HTTPS
TLS
TLS
Legend
Browser
Nonbrowser
Retailer E-Commerce Platform Administrator Authentication (TokenOne)
Authentication Server (TokenOne) Cloud-Based

The *risk engine* example build illustrated in Figure 1-2 uses the components listed in Table 1-2. The Risk Engine Adaptive Authentication component is highlighted in yellow within the green box.

Table 1-2 Risk Engine Architecture List of Components

Components	Installation Guidance
SKCE FIDO U2F server and CryptoEngine plug-in	Section 2.1
Magento Open Source e-commerce platform	Section 2.2
RSA Adaptive Authentication	Section 2.4
TokenOne Authentication	Section 2.5
Splunk Enterprise logging/reporting dashboard	Section 2.6
Yubico YubiKey NEO Security Key	Section 2.7

1.2.3 General Infrastructure Details and Requirements

The lab network architecture is shown in Figure 1-3, where the relationship among the MFA example implementation components, firewalls, and network design are illustrated. The installation and configuration for many of the components shown in Figure 1-3 will be referenced in this volume of the guide.

Figure 1-3 MFA for E-Commerce Lab Network Architecture

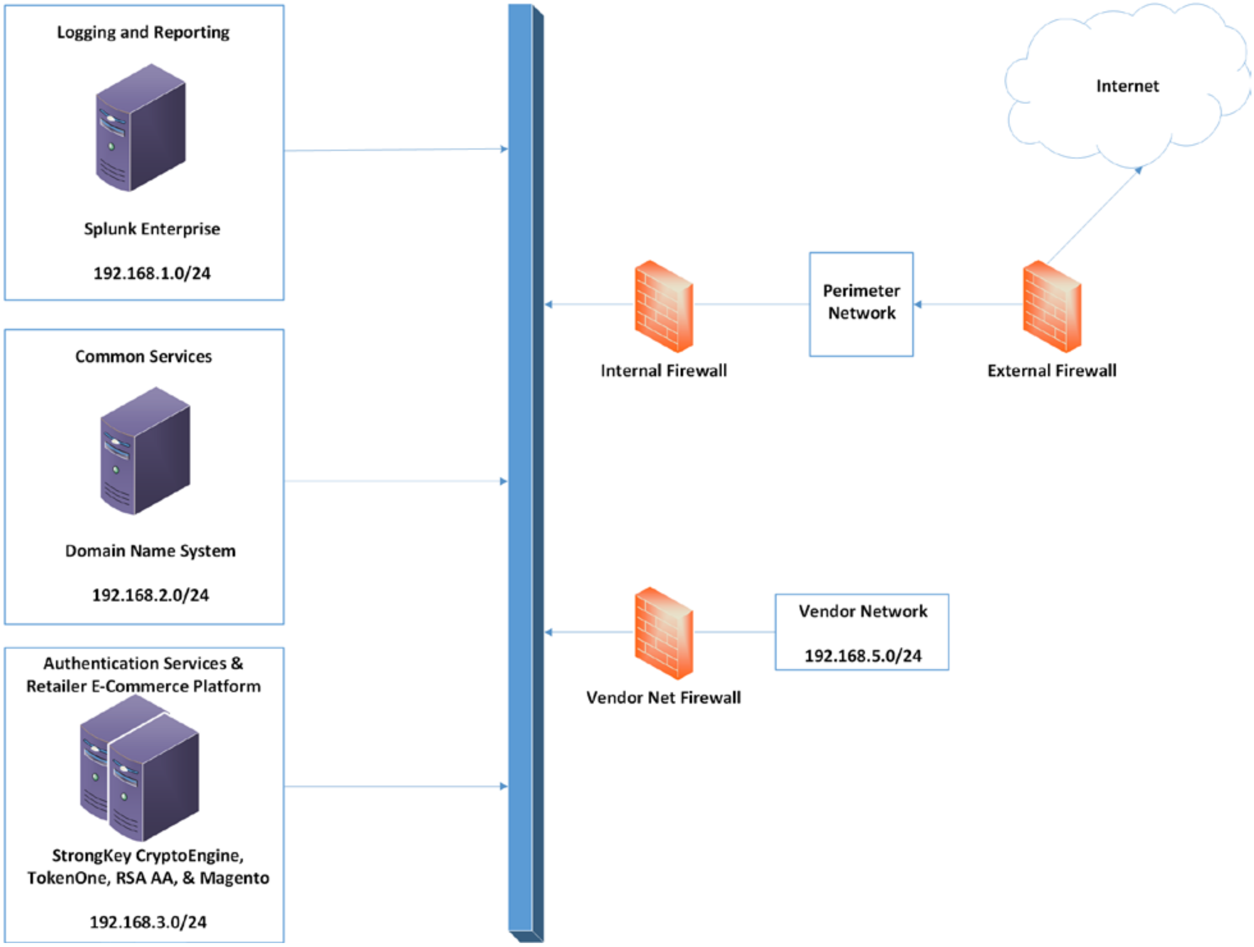


Table 1-3 lists the MFA example lab build's network internet protocol (IP) address range, system, and associated IP addresses. These network addresses were used in the example implementation builds and will be modified to reflect actual network architectures when deployed into a retailer's information system network.

Table 1-3 MFA Example Lab Build Network Details

Network	System	IP Address
192.168.1.0/24	Splunk Enterprise server logging and reporting	192.168.1.10
192.168.2.0/24	domain name system (DNS) common services	192.168.2.10
192.168.3.0/24	SKCE FIDO U2F server authentication services	192.168.3.30
192.168.3.0/24	RSA Adaptive Authentication connectivity, TokenOne, Magento Open Source authentication services and retailer e-commerce platform	192.168.3.155
192.168.5.0/24	Optional future services for vendor network	As assigned

There are both prerequisite infrastructure and example implementation components, whose installation and configuration are described below.

1.2.3.1 Domain Name System

DNS was configured within the lab to facilitate data communication among the example implementation components. The domain names and IP address ranges will be modified to reflect actual network architectures when deployed into an online retailer’s information system network.

The name of the domain used for this example build is mfa.local. Create the following host records in the mfa.local forward lookup zone by using the host names, fully qualified domain names (FQDNs), and IP addresses listed in Table 1-4.

Table 1-4 Lab Network Host Record Information

Host Name	FQDN	IP Address
Splunk	Splunk.mfa.local	192.168.1.10
DNS	DNS.mfa.local	192.168.2.10
Magento	Magento.mfa.local	192.168.3.30
Magento2	Magento2.mfa.local	192.168.3.155

The network adapter configuration for the DNS server is as follows:

- Network Configuration (Interface 1)
  - IPv4 Manual
  - IPv6 Disabled

    - IP Address: 192.168.2.10
    - Netmask: 255.255.255.0
    - Gateway: 192.168.2.1
    - DNS Name Servers: 192.168.2.10
  - DNS-Search Domains: mfa.local

1.3 Typographic Conventions

The following table presents typographic conventions used in this volume.

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

2 How to Install and Configure

This section of the practice guide contains detailed instructions for installing and configuring the products used to build the example implementations.

2.1 StrongKey CryptoEngine FIDO U2F Server

This section of the guide provides installation and configuration guidance for the SKCE, which provides FIDO authentication services.

2.1.1 StrongKey CryptoEngine Overview

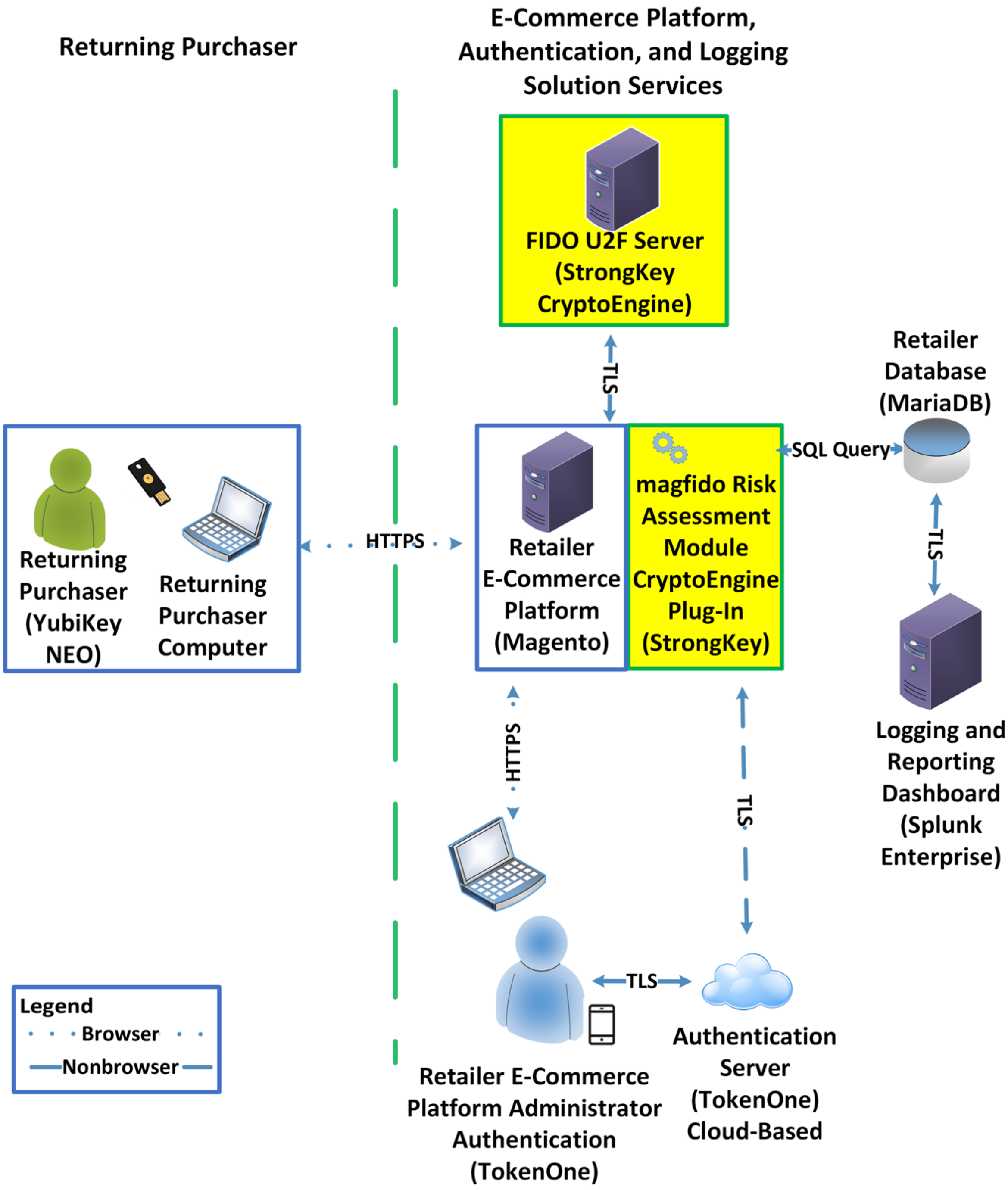
The SKCE 2.0 Build 163 from StrongKey [3] performs the FIDO U2F [1], [2] server functionality in the build architecture.

SKCE is provided in the StrongKey Key Appliance, but the company also distributes some of its software under the Lesser General Public License, published by the Free Software Foundation. SKCE was downloaded from the StrongKey repository on SourceForge and was used in this build.

The CryptoEngine plug-in enables Magento to communicate with the SKCE when the returning purchasers require MFA.

Both the *cost threshold* and *risk engine* example implementations use the SKCE's capabilities. The components that are installed by using the instructions in this section are illustrated in Figure 2-1 and are highlighted in yellow within the green box.

Figure 2-1 StrongKey CryptoEngine Components


Returning Purchaser
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Authentication Server (TokenOne) Cloud-Based

Installation instructions and the product download site for StrongKey's FIDO U2F server, SKCE, can be found at https://sourceforge.net/projects/skce/. For this example implementation, we installed and configured a local copy of SKCE by using the SKCE installation instructions documented below in Section 2.1.2.

2.1.2 SKCE Requirements

The following subsections document the software, hardware, and network requirements for SKCE Version 2.0.

2.1.2.1 SKCE Software Requirements

For this build, SKCE was installed on a Community Enterprise Operating System (CentOS) 7.4 64-bit server.

Because SKCE is a Java application, it is compatible with operating systems that support a compatible version of Java and the other required software. The application was built with the Oracle Java Development Kit (JDK) Version 8, Update 72. Instructions for obtaining Oracle JDK and the other necessary components are provided in this section.

SKCE can be installed manually or with an installation script included in the download. SKCE depends on other software components, including a Structured Query Language (SQL) database, a lightweight directory access protocol (LDAP) directory server, and the Glassfish Java application server. By default, the script will install MariaDB, OpenDJ, and Glassfish all on a single server.

For this build, the scripted installation was used with the default software components. The required software components listed below must be downloaded prior to running the installation script:

- Glassfish 4.1 2010
- Java Cryptography Extension Unlimited Strength Jurisdiction Policy Files 8 2011
- JDK 8, Update 121 2012
- OpenDJ 3.0.0 2013
- MariaDB 10.1.22 2014
- MariaDB Java Client 2015

Reference StrongKey's scripted installation instructions for details and preinstallation software download links (StrongKey, n.d.).

Note: To download OpenDJ, the user must register for a free account for ForgeRock BackStage.

2.1.2.2 Hardware Requirements

StrongKey recommends installing SKCE on a server with at least 10 gigabytes (GB) of available disk space and 4 GB of random access memory (RAM).

2.1.2.3 Network Requirements

The SKCE application programming interface (API) uses transmission control protocol (TCP) Port 8181 (Table 2-1). Any applications that request U2F registration, authentication, or deregistration actions from the SKCE need to be able to connect on this port. Glassfish runs a hypertext transfer protocol secure (https) service on this port. Use firewall-cmd, iptables, or any other system utility for manipulating the firewall to open this port.

Table 2-1 Network Ports to Be Enabled

Port	Use
TCP 8181	U2F Application Access

Other network services listen on the ports listed in Table 2-2. For the scripted installation, where all of these services are installed on a single server, there is no need to adjust firewall rules for these services when they are only accessed from localhost.

Table 2-2 Local Ports

Port	Use
TCP 3306	MariaDB listener
TCP 4848	Glassfish administrative console
TCP 1389	OpenDJ LDAP service

2.1.3 Install SKCE, the FIDO U2F Authentication Server

The installation procedure consists of the following steps:

- Download the software dependencies to the server where SKCE will be installed.
- Make any required changes to the installation script.
- Run the script as root/administrator.
- Perform post-installation configuration.
- Reference StrongKey's scripted installation instructions for details and preinstallation software download links (StrongKey, n.d.).

The installation script creates a “strongauth” Linux user and installs all software under */usr/local/strongauth*. Rather than reproduce the installation steps here, this section provides some notes on the installation procedure:

1. Download the software. Download and unzip the SKCE build to a directory on the server where SKCE is being installed. Download all installers as directed in the SKCE instructions to the same directory.

2. Change software versions as required in the installation script. If different versions of any of the software dependencies were downloaded, update the file names in the installation script *(install-skce.sh)*. Using different versions of the dependencies, apart from minor point-release versions, is not recommended. For the lab build, JDK Version 8u151 was used instead of the version referenced in the instructions. This required updating the JDK and JDKVER settings in the file.

3. Change passwords in the installation script. Changing the default passwords in the delivered script is strongly recommended. The defaults are readily discoverable, as they are distributed with the software. Passwords should be stored in a password vault or other agency-approved secure storage. Once the installation script has been run successfully, the script should be deleted or sanitized to remove passwords. The following lines in the installation script contain passwords:

   ```
   LINUX_PASSWORD=ShaZam123         # For 'strongauth' account
   GLASSFISH_PASSWORD=adminadmin    # Glassfish Admin password
   MYSQL_ROOT_PASSWORD=BigKahuna    # MySQL 'root' password
   MYSQL_PASSWORD=AbracaDabra       # MySQL 'skles' password
   SKCE_SERVICE_PASS=Abcd1234!      # Webservice user 'service-cc-ce' password
   SAKA_PASS=Abcd1234!
   SERVICE_LDAP_BIND_PASS=Abcd1234!
   SEARCH_LDAP_BIND_PASS=Abcd1234!
   ```

4. Set the App ID (identifier) uniform resource locator (URL): The App ID setting in *install-skce.sh* should point to a URL that will be accessible to clients where the *app.json* file can be downloaded. The default location is a URL on the SKCE server, but the SKCE would not be exposed to mobile clients in a typical production deployment. In the lab, *app.json* was hosted on the following SKCE server:

   /usr/local/strongauth/payara41/glassfish/domains/domain1/docroot/app.json

   This enables the file to be accessed by clients at the following URL: *https://magento.mfa.local:8181/app.json*.

5. Run the script. *install-skce.sh* must be run as the root user. If the installation script terminates with an error, then troubleshoot and correct any problems before continuing.

6. (For CentOS 7) create the firewall rule. The installation script attempts to open the required port by using iptables, which does not work on CentOS 7. In that case, the following commands will open the port:

```
# firewall-cmd --permanent --add-port 8181/tcp
success
# firewall-cmd --reload

success
```

7. Restart Glassfish. On CentOS 7, run the following command:

```
$ sudo systemctl restart glassfishd
```

8. Complete Step 3b in the SKCE installation instructions to activate the cryptographic module.

9. Complete Step 3c in the SKCE installation instructions to create the domain signing key. When prompted for the App ID, use the URL referenced above in the App ID setting of the *install-skce.sh* script.

10. Complete Step 4 in the SKCE installation instructions if secondary SKCE instances are being installed; this was not done for this build but is recommended for a production installation.

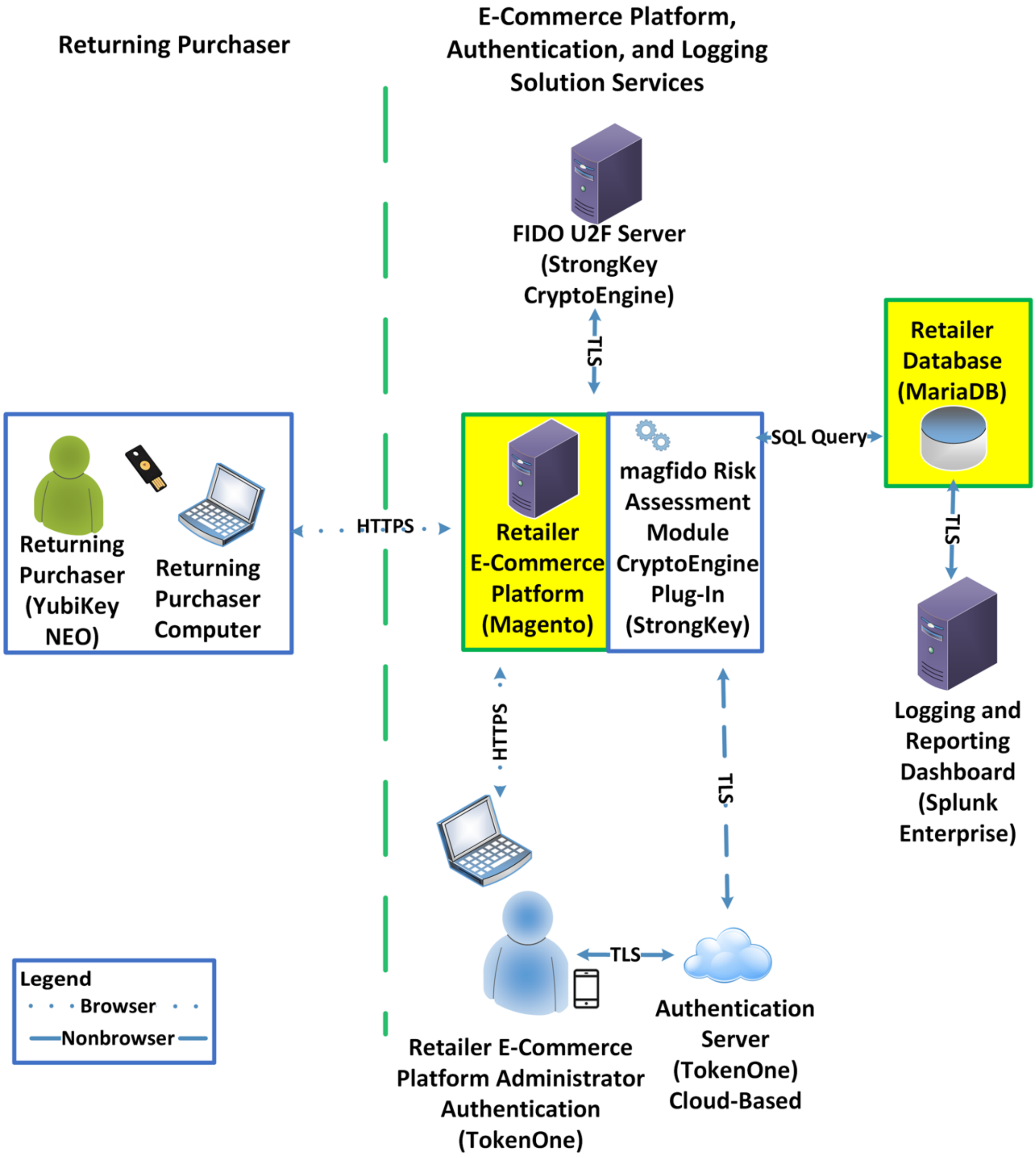
11. Test the FIDO Engine. Follow the testing instructions under Step D at the following URL: https://sourceforge.net/p/skce/wiki/Test%20SKCE%202.0%20Using%20a%20Client%20Program%20%28Build%20163%29/.

    There are additional tests on that web page to test the other cryptographic functions of the SKCE; however, only the FIDO Engine tests are critical for this build.

2.2 Magento Open Source Electronic Commerce Platform

This section provides installation and configuration guidance for the Magento Open Source e-commerce platform. The Magento platform provides connectivity to most of the example implementations' components. Both example implementation builds use Magento. The location of the Magento components that are installed using the instructions in this section are illustrated in Figure 2-2 and are highlighted in yellow within the green boxes.

Figure 2-2 Magento Open Source E-Commerce Platform Components


Returning Purchaser
E-Commerce Platform, Authentication, and Logging Solution Services
FIDO U2F Server (StrongKey CryptoEngine)
TLS
Retailer Database (MariaDB)
SQL Query
Returning Purchaser (YubiKey NEO)
Returning Purchaser Computer
HTTPS
Retailer E-Commerce Platform (Magento)
magfido Risk Assessment Module CryptoEngine Plug-In (StrongKey)
TLS
Logging and Reporting Dashboard (Splunk Enterprise)
HTTPS
TLS
TLS
Retailer E-Commerce Platform Administrator Authentication (TokenOne)
Authentication Server (TokenOne) Cloud-Based
Legend
Browser
Nonbrowser

2.2.1 Magento Overview

Magento is an e-commerce platform that offers on-premises and cloud solutions to retailers. For this lab implementation, we leveraged the Magento Open Source version of this platform, which was hosted on-premises. This section describes how to install and configure Magento Open Source [4], [5] and how to configure it with StrongKey's SKCE FIDO U2F server capabilities. For the e-commerce platform, Magento Open Source Version 2.1.8 was used in the example implementation.

The installation procedure consists of the following steps:

- Download the Magento software to the server where it will be installed.
- Download the software dependencies to the server where Magento will be installed.
- Execute commands as root/administrator.
- Perform post-installation configuration.

2.2.2 Magento Requirements

The following subsections document the software, hardware, and network requirements for Magento Open Source 2.1.X.

2.2.2.1 Software Requirements

For this implementation, Magento was installed on a CentOS 7.0 server.

Magento Open Source developer's documentation states that Magento can operate on Linux operating systems, such as these:

- Red Hat Enterprise Linux
- CentOS
- Ubuntu
- Debian

Magento Open Source 2.1.X requires the following installations:

- Web Server: Apache 2.2 or 2.4 or NGINX 1.X
- Database: MySQL 5.6, MariaDB, Percona, or other binary-compatible MySQL technologies
- Hypertext Preprocessor (PHP): 7.0.2, 7.0.4, 7.0.6-7.0.X, or 7.1.X
- Secure Sockets Layer (SSL)
- Mail Server: Redis 3.0, Varnish 3.5, memcached

See Magento's developer's documentation for additional details and download links: https://devdocs.magento.com/guides/v2.1/install-gde/system-requirements-tech.html.

2.2.2.2 Hardware Requirements

Magento requires installing Magento Open Source on a server with at least 2 GB of RAM.

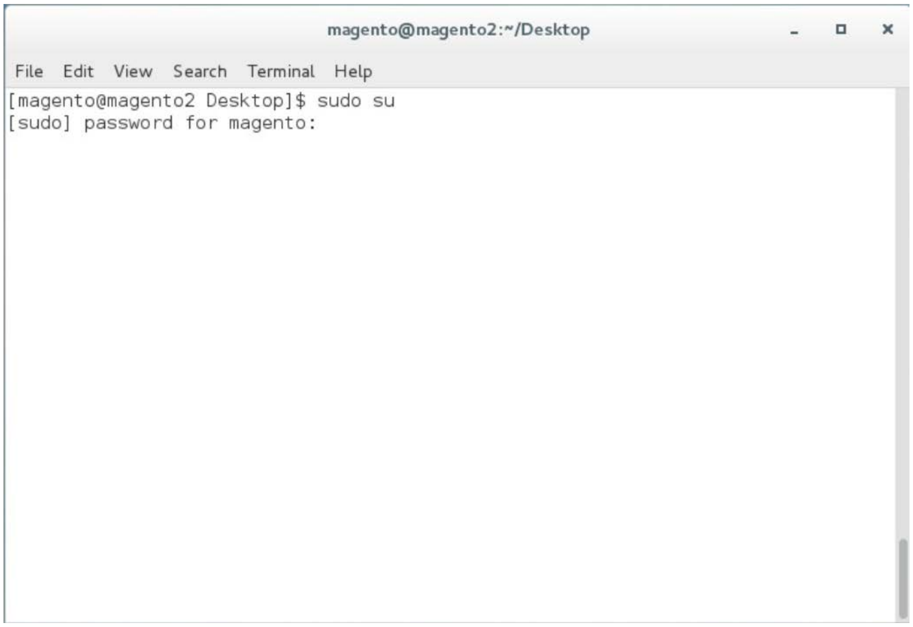
2.2.3 Magento Preinstallation

Magento requires the Linux, Apache, MySQL, PHP (LAMP) software stack. This section describes the process of installing and configuring the LAMP software stack that uses versions compatible with Magento.

1. Open a terminal window, and enter the following command to log in as root:

   ```
   sudo su
   ```

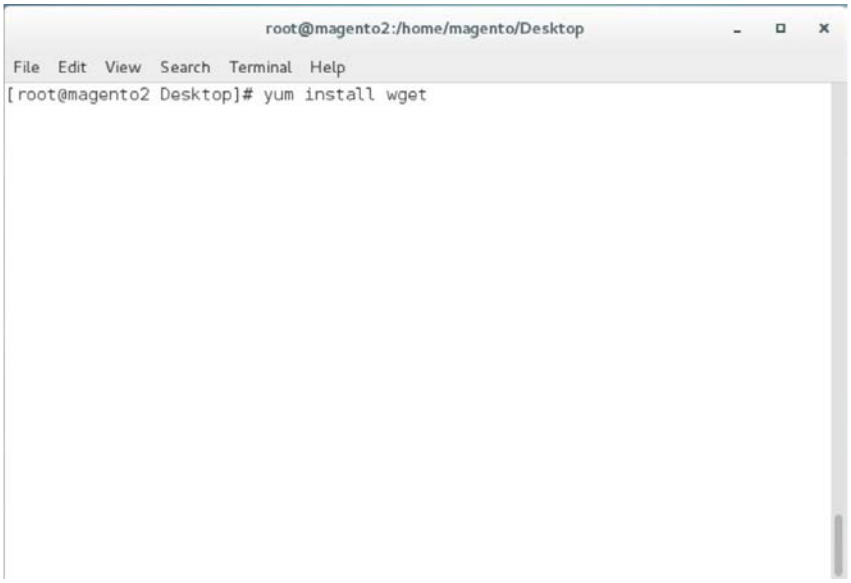
   a. After entering the command, you will be prompted to enter the password for the current user.


magento@magento2:~/Desktop
File Edit View Search Terminal Help

```
[magento@magento2 Desktop]$ sudo su
[sudo] password for magento:
```

2. To install wget from the terminal, enter the following command:

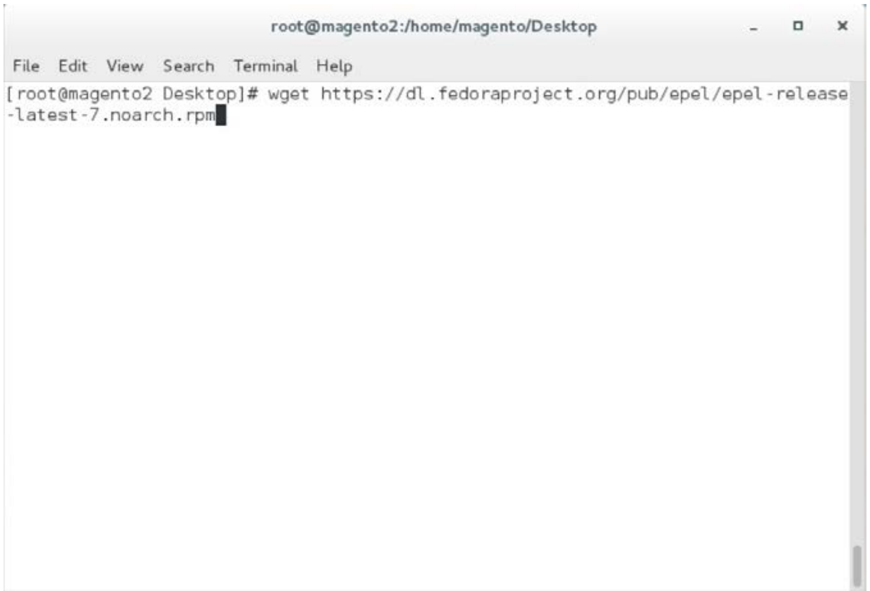
   ```
   yum install wget
   ```


root@magento2:/home/magento/Desktop
File Edit View Search Terminal Help

```
[root@magento2 Desktop]# yum install wget
```

3. Download the Extra Packages for Enterprise Linux repository by entering the following command:

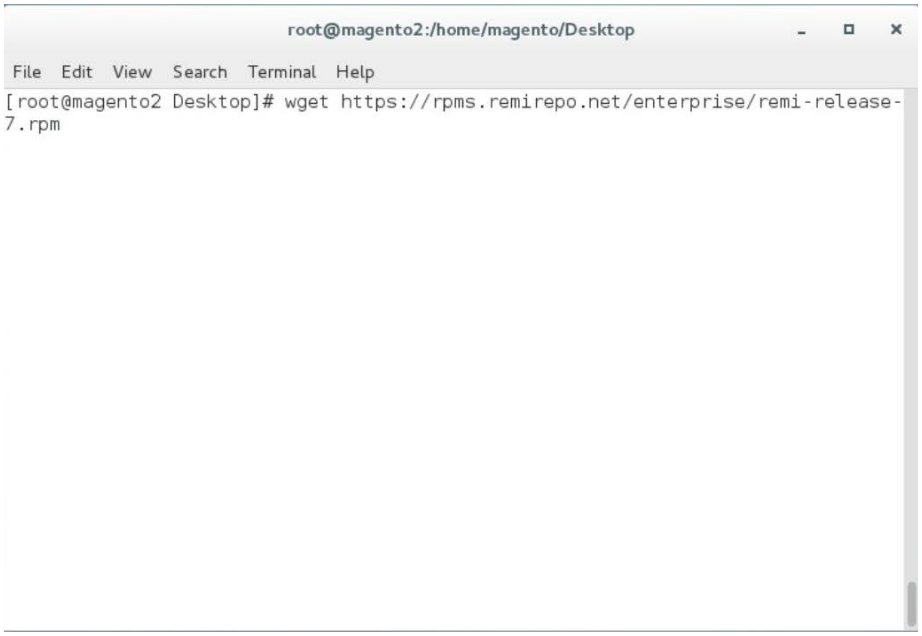
   `wget https://dl.fedoraproject.org/pub/epel/epel-release-latest-7.noarch.rpm`


root@magento2:/home/magento/Desktop
File Edit View Search Terminal Help

```
[root@magento2 Desktop]# wget https://dl.fedoraproject.org/pub/epel/epel-release
-latest-7.noarch.rpm
```

4. Download the Remi repository by entering the following command:

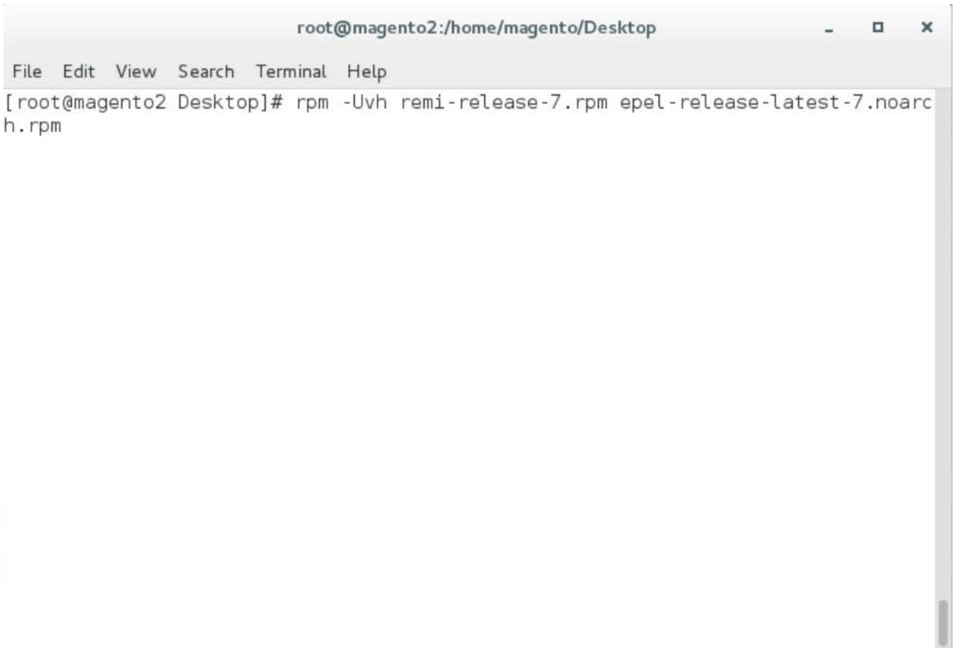
   `wget http://rpms.remirepo.net/enterprise/remi-release-7.rpm`


root@magento2:/home/magento/Desktop
File Edit View Search Terminal Help

```
[root@magento2 Desktop]# wget https://rpms.remirepo.net/enterprise/remi-release-
7.rpm
```

5. Add the two repositories—so that Yellowdog Updater Modified (YUM) can locate them when needed—by entering the following command:

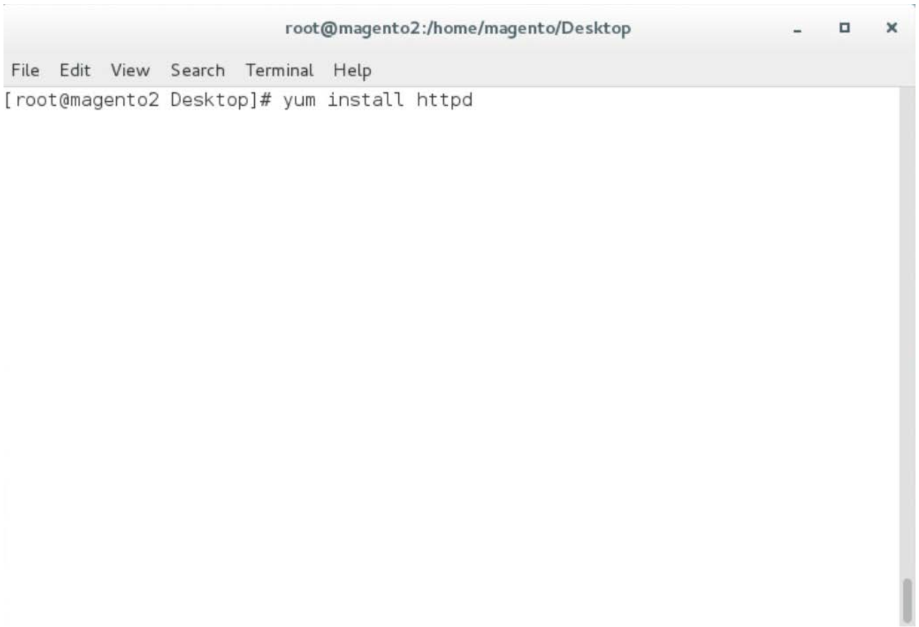
   `rpm -Uvh remi-release-7.rpm epel-release-latest-7.noarch.rpm`


root@magento2:/home/magento/Desktop
File Edit View Search Terminal Help

```
[root@magento2 Desktop]# rpm -Uvh remi-release-7.rpm epel-release-latest-7.noarc
h.rpm
```

6. Install the Apache server by entering the following command:

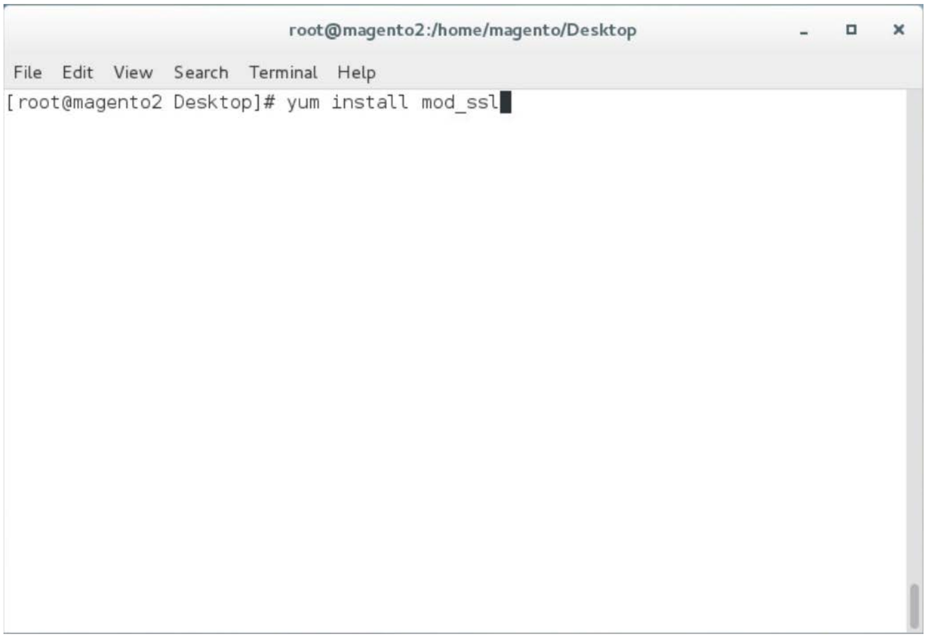
   ```
   yum install httpd
   ```


root@magento2:/home/magento/Desktop
File Edit View Search Terminal Help

```
[root@magento2 Desktop]# yum install httpd
```

7. Install Transport Layer Security (TLS)/SSL support for Hypertext Transfer Protocol Daemon (HTTPD) by entering the following command:

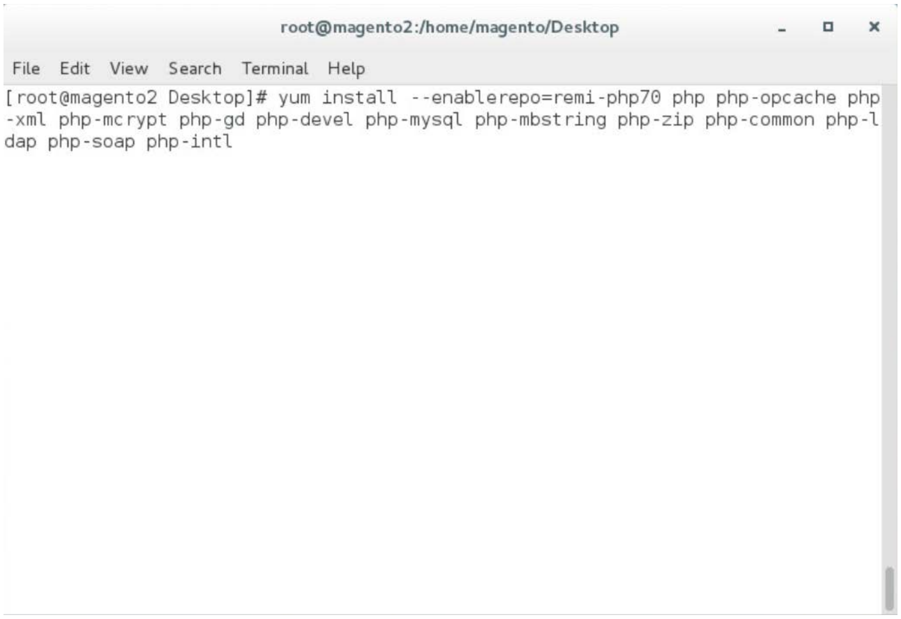
   ```
   yum install mod_ssl
   ```


root@magento2:/home/magento/Desktop
File Edit View Search Terminal Help

```
[root@magento2 Desktop]# yum install mod_ssl
```

8. Install PHP by entering the following command:

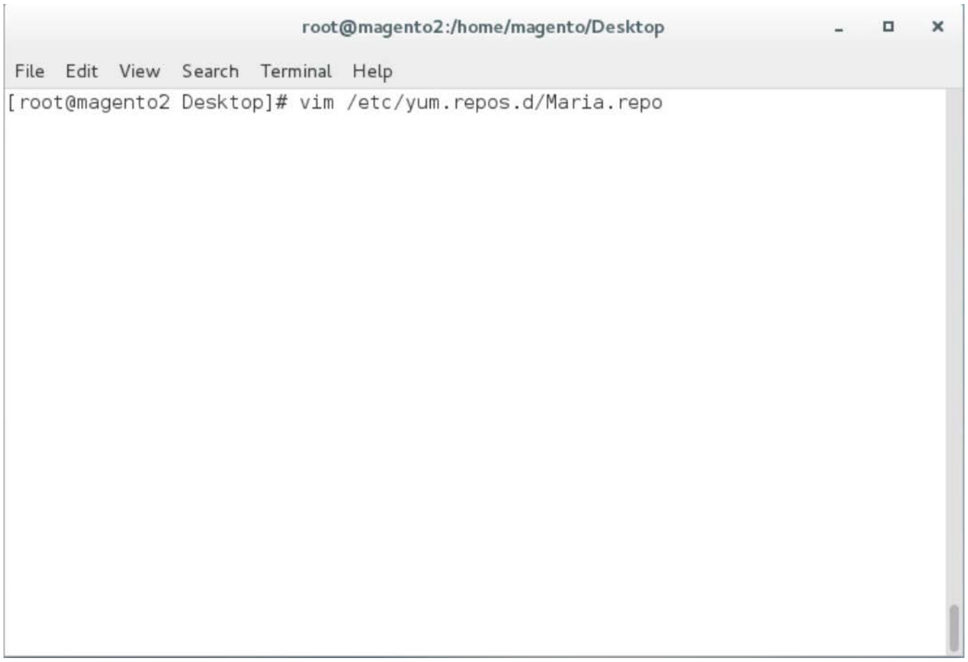
   ```
   yum install --enablerepo=remi-php70 php php-opcache php-xml php-mcrypt php-gd
   php-devel php-mysql php-mbstring php-zip phpcommon php-ldap php-soap php-intl
   ```


root@magento2:/home/magento/Desktop
File Edit View Search Terminal Help

```
[root@magento2 Desktop]# yum install --enablerepo=remi-php70 php php-opcache php
-xml php-mcrypt php-gd php-devel php-mysql php-mbstring php-zip php-common php-l
dap php-soap php-intl
```

9. Create a file named *Maria.repo* in the */etc/yum.repos.d* by entering the following command:

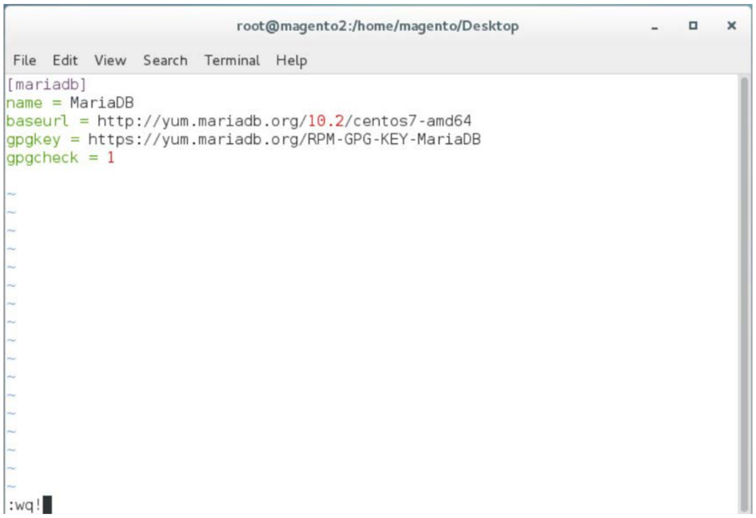
   ```
   vim /etc/yum.repos.d/Maria.repo
   ```


root@magento2:/home/magento/Desktop
File Edit View Search Terminal Help

```
[root@magento2 Desktop]# vim /etc/yum.repos.d/Maria.repo
```

10. In the text editor, enter the following contents:

```
[mariadb]

name = MariaDB

baseurl = http://yum.mariadb.org/10.2/centos7-amd64

gpgkey = https://yum.mariadb.org/RPM-GPG-KEY-MariaDB

gpgcheck = 1
```


root@magento2:/home/magento/Desktop
File Edit View Search Terminal Help

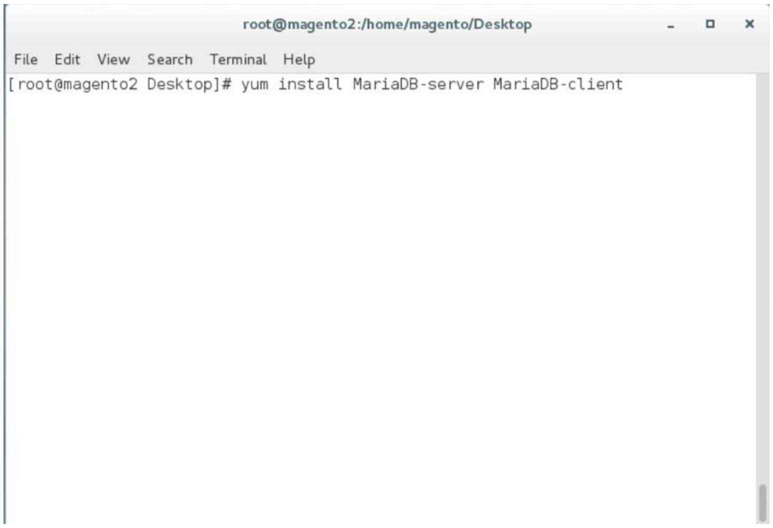
```
[mariadb]
name = MariaDB
baseurl = http://yum.mariadb.org/10.2/centos7-amd64
gpgkey = https://yum.mariadb.org/RPM-GPG-KEY-MariaDB
gpgcheck = 1
~
~
~
~
~
~
~
~
~
~
~
~
~
~
~
~
~
~
:wq!
```

11. Save the file, and exit by entering the following command:

    ```
    :wq!
    ```

12. Install MariaDB by entering the following command:

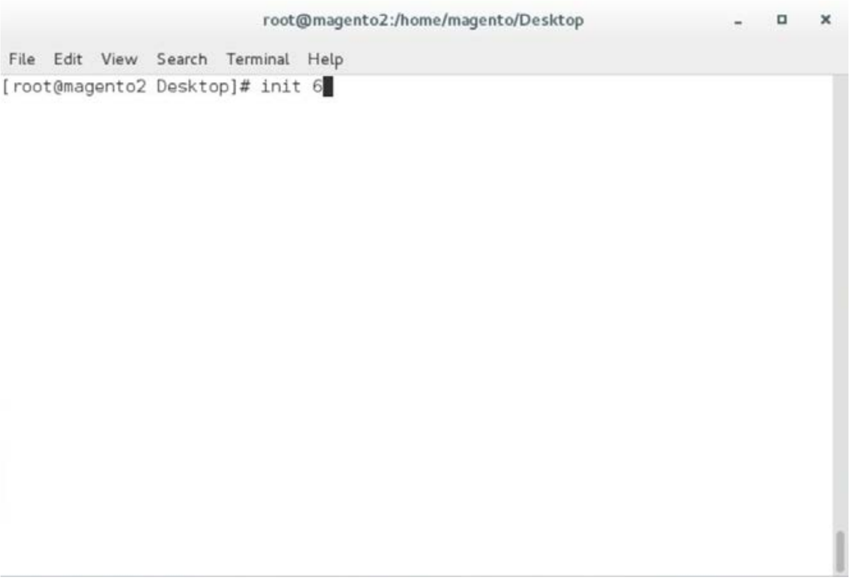
    ```
    yum install mariadb-server mariadb-client
    ```


root@magento2:/home/magento/Desktop
File Edit View Search Terminal Help

```
[root@magento2 Desktop]# yum install MariaDB-server MariaDB-client
```

13. Restart the computer system by entering the following command:

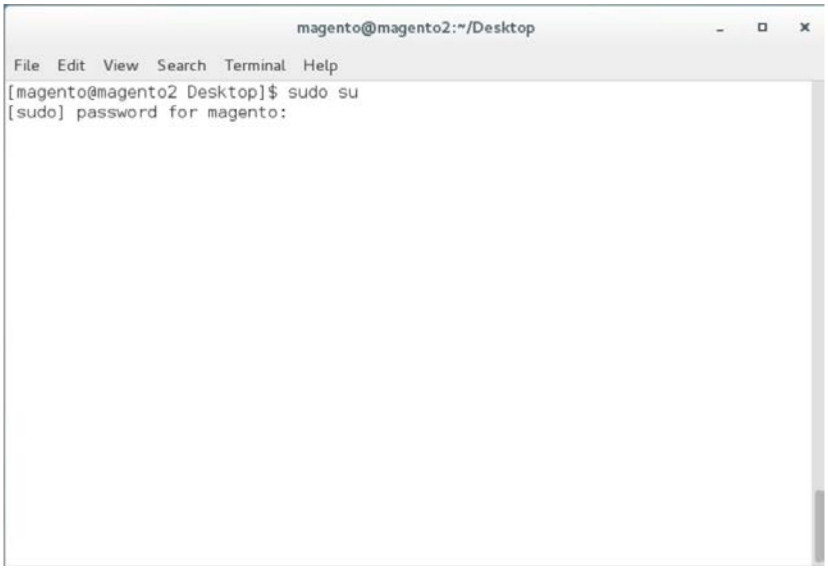
    ```
    init 6
    ```


root@magento2:/home/magento/Desktop
File Edit View Search Terminal Help

```
[root@magento2 Desktop]# init 6
```

14. Open a terminal window, and enter the following command to log in as root:

```
sudo su
```

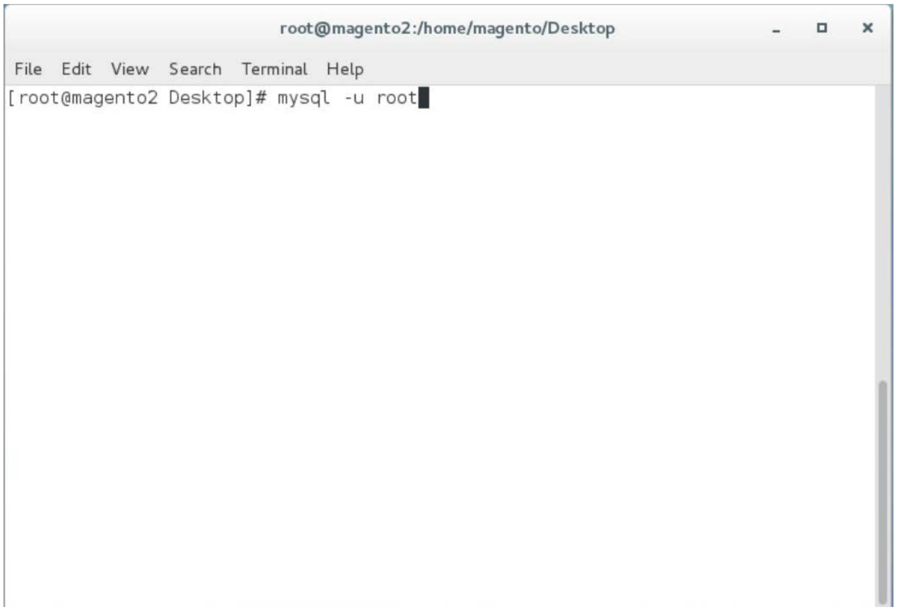


magento@magento2:~/Desktop
File Edit View Search Terminal Help

```
[magento@magento2 Desktop]$ sudo su
[sudo] password for magento:
```

15. Log in to MariaDB as root by entering the following command (Note: Even though the MariaDB relational database is being used, it uses the same tools as the MySQL database.):

```
mysql -u root
```

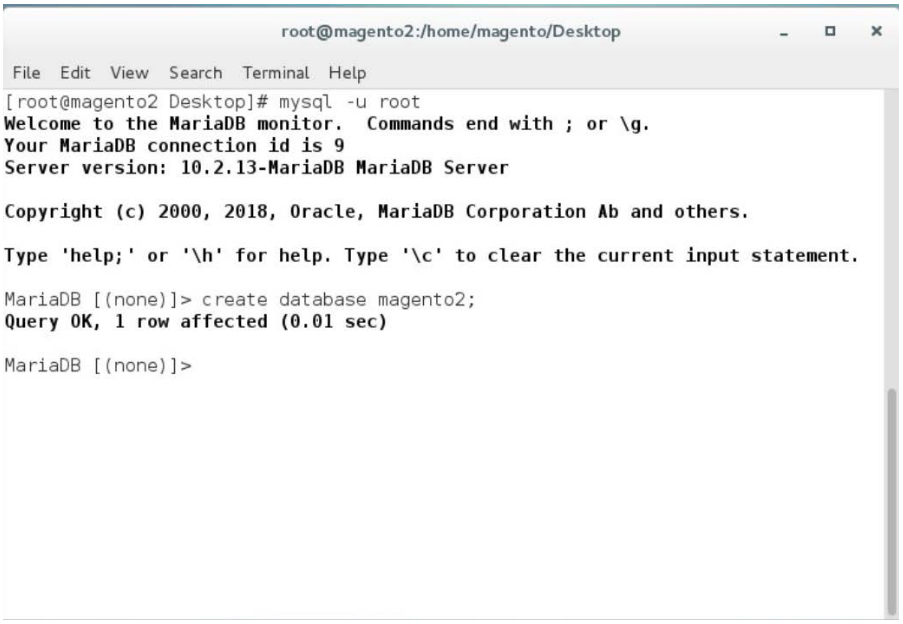


root@magento2:/home/magento/Desktop
File Edit View Search Terminal Help

```
[root@magento2 Desktop]# mysql -u root
```

16. Create the Magento database by entering the following SQL command:

```
create database magento2;
```

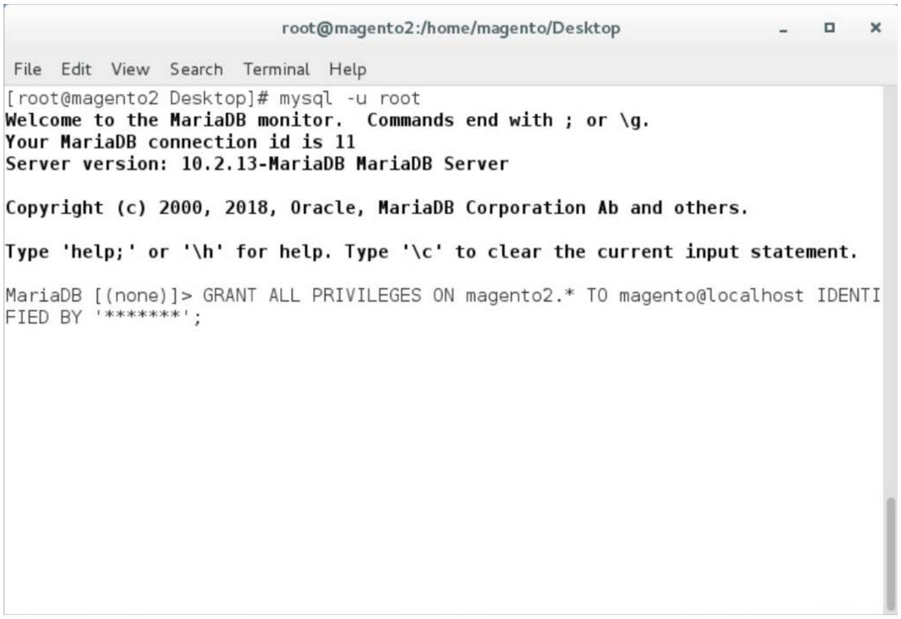


root@magento2:/home/magento/Desktop
File Edit View Search Terminal Help

```
[root@magento2 Desktop]# mysql -u root
Welcome to the MariaDB monitor.  Commands end with ; or \g.
Your MariaDB connection id is 9
Server version: 10.2.13-MariaDB MariaDB Server

Copyright (c) 2000, 2018, Oracle, MariaDB Corporation Ab and others.

Type 'help;' or '\h' for help. Type '\c' to clear the current input statement.

MariaDB [(none)]> create database magento2;
Query OK, 1 row affected (0.01 sec)

MariaDB [(none)]>
```

17. Create the Magento user by entering the following command, replacing parameters in <> with values appropriate for your installation:

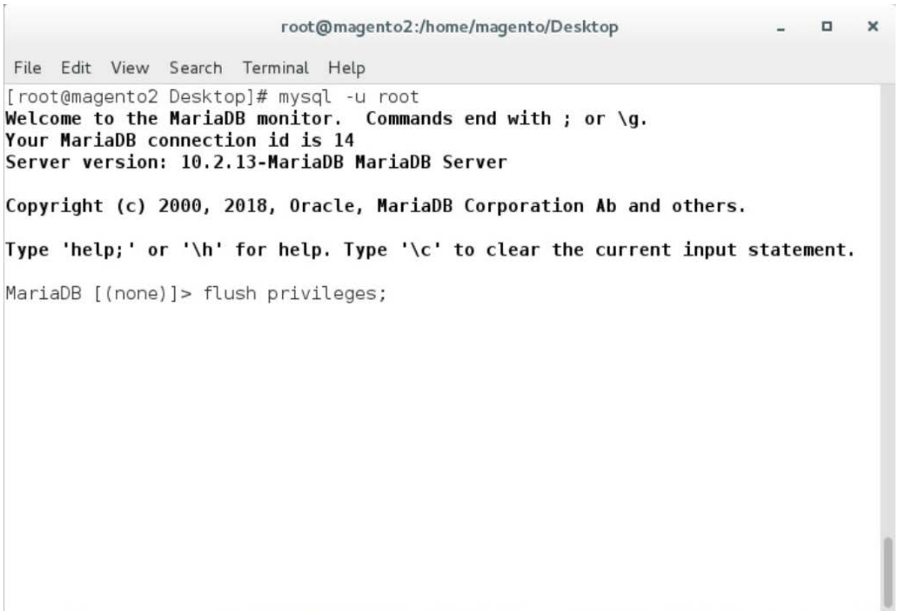
```
GRANT ALL PRIVILEGES ON magento2.* TO magento@localhost IDENTIFIED BY '<db
password>';
```


root@magento2:/home/magento/Desktop
File Edit View Search Terminal Help

```
[root@magento2 Desktop]# mysql -u root
Welcome to the MariaDB monitor.  Commands end with ; or \g.
Your MariaDB connection id is 11
Server version: 10.2.13-MariaDB MariaDB Server

Copyright (c) 2000, 2018, Oracle, MariaDB Corporation Ab and others.

Type 'help;' or '\h' for help. Type '\c' to clear the current input statement.

MariaDB [(none)]> GRANT ALL PRIVILEGES ON magento2.* TO magento@localhost IDENTI
FIED BY '*******';
```

18. Flush the database privileges by entering the following SQL command:

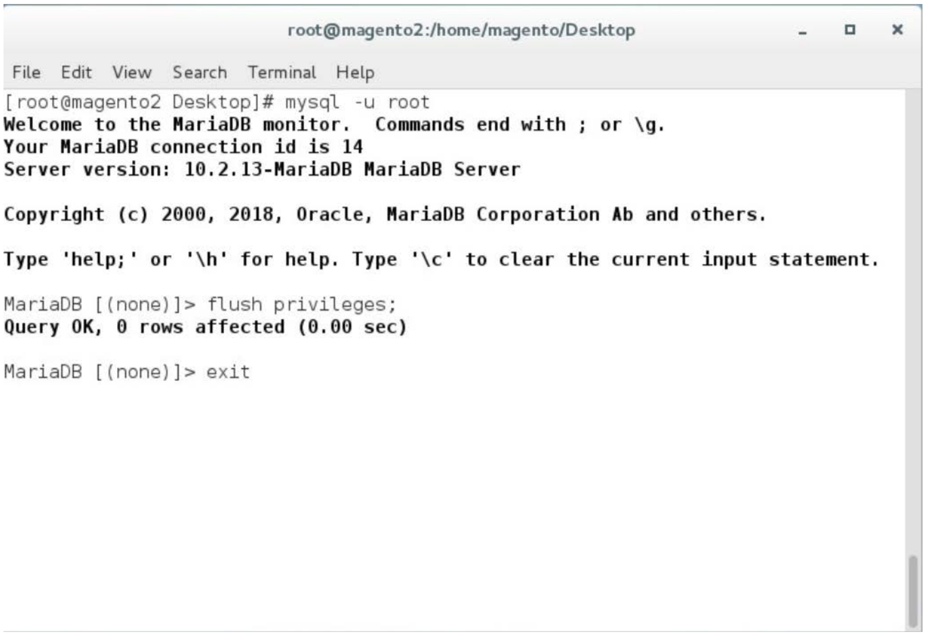
```
flush privileges;
```


root@magento2:/home/magento/Desktop
File Edit View Search Terminal Help

```
[root@magento2 Desktop]# mysql -u root
Welcome to the MariaDB monitor.  Commands end with ; or \g.
Your MariaDB connection id is 14
Server version: 10.2.13-MariaDB MariaDB Server

Copyright (c) 2000, 2018, Oracle, MariaDB Corporation Ab and others.

Type 'help;' or '\h' for help. Type '\c' to clear the current input statement.

MariaDB [(none)]> flush privileges;
```

19. Exit the MariaDB shell by entering the following command:

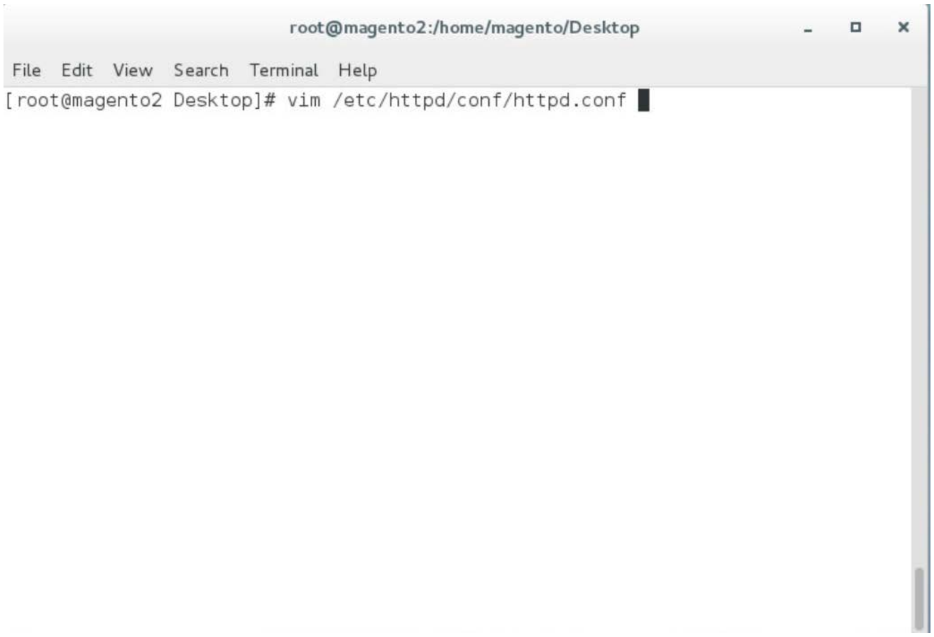
```
exit
```


root@magento2:/home/magento/Desktop
File Edit View Search Terminal Help

```
[root@magento2 Desktop]# mysql -u root
Welcome to the MariaDB monitor.  Commands end with ; or \g.
Your MariaDB connection id is 14
Server version: 10.2.13-MariaDB MariaDB Server

Copyright (c) 2000, 2018, Oracle, MariaDB Corporation Ab and others.

Type 'help;' or '\h' for help. Type '\c' to clear the current input statement.

MariaDB [(none)]> flush privileges;
Query OK, 0 rows affected (0.00 sec)

MariaDB [(none)]> exit
```

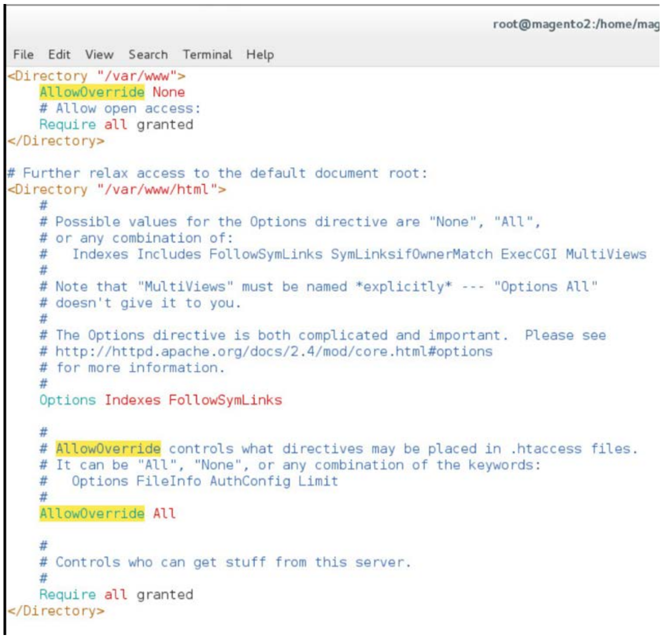
20. Open *httpd.conf* to modify Apache settings by entering the following command:

    ```
    vim /etc/httpd/conf/httpd.conf
    ```


root@magento2:/home/magento/Desktop
File Edit View Search Terminal Help

```
[root@magento2 Desktop]# vim /etc/httpd/conf/httpd.conf
```

21. Locate the `<Directory “/var/www/html”>` section, and change `“AllowOverride None”` to `“AllowOverride All”`.



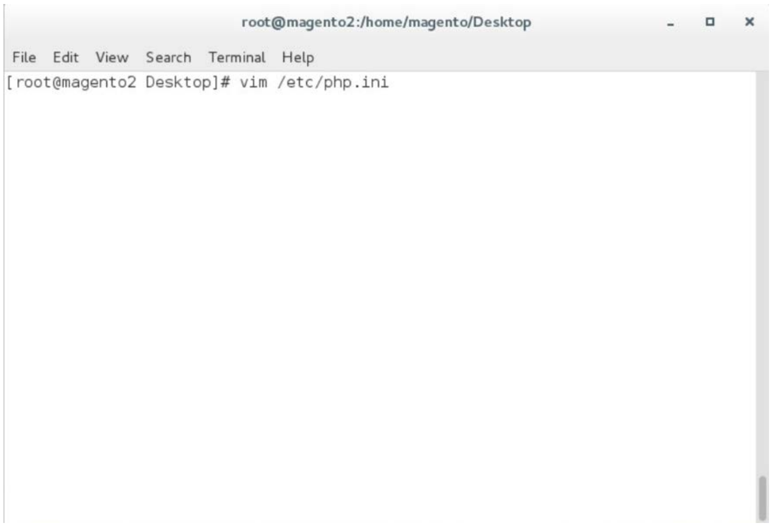
```
<Directory "/var/www">
    AllowOverride None
    # Allow open access:
    Require all granted
</Directory>

# Further relax access to the default document root:
<Directory "/var/www/html">
    #
    # Possible values for the Options directive are "None", "All",
    # or any combination of:
    #   Indexes Includes FollowSymLinks SymLinksifOwnerMatch ExecCGI MultiViews
    #
    # Note that "MultiViews" must be named *explicitly* --- "Options All"
    # doesn't give it to you.
    #
    # The Options directive is both complicated and important.  Please see
    # http://httpd.apache.org/docs/2.4/mod/core.html#options
    # for more information.
    #
    Options Indexes FollowSymLinks

    #
    # AllowOverride controls what directives may be placed in .htaccess files.
    # It can be "All", "None", or any combination of the keywords:
    #   Options FileInfo AuthConfig Limit
    #
    AllowOverride All

    #
    # Controls who can get stuff from this server.
    #
    Require all granted
</Directory>
```

22. Save, and exit by entering the following command:

    ```
    :wq!
    ```

23. Open *php.ini* to modify PHP settings by entering the following command:

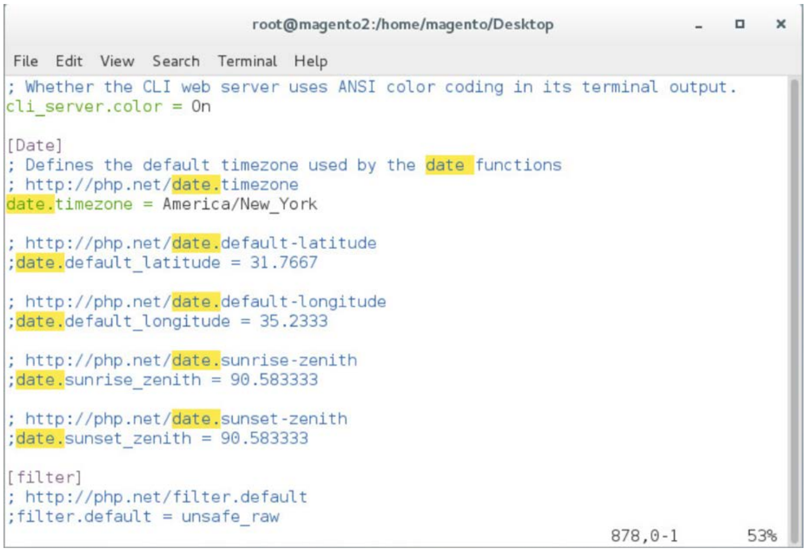
    ```
    vim /etc/php.ini
    ```


root@magento2:/home/magento/Desktop
File Edit View Search Terminal Help

```
[root@magento2 Desktop]# vim /etc/php.ini
```

24. Uncomment the line containing `date.timezone` by removing the ";" character preceding the text, and enter your time zone as shown below (this example is for the eastern United States).

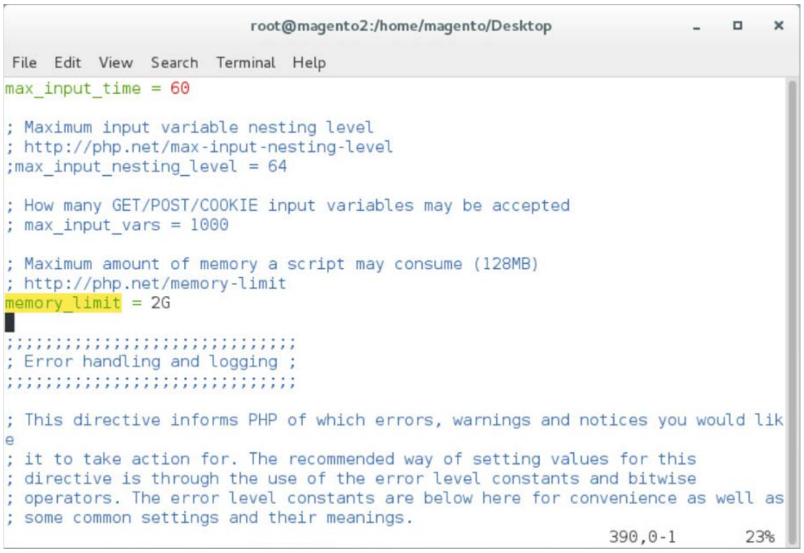
    ```
    date.timezone = America/New_York
    ```



```
; Whether the CLI web server uses ANSI color coding in its terminal output.
cli_server.color = On

[Date]
; Defines the default timezone used by the date functions
; http://php.net/date.timezone
date.timezone = America/New_York

; http://php.net/date.default-latitude
;date.default_latitude = 31.7667

; http://php.net/date.default-longitude
;date.default_longitude = 35.2333

; http://php.net/date.sunrise-zenith
;date.sunrise_zenith = 90.583333

; http://php.net/date.sunset-zenith
;date.sunset_zenith = 90.583333

[filter]
; http://php.net/filter.default
;filter.default = unsafe_raw
                                                              878,0-1       53%
```

25. Uncomment the line containing `memory_limit` by removing the ";" character preceding the text, and enter 2G as the value, as shown below.

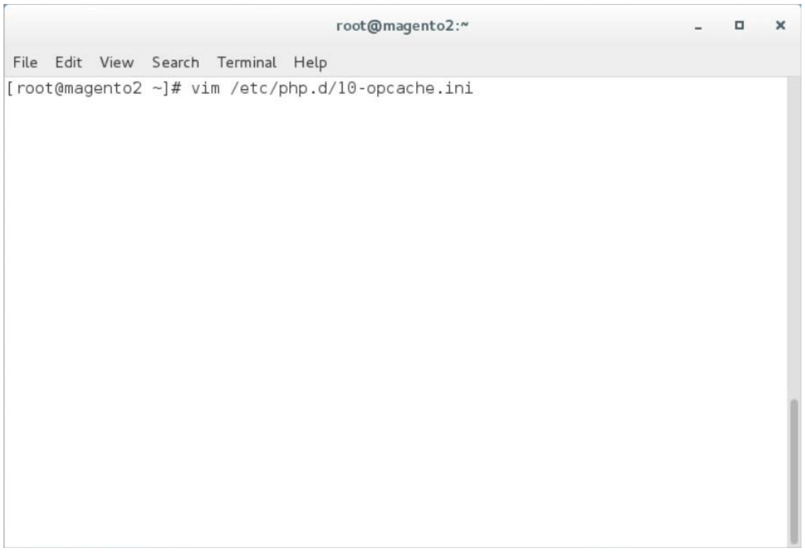
    ```
    memory_limit = 2G
    ```



```
max_input_time = 60

; Maximum input variable nesting level
; http://php.net/max-input-nesting-level
;max_input_nesting_level = 64

; How many GET/POST/COOKIE input variables may be accepted
; max_input_vars = 1000

; Maximum amount of memory a script may consume (128MB)
; http://php.net/memory-limit
memory_limit = 2G

;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
; Error handling and logging ;
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;

; This directive informs PHP of which errors, warnings and notices you would lik
e
; it to take action for. The recommended way of setting values for this
; directive is through the use of the error level constants and bitwise
; operators. The error level constants are below here for convenience as well as
; some common settings and their meanings.
                                                              390,0-1       23%
```

26. Open *10-opcache.ini* to modify PHP settings by entering the following command:

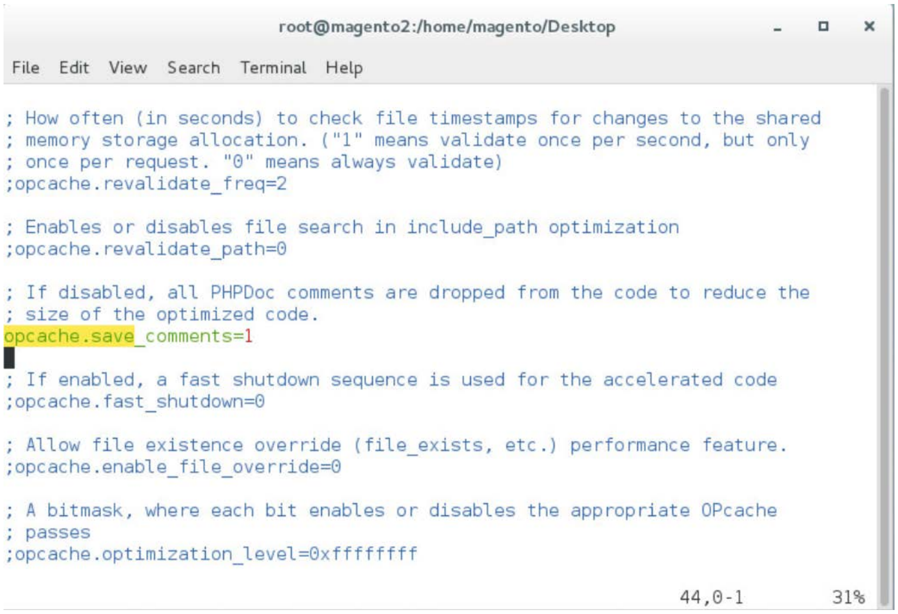
    ```
    vim /etc/php.d/10-opcache.ini
    ```



```
[root@magento2 ~]# vim /etc/php.d/10-opcache.ini
```

27. Uncomment the line containing `opcache.save_comments` by removing the ";" character preceding the text. The line should then read as shown below.

    ```
    opcache.save_comments=1
    ```


root@magento2:/home/magento/Desktop
File Edit View Search Terminal Help

```
; How often (in seconds) to check file timestamps for changes to the shared
; memory storage allocation. ("1" means validate once per second, but only
; once per request. "0" means always validate)
;opcache.revalidate_freq=2

; Enables or disables file search in include_path optimization
;opcache.revalidate_path=0

; If disabled, all PHPDoc comments are dropped from the code to reduce the
; size of the optimized code.
opcache.save_comments=1

; If enabled, a fast shutdown sequence is used for the accelerated code
;opcache.fast_shutdown=0

; Allow file existence override (file_exists, etc.) performance feature.
;opcache.enable_file_override=0

; A bitmask, where each bit enables or disables the appropriate OPcache
; passes
;opcache.optimization_level=0xffffffff
                                                              44,0-1        31%
```

2.2.4 Magento Installation

For the e-commerce platform, Magento Open Source Version 2.1.8 [5] was used in the example implementation.

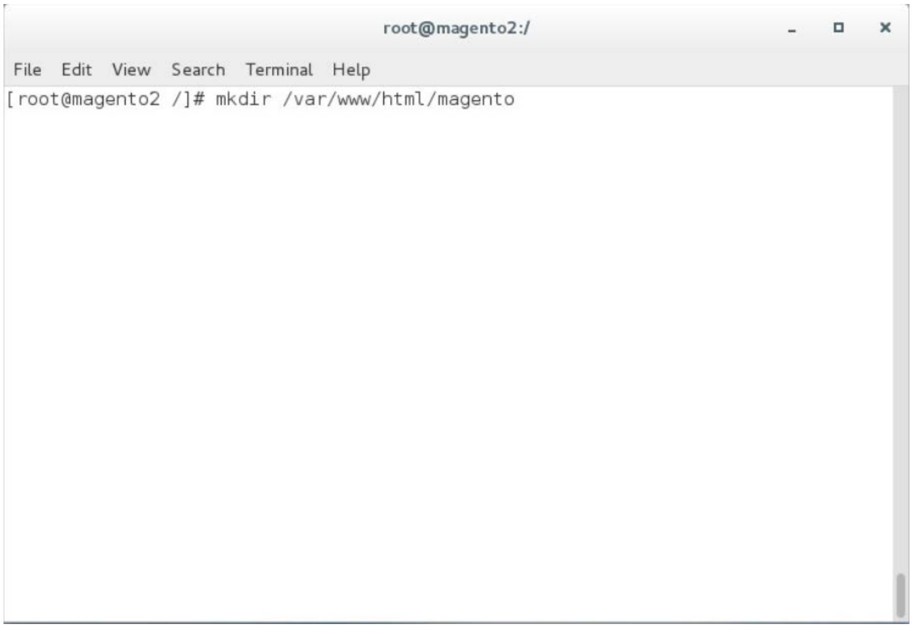
> To download the open-source copy of Magento, navigate to the site: https://magento.com/products/open-source.

When redirected to the resource page, specify the download format. In the example implementation, we installed Magento on CentOS by selecting a file that ends in `.gz`, as shown in the example below.

```
Magento-Community-Edition-2.1.8.tar.gz
```

1. Create a Magento directory inside HTTPD's DocumentRoot folder by entering the following command:

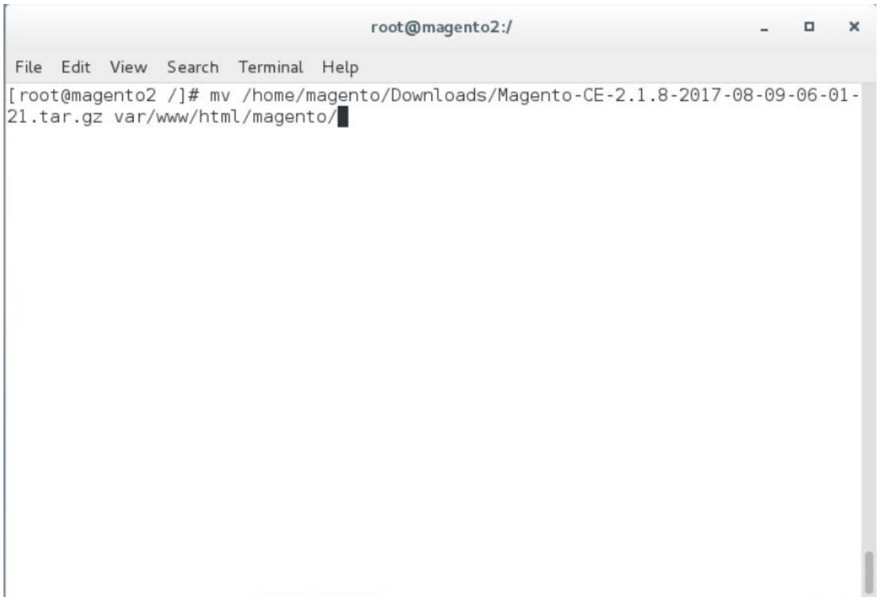
   ```
   mkdir /var/www/html/magento
   ```



```
[root@magento2 /]# mkdir /var/www/html/magento
```

2. Move the *Magento-CE-2.1.8.tar.gz* into the Magento directory with the following command:

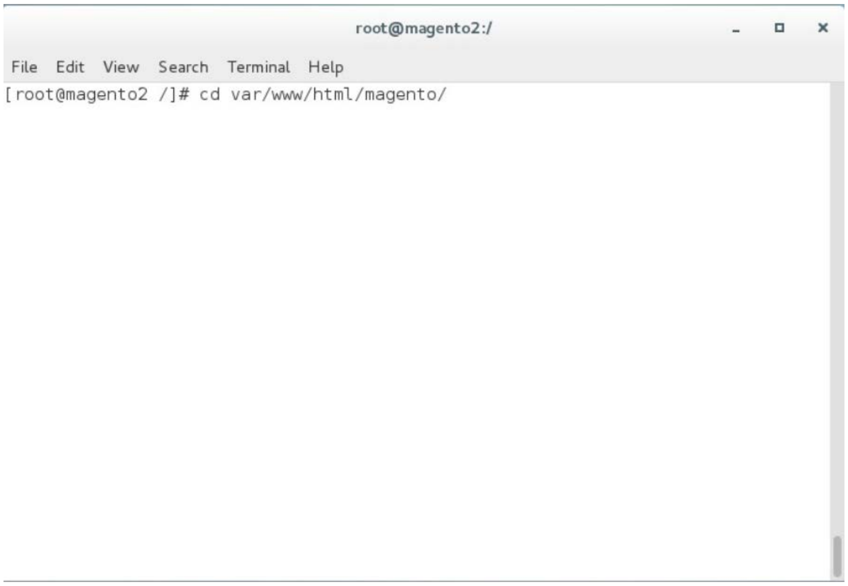
   ```
   mv <download location>/Magento-CE-2.1.8-2017-08-09-96-91-21.tar.gz
   /var/www/html/magento
   ```



```
[root@magento2 /]# mv /home/magento/Downloads/Magento-CE-2.1.8-2017-08-09-06-01-
21.tar.gz var/www/html/magento/
```

3. Change the directory to the Magento directory by entering the following command (all commands following this step should be run from this directory):

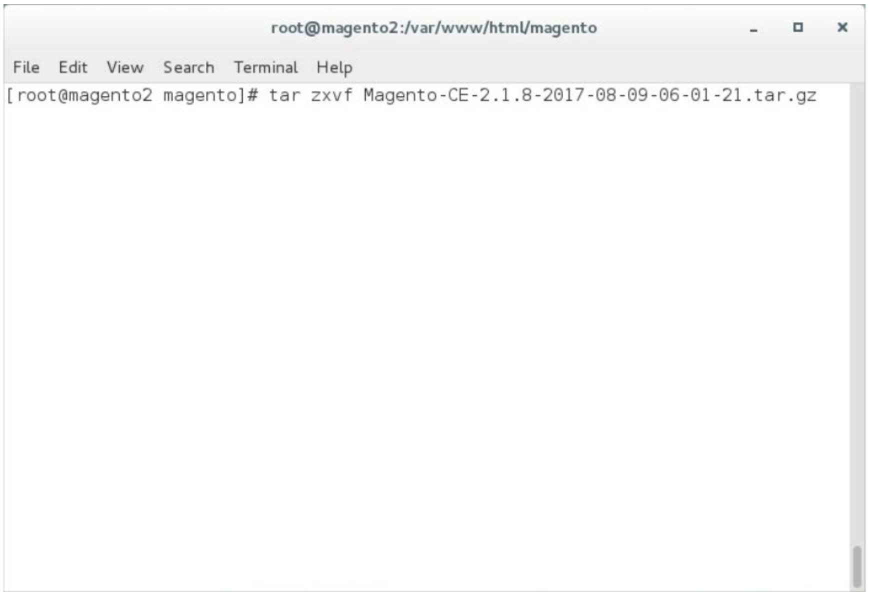
   ```
   cd /var/www/html/magento
   ```



```
[root@magento2 /]# cd var/www/html/magento/
```

4. Extract the Magento distribution from *Magento-CE-2.1.8.tar.gz* by entering the following command:

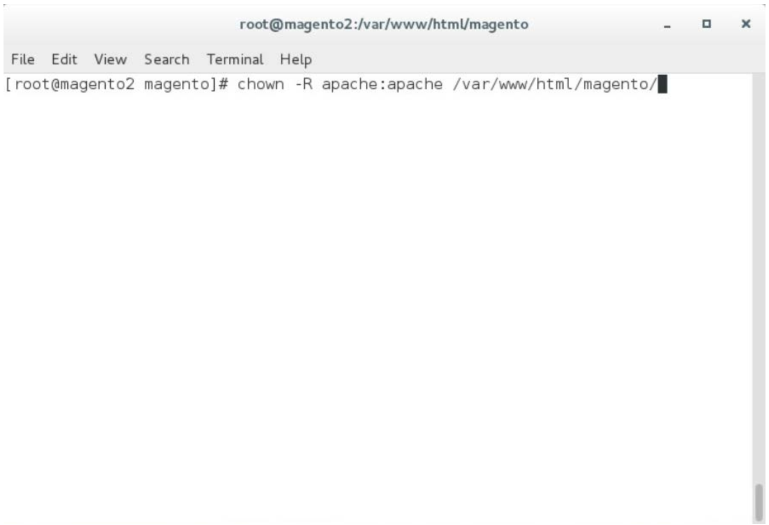
   ```
   tar zxvf Magento-CE-2.1.8-2017-08-09-96-91-21.tar.gz
   ```


root@magento2:/var/www/html/magento
File Edit View Search Terminal Help

```
[root@magento2 magento]# tar zxvf Magento-CE-2.1.8-2017-08-09-06-01-21.tar.gz
```

5. Change ownership of the extracted files to the Apache user by entering the following command:

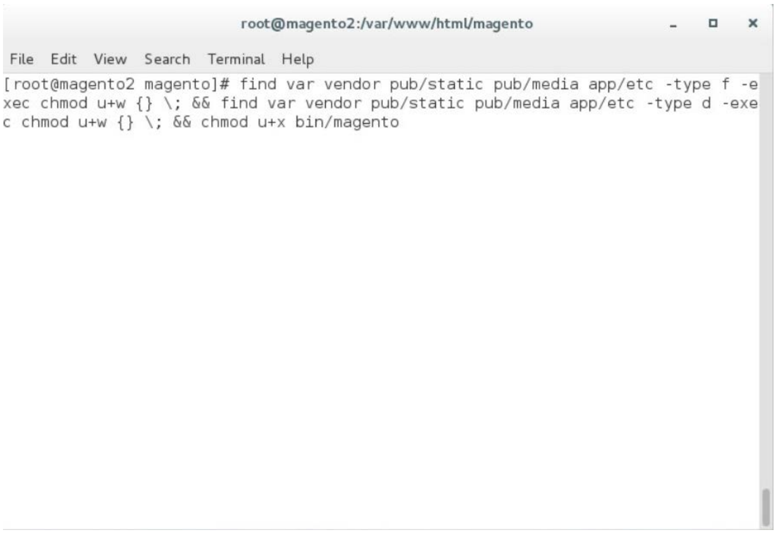
   ```
   chown -R apache:apache /var/www/html/magento
   ```


root@magento2:/var/www/html/magento
File Edit View Search Terminal Help

```
[root@magento2 magento]# chown -R apache:apache /var/www/html/magento/
```

6. Change file permissions by entering the following command (Note: This is a single command that must be executed on a single line.):

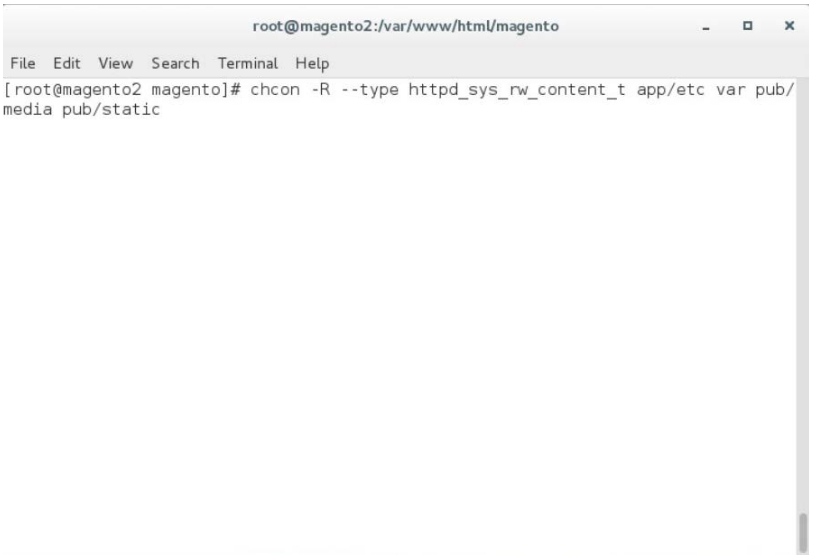
   ```
   find var vendor pub/static pub/media app/etc -type f -exec chmod u+w {} \; &&
   find var vendor pub/static pub/media app/etc -type d -exec chmod u+w {} \; &&
   chmod u+x bin/magento
   ```


root@magento2:/var/www/html/magento
File Edit View Search Terminal Help

```
[root@magento2 magento]# find var vendor pub/static pub/media app/etc -type f -e
xec chmod u+w {} \; && find var vendor pub/static pub/media app/etc -type d -exe
c chmod u+w {} \; && chmod u+x bin/magento
```

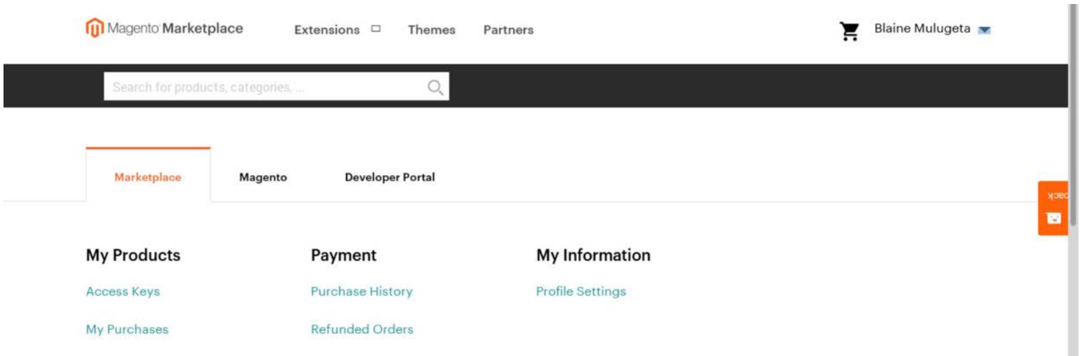
7. Change the Security-Enhanced Linux (SELinux) context permissions to allow the Apache user to have read/write access to specific directories within the Magento directory by entering the following command:

   ```
   chcon -R --type httpd_sys_rw_content_t app/etc var pub/media pub/static
   ```

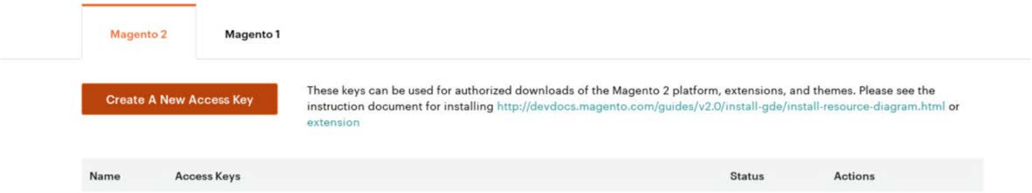

root@magento2:/var/www/html/magento
File Edit View Search Terminal Help

```
[root@magento2 magento]# chcon -R --type httpd_sys_rw_content_t app/etc var pub/
media pub/static
```

8. Open the web browser to log in to https://marketplace.magento.com and access your account. Click **Access Keys.**



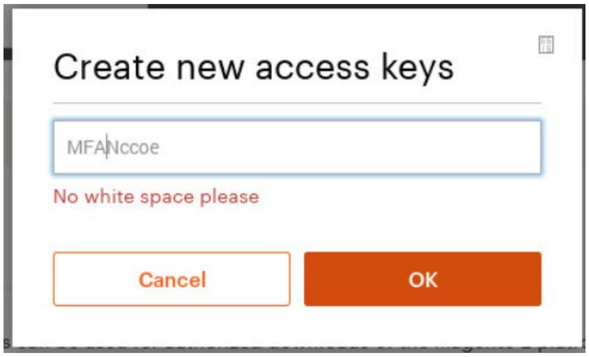
9. In the Magento tab, click **Create A New Access Key.**



These keys can be used for authorized downloads of the Magento 2 platform, extensions, and themes. Please see the instruction document for installing http://devdocs.magento.com/guides/v2.0/install-gde/install-resource-diagram.html or extension

Name	Access Keys	Status	Actions

10. Enter a name for your new access key, and click **OK.**

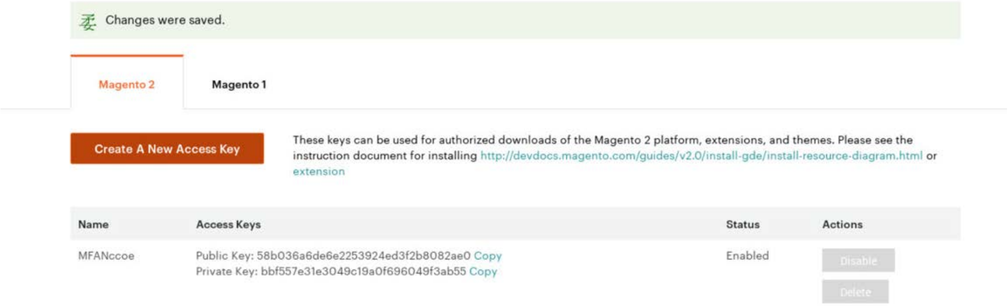


Create new access keys

MFANccoe

No white space please

11. The new access keys will be displayed in the menu with the **Status** of **Enabled.**



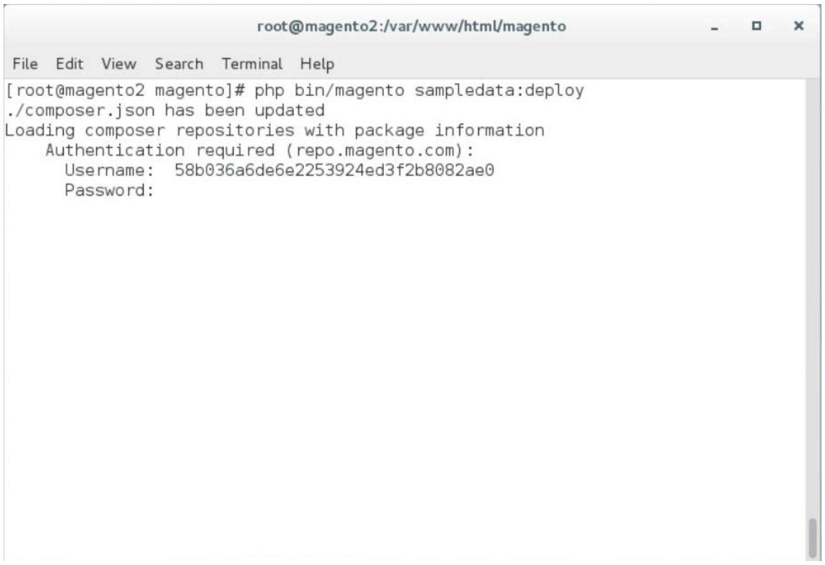
Changes were saved.

These keys can be used for authorized downloads of the Magento 2 platform, extensions, and themes. Please see the instruction document for installing http://devdocs.magento.com/guides/v2.0/install-gde/install-resource-diagram.html or extension

Name	Access Keys	Status	Actions
MFANccoe	Public Key: 58b036a6de6e2253924ed3f2b8082ae0 Copy Private Key: bbf557e31e3049c19a0f696049f3ab55 Copy	Enabled	Disable Delete

12. Install Magento's sample data by entering the following command and then providing <public key> when a **Username** is requested and <private key> as the **Password** when prompted:

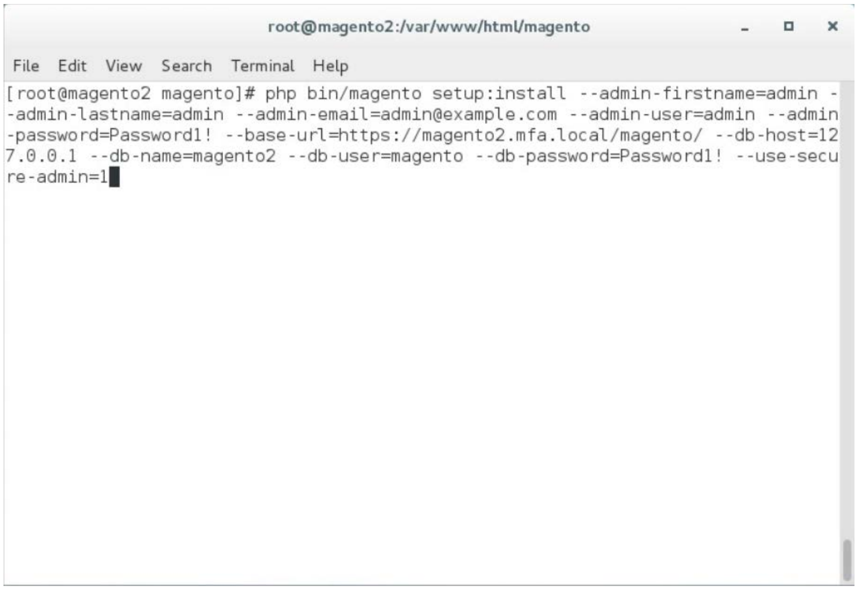
    ```
    php bin/magento sampledata:deploy
    ```


root@magento2:/var/www/html/magento
File Edit View Search Terminal Help

```
[root@magento2 magento]# php bin/magento sampledata:deploy
./composer.json has been updated
Loading composer repositories with package information
    Authentication required (repo.magento.com):
      Username:  58b036a6de6e2253924ed3f2b8082ae0
      Password:
```

13. Install the Magento software distribution by issuing the following command, replacing parameters in <> with values appropriate for your installation (Note: This is a single command that must be executed on a single line.):

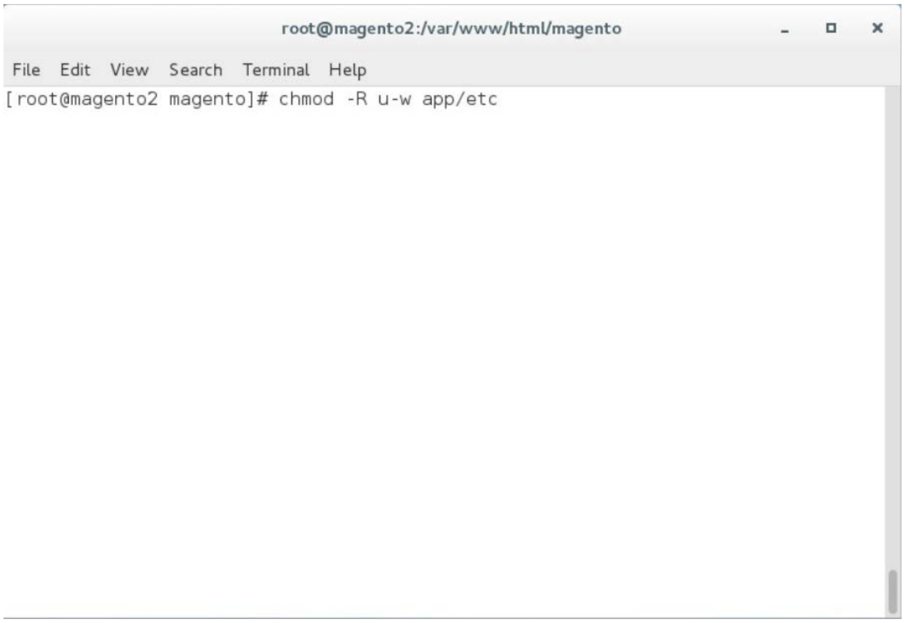
    ```
    php bin/magento setup:install --admin-firstname=<First Name> --admin-
    lastname=<Last Name> --admin-email=<email> --admin-user=strongauth --admin-
    password=<password> --base-url=https://<fully-qualified-domainname>/magento/ --
    db-host=127.0.01 --db-name=magento2 --db-user=magento --db-password=<db
    password> --use-secure-admin=1
    ```


root@magento2:/var/www/html/magento
File Edit View Search Terminal Help

```
[root@magento2 magento]# php bin/magento setup:install --admin-firstname=admin -
-admin-lastname=admin --admin-email=admin@example.com --admin-user=admin --admin
-password=Password1! --base-url=https://magento2.mfa.local/magento/ --db-host=12
7.0.0.1 --db-name=magento2 --db-user=magento --db-password=Password1! --use-secu
re-admin=1
```

14. Modify compiled file permissions by issuing the following command:

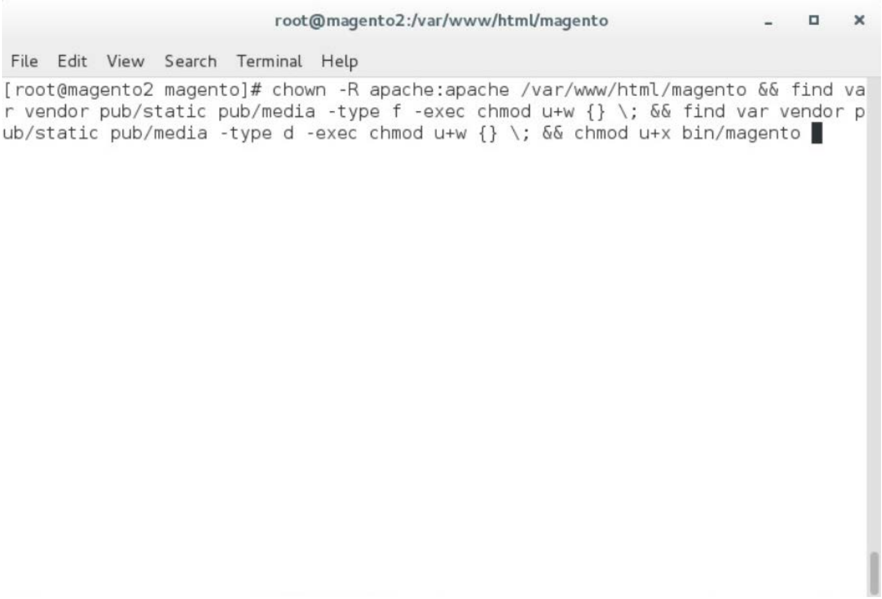
    ```
    chmod -R u-w app/etc
    ```


root@magento2:/var/www/html/magento
File Edit View Search Terminal Help

```
[root@magento2 magento]# chmod -R u-w app/etc
```

15. Modify compiled file permissions by issuing the following command:

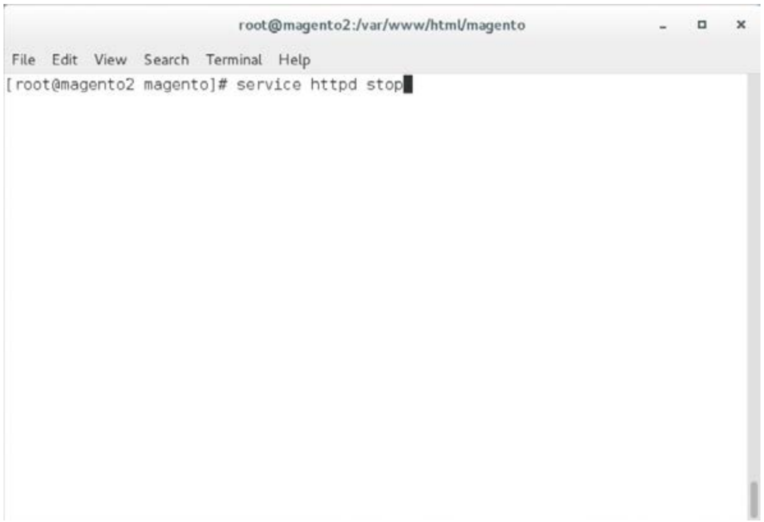
    ```
    chown -R apache:apache /var/www/html/magento && find var vendor pub/static
    pub/media -type f -exec chmod u+w {} \; && find var vendor pub/static pub/media
    -type d -exec chmod u+w {} \; && chmod u+x bin/magento
    ```


root@magento2:/var/www/html/magento
File Edit View Search Terminal Help

```
[root@magento2 magento]# chown -R apache:apache /var/www/html/magento && find va
r vendor pub/static pub/media -type f -exec chmod u+w {} \; && find var vendor p
ub/static pub/media -type d -exec chmod u+w {} \; && chmod u+x bin/magento
```

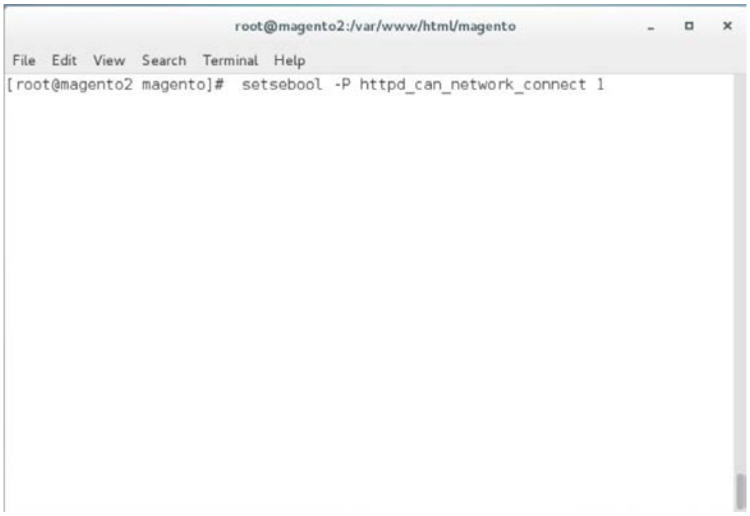
16. Modify SELinux permissions, to enable HTTPD to access the database, by executing the following commands:

    a. `service httpd stop`


root@magento2:/var/www/html/magento
File Edit View Search Terminal Help

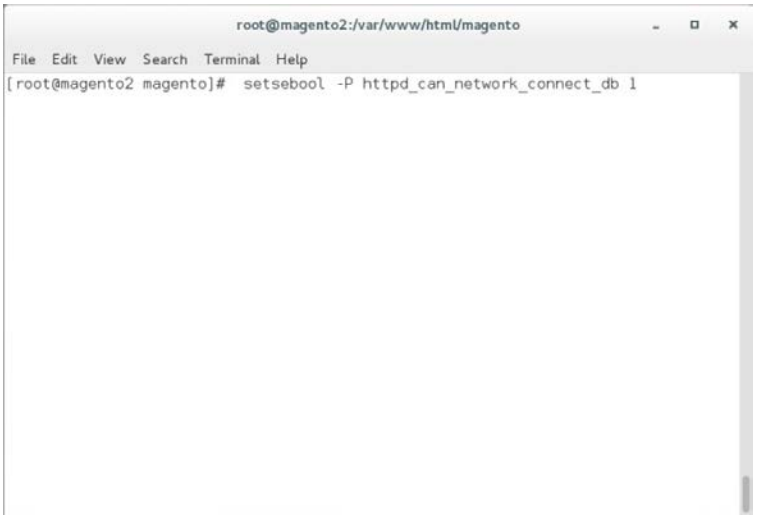
```
[root@magento2 magento]# service httpd stop
```

    b. `setsebool -P httpd_can_network_connect 1`


root@magento2:/var/www/html/magento
File Edit View Search Terminal Help

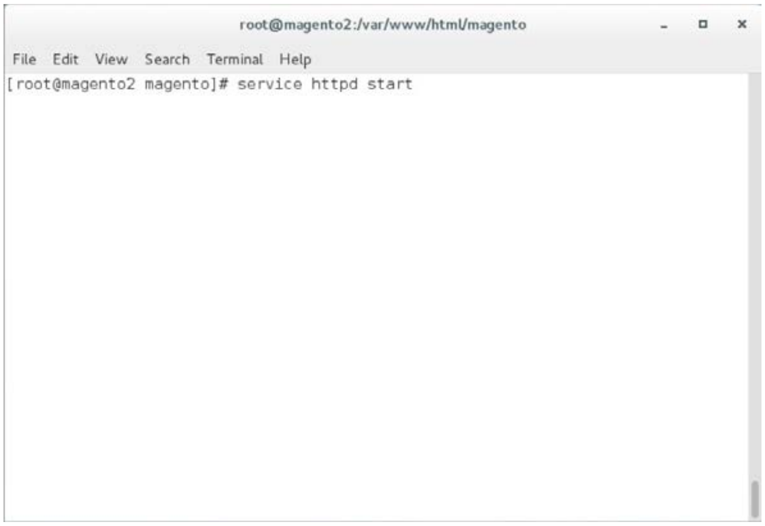
```
[root@magento2 magento]#  setsebool -P httpd_can_network_connect 1
```

c. `setsebool -P httpd_can_network_connect_db 1`


root@magento2:/var/www/html/magento
File Edit View Search Terminal Help

```
[root@magento2 magento]#  setsebool -P httpd_can_network_connect_db 1
```

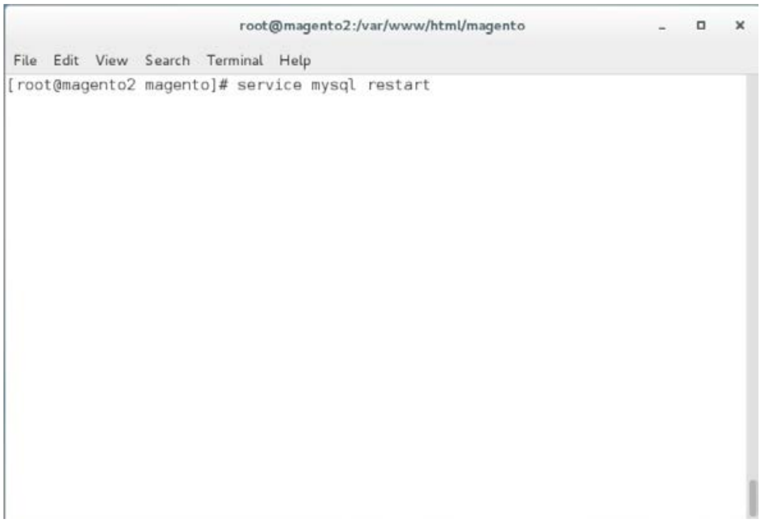
d. `service httpd start`



root@magento2:/var/www/html/magento
File Edit View Search Terminal Help

```
[root@magento2 magento]# service httpd start
```

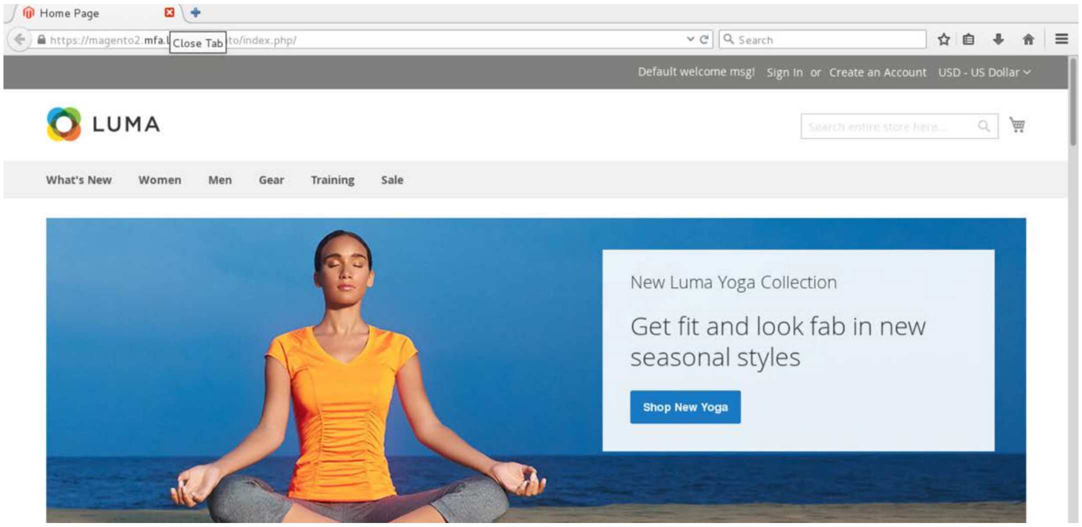
e. `service mysql restart`



root@magento2:/var/www/html/magento
File Edit View Search Terminal Help

```
[root@magento2 magento]# service mysql restart
```

17. Verify the installation by navigating in the browser to the store URL, which was set up in Section 2.2.4, Step 13 (*https://magento2.mfa.local/magento*).

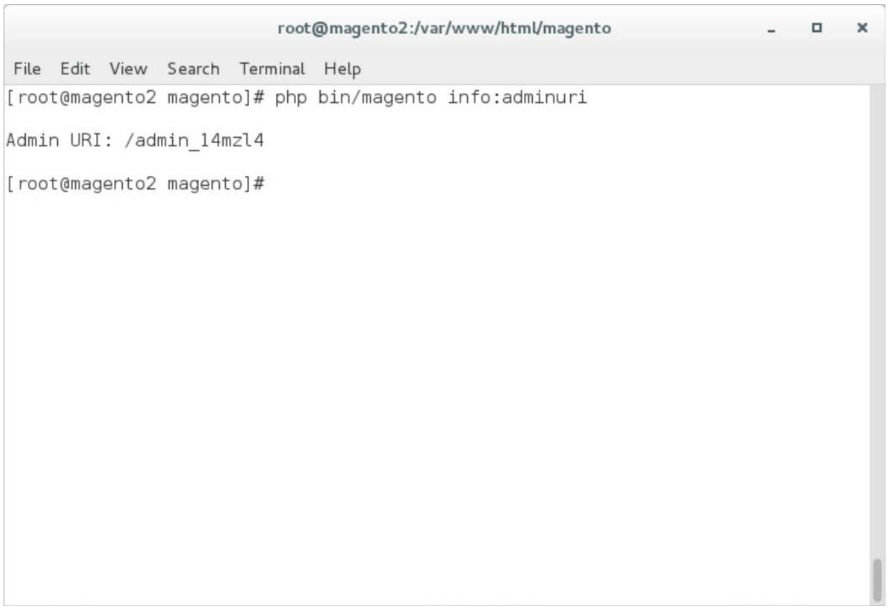

Home Page
https://magento2.mfa.l Close Tab to/index.php/
Search
Default welcome msg! Sign In or Create an Account USD - US Dollar
LUMA
Search entire store here...
What's New
Women
Men
Gear
Training
Sale
New Luma Yoga Collection
Get fit and look fab in new seasonal styles
Shop New Yoga

2.2.5 Configuring the Magento Account Lockout Feature

This section describes the steps required to configure account lockouts after a specified number of failed login attempts. For our example implementation, we specified five as the maximum number of login-attempt failures before temporarily disabling the account, and 20 minutes as the lockout time. These parameters can be adjusted, and the administrator of the Magento site has the information system privileges to set these values based on the implementer’s preference.

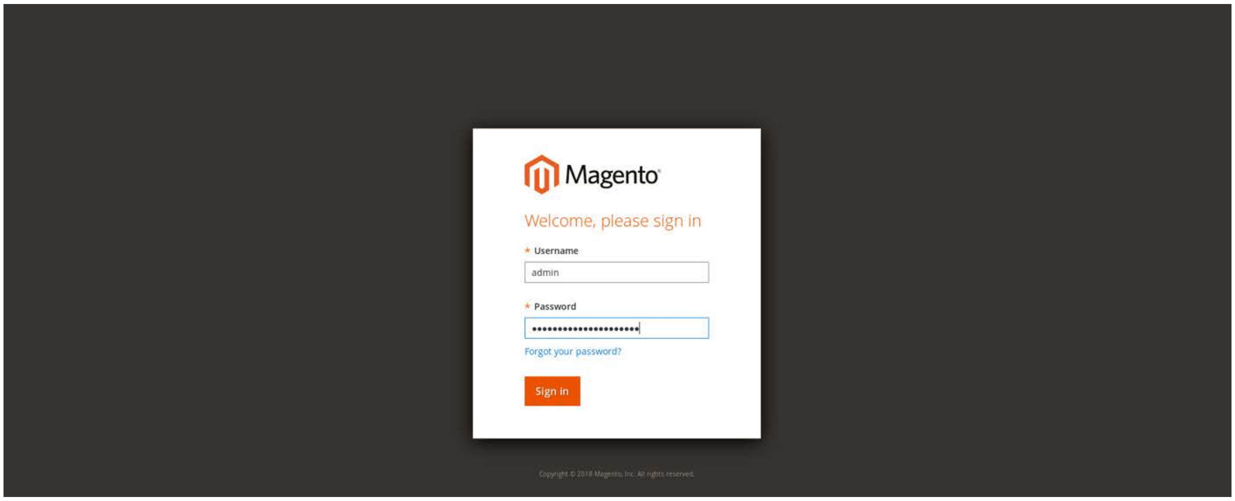
1. Determine the admin uniform resource identifier (URI) by running the following command:

   ```
   php bin/magento info:adminuri
   ```


root@magento2:/var/www/html/magento
File Edit View Search Terminal Help

```
[root@magento2 magento]# php bin/magento info:adminuri

Admin URI: /admin_14mzl4

[root@magento2 magento]#
```

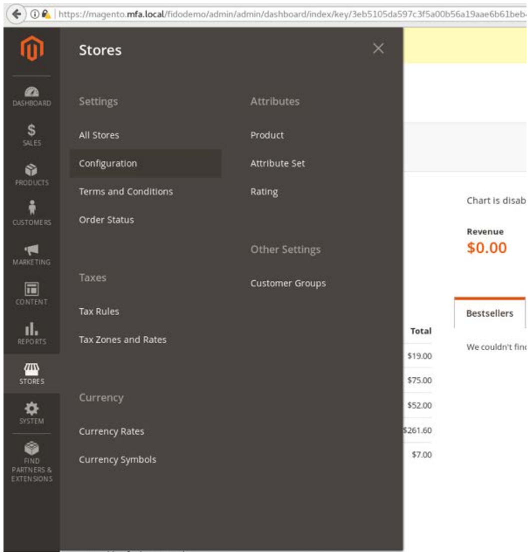
2. Navigate to the admin URI identified in Section 2.2.5, Step 1, and sign in with the Magento **Username** and **Password** created in Section 2.2.4, Step 13 (the example implementation URI is *https://magento2.mfa.local/admin_14mzl4*).



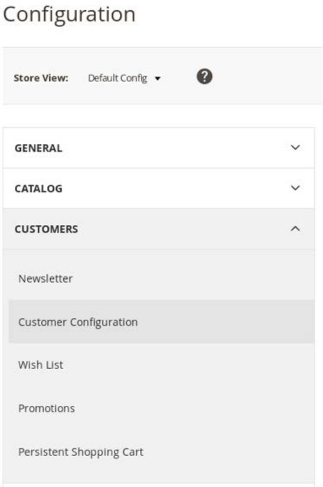
* Username: admin

* Password: ••••••••••••••••••••••

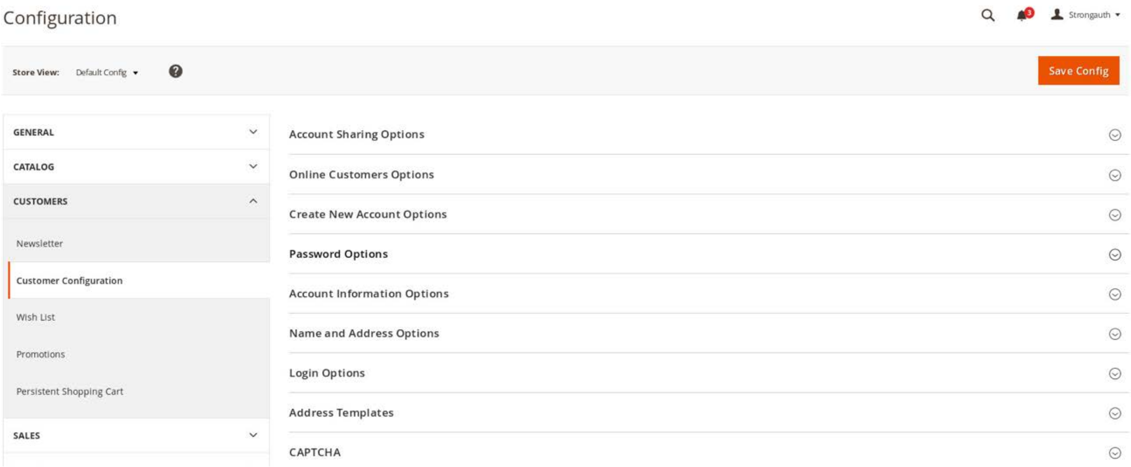
3. Proceed to the Configuration page: **STORES > Configuration.**



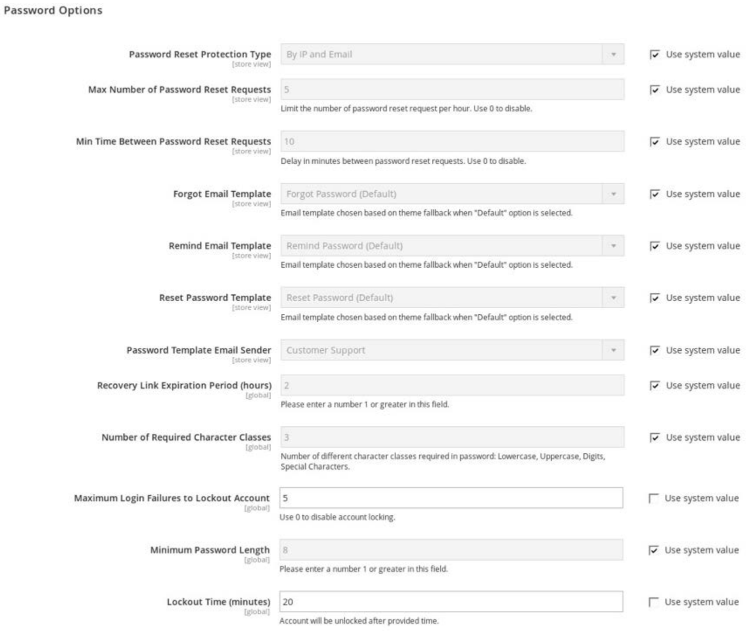
4. Click the **CUSTOMERS** drop-down from the menu in the **Configuration** page, and select **Customer Configuration.**



5. Click the **Password Options** drop-down.



6. Uncheck the **Use system value** fields for the **Maximum Login Failures to Lockout Account** and **Lockout Time (minutes)** to modify the settings for the **Password Options.**



Password Options

Password Reset Protection Type [store view]: By IP and Email ☑ Use system value

Max Number of Password Reset Requests [store view]: 5 ☑ Use system value
Limit the number of password reset request per hour. Use 0 to disable.

Min Time Between Password Reset Requests [store view]: 10 ☑ Use system value
Delay in minutes between password reset requests. Use 0 to disable.

Forgot Email Template [store view]: Forgot Password (Default) ☑ Use system value
Email template chosen based on theme fallback when "Default" option is selected.

Remind Email Template [store view]: Remind Password (Default) ☑ Use system value
Email template chosen based on theme fallback when "Default" option is selected.

Reset Password Template [store view]: Reset Password (Default) ☑ Use system value
Email template chosen based on theme fallback when "Default" option is selected.

Password Template Email Sender [store view]: Customer Support ☑ Use system value

Recovery Link Expiration Period (hours) [global]: 2 ☑ Use system value
Please enter a number 1 or greater in this field.

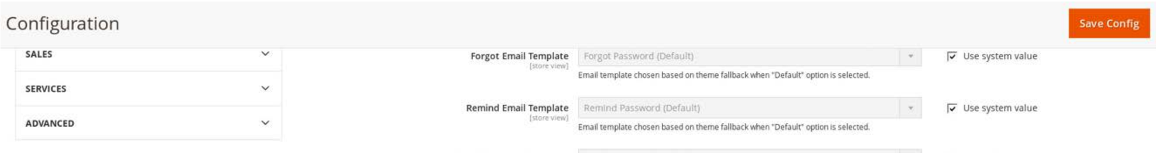
Number of Required Character Classes [global]: 3 ☑ Use system value
Number of different character classes required in password: Lowercase, Uppercase, Digits, Special Characters.

Maximum Login Failures to Lockout Account [global]: 5 □ Use system value
Use 0 to disable account locking.

Minimum Password Length [global]: 8 ☑ Use system value
Please enter a number 1 or greater in this field.

Lockout Time (minutes) [global]: 20 □ Use system value
Account will be unlocked after provided time.

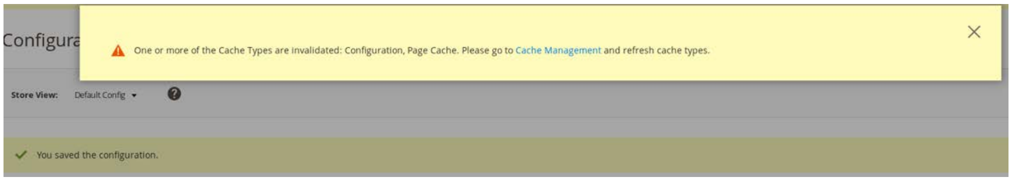
7. Click **Save Config** to save the changes made.



Forgot Email Template [store view]: Forgot Password (Default) ☑ Use system value
Email template chosen based on theme fallback when "Default" option is selected.

Remind Email Template [store view]: Remind Password (Default) ☑ Use system value
Email template chosen based on theme fallback when "Default" option is selected.

8. The following pop-up will appear, notifying you to refresh Cache Types. Click the **Cache Management** link in the message.



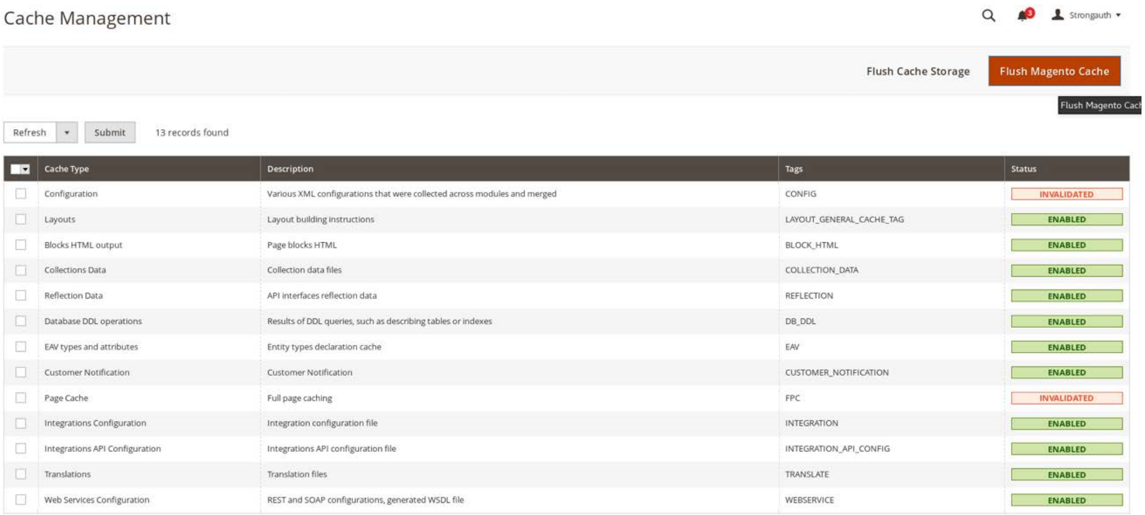
Configura

One or more of the Cache Types are invalidated: Configuration, Page Cache. Please go to Cache Management and refresh cache types.

Store View: Default Config

You saved the configuration.

9. You will be redirected to the **Cache Management** page. Click **Flush Magento Cache** to resolve the **INVALIDATED** Cache Types.

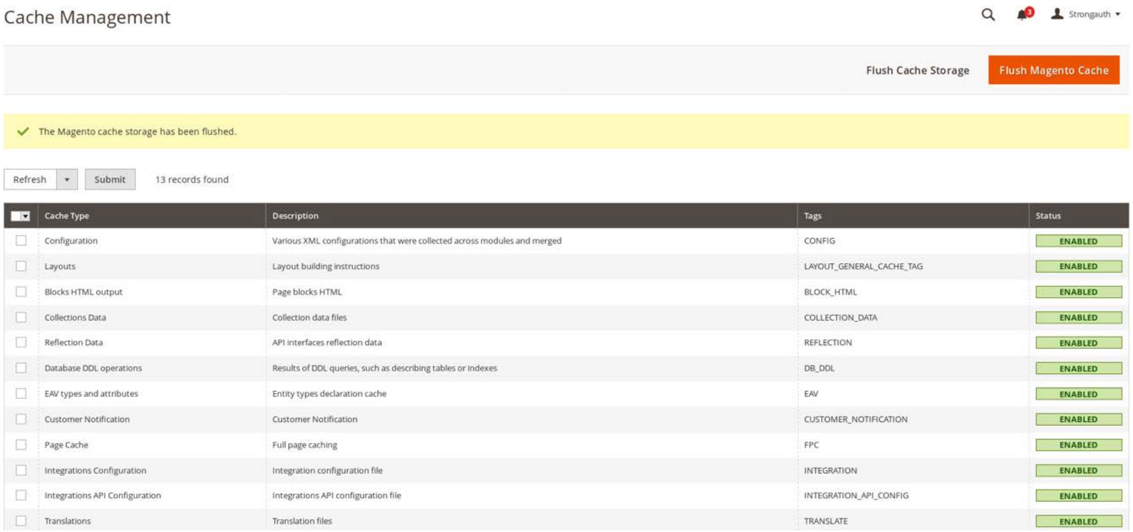


Cache Management

13 records found

Cache Type	Description	Tags	Status
Configuration	Various XML configurations that were collected across modules and merged	CONFIG	INVALIDATED
Layouts	Layout building instructions	LAYOUT_GENERAL_CACHE_TAG	ENABLED
Blocks HTML output	Page blocks HTML	BLOCK_HTML	ENABLED
Collections Data	Collection data files	COLLECTION_DATA	ENABLED
Reflection Data	API interfaces reflection data	REFLECTION	ENABLED
Database DDL operations	Results of DDL queries, such as describing tables or indexes	DB_DDL	ENABLED
EAV types and attributes	Entity types declaration cache	EAV	ENABLED
Customer Notification	Customer Notification	CUSTOMER_NOTIFICATION	ENABLED
Page Cache	Full page caching	FPC	INVALIDATED
Integrations Configuration	Integration configuration file	INTEGRATION	ENABLED
Integrations API Configuration	Integrations API configuration file	INTEGRATION_API_CONFIG	ENABLED
Translations	Translation files	TRANSLATE	ENABLED
Web Services Configuration	REST and SOAP configurations, generated WSDL file	WEBSERVICE	ENABLED

10. Upon completion of the flush, the page will reflect the changes.



Cache Management

The Magento cache storage has been flushed.

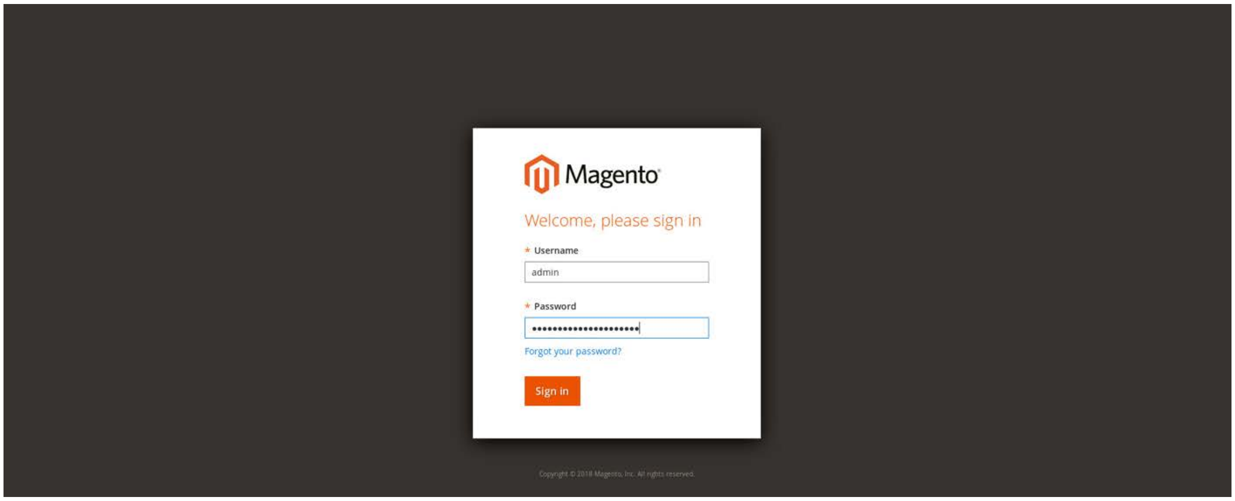
13 records found

Cache Type	Description	Tags	Status
Configuration	Various XML configurations that were collected across modules and merged	CONFIG	ENABLED
Layouts	Layout building instructions	LAYOUT_GENERAL_CACHE_TAG	ENABLED
Blocks HTML output	Page blocks HTML	BLOCK_HTML	ENABLED
Collections Data	Collection data files	COLLECTION_DATA	ENABLED
Reflection Data	API interfaces reflection data	REFLECTION	ENABLED
Database DDL operations	Results of DDL queries, such as describing tables or indexes	DB_DDL	ENABLED
EAV types and attributes	Entity types declaration cache	EAV	ENABLED
Customer Notification	Customer Notification	CUSTOMER_NOTIFICATION	ENABLED
Page Cache	Full page caching	FPC	ENABLED
Integrations Configuration	Integration configuration file	INTEGRATION	ENABLED
Integrations API Configuration	Integrations API configuration file	INTEGRATION_API_CONFIG	ENABLED
Translations	Translation files	TRANSLATE	ENABLED

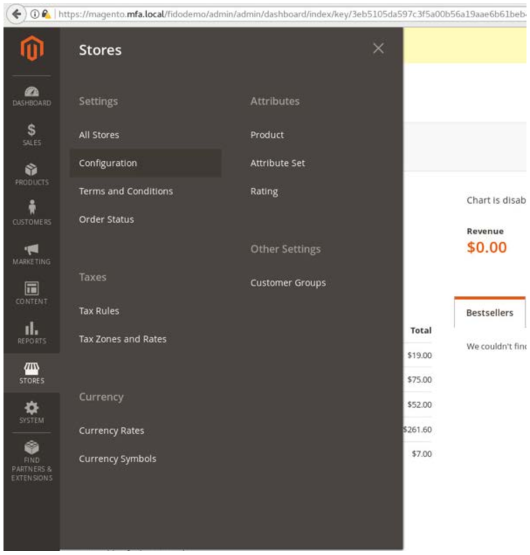
2.2.6 Disabling Magento Guest Checkout

This section describes steps to disable Magento's guest checkout feature to ensure that purchasers cannot choose to check out as a guest.

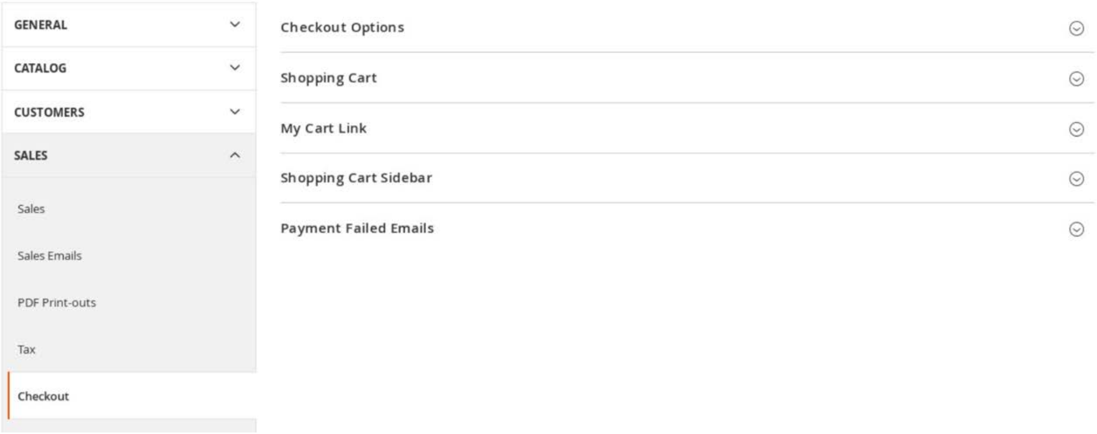
1. Navigate to the admin URI identified in Section 2.2.5, Step 1 (*https://magento2.mfa.local/admin_14mzl4*), and sign in with the **Username** and **Password** created in Section 2.2.4, Step 13.



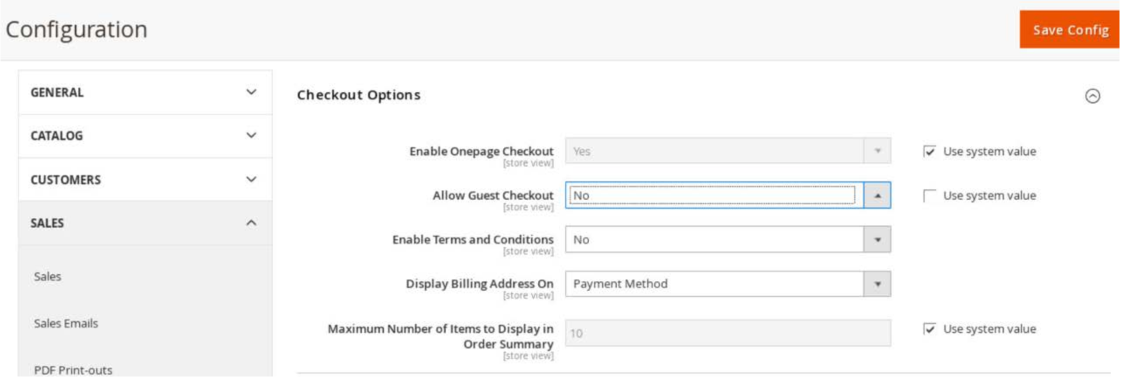
2. Proceed to the **Configuration** page: **STORES > Configuration.**


https://magento.mfa.local/fidodemo/admin/admin/dashboard/index/key/3eb5105da597c3f5a00b56a19aae6b61beb

3. Click the **SALES** drop-down from the menu on the **Configuration** page, select **Checkout**, and expand the **Checkout Options.**



4. Uncheck the **Use system value** fields for the **Allow Guest Checkout** setting, and modify the settings to **No** for the **Checkout Options.**



Enable Onepage Checkout [store view] Yes ☑ Use system value

Allow Guest Checkout [store view] No □ Use system value

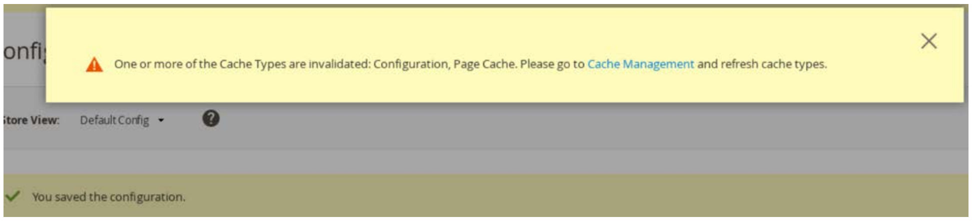
Enable Terms and Conditions [store view] No

Display Billing Address On [store view] Payment Method

Maximum Number of Items to Display in Order Summary [store view] 10 ☑ Use system value

5. Click **Save Config.**

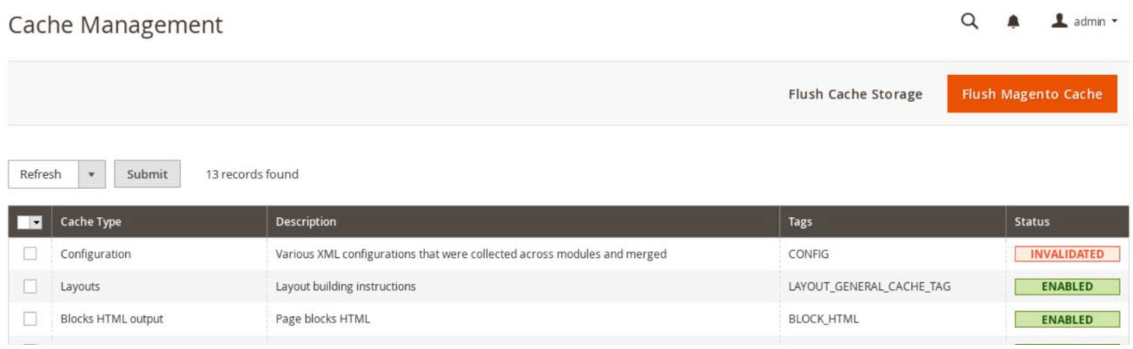
6. The following pop-up will appear, notifying you to refresh Cache Types. Click the **Cache Management** link in the message.



One or more of the Cache Types are invalidated: Configuration, Page Cache. Please go to Cache Management and refresh cache types.

✓ You saved the configuration.

7. You will be redirected to the **Cache Management** page. Click **Flush Magento Cache** to resolve the **INVALIDATED** Cache Types.

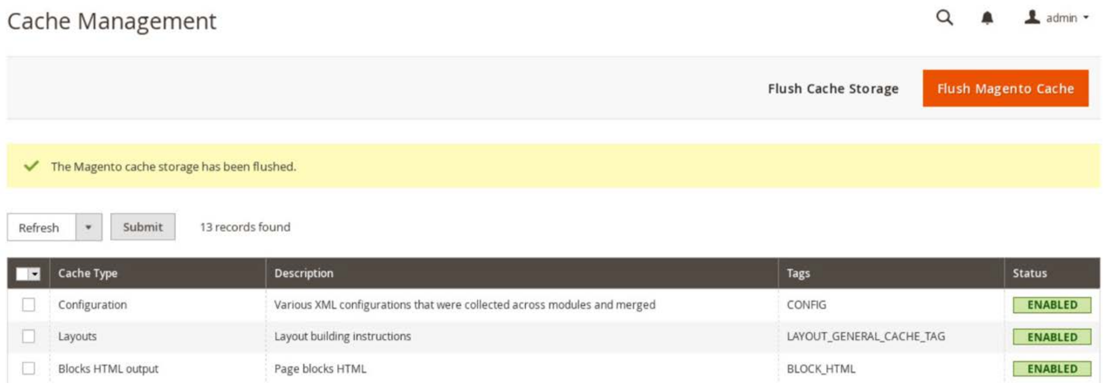


Cache Management

13 records found

☐	Cache Type	Description	Tags	Status
☐	Configuration	Various XML configurations that were collected across modules and merged	CONFIG	INVALIDATED
☐	Layouts	Layout building instructions	LAYOUT_GENERAL_CACHE_TAG	ENABLED
☐	Blocks HTML output	Page blocks HTML	BLOCK_HTML	ENABLED

8. Upon completion of the flush, the page will reflect the changes.



Cache Management

✓ The Magento cache storage has been flushed.

13 records found

☐	Cache Type	Description	Tags	Status
☐	Configuration	Various XML configurations that were collected across modules and merged	CONFIG	ENABLED
☐	Layouts	Layout building instructions	LAYOUT_GENERAL_CACHE_TAG	ENABLED
☐	Blocks HTML output	Page blocks HTML	BLOCK_HTML	ENABLED

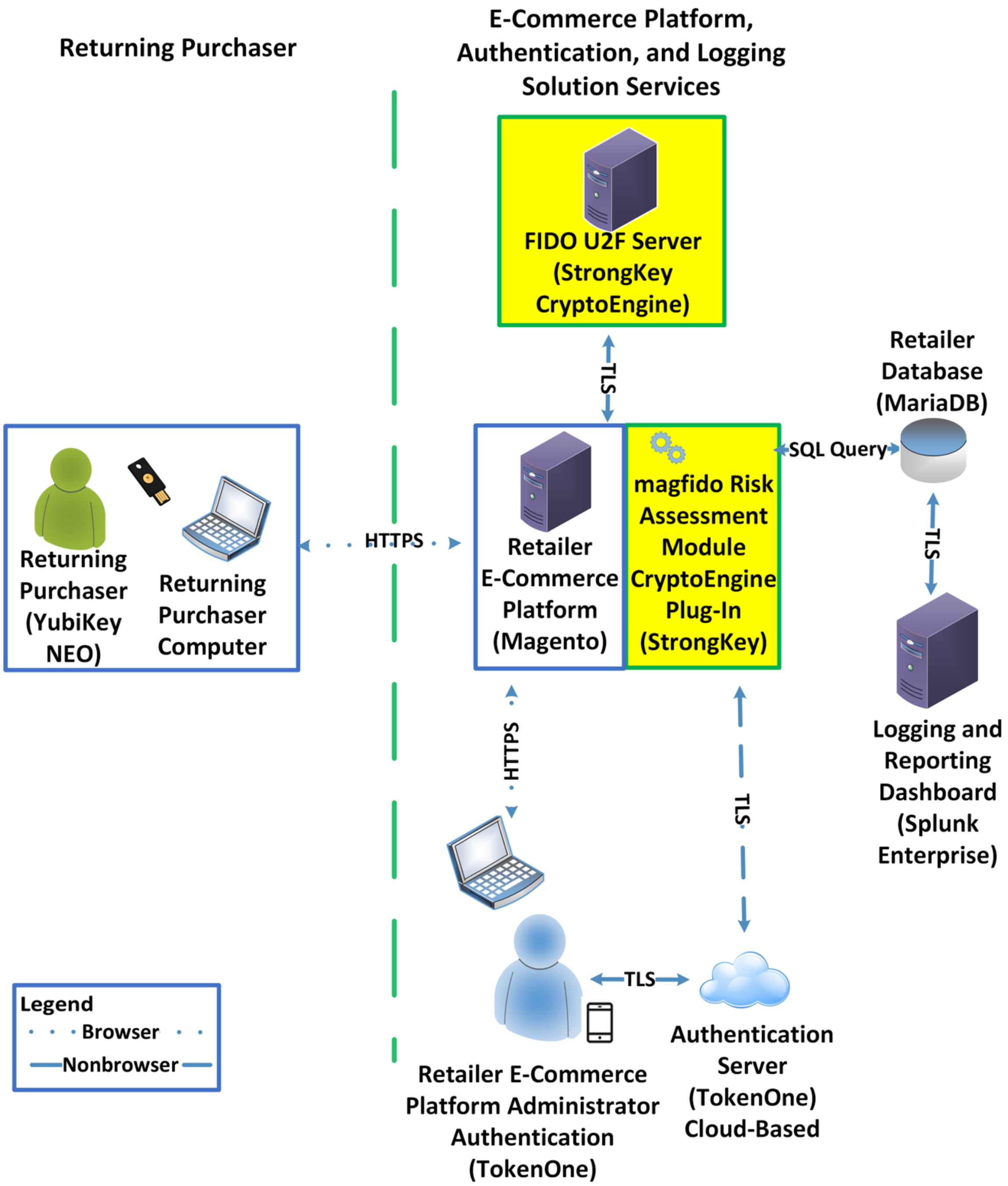
2.3 StrongKey magfido Module

This section of the guide provides installation and configuration guidance for the StrongKey magfido *FIDOU2FAuthenticator* module [6]. While the core feature of the magfido module is to enable U2F authentication, the magfido module also allows registration of FIDO U2F Security Keys. Additional information on magfido and how the registration feature works can be found in Appendix A.

2.3.1 StrongKey magfido Overview

The magfido module is used in the *cost threshold* example implementation build to examine the shopping cart's characteristics and to recommend whether MFA is required for the returning purchaser. The magfido module will modify the default behavior of Magento to register *FIDOU2FAuthenticators,* also known as FIDO Security Keys, and for FIDO authentication on purchases that exceed a total of $25. The StrongKey magfido components that are installed by using the instructions in this section are illustrated in Figure 2-3 and are highlighted in yellow within the green boxes.

Figure 2-3 StrongKey magfido Module Components


Returning Purchaser
E-Commerce Platform, Authentication, and Logging Solution Services
FIDO U2F Server (StrongKey CryptoEngine)
TLS
Retailer Database (MariaDB)
SQL Query
magfido Risk Assessment Module CryptoEngine Plug-In (StrongKey)
Retailer E-Commerce Platform (Magento)
HTTPS
Returning Purchaser (YubiKey NEO)
Returning Purchaser Computer
TLS
Logging and Reporting Dashboard (Splunk Enterprise)
HTTPS
TLS
TLS
Legend
Browser
Nonbrowser
Retailer E-Commerce Platform Administrator Authentication (TokenOne)
Authentication Server (TokenOne) Cloud-Based

2.3.2 StrongKey magfido Installation and Configuration

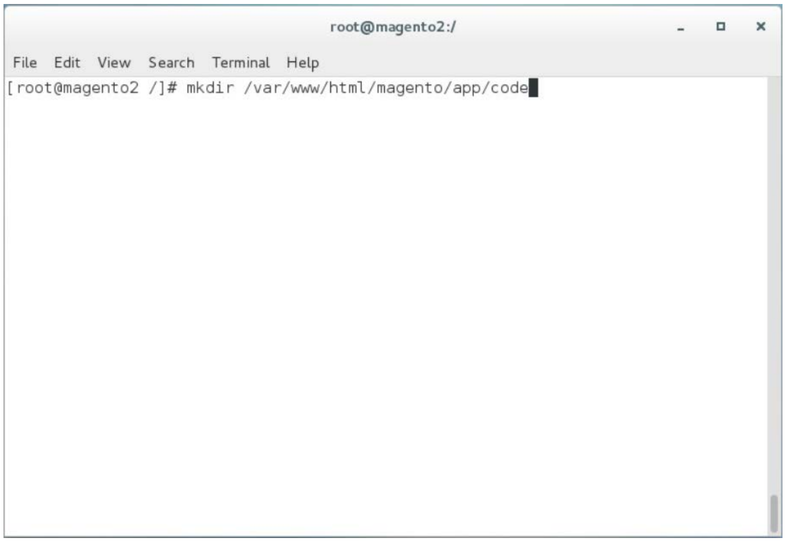
The installation procedure consists of the following steps.

- Download the software module to the Magento server where magfido will be installed.
- Execute commands as root/administrator.
- Perform post-installation configuration.

Navigate to the following site, and proceed to download the code: https://sourceforge.net/projects/magfido/.

1. Create a code directory inside Magento's app folder by entering the following command:

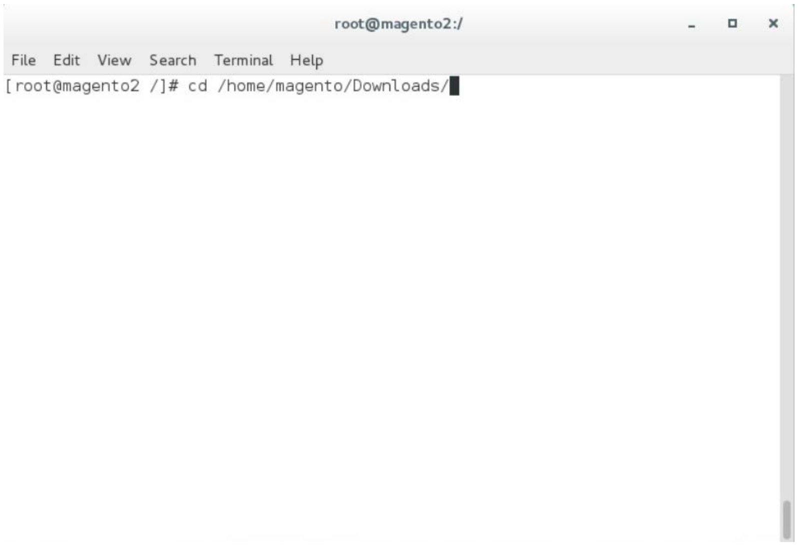
```
mkdir /var/www/html/magento/app/code
```



```
[root@magento2 /]# mkdir /var/www/html/magento/app/code
```

2. Change your current directory to the Downloads directory by entering the following command:

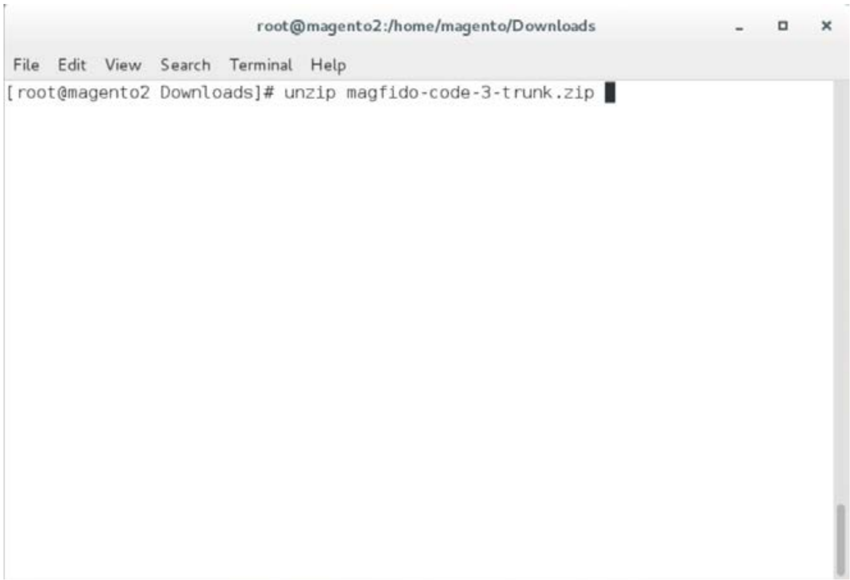
```
cd /home/magento/Downloads/
```



```
[root@magento2 /]# cd /home/magento/Downloads/
```

3. Unzip the *magfido-code-3-trunk.zip* by entering the following command:

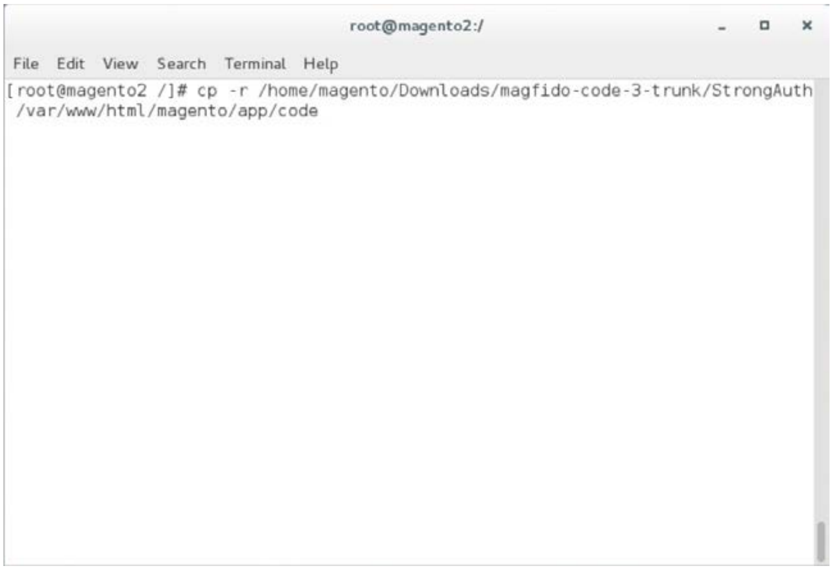
   ```
   unzip magfido-code-3-trunk.zip
   ```


root@magento2:/home/magento/Downloads
File Edit View Search Terminal Help

```
[root@magento2 Downloads]# unzip magfido-code-3-trunk.zip
```

4. Move the *StrongAuth_FIDOU2FAuthenticator* module to the code directory by entering the following command:

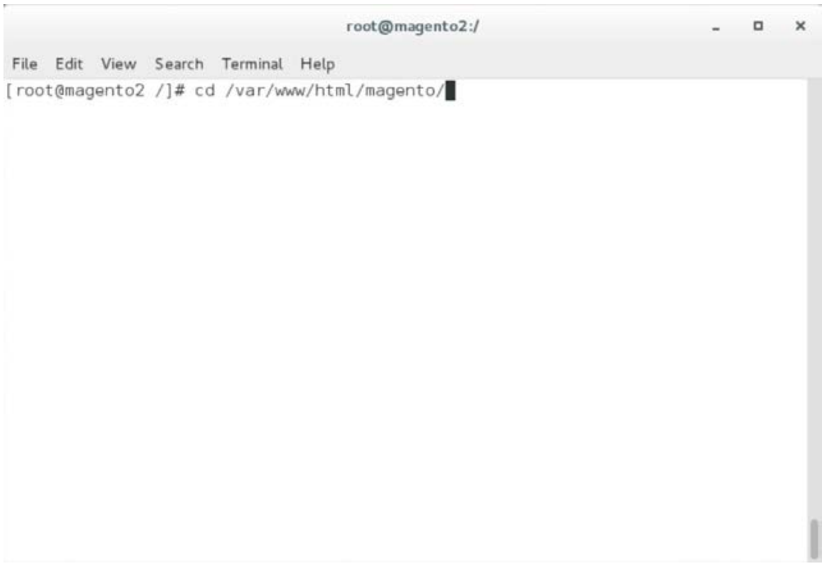
   ```
   cp -r home/magento/Downloads/magfido-code-3-trunk/StrongAuth
   /var/www/html/magento/app/code
   ```



```
[root@magento2 /]# cp -r /home/magento/Downloads/magfido-code-3-trunk/StrongAuth
 /var/www/html/magento/app/code
```

5. Change directories to the Magento directory by entering the following command:

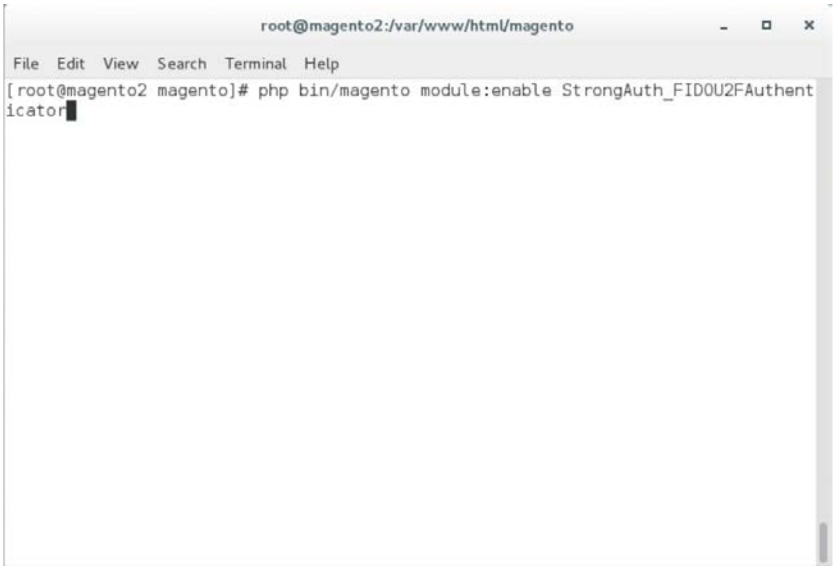
   `cd /var/www/html/magento`



```
[root@magento2 /]# cd /var/www/html/magento/
```

6. Enable the *StrongAuth_FIDOU2FAuthenticator* module by entering the following command:

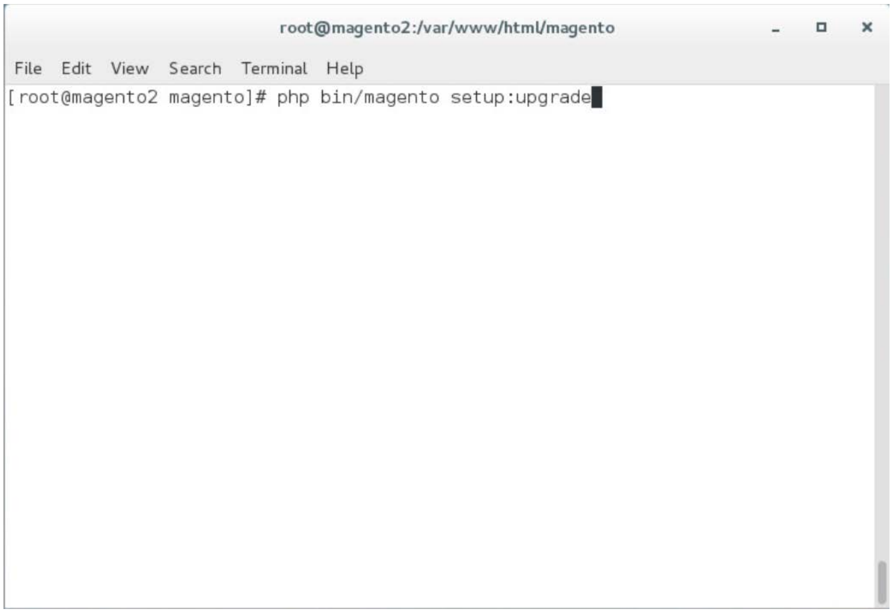
   `php bin/magento module:enable StrongAuth_FIDOU2FAuthenticator`


root@magento2:/var/www/html/magento
File Edit View Search Terminal Help

```
[root@magento2 magento]# php bin/magento module:enable StrongAuth_FIDOU2FAuthent
icator
```

7. Register the *StrongAuth_FIDOU2FAuthenticator* module by entering the following command:

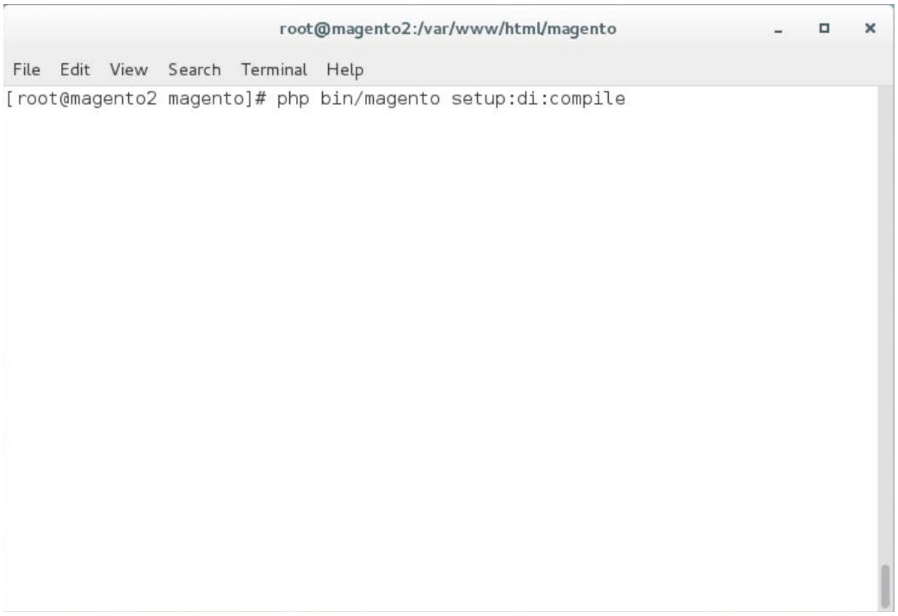
   `php bin/magento setup:upgrade`


root@magento2:/var/www/html/magento
File Edit View Search Terminal Help

```
[root@magento2 magento]# php bin/magento setup:upgrade
```

8. Recompile dependencies by entering the following command:

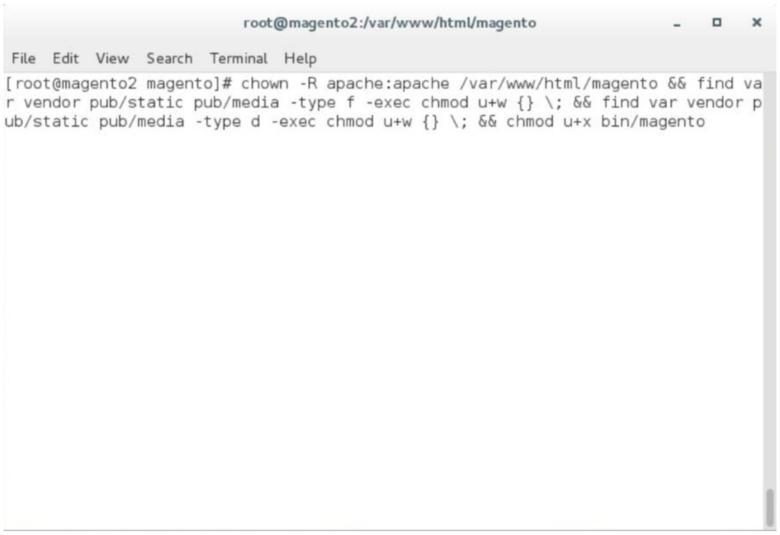
   `php bin/magento setup:di:compile`


root@magento2:/var/www/html/magento
File Edit View Search Terminal Help

```
[root@magento2 magento]# php bin/magento setup:di:compile
```

9. Adjust the compiled file permissions by entering the following command:

```
chown -R apache:apache /var/www/html/magento && find var vendor pub/static
pub/media -type f -exec chmod u+w {} \; && find var vendor pub/static pub/media
-type d -exec chmod u+w {} \; && chmod u+x bin/magento
```

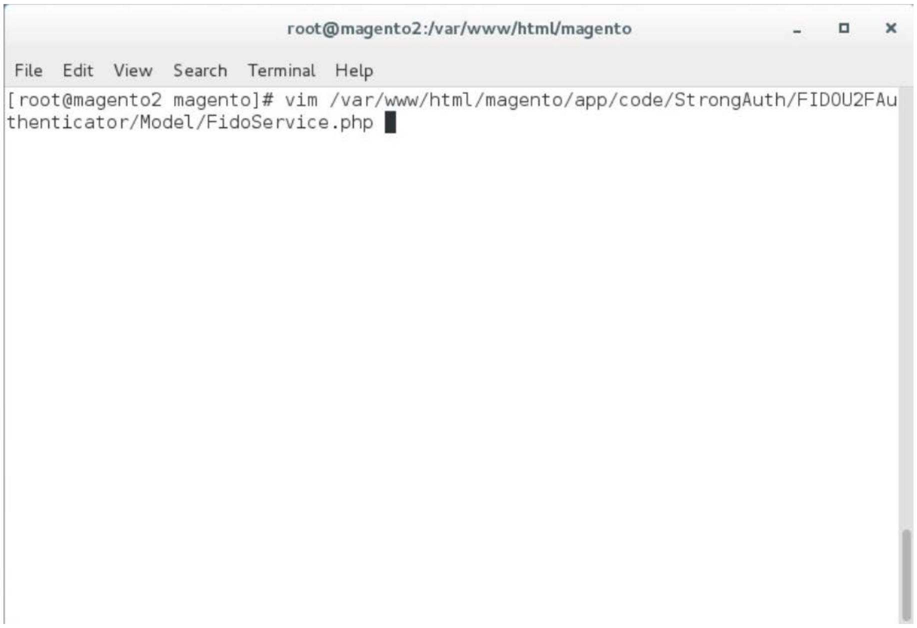

root@magento2:/var/www/html/magento
File Edit View Search Terminal Help

```
[root@magento2 magento]# chown -R apache:apache /var/www/html/magento && find va
r vendor pub/static pub/media -type f -exec chmod u+w {} \; && find var vendor p
ub/static pub/media -type d -exec chmod u+w {} \; && chmod u+x bin/magento
```

10. Configure the locally installed SKCE with the following steps:

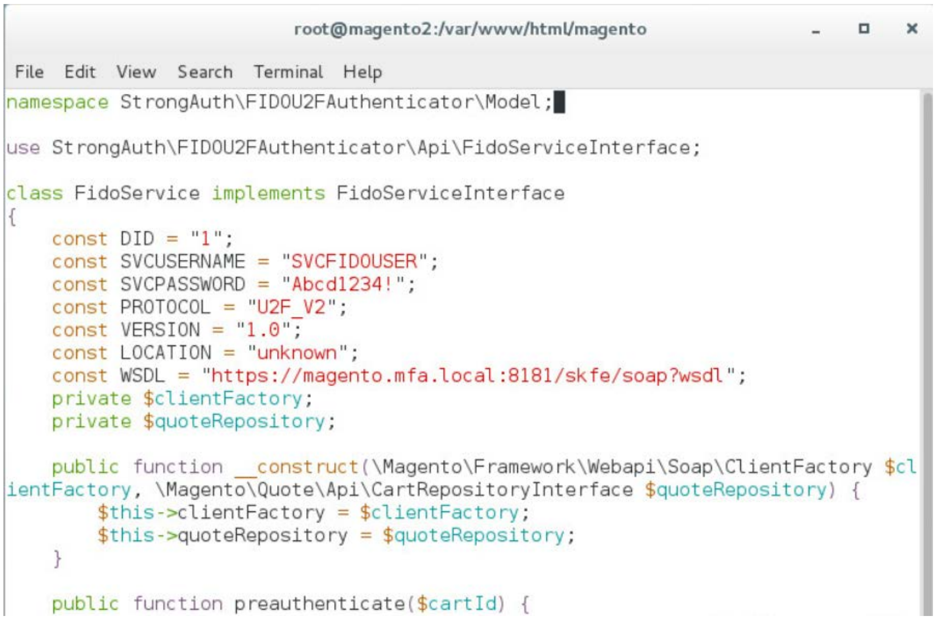
    a. Open *FidoService.php* by entering the following command:

```
Vim
/var/www/html/magento/app/code/StrongAuth/FIDOU2FAuthenticator/Model/Fido
Service.php
```


root@magento2:/var/www/html/magento
File Edit View Search Terminal Help

```
[root@magento2 magento]# vim /var/www/html/magento/app/code/StrongAuth/FIDOU2FAu
thenticator/Model/FidoService.php
```

    b. Modify the file to include the following information:


root@magento2:/var/www/html/magento
File Edit View Search Terminal Help

```
namespace StrongAuth\FIDOU2FAuthenticator\Model;

use StrongAuth\FIDOU2FAuthenticator\Api\FidoServiceInterface;

class FidoService implements FidoServiceInterface
{
    const DID = "1";
    const SVCUSERNAME = "SVCFIDOUSER";
    const SVCPASSWORD = "Abcd1234!";
    const PROTOCOL = "U2F_V2";
    const VERSION = "1.0";
    const LOCATION = "unknown";
    const WSDL = "https://magento.mfa.local:8181/skfe/soap?wsdl";
    private $clientFactory;
    private $quoteRepository;

    public function __construct(\Magento\Framework\Webapi\Soap\ClientFactory $cl
ientFactory, \Magento\Quote\Api\CartRepositoryInterface $quoteRepository) {
        $this->clientFactory = $clientFactory;
        $this->quoteRepository = $quoteRepository;
    }

    public function preauthenticate($cartId) {
```

i. The **DID** parameter is the Domain ID of SKCE.

ii. The **SVCUSERNAME** parameter is the SKCE user responsible for authorizing requests to the FIDO server.

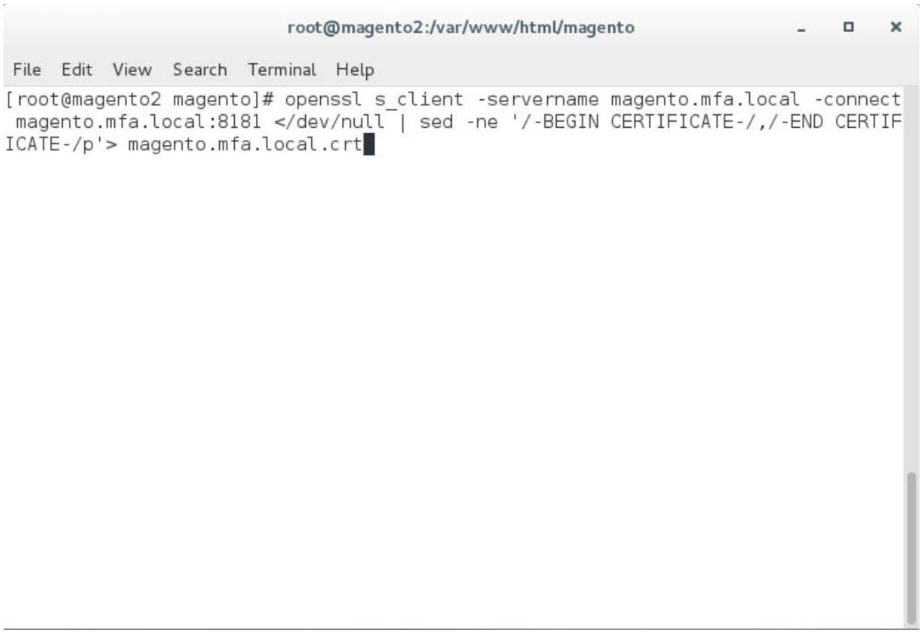
iii. The **SVCPASSWORD** parameter is the password of the SKCE user.

iv. The **PROTOCOL, VERSION,** and **LOCATION** are parameters used for reference for the FIDO server. They should be left as is.

v. The **WSDL** (Web Services Description Language) parameter specifies the web service end point with which the Magento server will communicate to send web-service requests to the FIDO server. The default SKCE install will have the WSDL as "https://<fully-qualified-domainname>:8181/skfe/soap?wsdl."

c. Retrieve a copy of the FIDO server's TLS digital certificate by entering the following command (Note: This is a single command that must be executed on a single line.):

```
openssl s_client -servername <fully-qualified-domain-name> -connect
<fully-qualified-domain-name>:8181 </dev/null | sed -ne '/BEGIN
CERTIFICATE-/,/-END CERTIFICATE-/p' > <FQDN>.crt
```

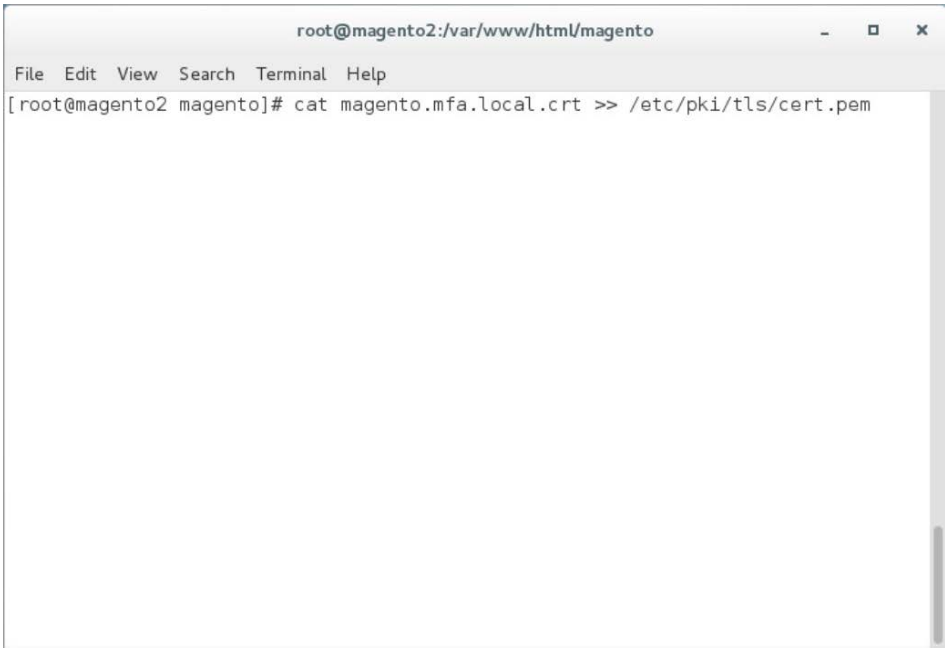


root@magento2:/var/www/html/magento
File Edit View Search Terminal Help

```
[root@magento2 magento]# openssl s_client -servername magento.mfa.local -connect
 magento.mfa.local:8181 </dev/null | sed -ne '/-BEGIN CERTIFICATE-/,/-END CERTIF
ICATE-/p'> magento.mfa.local.crt
```

d. Add the certificate to the list of trusted certificates by entering the following command:

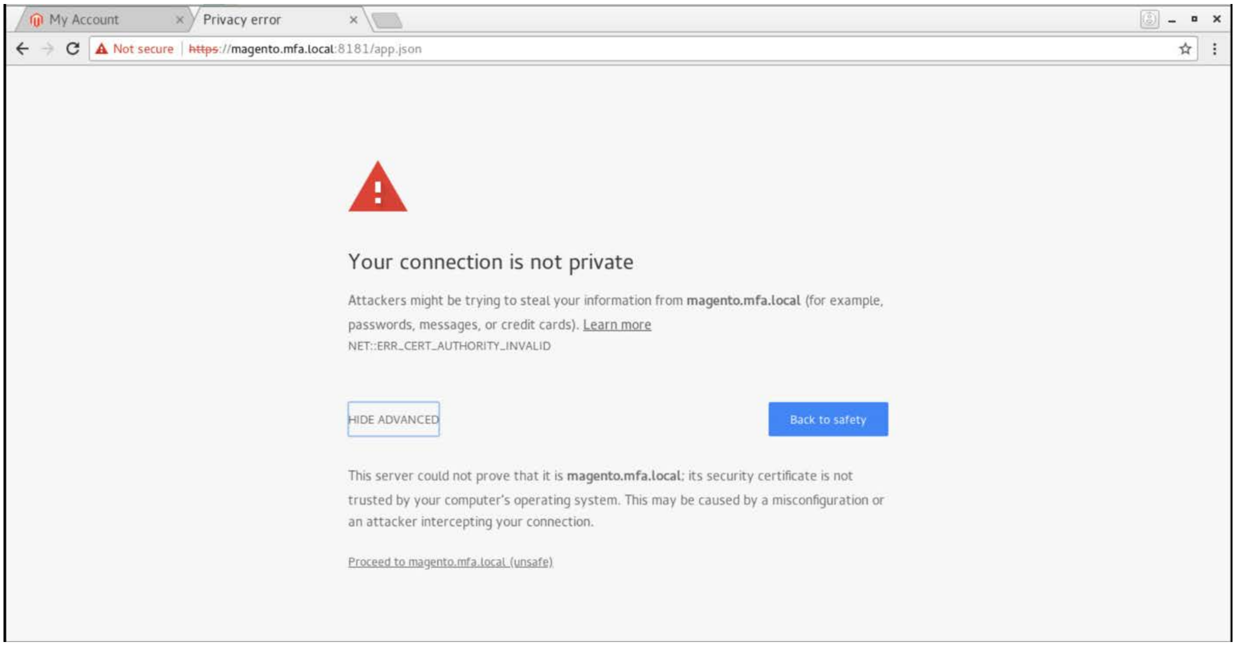
```
cat <fully-qualified-domain-name>.crt >> /etc/pki/tls/cert.pem
```



root@magento2:/var/www/html/magento
File Edit View Search Terminal Help

```
[root@magento2 magento]# cat magento.mfa.local.crt >> /etc/pki/tls/cert.pem
```

e. Open the Chrome browser and navigate to *https://magento.mfa.local:8181/app.json*.



Your connection is not private

Attackers might be trying to steal your information from **magento.mfa.local** (for example, passwords, messages, or credit cards). Learn more

NET::ERR_CERT_AUTHORITY_INVALID

This server could not prove that it is **magento.mfa.local**; its security certificate is not trusted by your computer's operating system. This may be caused by a misconfiguration or an attacker intercepting your connection.

Proceed to magento.mfa.local (unsafe)

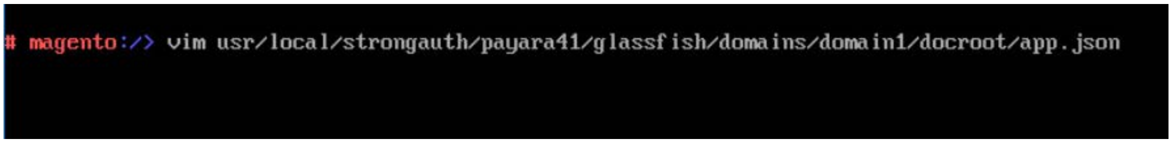
i. A warning will appear, stating that "Your connection is not private."

ii. Click **HIDE ADVANCED.**

iii. Click **Proceed to <fully-qualified-domain-name> (unsafe).**

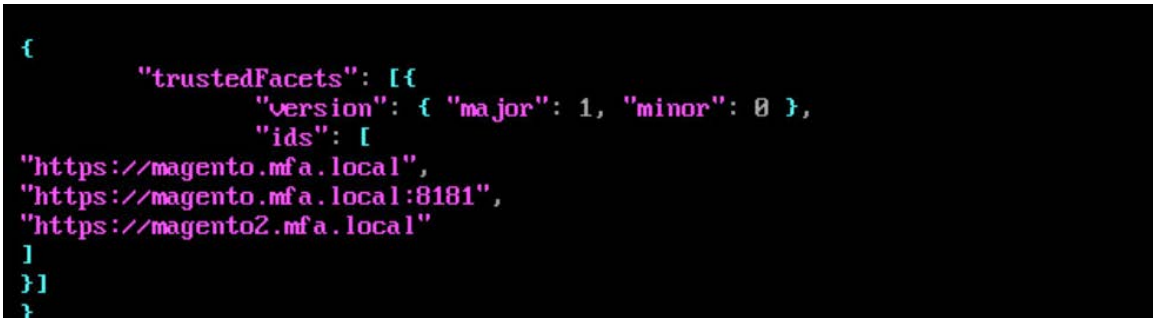
f. On your SKCE machine, edit the *app.json* file by entering the following command:

```
vim
usr/local/strongauth/payara41/glassfish/domains/domain1/docroot/app.json
```



```
# magento:/> vim usr/local/strongauth/payara41/glassfish/domains/domain1/docroot/app.json
```

g. Add the FQDN of the machine hosting the Magento application in the ids array, and save the file.

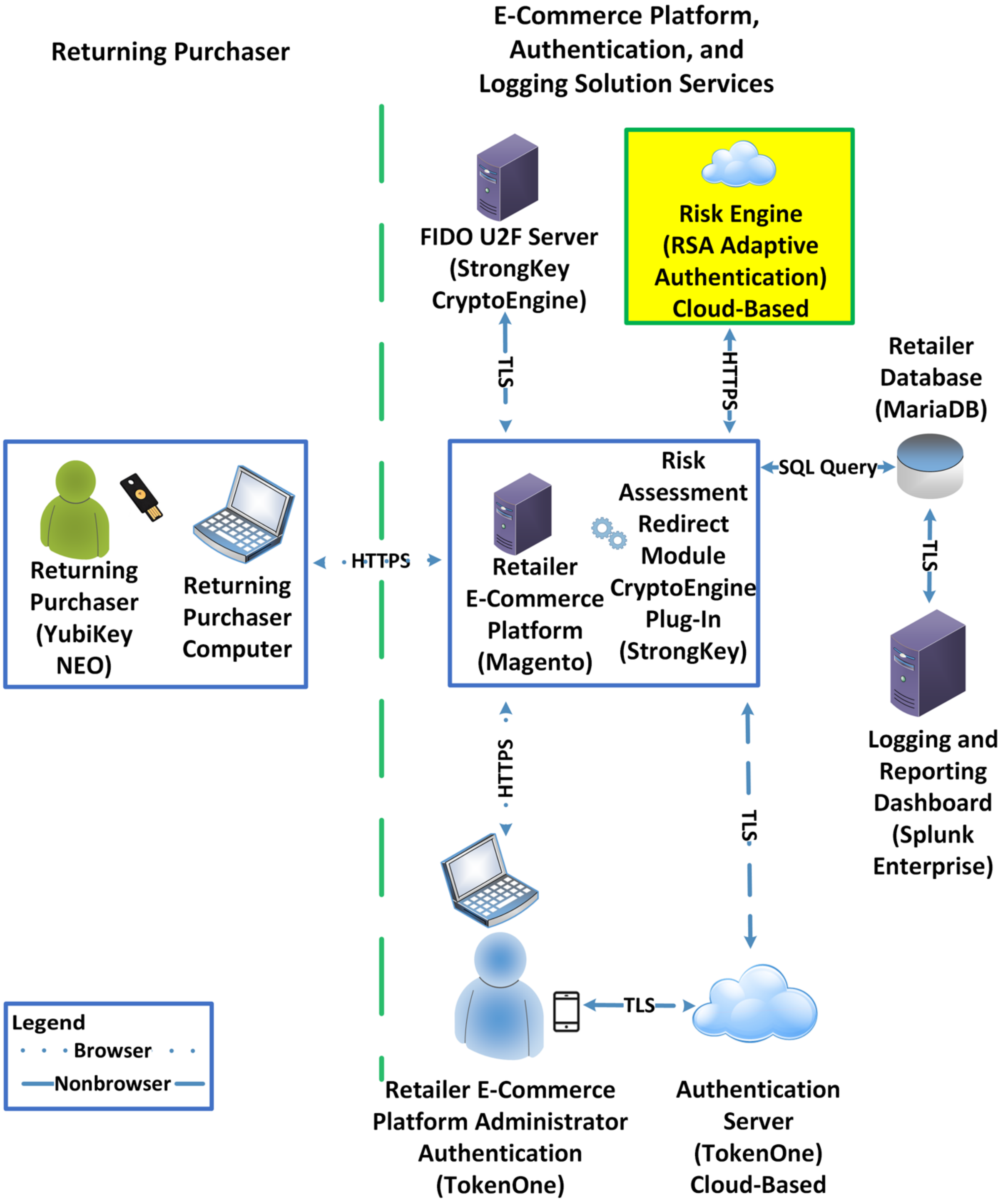


```
{
        "trustedFacets": [{
                "version": { "major": 1, "minor": 0 },
                "ids": [
"https://magento.mfa.local",
"https://magento.mfa.local:8181",
"https://magento2.mfa.local"
]
}]
}
```

2.4 RSA Adaptive Authentication

This section of the guide provides installation and configuration guidance for the RSA Adaptive Authentication risk engine. The RSA Adaptive Authentication product performs a risk analysis and then prompts the returning user to provide an MFA authenticator when required for the *risk engine* example implementation build. The purpose of the RSA Adaptive Authentication is to minimize fraud with a low-friction consumer experience. This example implementation uses the RSA Adaptive Authentication cloud offering. The components that integrate Magento with RSA Adaptive Authentication are installed by using the instructions in this section. The components are illustrated in Figure 2-4 and are highlighted in yellow within the green box.

Figure 2-4 RSA Adaptive Authentication Components



Returning Purchaser
E-Commerce Platform, Authentication, and Logging Solution Services
FIDO U2F Server (StrongKey CryptoEngine)
Risk Engine (RSA Adaptive Authentication) Cloud-Based
TLS
HTTPS
Retailer Database (MariaDB)
Returning Purchaser (YubiKey NEO)
Returning Purchaser Computer
HTTPS
Retailer E-Commerce Platform (Magento)
Risk Assessment Redirect Module CryptoEngine Plug-In (StrongKey)
SQL Query
TLS
Logging and Reporting Dashboard (Splunk Enterprise)
HTTPS
TLS
TLS
Retailer E-Commerce Platform Administrator Authentication (TokenOne)
Authentication Server (TokenOne) Cloud-Based
Legend
Browser
Nonbrowser

2.4.1 RSA Overview

RSA [7] offers an Adaptive Authentication [8] capability, which is part of the *risk engine* example implementation.

The installation procedure consists of the following steps:

- Preinstallation:
    - Download the RSA Project Library.
    - Configure Magento to accept additional extension attributes.
- Installation and configuration:
    - Integrate RSA files into Magento.
    - Create policy in RSA Back Office.

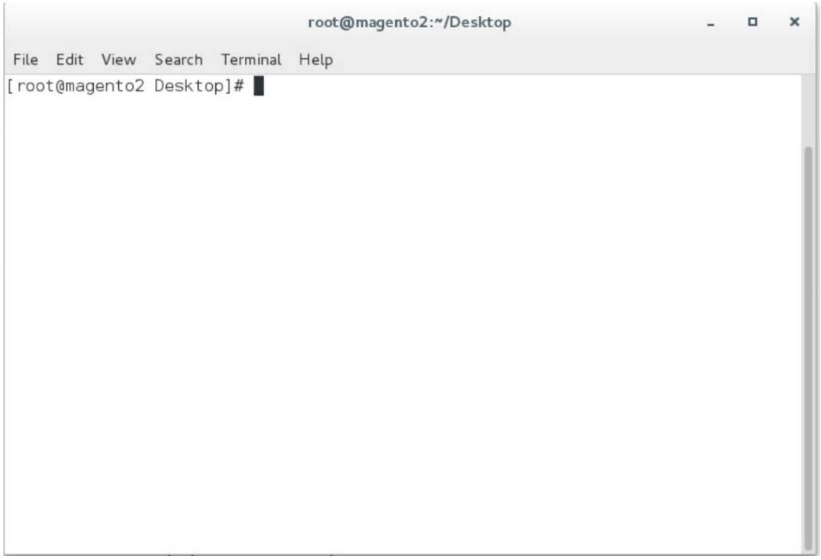
2.4.2 RSA Preinstallation Steps

Before beginning installation, perform the following steps.

- Contact your RSA representative regarding access to RSA project library files *(RSA.zip)* and *RSA.php* files. Download these files to the */home/magento/Downloads* directory.
- Configure Magento to accept additional extension attributes as outlined below.

This section will discuss how to add extension attributes to Magento to pass necessary information to RSA Adaptive Authentication.

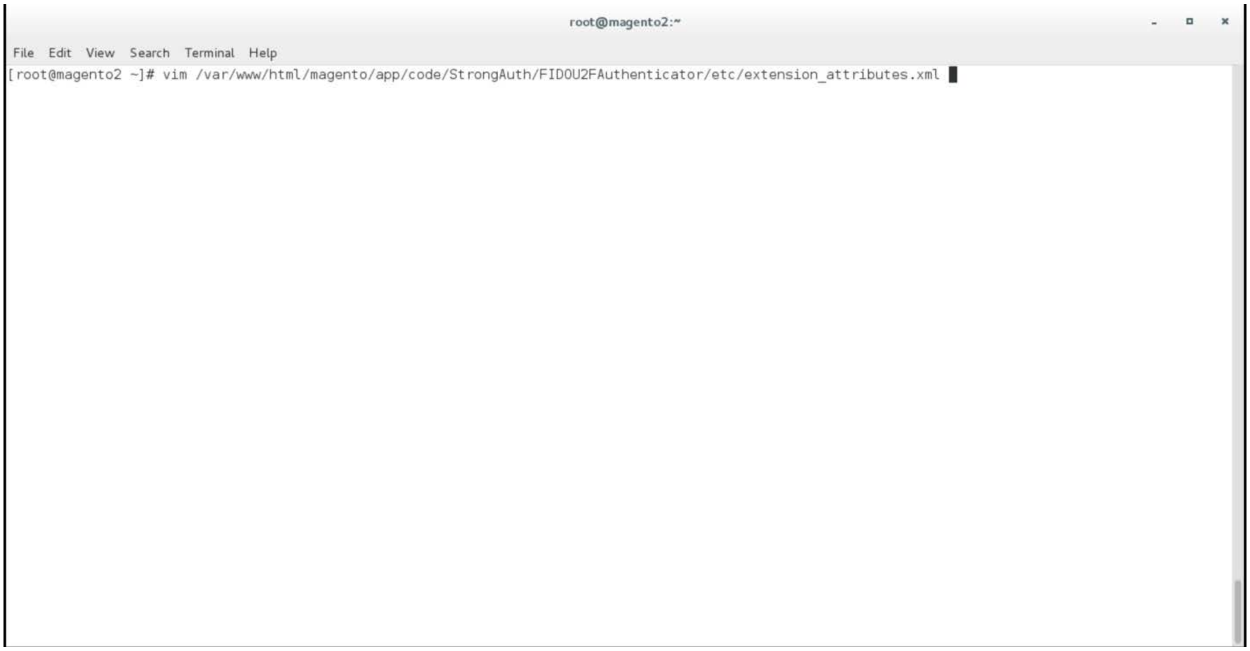
1. Open a terminal window.



```
[root@magento2 Desktop]#
```

2. To edit the file containing Magento's extension attributes, issue the following commands:

   a. `vim /var/www/html/magento/app/code/StrongAuth/FIDOU2FAuthenticator/etc/extension_attributes.xml`

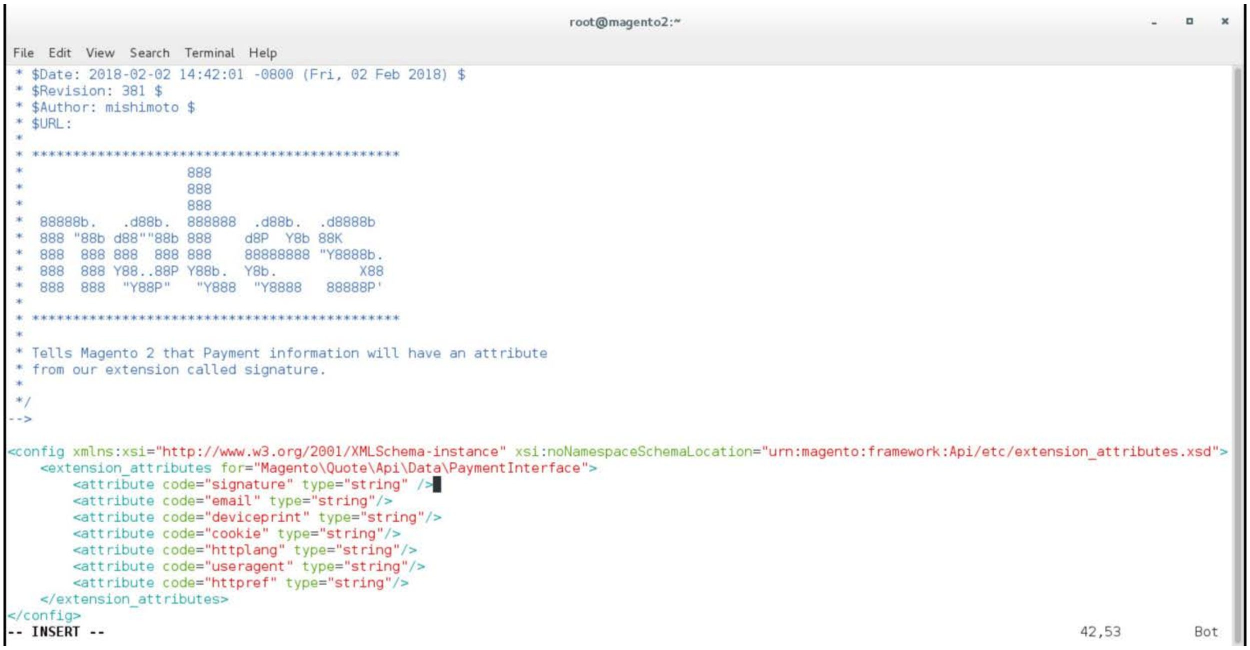


```
[root@magento2 ~]# vim /var/www/html/magento/app/code/StrongAuth/FIDOU2FAuthenticator/etc/extension_attributes.xml
```

   b. Press **i** to enter insertion mode.

3. Following Line 53, which contains `<attribute code="signature" type="string" />`, insert the following lines (shown in the picture below):

```
<attribute code="email" type="string"/>

<attribute code="deviceprint" type="string"/>

<attribute code="cookie" type="string"/>

<attribute code="httplang" type="string"/>

<attribute code="useragent" type="string"/>

<attribute code="httpref" type="string"/>
```



root@magento2:~

```
 * $Date: 2018-02-02 14:42:01 -0800 (Fri, 02 Feb 2018) $
 * $Revision: 381 $
 * $Author: mishimoto $
 * $URL:
 *
 * *********************************************
 *                    888
 *                    888
 *                    888
 *  88888b.   .d88b.  888888  .d88b.  .d8888b
 *  888 "88b d88""88b 888    d8P  Y8b 88K
 *  888  888 888  888 888    88888888 "Y8888b.
 *  888  888 Y88..88P Y88b.  Y8b.          X88
 *  888  888  "Y88P"   "Y888  "Y8888   88888P'
 *
 * *********************************************
 *
 * Tells Magento 2 that Payment information will have an attribute
 * from our extension called signature.
 *
 */
-->

<config xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:noNamespaceSchemaLocation="urn:magento:framework:Api/etc/extension_attributes.xsd">
    <extension_attributes for="Magento\Quote\Api\Data\PaymentInterface">
        <attribute code="signature" type="string" />
        <attribute code="email" type="string"/>
        <attribute code="deviceprint" type="string"/>
        <attribute code="cookie" type="string"/>
        <attribute code="httplang" type="string"/>
        <attribute code="useragent" type="string"/>
        <attribute code="httpref" type="string"/>
    </extension_attributes>
</config>
-- INSERT --                                                                                        42,53         Bot
```

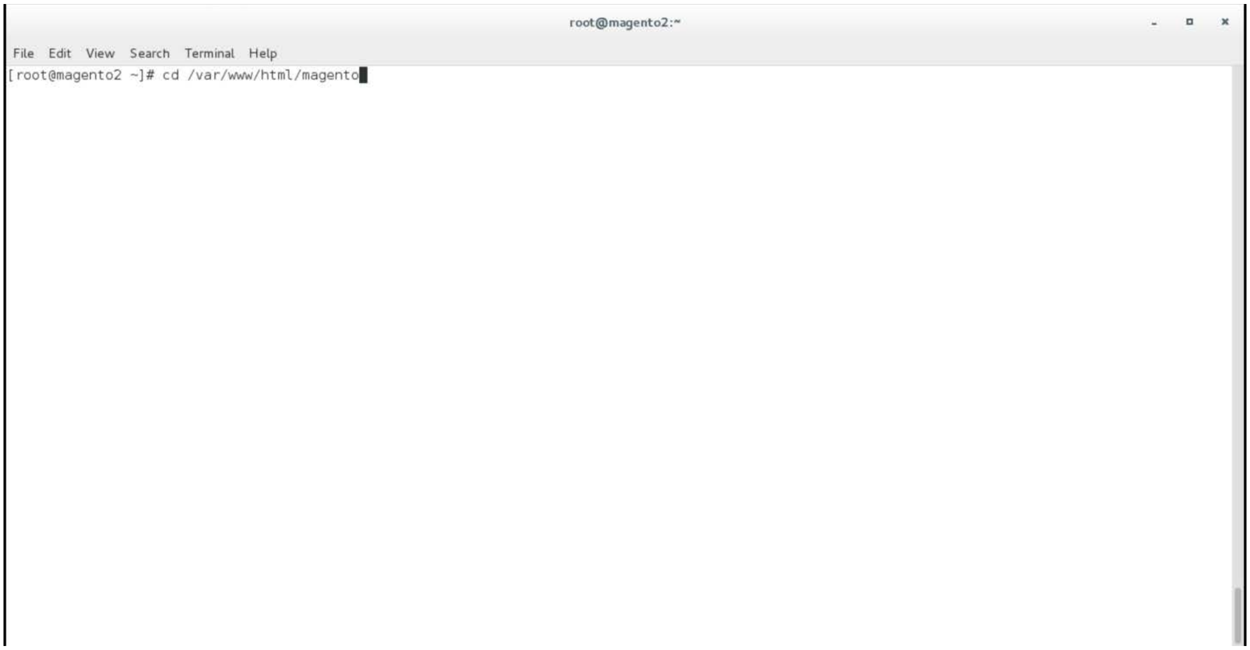
4. Press the Esc key to exit insert mode.

5. Save changes, and exit by entering the following command: `:wq`.

6. Return to the terminal window.

7. Change to the Magento folder by entering the following command:

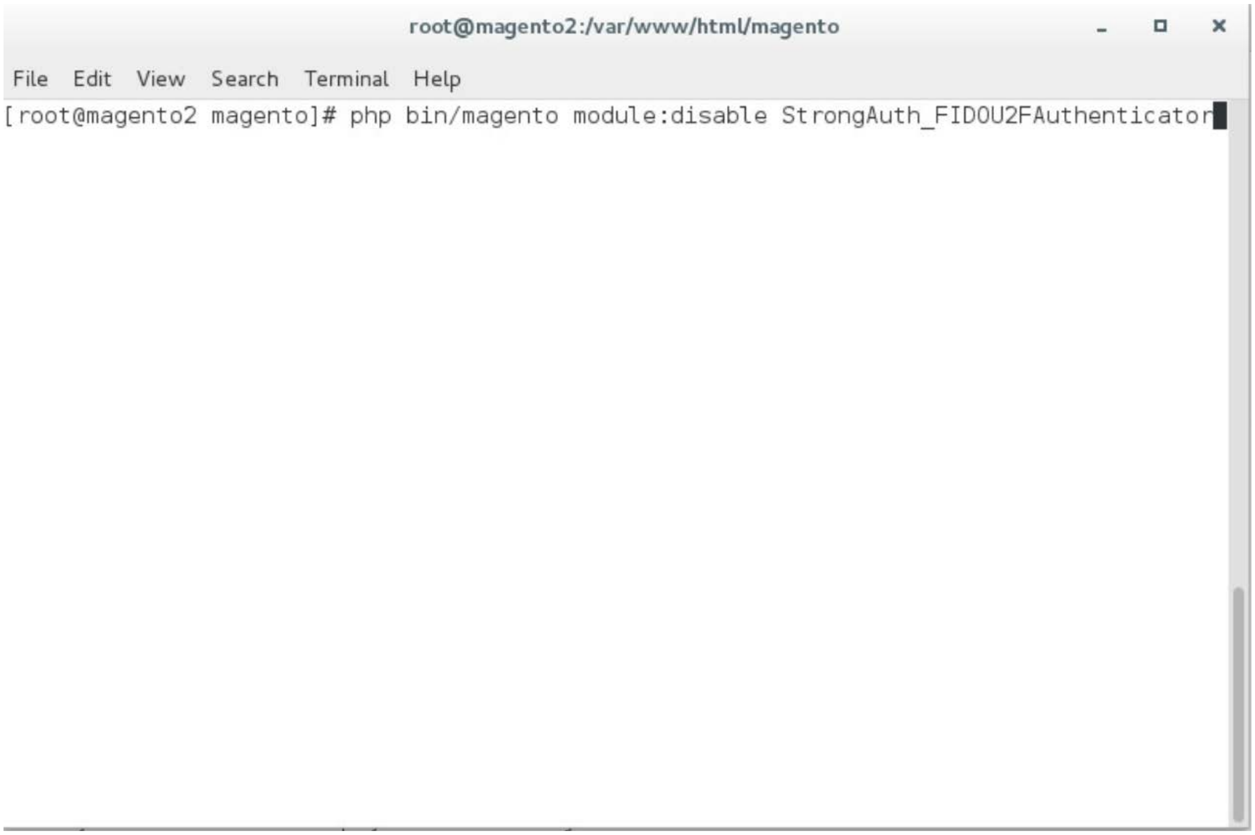
   ```
   cd /var/www/html/magento
   ```



```
[root@magento2 ~]# cd /var/www/html/magento
```

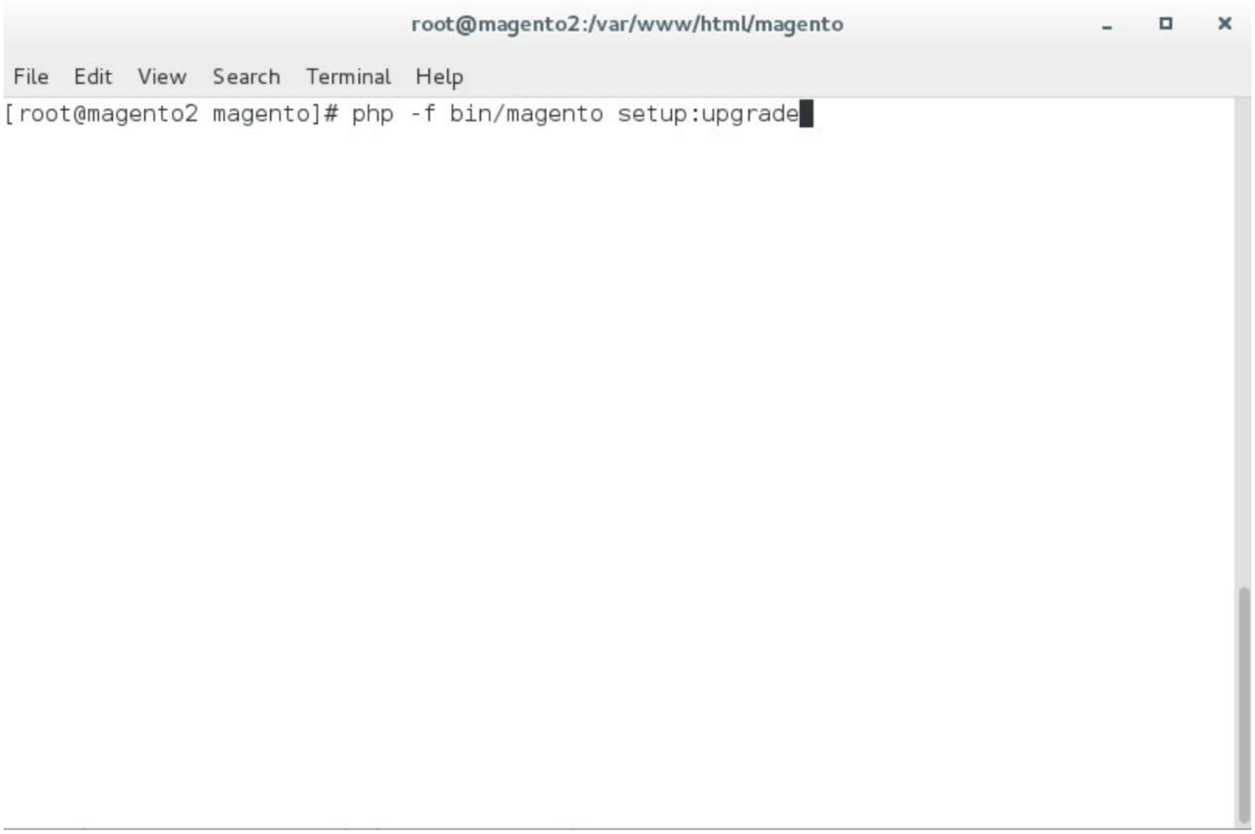
8. To recompile Magento to reflect the changes made to the extension attributes file, issue the following commands:

   a. `php bin/magento module:disable StrongAuth_FIDOU2FAuthenticator`


root@magento2:/var/www/html/magento
File Edit View Search Terminal Help

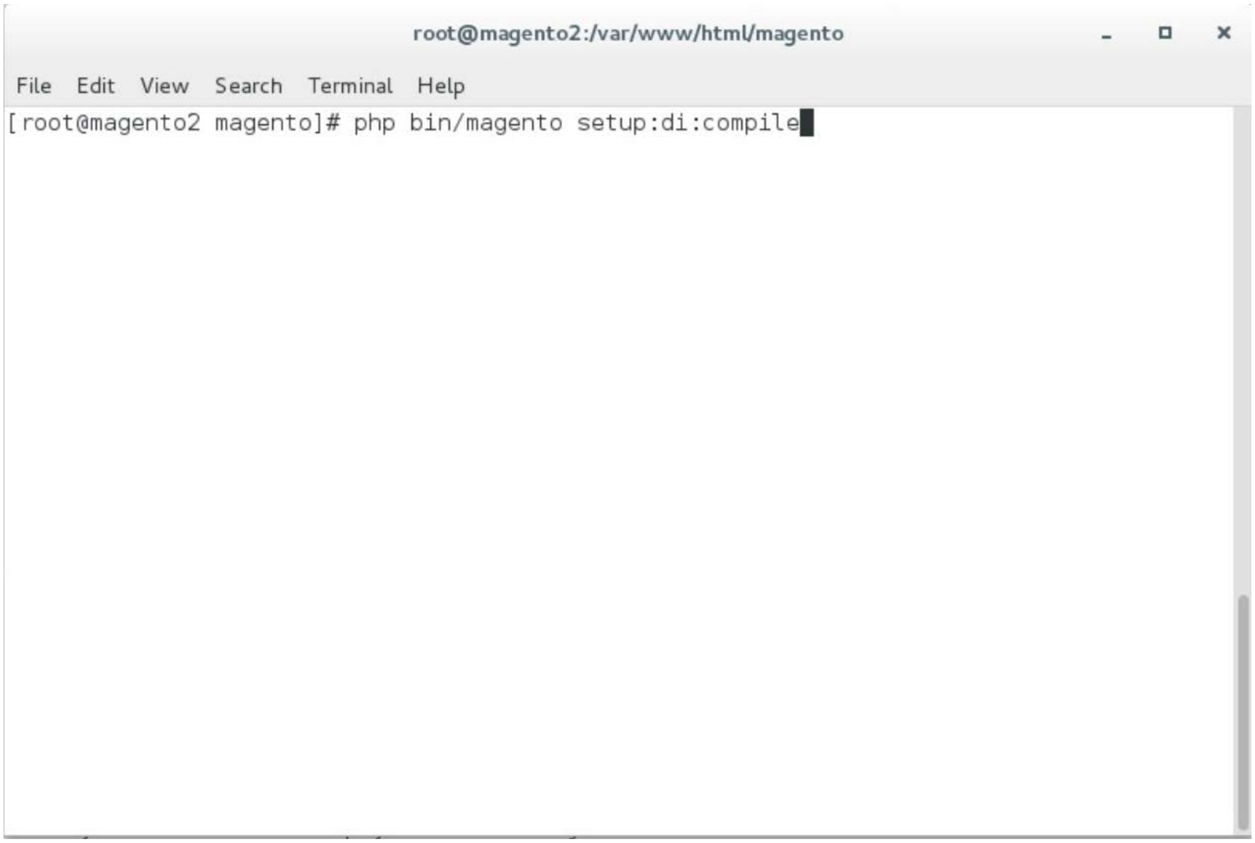
```
[root@magento2 magento]# php bin/magento module:disable StrongAuth_FIDOU2FAuthenticator
```

b. `php -f bin/magento setup:upgrade`


root@magento2:/var/www/html/magento
File Edit View Search Terminal Help

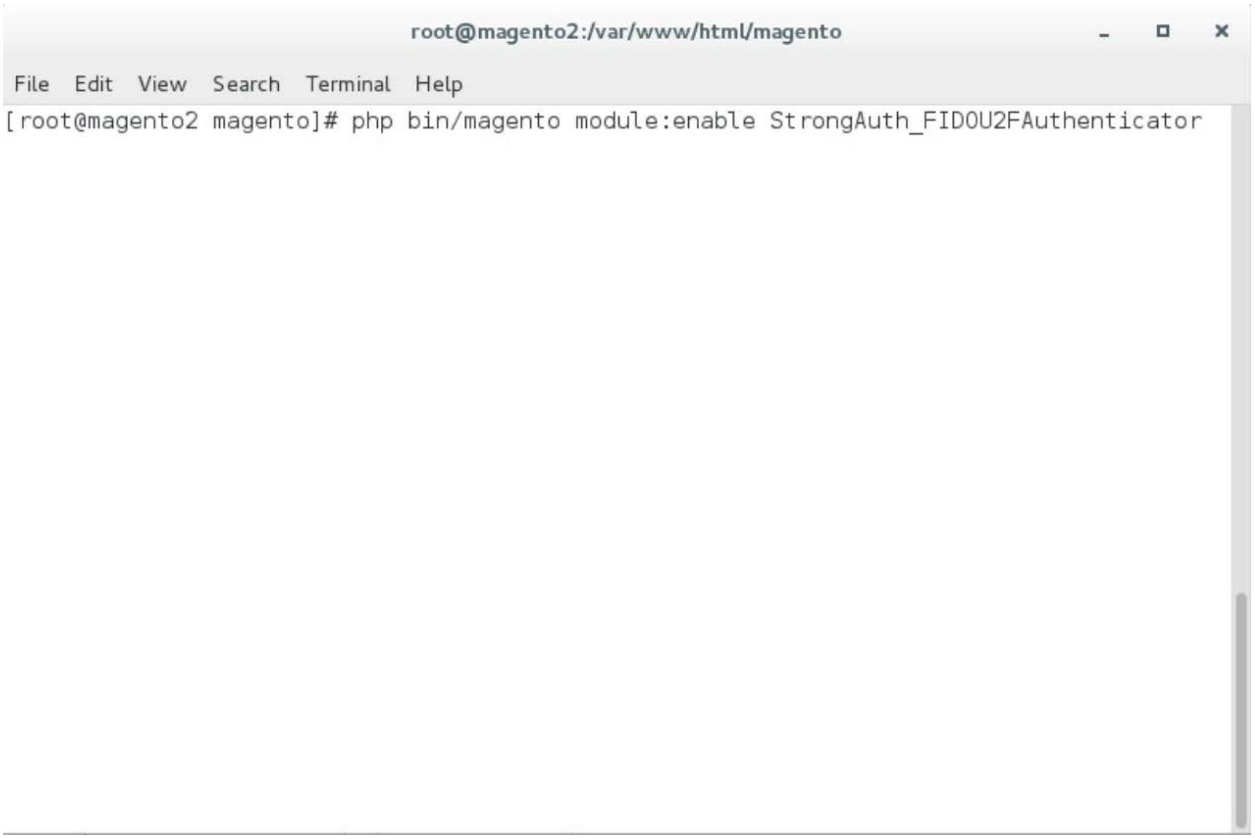
```
[root@magento2 magento]# php -f bin/magento setup:upgrade
```

c. `php bin/magento setup:di:compile`


root@magento2:/var/www/html/magento
File Edit View Search Terminal Help

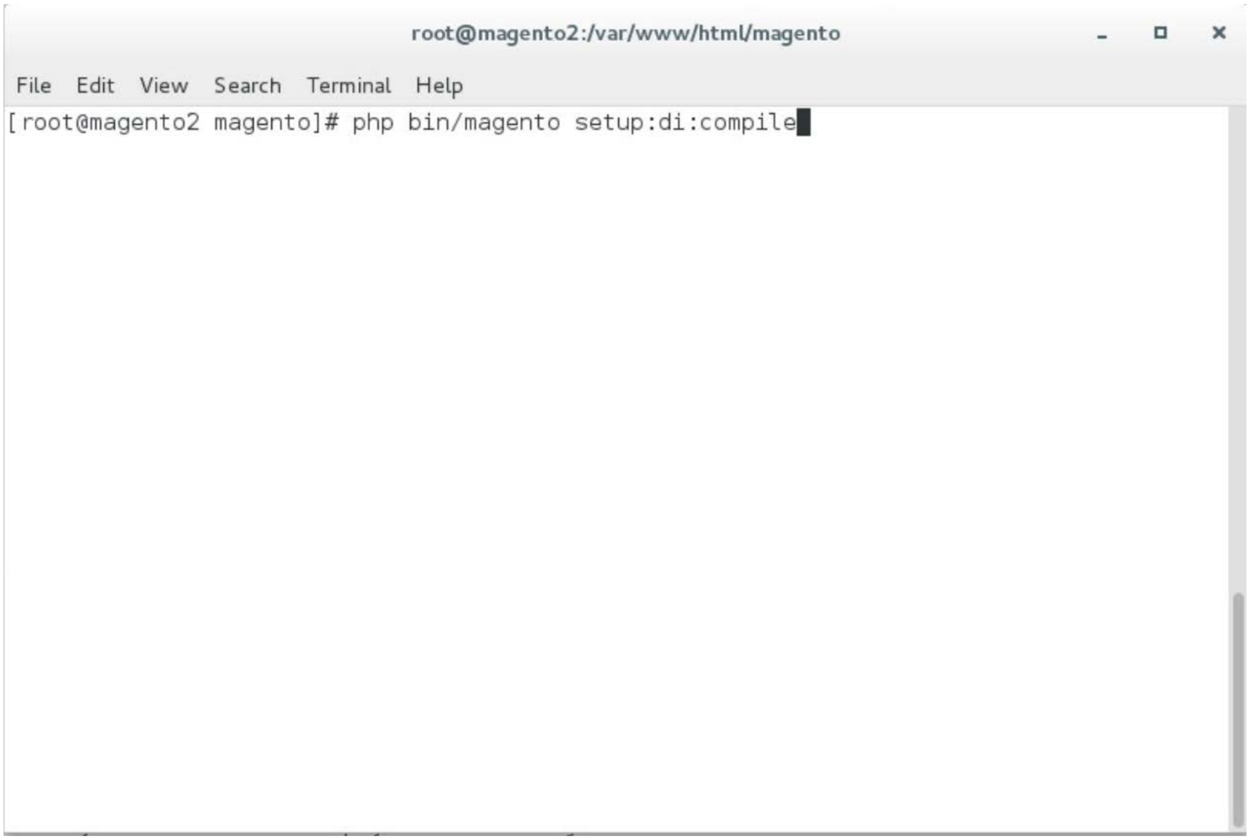
```
[root@magento2 magento]# php bin/magento setup:di:compile
```

d. `php bin/magento module:enable StrongAuth_FIDOU2FAuthenticator`


root@magento2:/var/www/html/magento
File Edit View Search Terminal Help

```
[root@magento2 magento]# php bin/magento module:enable StrongAuth_FIDOU2FAuthenticator
```

e. `php bin/magento setup:di:compile`

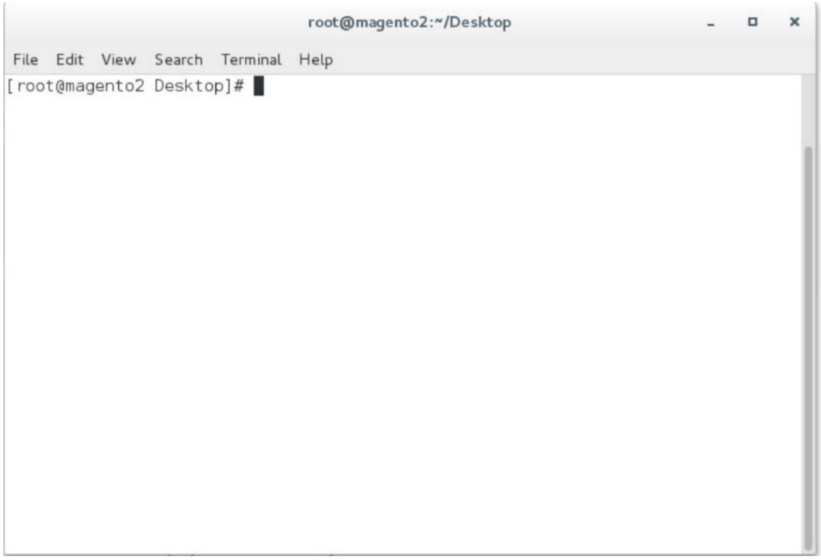

root@magento2:/var/www/html/magento
File Edit View Search Terminal Help

```
[root@magento2 magento]# php bin/magento setup:di:compile
```

2.4.3 Adaptive Authentication Installation and Configuration

This section provides a step-by-step installation guide for integrating RSA Adaptive Authentication. Before you begin, make sure that you have received your RSA project libraries from your RSA representative.

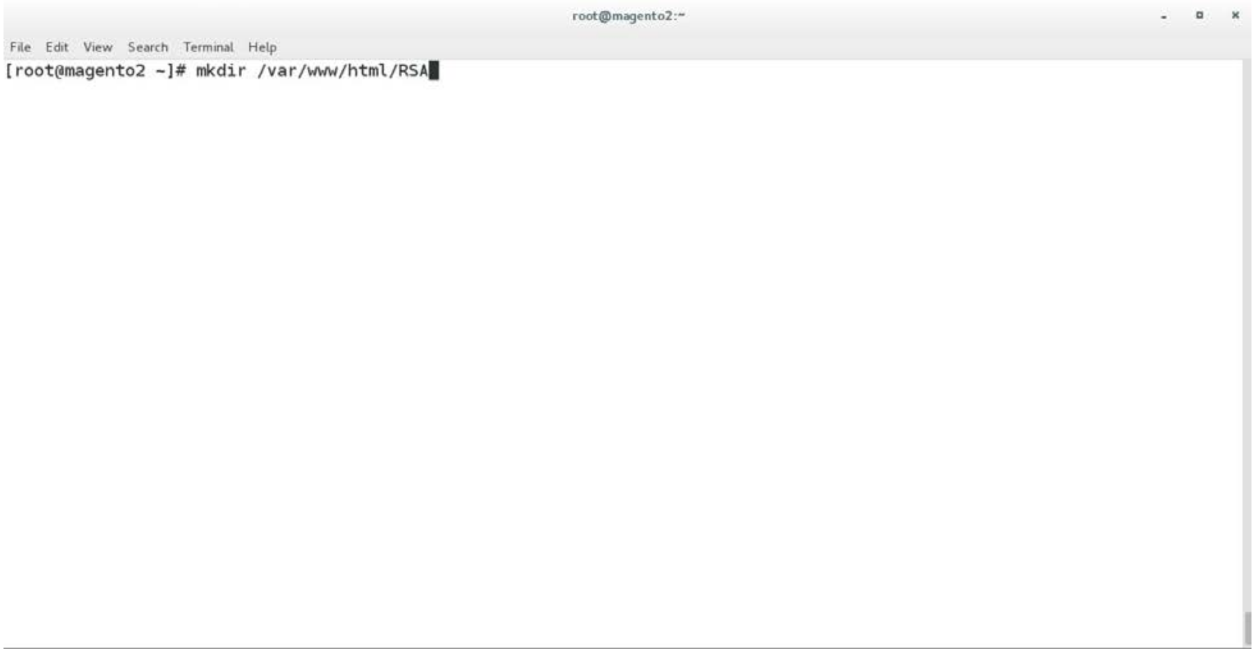
1. Open a terminal window.



```
[root@magento2 Desktop]#
```

2. Create a new directory by entering the following command:

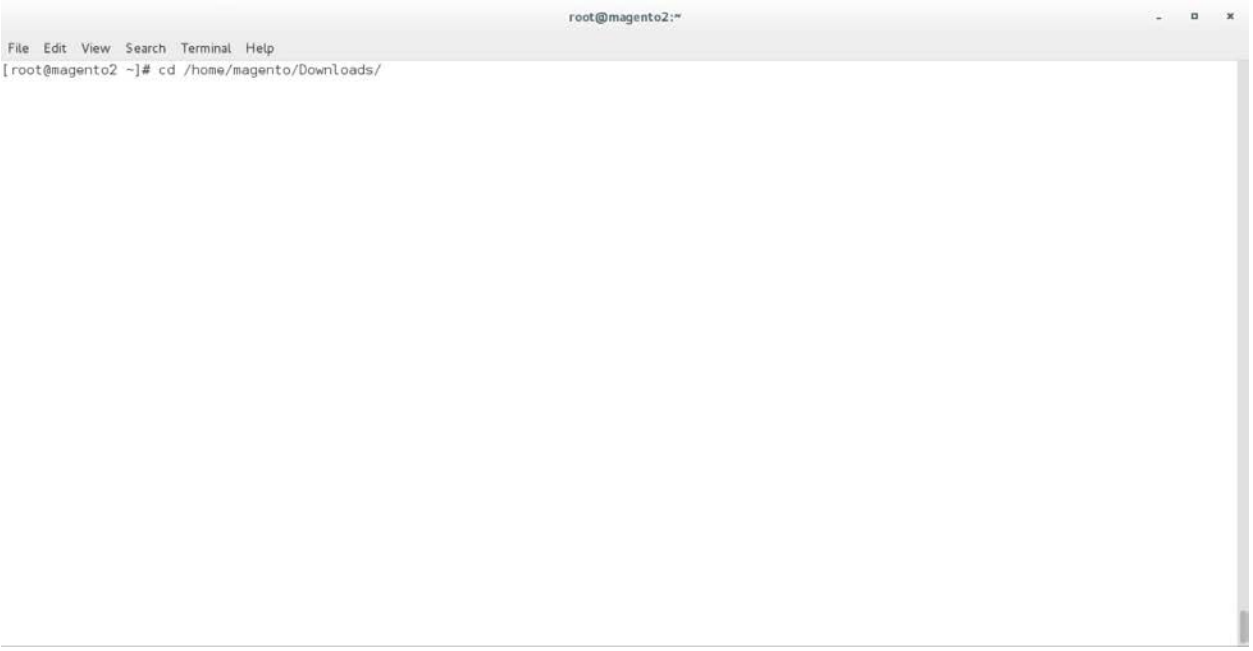
   ```
   Mkdir /var/www/html/RSA
   ```



```
[root@magento2 ~]# mkdir /var/www/html/RSA
```

3. Obtain the RSA zip file from your RSA representative.
4. Change to the Downloads directory by entering the following command:

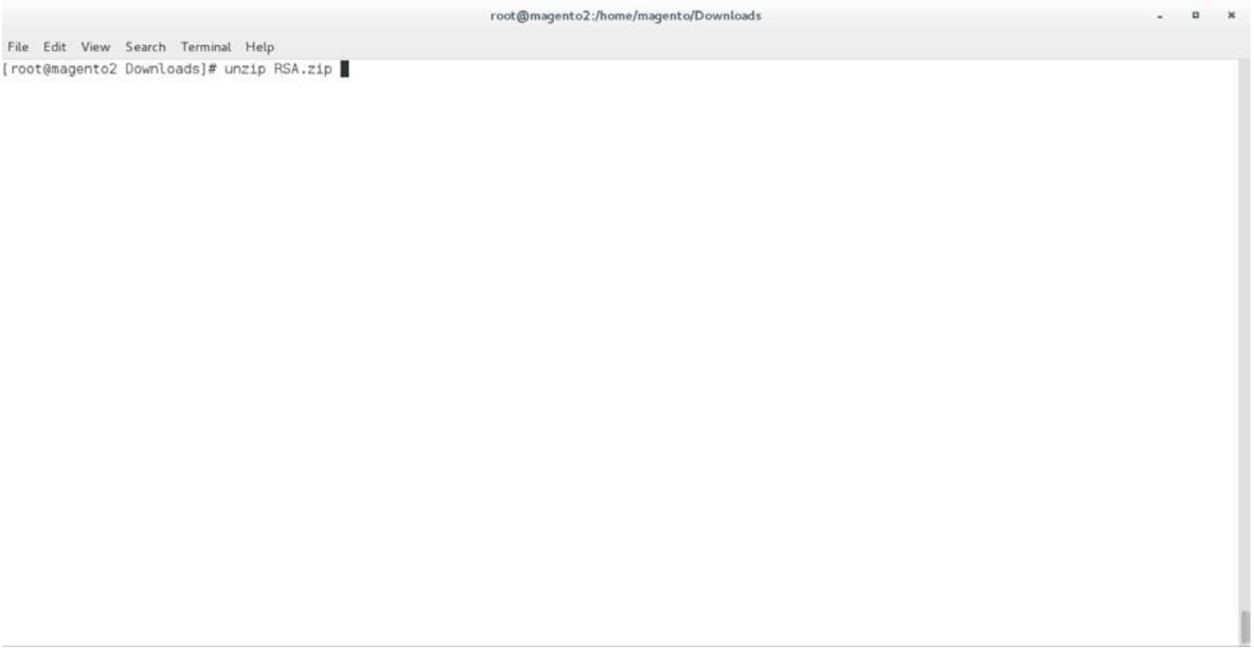
   ```
   cd /home/magento/Downloads
   ```



```
[root@magento2 ~]# cd /home/magento/Downloads/
```

5. Unzip the RSA directory by entering the following command:

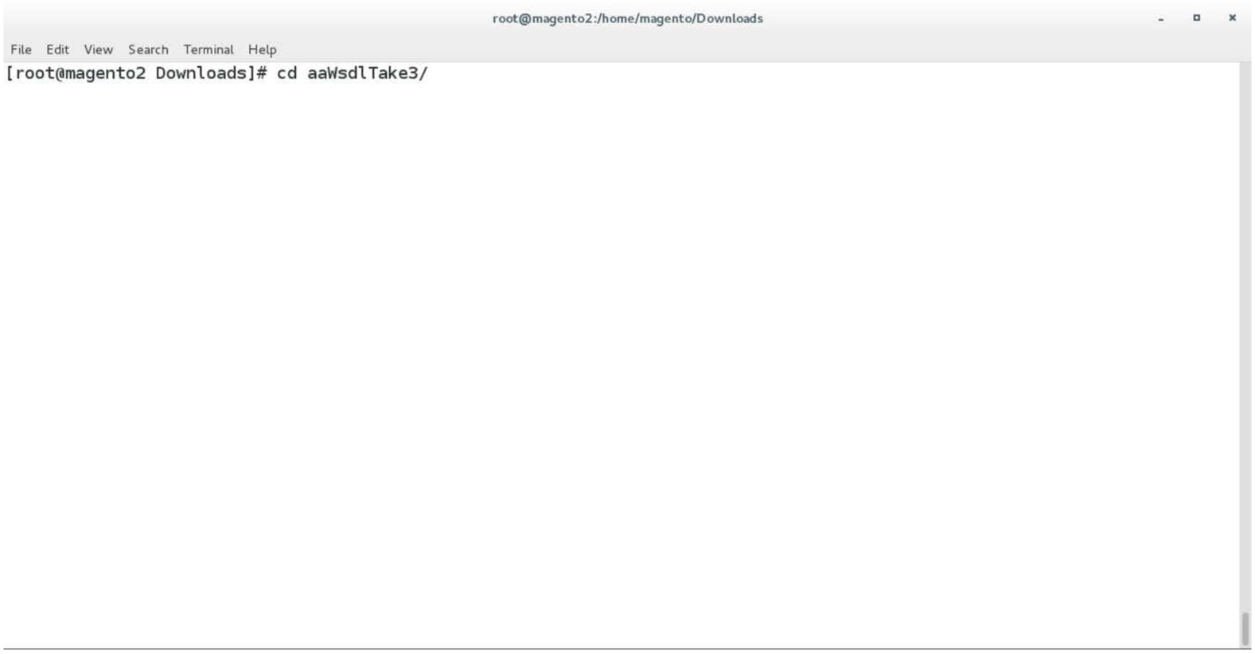
   ```
   unzip RSA.zip
   ```


root@magento2:/home/magento/Downloads
File Edit View Search Terminal Help

```
[root@magento2 Downloads]# unzip RSA.zip
```

6. Change to the newly unzipped directory by entering the following command:

```
cd aaWsdlTake3/
```

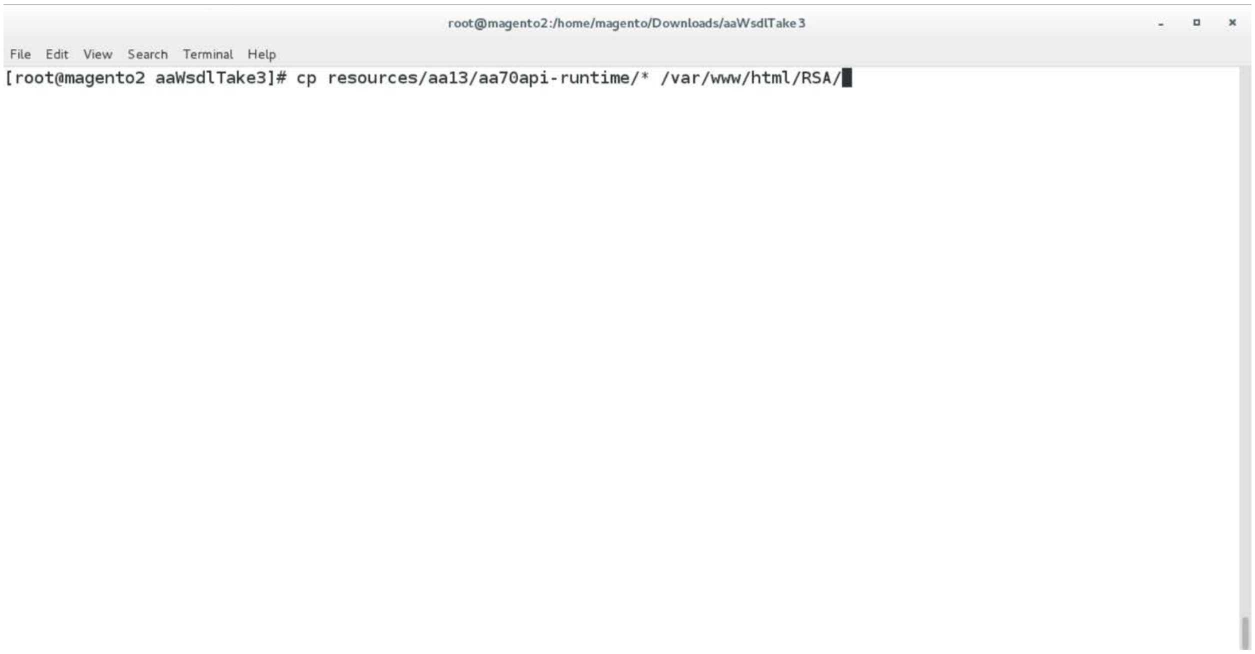


root@magento2:/home/magento/Downloads
File Edit View Search Terminal Help

```
[root@magento2 Downloads]# cd aaWsdlTake3/
```

7. Copy the contents of the API runtime directory to the RSA directory, which was created in Step 2, by entering the following command:

```
cp resources/aa13/aa70api-runtime/* /var/www/html/RSA/
```

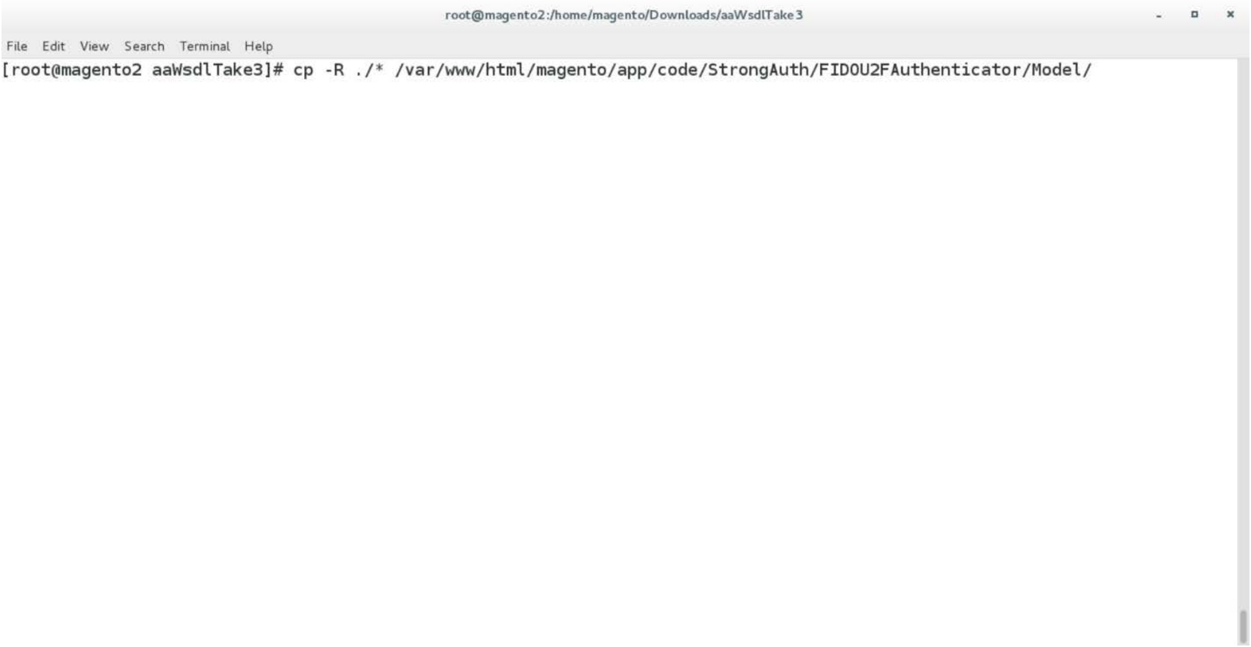


root@magento2:/home/magento/Downloads/aaWsdlTake3
File Edit View Search Terminal Help

```
[root@magento2 aaWsdlTake3]# cp resources/aa13/aa70api-runtime/* /var/www/html/RSA/
```

8. Copy the contents of the aaWsdlTake3 directory to the StrongAuth model directory by entering the following command:

   ```
   cp -R ./* /var/www/html/magento/app/code/StrongAuth/FIDOU2FAuthenticator/Model/
   ```

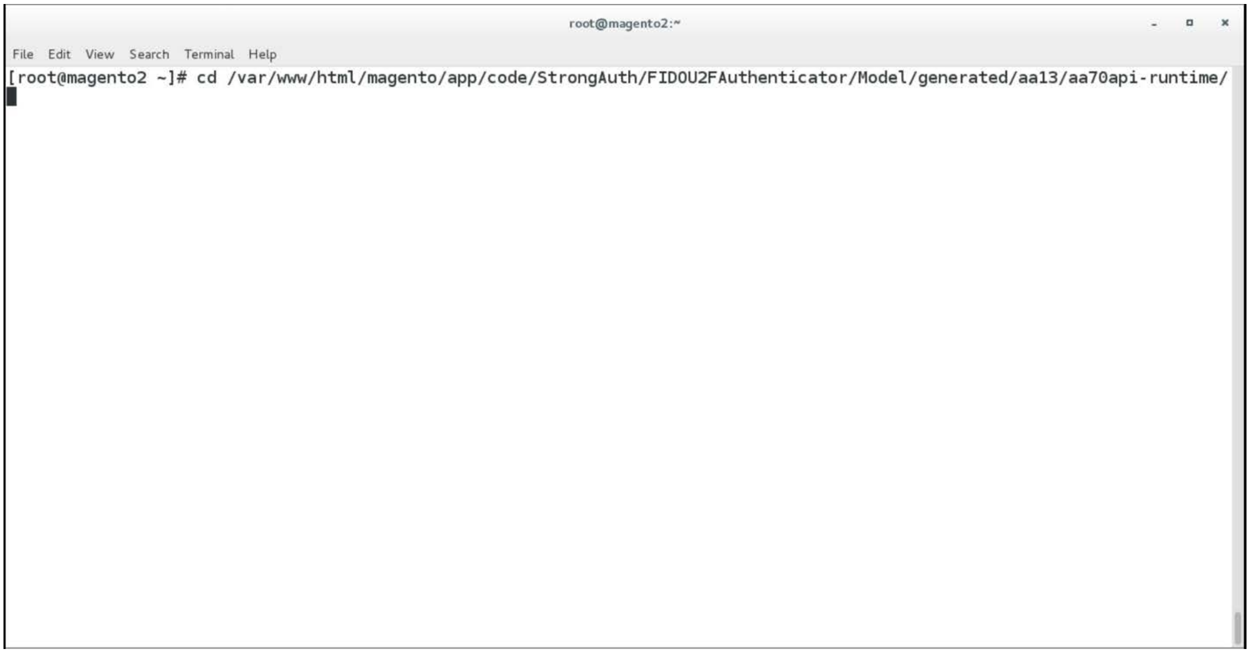


root@magento2:/home/magento/Downloads/aaWsdlTake3
File Edit View Search Terminal Help

```
[root@magento2 aaWsdlTake3]# cp -R ./* /var/www/html/magento/app/code/StrongAuth/FIDOU2FAuthenticator/Model/
```

9. Change to the generated RSA API runtime folder by entering the following command:

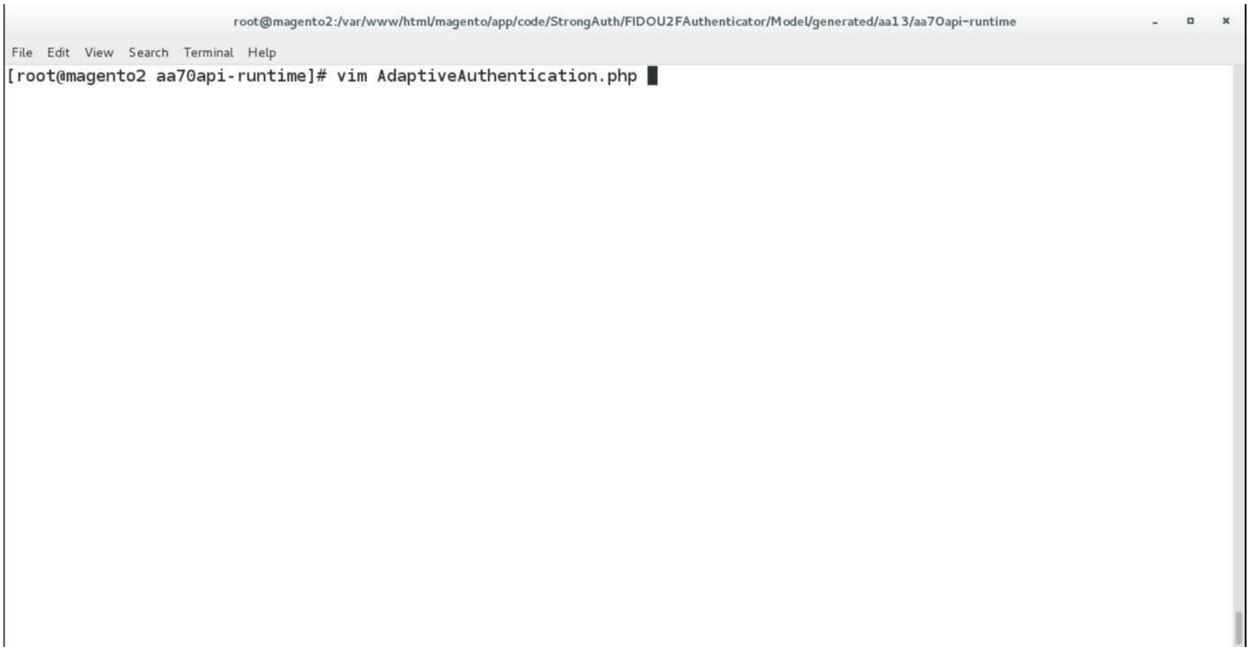
```
cd
/var/www/html/magento/app/code/StrongAuth/FIDOU2FAuthenticator/Model/generated/
aa13/aa70api-runtime/
```



```
[root@magento2 ~]# cd /var/www/html/magento/app/code/StrongAuth/FIDOU2FAuthenticator/Model/generated/aa13/aa70api-runtime/
```

10. Edit the Adaptive Authentication file by entering the following command:

```
vim AdaptiveAuthentication.php
```



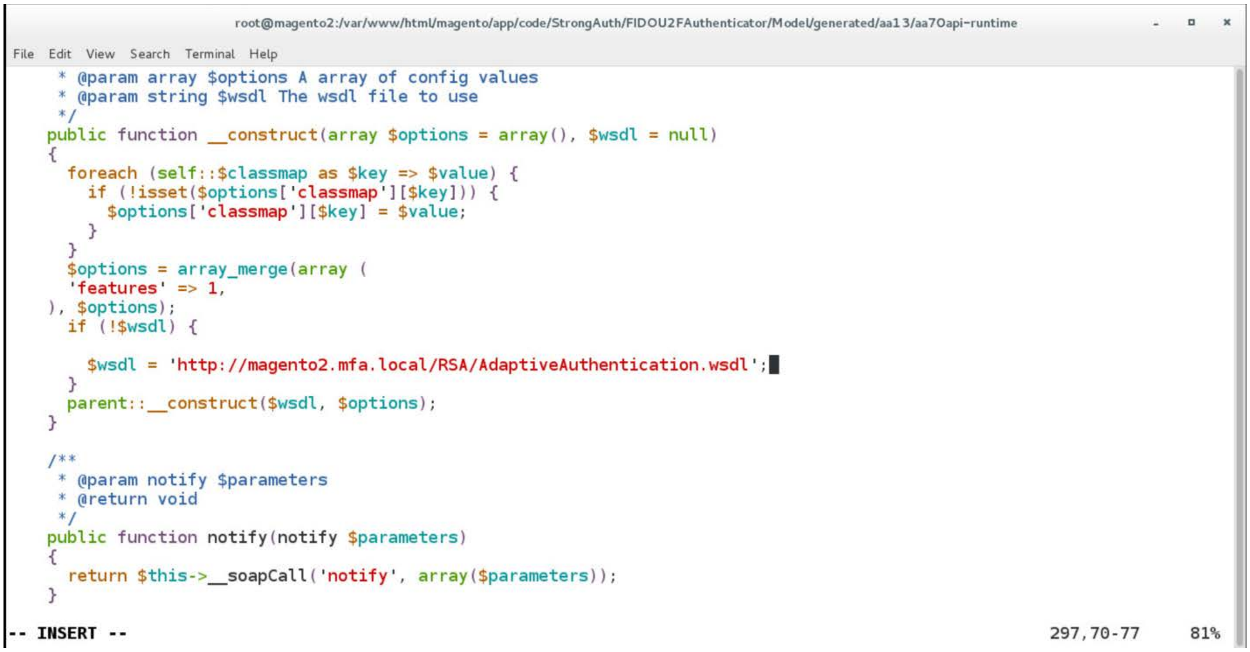
root@magento2:/var/www/html/magento/app/code/StrongAuth/FIDOU2FAuthenticator/Model/generated/aa13/aa70api-runtime

```
[root@magento2 aa70api-runtime]# vim AdaptiveAuthentication.php
```

11. Make edits in the Adaptive Authentication file by pressing the **i** key to enter insert mode.

12. Change Line 297 of the document to the following line:

```
$wsdl = ‘http://magento2.mfa.local/RSA/AdaptiveAuthentication.wsdl’;
```



root@magento2:/var/www/html/magento/app/code/StrongAuth/FIDOU2FAuthenticator/Model/generated/aa13/aa70api-runtime

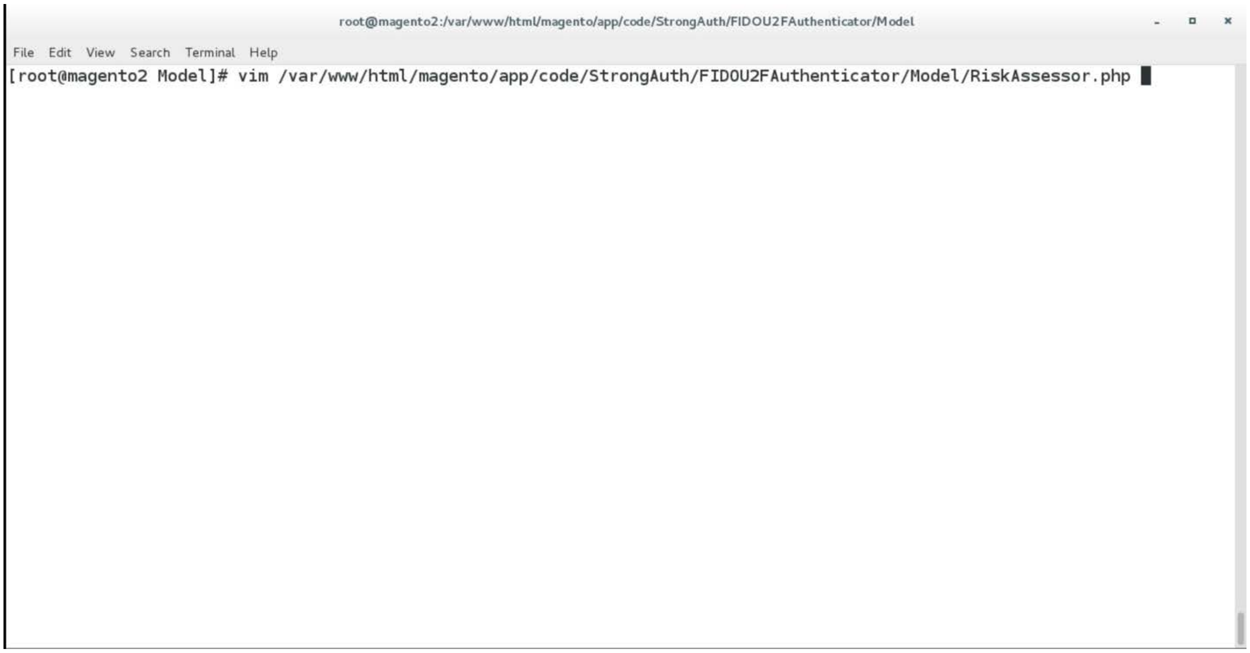
```
     * @param array $options A array of config values
     * @param string $wsdl The wsdl file to use
     */
    public function __construct(array $options = array(), $wsdl = null)
    {
      foreach (self::$classmap as $key => $value) {
        if (!isset($options['classmap'][$key])) {
          $options['classmap'][$key] = $value;
        }
      }
      $options = array_merge(array (
      'features' => 1,
    ), $options);
      if (!$wsdl) {

        $wsdl = 'http://magento2.mfa.local/RSA/AdaptiveAuthentication.wsdl';
      }
      parent::__construct($wsdl, $options);
    }

    /**
     * @param notify $parameters
     * @return void
     */
    public function notify(notify $parameters)
    {
      return $this->__soapCall('notify', array($parameters));
    }

-- INSERT --                                                      297,70-77     81%
```

13. Press the **Esc** key to exit insert mode.

14. Save changes, and exit by entering the following command: `:wq`.

15. Edit the RSA Risk Assessor File by entering the following command:

```
vim
/var/www/html/magento/app/code/StrongAuth/FIDOU2FAuthenticator/Model/RiskAssess
or.php
```


root@magento2:/var/www/html/magento/app/code/StrongAuth/FIDOU2FAuthenticator/Model
File Edit View Search Terminal Help

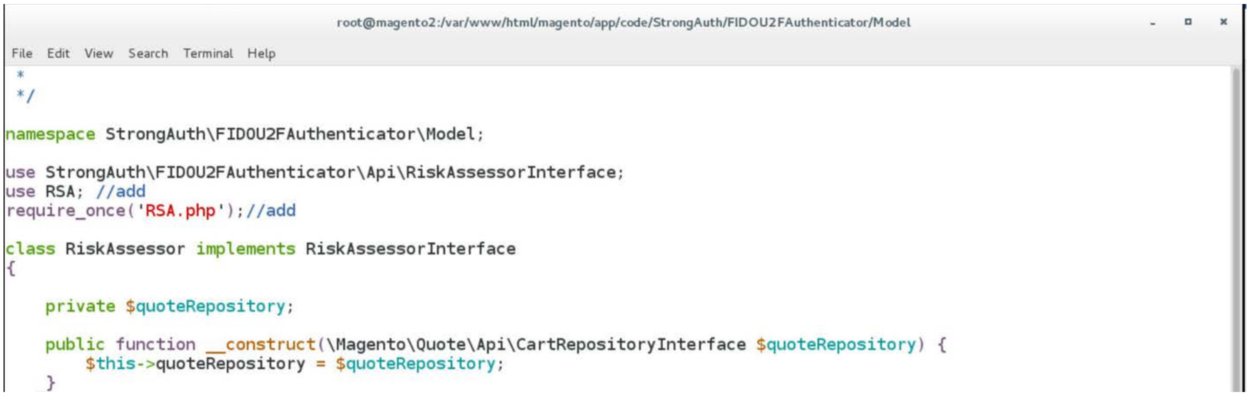
```
[root@magento2 Model]# vim /var/www/html/magento/app/code/StrongAuth/FIDOU2FAuthenticator/Model/RiskAssessor.php
```

16. Press the **i** key to enter editor mode.

17. Make the following changes to the *RiskAssessor.php* file:

    a. After Line 41, add the following two lines:

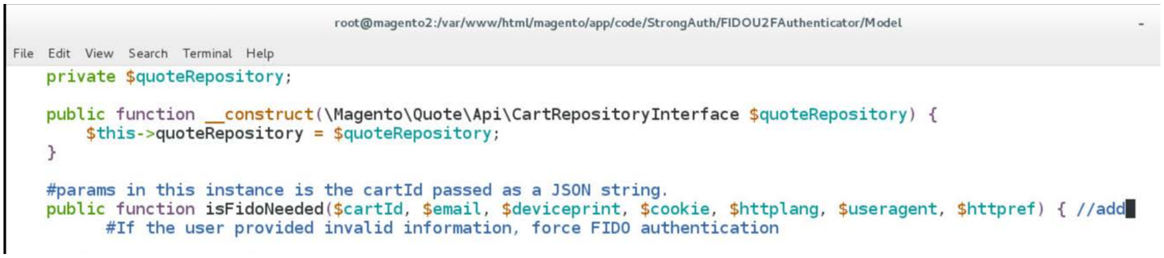
    ```
    use RSA;

    require_once(‘RSA.php’);
    ```


root@magento2:/var/www/html/magento/app/code/StrongAuth/FIDOU2FAuthenticator/Model
File Edit View Search Terminal Help

```
 *
 */

namespace StrongAuth\FIDOU2FAuthenticator\Model;

use StrongAuth\FIDOU2FAuthenticator\Api\RiskAssessorInterface;
use RSA; //add
require_once('RSA.php');//add

class RiskAssessor implements RiskAssessorInterface
{

    private $quoteRepository;

    public function __construct(\Magento\Quote\Api\CartRepositoryInterface $quoteRepository) {
        $this->quoteRepository = $quoteRepository;
    }
```

b. Change Line 55 to the following line:

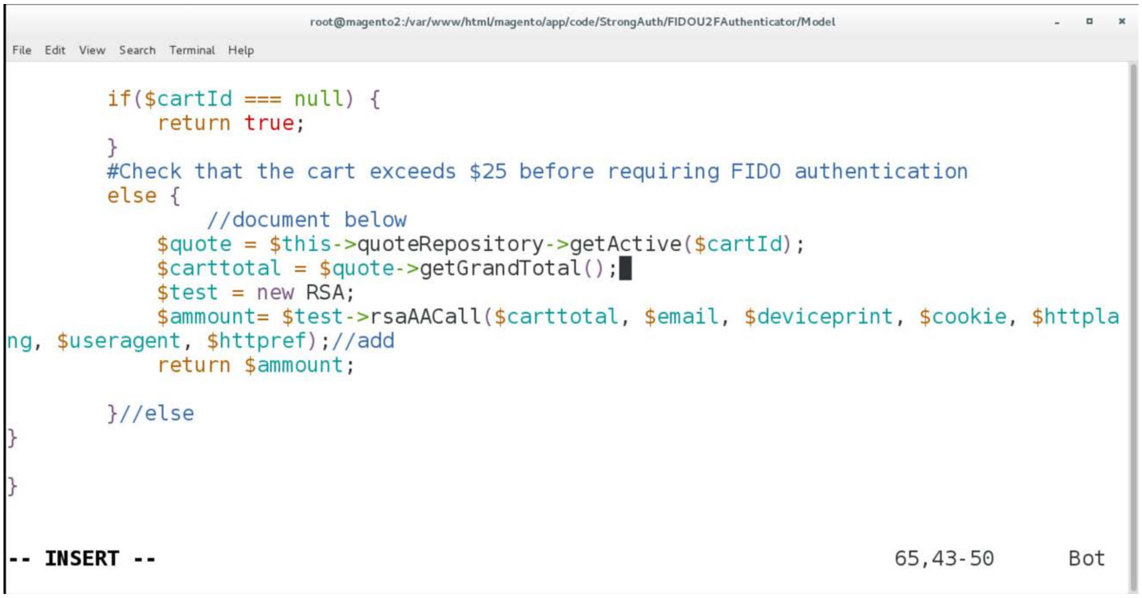
```
Public function isFidoNeeded($cartId, $email, $deviceprint, $cookie,
$httplan, $useragent, $httpref)
```


root@magento2:/var/www/html/magento/app/code/StrongAuth/FIDOU2FAuthenticator/Model
File Edit View Search Terminal Help

```
    private $quoteRepository;

    public function __construct(\Magento\Quote\Api\CartRepositoryInterface $quoteRepository) {
        $this->quoteRepository = $quoteRepository;
    }

    #params in this instance is the cartId passed as a JSON string.
    public function isFidoNeeded($cartId, $email, $deviceprint, $cookie, $httplang, $useragent, $httpref) { //add
          #If the user provided invalid information, force FIDO authentication
```

c. After Line 65, edit the following lines:

```
$test = new RSA;

$amount = $test->rsaAACall($cartId, $email, $deviceprint, $cookie,
$httplan, $useragent, $httpref);

return $amount;
```


root@magento2:/var/www/html/magento/app/code/StrongAuth/FIDOU2FAuthenticator/Model
File Edit View Search Terminal Help

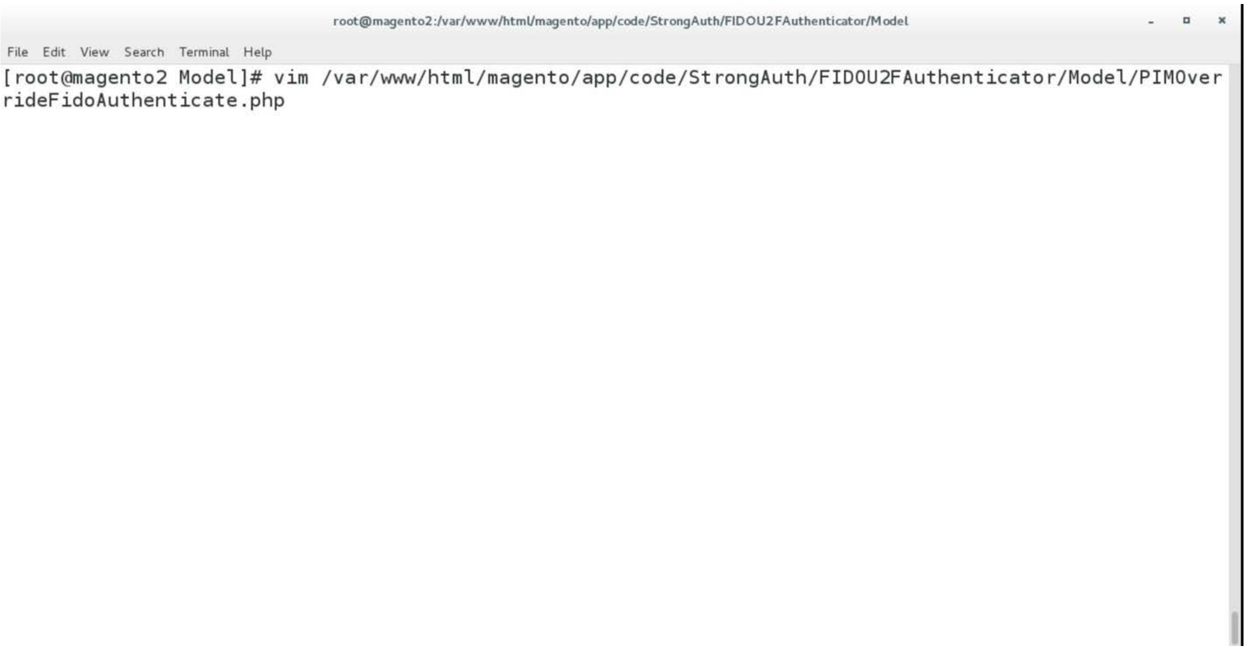
```
        if($cartId === null) {
            return true;
        }
        #Check that the cart exceeds $25 before requiring FIDO authentication
        else {
                //document below
            $quote = $this->quoteRepository->getActive($cartId);
            $carttotal = $quote->getGrandTotal();
            $test = new RSA;
            $ammount= $test->rsaAACall($carttotal, $email, $deviceprint, $cookie, $httpla
ng, $useragent, $httpref);//add
            return $ammount;

        }//else
}

}

-- INSERT --                                                      65,43-50      Bot
```

d. Press the **Esc** key to exit insert mode.

e. Save changes, and exit by entering the following command: `:wq`.

18. Open the *PIMOverrideFidoAuthenticate.php* file in the vim editor by entering the following command:

```
vim
/var/www/html/magento/app/code/StrongAuth/FIDOU2FAuthenticator/Model/PIMOverrid
eFidoAuthenticate.php
```


root@magento2:/var/www/html/magento/app/code/StrongAuth/FIDOU2FAuthenticator/Model
File Edit View Search Terminal Help

```
[root@magento2 Model]# vim /var/www/html/magento/app/code/StrongAuth/FIDOU2FAuthenticator/Model/PIMOver
rideFidoAuthenticate.php
```

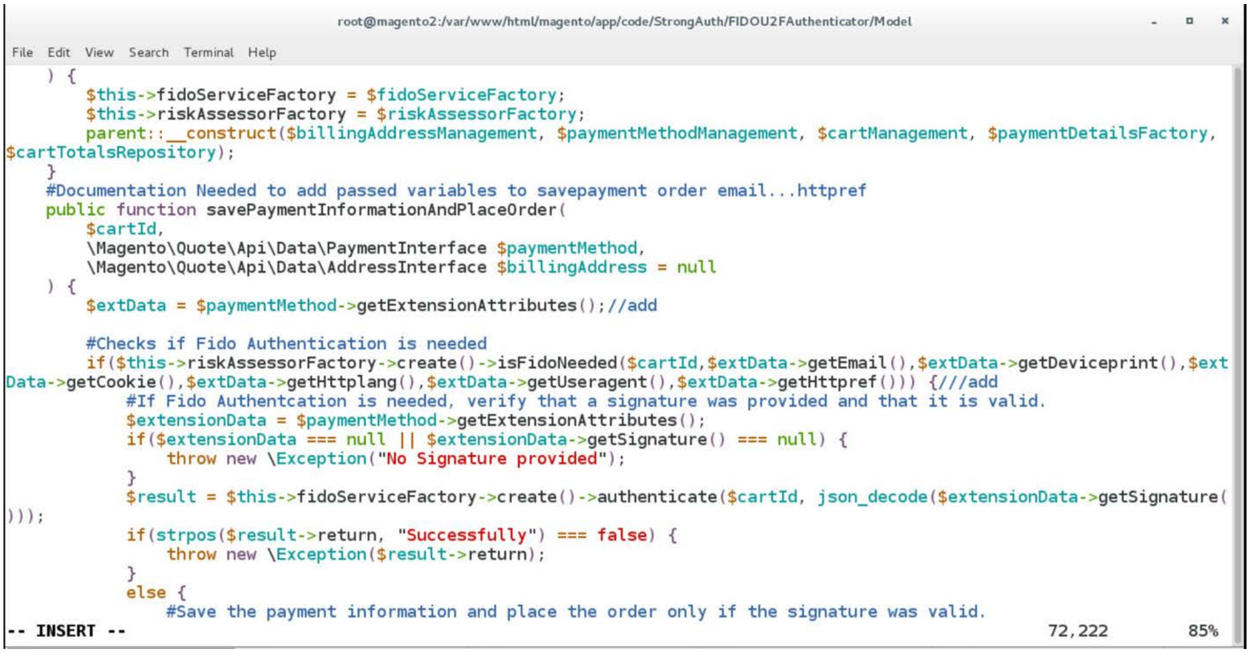
19. Press the **i** key to enter editor mode.

20. Make the following changes to the *PIMOverrideFidoAuthenticate.php* file:

    a. Between Lines 68 and 72, edit the following lines:

    ```
    extData = $paymentMethod->getExtensionAttributes();
    ```

    ```
    if($this->riskAssessorFactory->create()->isFidoNeeded($cartId,$extData->getEmail(),$extData->getDeviceprint(),$extData->getCookie,$extData->getHttplang(),$extData->getUseragent,$extData->getHttpref())) {
    ```


root@magento2:/var/www/html/magento/app/code/StrongAuth/FIDOU2FAuthenticator/Model
File Edit View Search Terminal Help

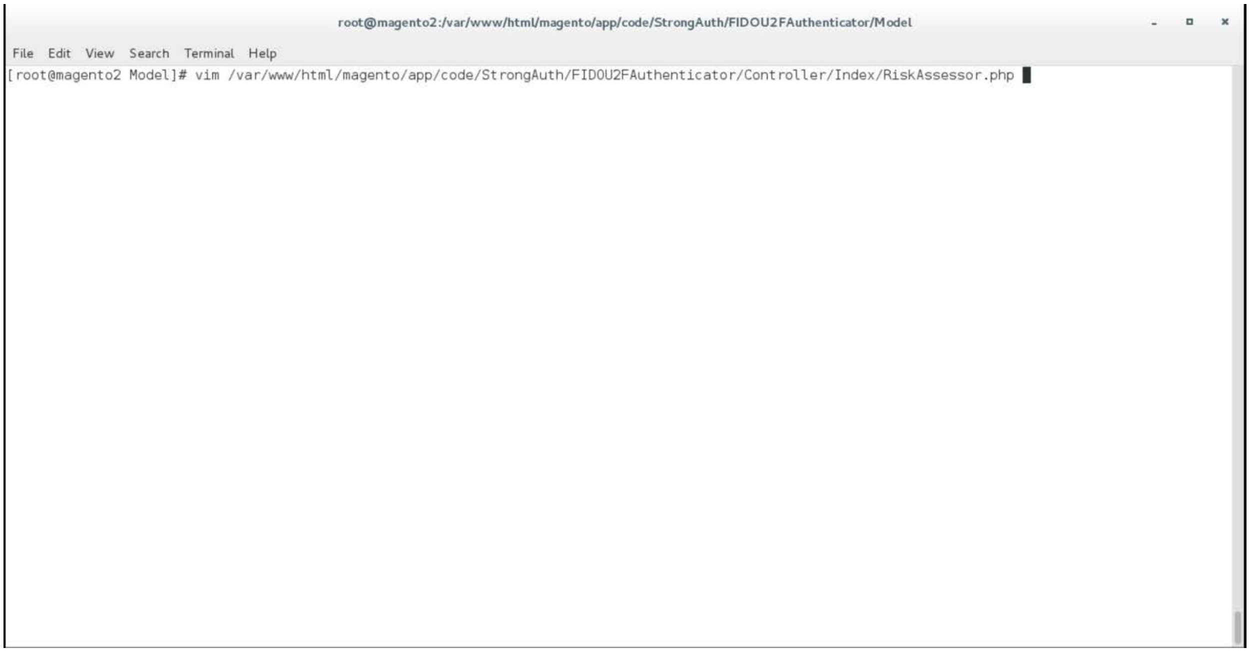
```
    ) {
        $this->fidoServiceFactory = $fidoServiceFactory;
        $this->riskAssessorFactory = $riskAssessorFactory;
        parent::__construct($billingAddressManagement, $paymentMethodManagement, $cartManagement, $paymentDetailsFactory,
$cartTotalsRepository);
    }
    #Documentation Needed to add passed variables to savepayment order email...httpref
    public function savePaymentInformationAndPlaceOrder(
        $cartId,
        \Magento\Quote\Api\Data\PaymentInterface $paymentMethod,
        \Magento\Quote\Api\Data\AddressInterface $billingAddress = null
    ) {
        $extData = $paymentMethod->getExtensionAttributes();//add

        #Checks if Fido Authentication is needed
        if($this->riskAssessorFactory->create()->isFidoNeeded($cartId,$extData->getEmail(),$extData->getDeviceprint(),$ext
Data->getCookie(),$extData->getHttplang(),$extData->getUseragent(),$extData->getHttpref())) {///add
            #If Fido Authentcation is needed, verify that a signature was provided and that it is valid.
            $extensionData = $paymentMethod->getExtensionAttributes();
            if($extensionData === null || $extensionData->getSignature() === null) {
                throw new \Exception("No Signature provided");
            }
            $result = $this->fidoServiceFactory->create()->authenticate($cartId, json_decode($extensionData->getSignature(
)));
            if(strpos($result->return, "Successfully") === false) {
                throw new \Exception($result->return);
            }
            else {
                #Save the payment information and place the order only if the signature was valid.
-- INSERT --                                                                                          72,222        85%
```

b. Press the **Esc** key to exit insert mode.

c. Save changes, and exit by entering the following command: `:wq`.

21. Open the RSA RiskAssessor Controller file by entering the following command:

```
vim
/var/www/html/magento/StrongAuth/FIDOU2FAuthenticator/Controller/Index/Riskasse
ssor.php
```



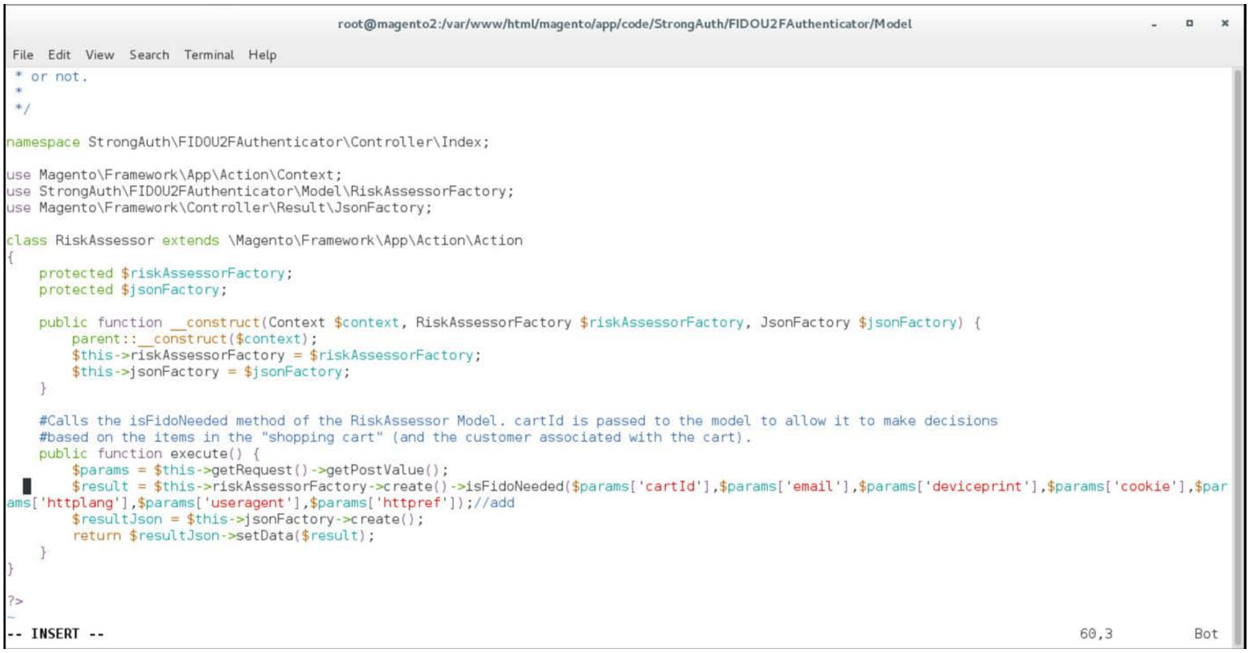
```
[root@magento2 Model]# vim /var/www/html/magento/app/code/StrongAuth/FIDOU2FAuthenticator/Controller/Index/RiskAssessor.php
```

22. Press the **i** key to enter editor mode.

23. Make the following changes to the *RiskAssessor.php* file:

    a. Change Line 60 to the following line:

    ```
    $result = $this->riskAssessorFactory->create()-
    >isFidoNeeded($params[‘cartId’], $params[‘email’],
    $params[‘deviceprint’], $params[‘cookie’], $params[‘httplang’],
    $params[‘useragent’], $params[‘httpref’]);
    ```



root@magento2:/var/www/html/magento/app/code/StrongAuth/FIDOU2FAuthenticator/Model
File Edit View Search Terminal Help

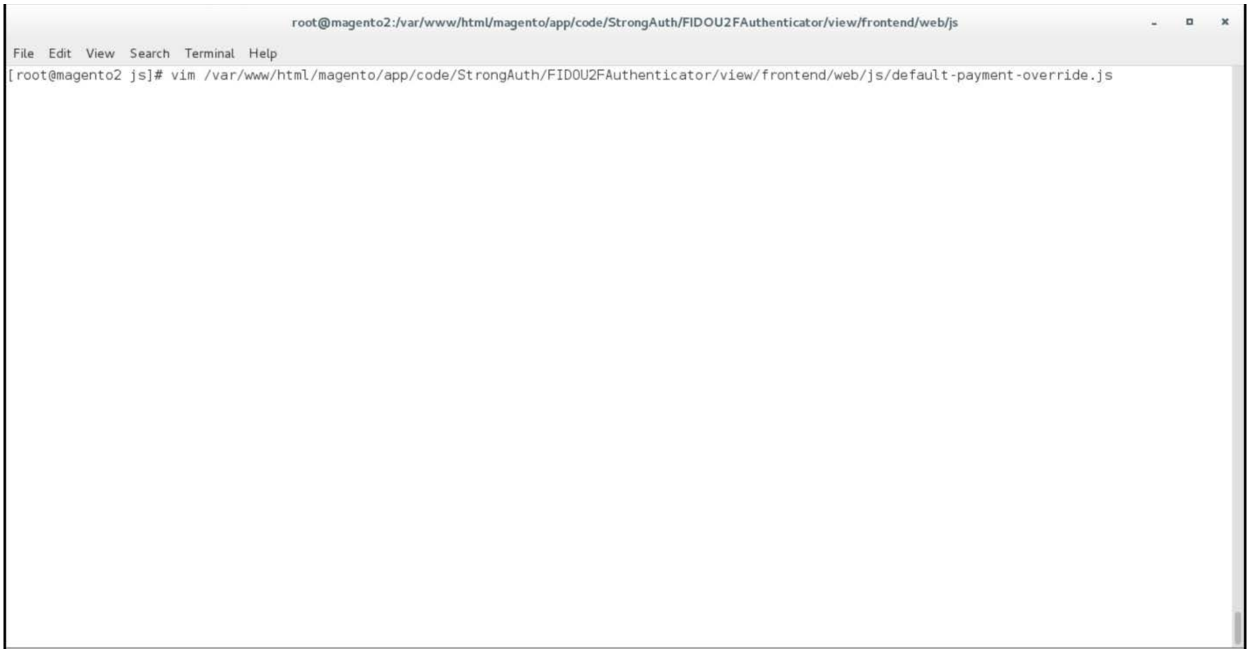
```
 * or not.
 *
 */

namespace StrongAuth\FIDOU2FAuthenticator\Controller\Index;

use Magento\Framework\App\Action\Context;
use StrongAuth\FIDOU2FAuthenticator\Model\RiskAssessorFactory;
use Magento\Framework\Controller\Result\JsonFactory;

class RiskAssessor extends \Magento\Framework\App\Action\Action
{
    protected $riskAssessorFactory;
    protected $jsonFactory;

    public function __construct(Context $context, RiskAssessorFactory $riskAssessorFactory, JsonFactory $jsonFactory) {
        parent::__construct($context);
        $this->riskAssessorFactory = $riskAssessorFactory;
        $this->jsonFactory = $jsonFactory;
    }

    #Calls the isFidoNeeded method of the RiskAssessor Model. cartId is passed to the model to allow it to make decisions
    #based on the items in the "shopping cart" (and the customer associated with the cart).
    public function execute() {
        $params = $this->getRequest()->getPostValue();
        $result = $this->riskAssessorFactory->create()->isFidoNeeded($params['cartId'],$params['email'],$params['deviceprint'],$params['cookie'],$par
ams['httplang'],$params['useragent'],$params['httpref']);//add
        $resultJson = $this->jsonFactory->create();
        return $resultJson->setData($result);
    }
}

?>
~
-- INSERT --                                                                                                           60,3          Bot
```

b. Press the **Esc** key to exit insert mode.

c. Save changes, and exit by entering the following command: `:wq`.

24. Open the RSA JavaScript Override file by entering the following command:

```
vim
/var/www/html/magento/StrongAuth/FIDOU2FAuthenticator/view/frontend/web/js/defa
ult-payment-override.js
```


root@magento2:/var/www/html/magento/app/code/StrongAuth/FIDOU2FAuthenticator/view/frontend/web/js
File Edit View Search Terminal Help

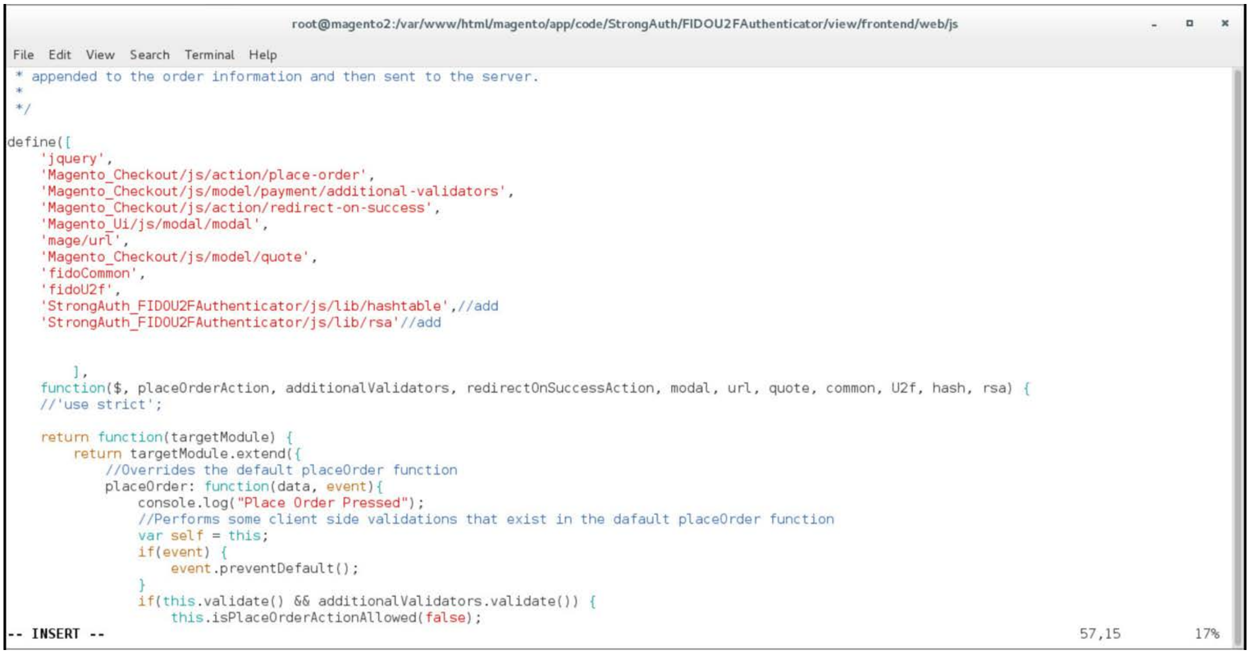
```
[root@magento2 js]# vim /var/www/html/magento/app/code/StrongAuth/FIDOU2FAuthenticator/view/frontend/web/js/default-payment-override.js
```

25. Press the **i** key to enter editor mode.

26. Make the following changes to the *default-payment-override.js* file:

    a. Add the following two lines after Line 57:

    ```
    'StrongAuth_FIDOU2FAuthenticator/js/lib/hashtable',
    'StrongAuth_FIDOU2FAuthenticator/js/lib/rsa'
    ```

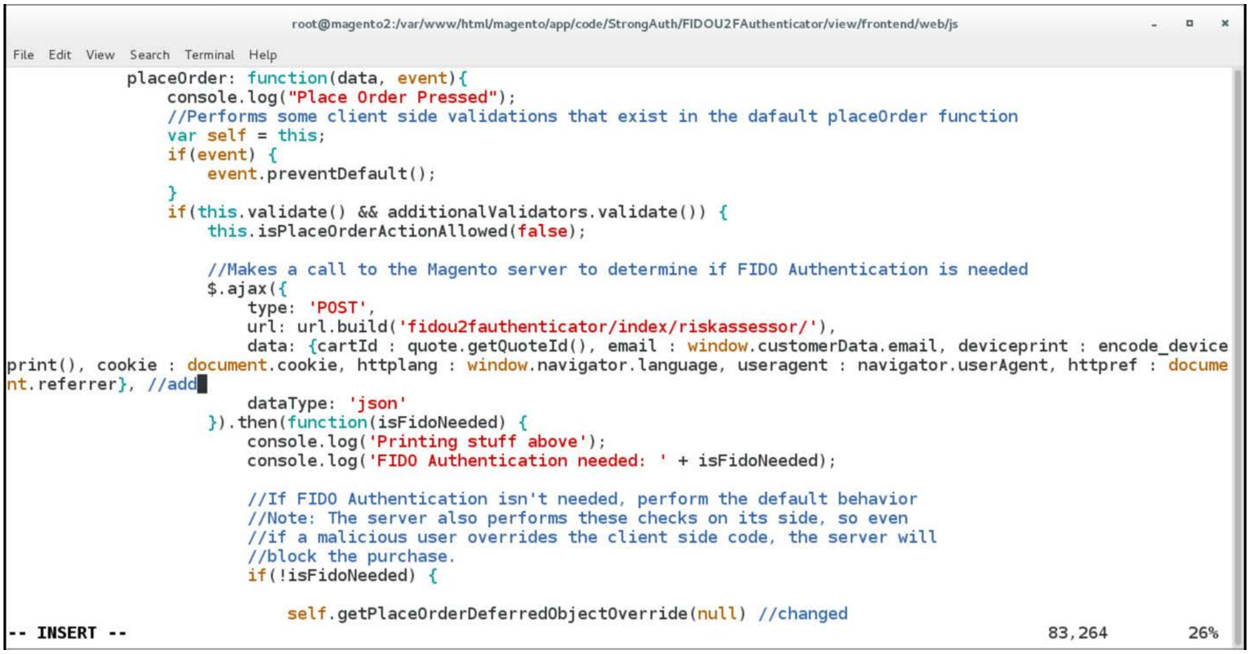


root@magento2:/var/www/html/magento/app/code/StrongAuth/FIDOU2FAuthenticator/view/frontend/web/js

```
 * appended to the order information and then sent to the server.
 *
 */

define([
    'jquery',
    'Magento_Checkout/js/action/place-order',
    'Magento_Checkout/js/model/payment/additional-validators',
    'Magento_Checkout/js/action/redirect-on-success',
    'Magento_Ui/js/modal/modal',
    'mage/url',
    'Magento_Checkout/js/model/quote',
    'fidoCommon',
    'fidoU2f',
    'StrongAuth_FIDOU2FAuthenticator/js/lib/hashtable',//add
    'StrongAuth_FIDOU2FAuthenticator/js/lib/rsa'//add


        ],
    function($, placeOrderAction, additionalValidators, redirectOnSuccessAction, modal, url, quote, common, U2f, hash, rsa) {
    //'use strict';

    return function(targetModule) {
        return targetModule.extend({
            //Overrides the default placeOrder function
            placeOrder: function(data, event){
                console.log("Place Order Pressed");
                //Performs some client side validations that exist in the dafault placeOrder function
                var self = this;
                if(event) {
                    event.preventDefault();
                }
                if(this.validate() && additionalValidators.validate()) {
                    this.isPlaceOrderActionAllowed(false);
-- INSERT --                                                                                          57,15         17%
```

b. Change Line 83 to the following line:

```
Data: {cartId: quote.getQuoteId(), email : window.customerData.email, deviceprint : encode_deviceprint(), cookie: document.cookie, httplang : window.navigator.language, useragent : navigator.userAgent, httpref : document.referrer},
```

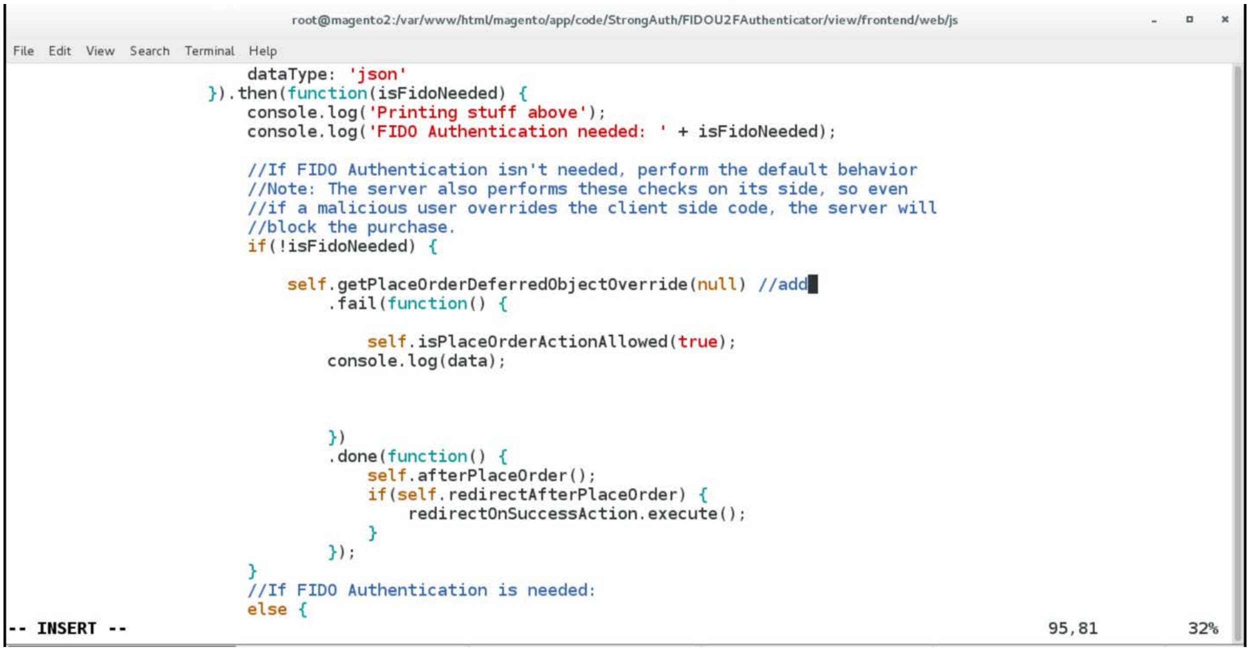


root@magento2:/var/www/html/magento/app/code/StrongAuth/FIDOU2FAuthenticator/view/frontend/web/js

```
            placeOrder: function(data, event){
                console.log("Place Order Pressed");
                //Performs some client side validations that exist in the dafault placeOrder function
                var self = this;
                if(event) {
                    event.preventDefault();
                }
                if(this.validate() && additionalValidators.validate()) {
                    this.isPlaceOrderActionAllowed(false);

                    //Makes a call to the Magento server to determine if FIDO Authentication is needed
                    $.ajax({
                        type: 'POST',
                        url: url.build('fidou2fauthenticator/index/riskassessor/'),
                        data: {cartId : quote.getQuoteId(), email : window.customerData.email, deviceprint : encode_device
print(), cookie : document.cookie, httplang : window.navigator.language, useragent : navigator.userAgent, httpref : docume
nt.referrer}, //add
                        dataType: 'json'
                    }).then(function(isFidoNeeded) {
                        console.log('Printing stuff above');
                        console.log('FIDO Authentication needed: ' + isFidoNeeded);

                        //If FIDO Authentication isn't needed, perform the default behavior
                        //Note: The server also performs these checks on its side, so even
                        //if a malicious user overrides the client side code, the server will
                        //block the purchase.
                        if(!isFidoNeeded) {

                            self.getPlaceOrderDeferredObjectOverride(null) //changed
-- INSERT --                                                                                 83,264        26%
```

c. Change Line 95 to the following line:

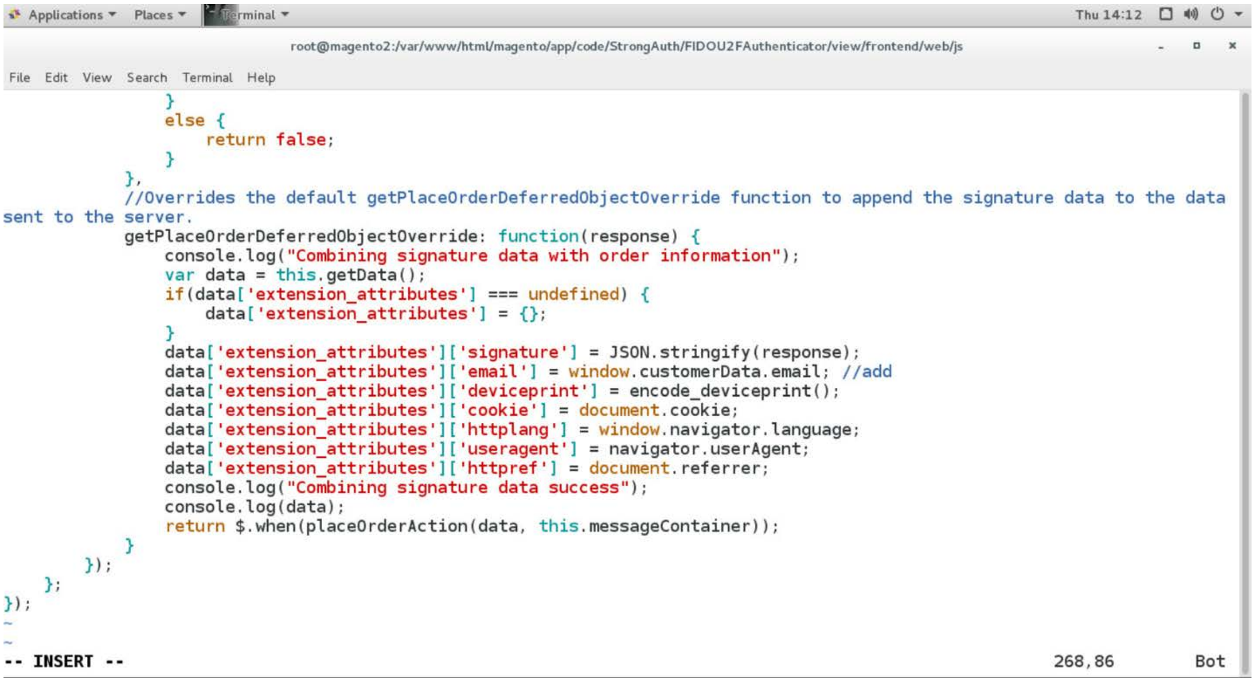
```
self.getPlaceOrderDeferredObjectOverride(null)
```


root@magento2:/var/www/html/magento/app/code/StrongAuth/FIDOU2FAuthenticator/view/frontend/web/js
File Edit View Search Terminal Help

```
        dataType: 'json'
    }).then(function(isFidoNeeded) {
        console.log('Printing stuff above');
        console.log('FIDO Authentication needed: ' + isFidoNeeded);

        //If FIDO Authentication isn't needed, perform the default behavior
        //Note: The server also performs these checks on its side, so even
        //if a malicious user overrides the client side code, the server will
        //block the purchase.
        if(!isFidoNeeded) {

            self.getPlaceOrderDeferredObjectOverride(null) //add
                .fail(function() {

                    self.isPlaceOrderActionAllowed(true);
                console.log(data);



                })
                .done(function() {
                    self.afterPlaceOrder();
                    if(self.redirectAfterPlaceOrder) {
                        redirectOnSuccessAction.execute();
                    }
                });
        }
        //If FIDO Authentication is needed:
        else {
-- INSERT --                                                                 95,81          32%
```

d. After Line 268, add the following lines:

```
Data[‘extension_attributes’][‘email’] = window.customerData.email;

Data[‘extension_attributes’][‘deviceprint’] = encode_deviceprint();

Data[‘extension_attributes’][‘cookie’] = document.cookie;

Data[‘extension_attributes’][‘httplang’] = window.navigator.language;

Data[‘extension_attributes’][‘useragent’] = navigator.userAgent;

Data[‘extension_attributes’][‘httpref’] = document.referrer;
```


Applications
Places
Terminal
Thu 14:12
root@magento2:/var/www/html/magento/app/code/StrongAuth/FIDOU2FAuthenticator/view/frontend/web/js
File Edit View Search Terminal Help

```
                }
                else {
                    return false;
                }
            },
            //Overrides the default getPlaceOrderDeferredObjectOverride function to append the signature data to the data sent to the server.
            getPlaceOrderDeferredObjectOverride: function(response) {
                console.log("Combining signature data with order information");
                var data = this.getData();
                if(data['extension_attributes'] === undefined) {
                    data['extension_attributes'] = {};
                }
                data['extension_attributes']['signature'] = JSON.stringify(response);
                data['extension_attributes']['email'] = window.customerData.email; //add
                data['extension_attributes']['deviceprint'] = encode_deviceprint();
                data['extension_attributes']['cookie'] = document.cookie;
                data['extension_attributes']['httplang'] = window.navigator.language;
                data['extension_attributes']['useragent'] = navigator.userAgent;
                data['extension_attributes']['httpref'] = document.referrer;
                console.log("Combining signature data success");
                console.log(data);
                return $.when(placeOrderAction(data, this.messageContainer));
            }
        });
    };
});
~
~
-- INSERT --                                                                           268,86        Bot
```

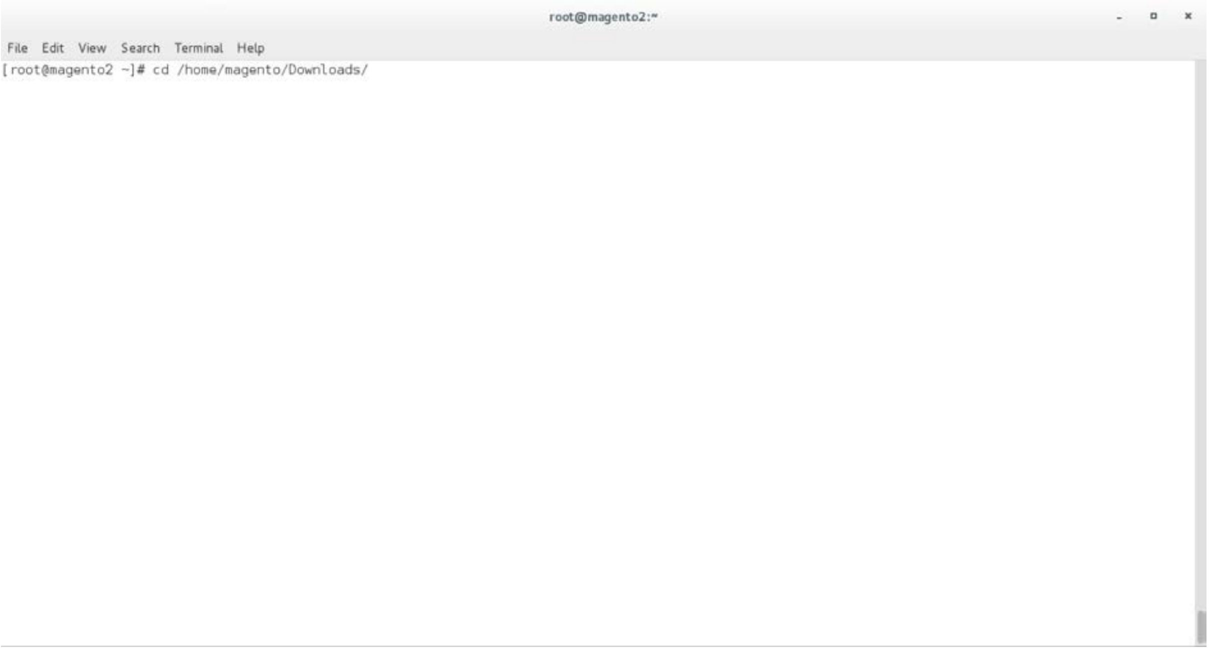
e. Press the **Esc** key to exit insert mode.

f. Save changes, and exit by entering the following command: `:wq`.

27. Download the RSA JavaScript files from your RSA representative.

28. Make the following change to the Downloads directory:

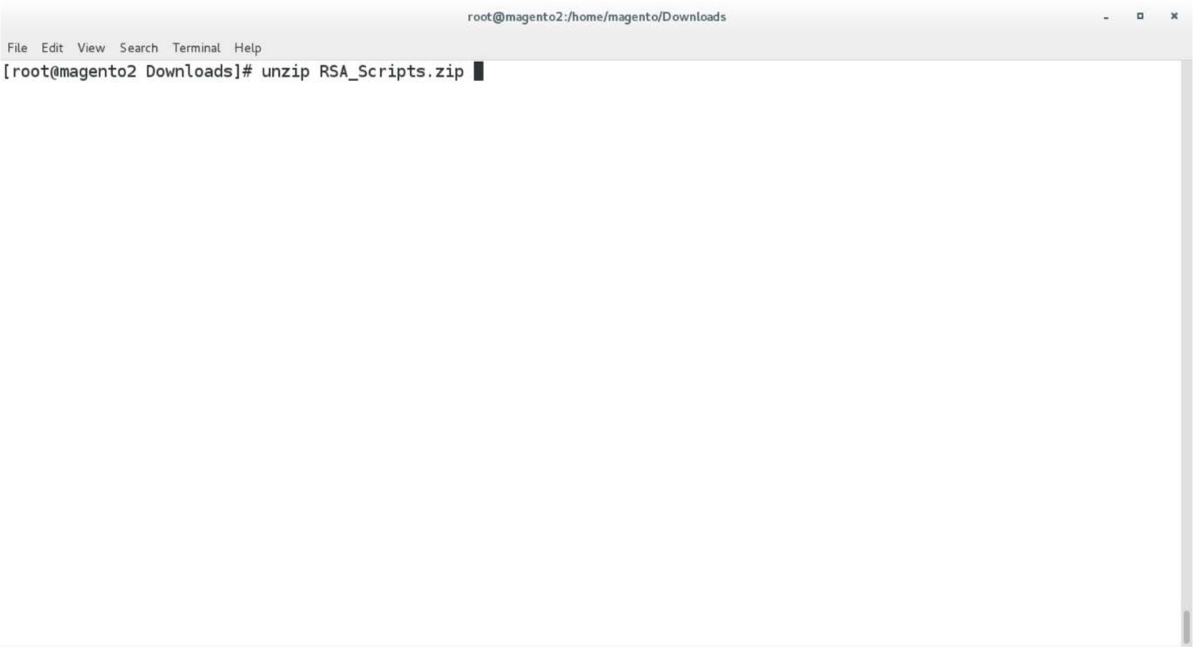
```
cd /home/magento/Downloads
```



```
[root@magento2 ~]# cd /home/magento/Downloads/
```

29. Unzip the contents of the RSA JavaScript folder by entering the following command:

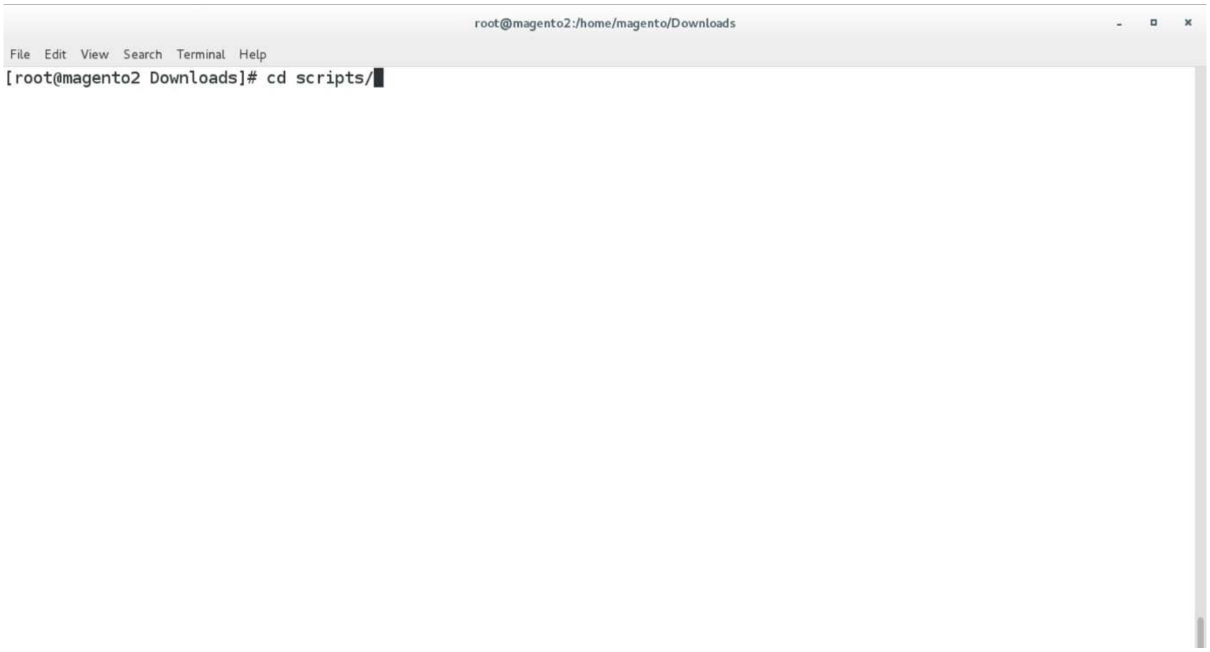
    `unzip RSA_Scripts.zip`


root@magento2:/home/magento/Downloads
File Edit View Search Terminal Help

```
[root@magento2 Downloads]# unzip RSA_Scripts.zip
```

30. Move to the newly unzipped scripts folder by entering the following command:

    ```
    cd scripts/
    ```

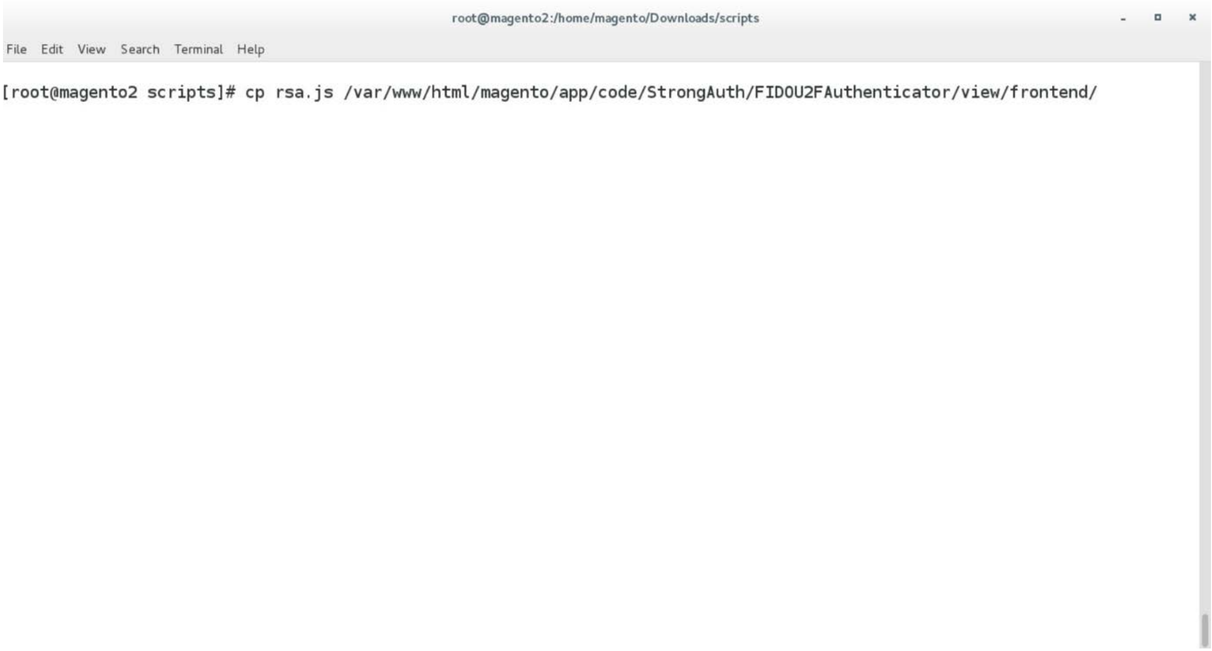


root@magento2:/home/magento/Downloads
File Edit View Search Terminal Help

```
[root@magento2 Downloads]# cd scripts/
```

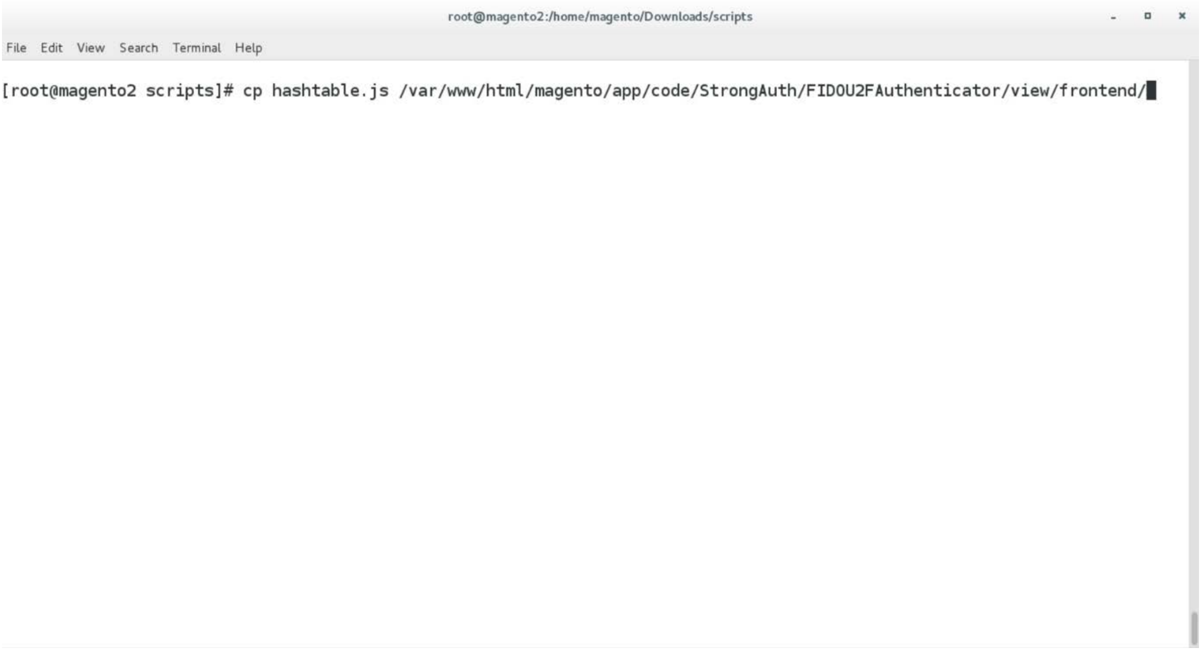
31. Copy the *rsa.js* and *hashtable.js* files to StrongAuth front-end JavaScript directory by entering the following commands:

    a.
    ```
    cp rsa.js
    /var/www/html/magento/app/code/StrongAuth/FIDOU2FAuthenticator/view/front
    end/web/js/lib/
    ```


root@magento2:/home/magento/Downloads/scripts
File Edit View Search Terminal Help

```
[root@magento2 scripts]# cp rsa.js /var/www/html/magento/app/code/StrongAuth/FIDOU2FAuthenticator/view/frontend/
```

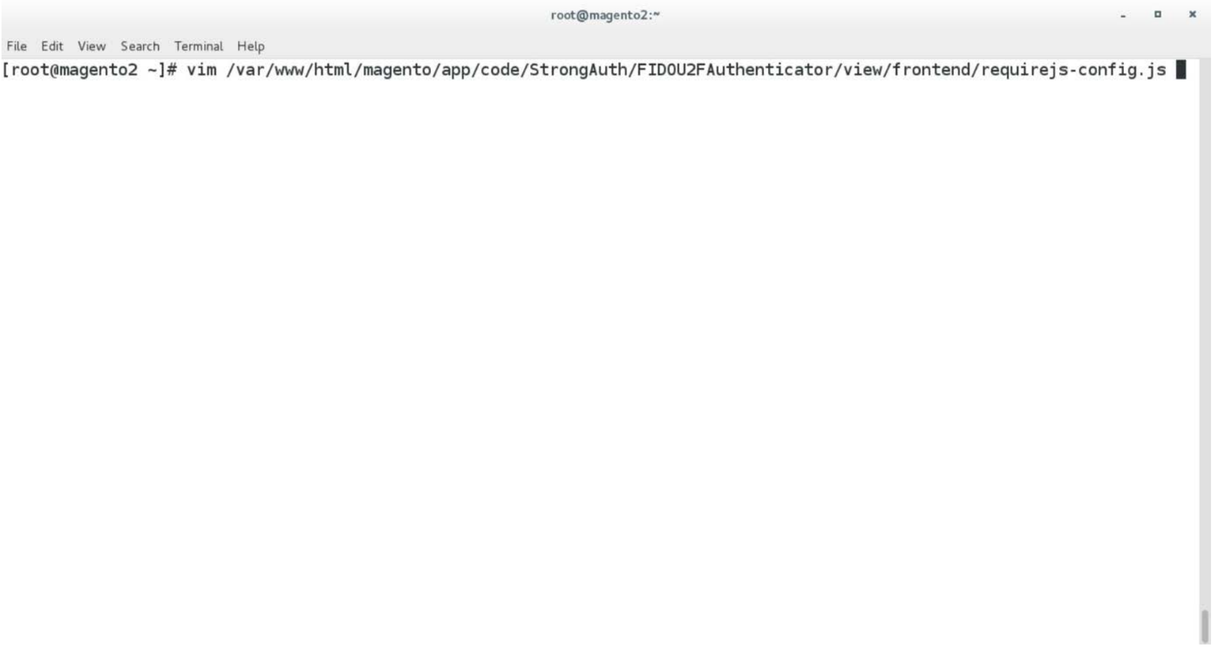
b. `cp hashtable.js /var/www/html/magento/app/code/StrongAuth/FIDOU2FAuthenticator/view/frontend/web/js/lib/`


root@magento2:/home/magento/Downloads/scripts
File Edit View Search Terminal Help

```
[root@magento2 scripts]# cp hashtable.js /var/www/html/magento/app/code/StrongAuth/FIDOU2FAuthenticator/view/frontend/
```

32. Open the StrongAuth JavaScript required file by entering the following command:

    ```
    vim
    /var/www/html/magento/app/code/StrongAuth/FIDOU2FAuthenticator/view/frontendreq
    uirejs-config.js
    ```



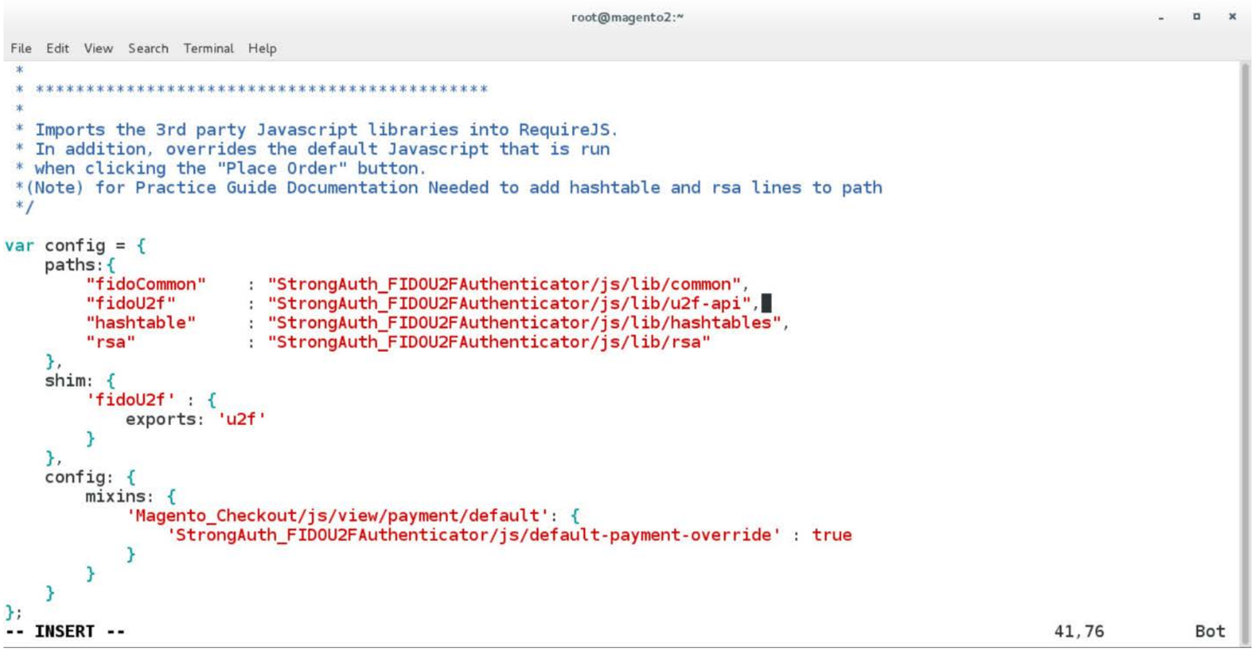
```
[root@magento2 ~]# vim /var/www/html/magento/app/code/StrongAuth/FIDOU2FAuthenticator/view/frontend/requirejs-config.js
```

33. Press the **i** key to enter editor mode.

34. Make the following edits to the *requirejs-config.js* file:

    a. After Line 41, insert the following lines:

    ```
    “hashtable” : “StrongAuth_FIDOU2FAuthenticator/js/lib/hastables”,
    “rsa” : “StrongAuth_FIDOU2FAuthenticator/js/lib/rsa
    ```



```
 *
 * ********************************************
 *
 * Imports the 3rd party Javascript libraries into RequireJS.
 * In addition, overrides the default Javascript that is run
 * when clicking the "Place Order" button.
 *(Note) for Practice Guide Documentation Needed to add hashtable and rsa lines to path
 */

var config = {
    paths:{
        "fidoCommon"    : "StrongAuth_FIDOU2FAuthenticator/js/lib/common",
        "fidoU2f"       : "StrongAuth_FIDOU2FAuthenticator/js/lib/u2f-api",
        "hashtable"     : "StrongAuth_FIDOU2FAuthenticator/js/lib/hashtables",
        "rsa"           : "StrongAuth_FIDOU2FAuthenticator/js/lib/rsa"
    },
    shim: {
        'fidoU2f' : {
            exports: 'u2f'
        }
    },
    config: {
        mixins: {
            'Magento_Checkout/js/view/payment/default': {
                'StrongAuth_FIDOU2FAuthenticator/js/default-payment-override' : true
            }
        }
    }
};
-- INSERT --                                                        41,76          Bot
```

b. Press the **Esc** key to exit insert mode.

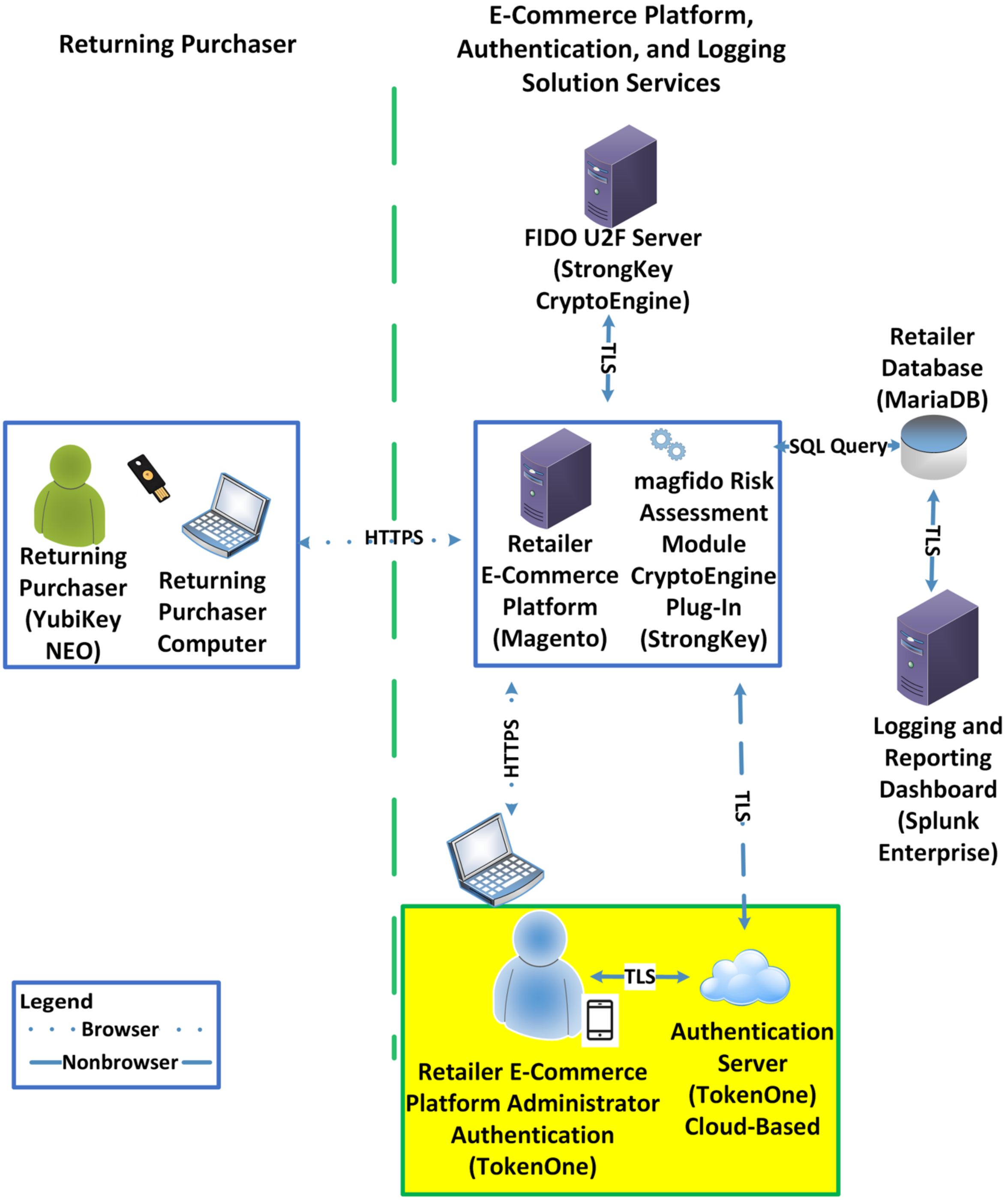
c. Save changes, and exit by entering the following command: `:wq`.

35. To create Adaptive Authentication policies, follow the product configuration instructions provided by your RSA representative.

2.5 TokenOne

This section provides installation and configuration guidance for TokenOne’s authentication capability [9]. TokenOne’s authentication product is used by the retailer e-commerce platform administrator when they are managing the Magento e-commerce platform. TokenOne developed a Magento connector that both the *cost threshold* and *risk engine* example implementations use. The TokenOne authentication components that are installed and configured in this section are illustrated in Figure 2-5 and are highlighted in yellow within the green box.

Figure 2-5 TokenOne Authentication Components


Returning Purchaser
E-Commerce Platform, Authentication, and Logging Solution Services
FIDO U2F Server (StrongKey CryptoEngine)
TLS
Retailer Database (MariaDB)
SQL Query
TLS
Returning Purchaser (YubiKey NEO)
Returning Purchaser Computer
HTTPS
Retailer E-Commerce Platform (Magento)
magfido Risk Assessment Module CryptoEngine Plug-In (StrongKey)
Logging and Reporting Dashboard (Splunk Enterprise)
HTTPS
TLS
TLS
Retailer E-Commerce Platform Administrator Authentication (TokenOne)
Authentication Server (TokenOne) Cloud-Based
Legend
Browser
Nonbrowser

2.5.1 TokenOne Overview

TokenOne allows software-based authentication through a onetime personal identification number (PIN). The Magento Admin URI portal has been configured to use Second Factor Authentication with TokenOne. When accessing Magento with TokenOne's authentication capability, the user's numeric PIN is not entered, transmitted, or stored, but the corresponding letter code—which is entered when accessing Magento—is different every time that the user accesses the system. The TokenOne smartphone application is not push-button. The user always enters the code in the Magento administration interface.

The installation procedure consists of the following steps:

- Preinstallation:
  - Download the TokenOne application.
  - Download the TokenOne module.
- Installation and configuration:
  - Integrate the TokenOne module into Magento.
  - Test connectivity and authentication.

2.5.2 Preinstallation Steps

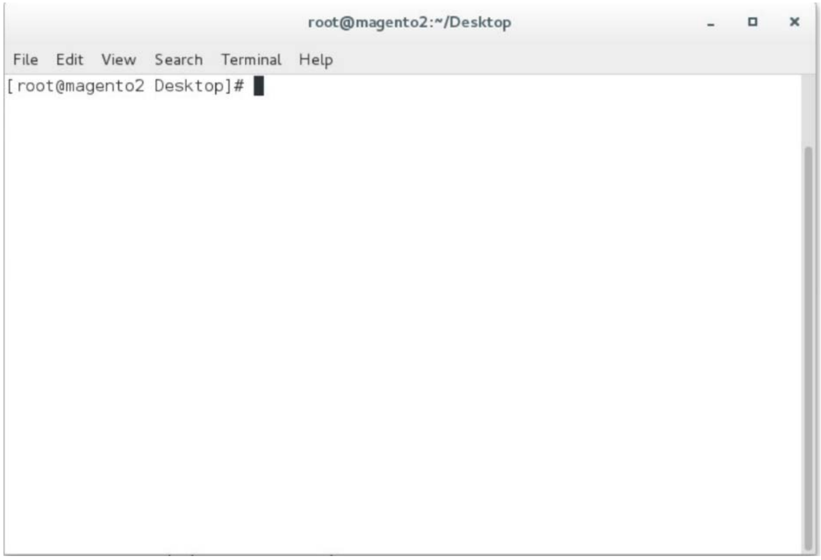
Before beginning installation, ensure that the following steps are completed:

- Download and install the TokenOne mobile application from either the Apple App Store or the Google Play Store.
- Speak with your TokenOne representative to receive the *TokenOne10.zip* file.
- Download the *TokenOne10.zip* file to the */home/magento/Downloads* directory.

2.5.3 TokenOne Installation and Configuration

To begin installation, perform the following steps:

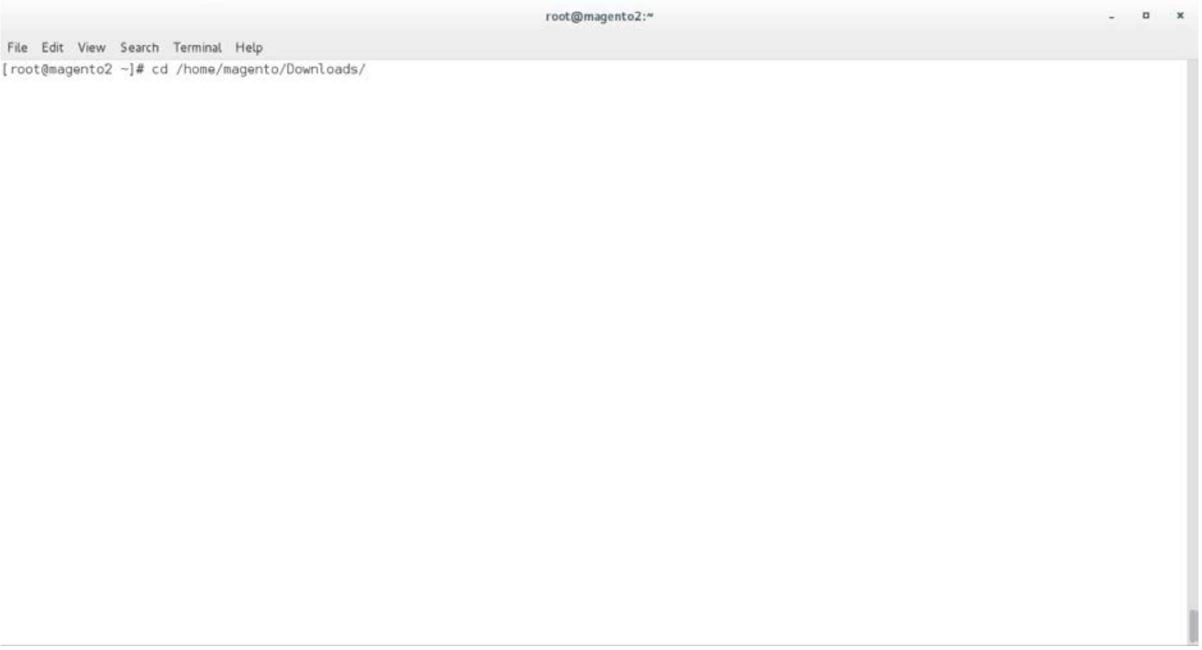
1. Open a terminal window.



```
[root@magento2 Desktop]#
```

2. Change to the Downloads directory by entering the following command:

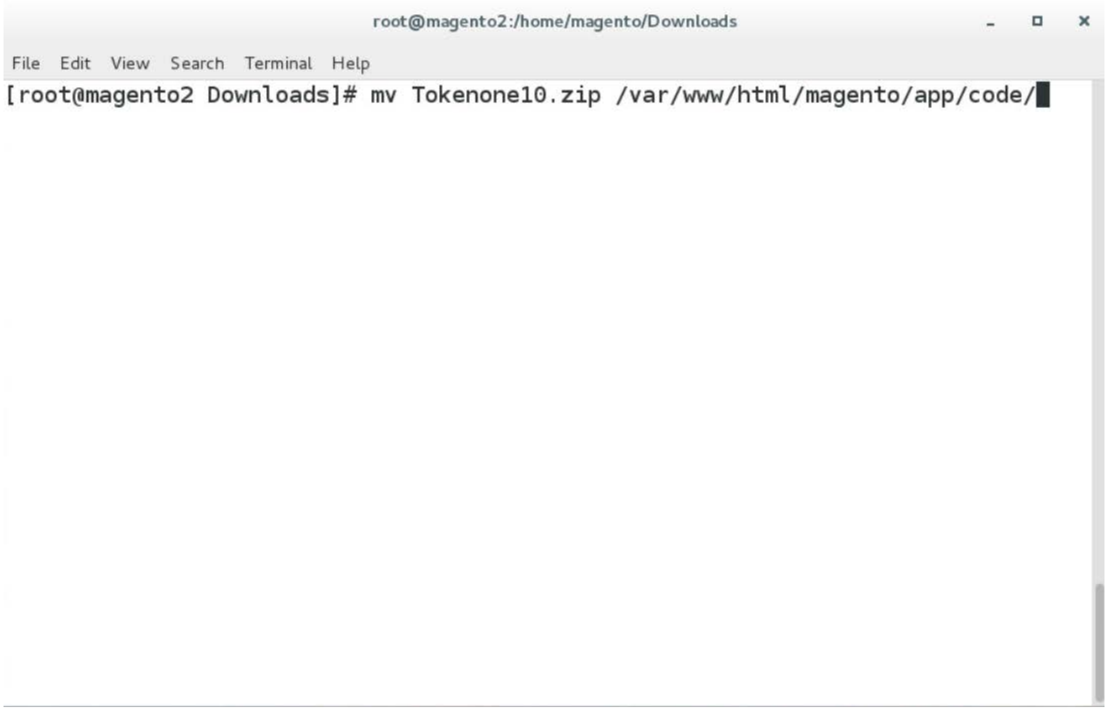
   `cd /home/magento/Downloads`



```
[root@magento2 ~]# cd /home/magento/Downloads/
```

3. Move the *Tokenone10.zip* file to the Magento application code directory by entering the following command:

   `mv Tokenone10.zip /var/www/html/magento/app/code/`

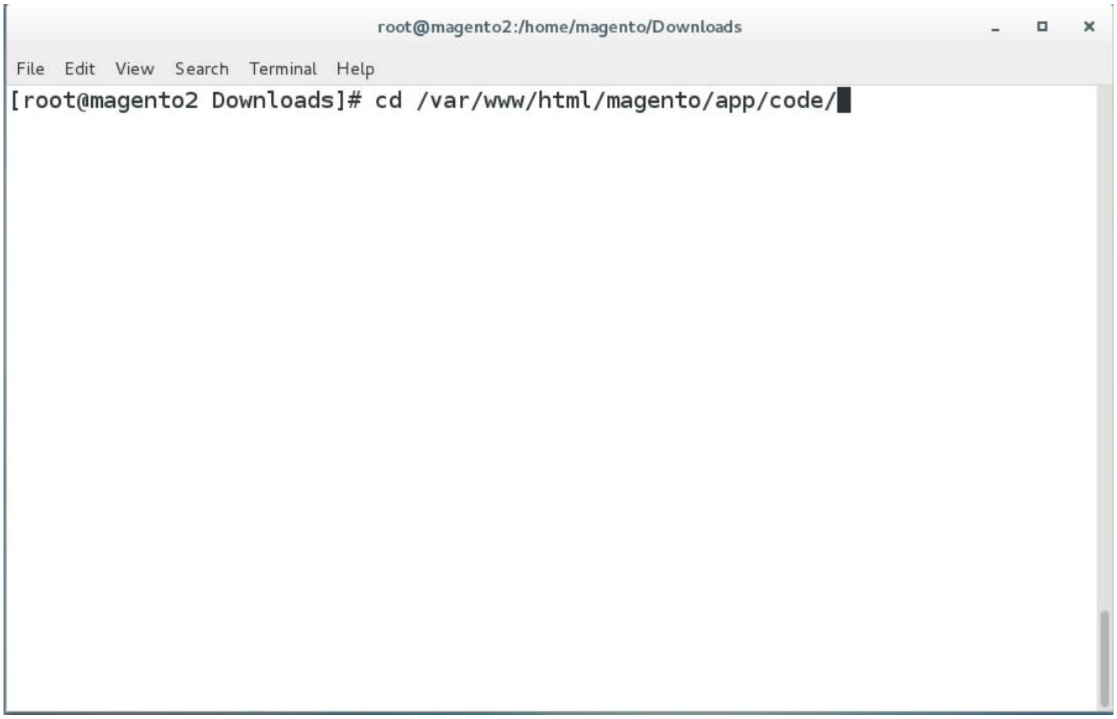


root@magento2:/home/magento/Downloads
File Edit View Search Terminal Help

```
[root@magento2 Downloads]# mv Tokenone10.zip /var/www/html/magento/app/code/
```

4. Change to the Magento application directory by entering the following command:

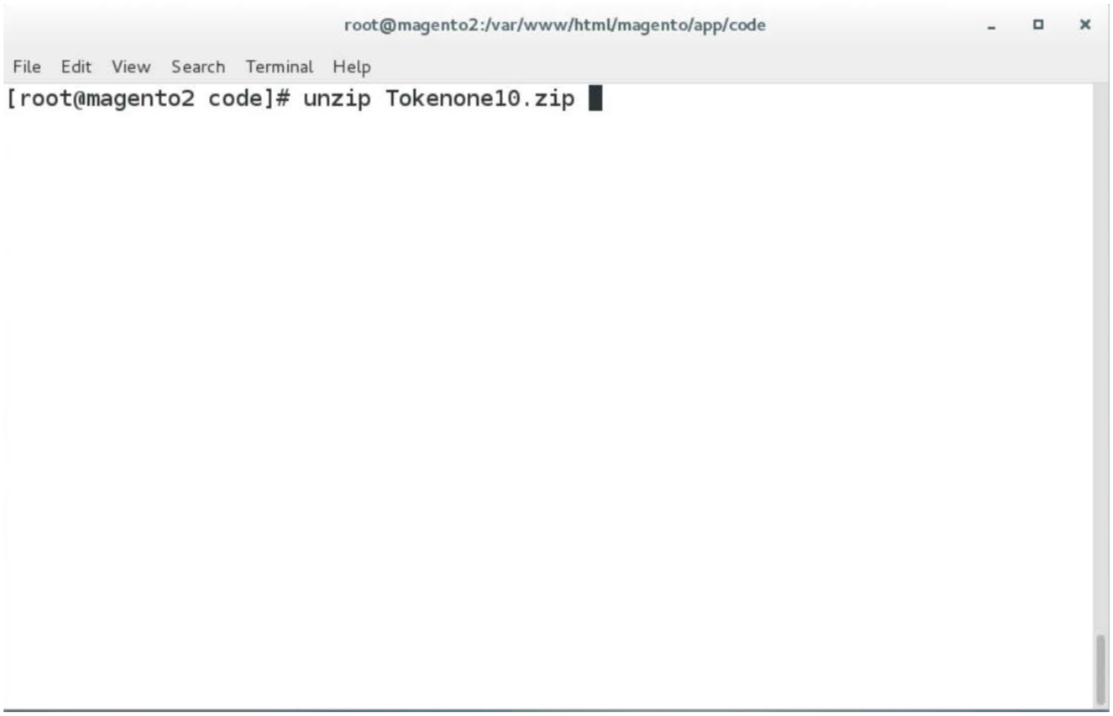
   ```
   cd /var/www/html/magento/app/code/
   ```


root@magento2:/home/magento/Downloads
File Edit View Search Terminal Help

```
[root@magento2 Downloads]# cd /var/www/html/magento/app/code/
```

5. Unzip the TokenOne zip file by entering the following command:

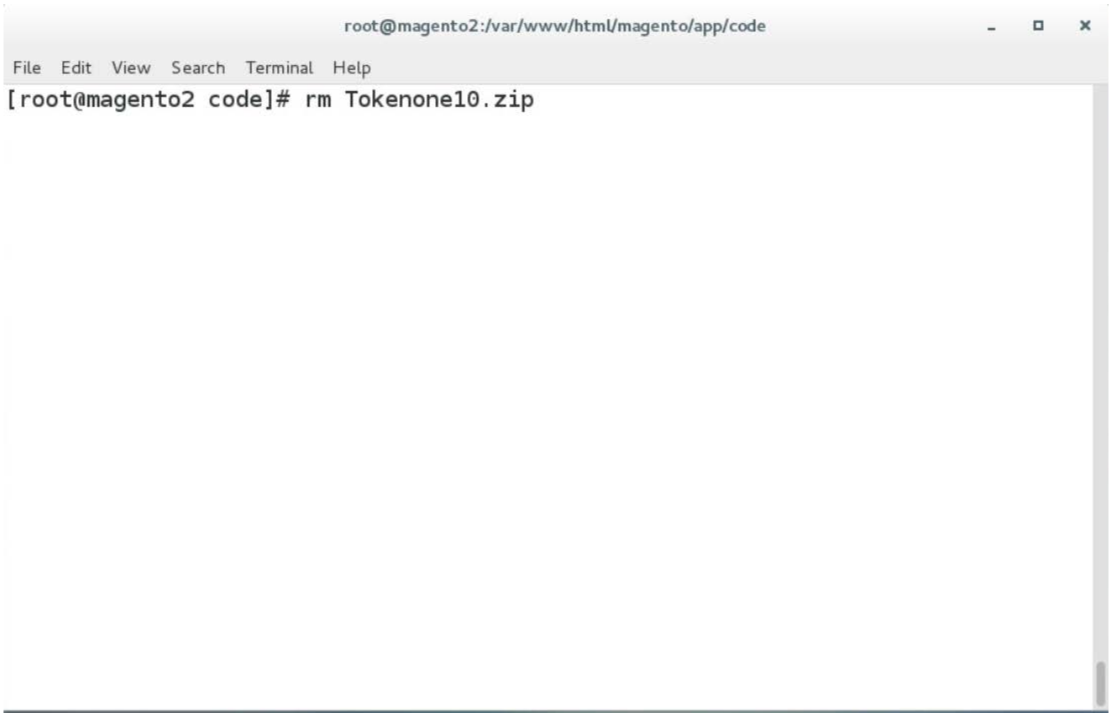
   `unzip Tokenone10.zip`


root@magento2:/var/www/html/magento/app/code
File Edit View Search Terminal Help

```
[root@magento2 code]# unzip Tokenone10.zip
```

6. Remove the zip file from the code directory by entering the following command:

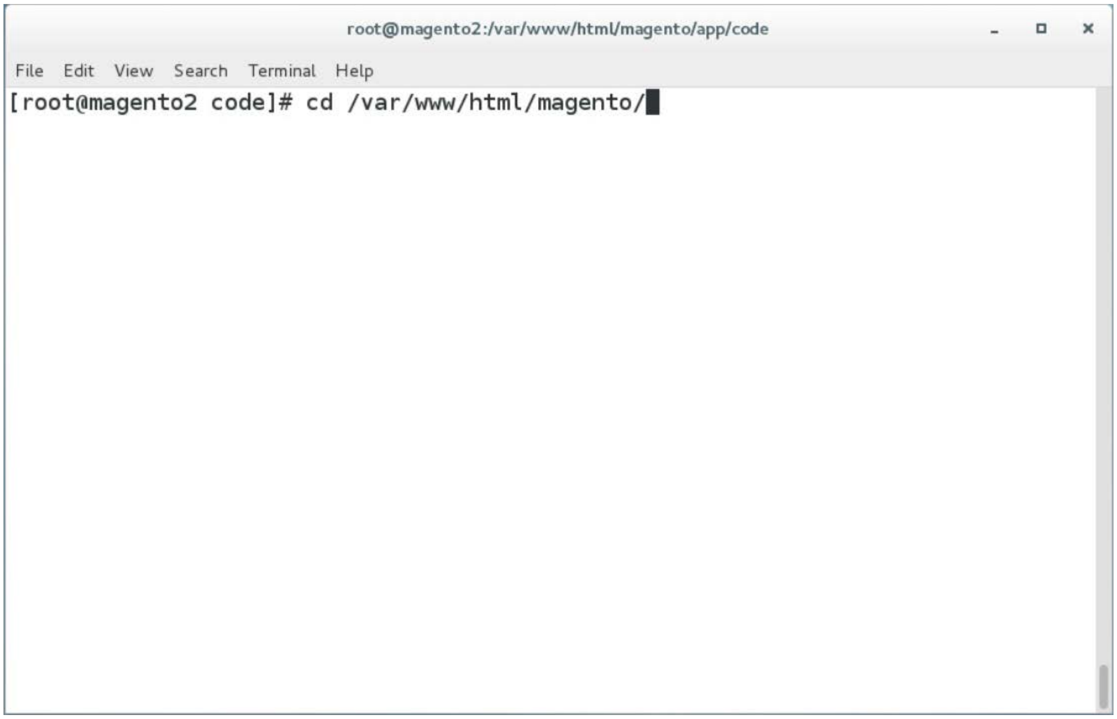
```
rm Tokenone10.zip
```


root@magento2:/var/www/html/magento/app/code
File Edit View Search Terminal Help

```
[root@magento2 code]# rm Tokenone10.zip
```

7. Change to the Magento web server directory by entering the following command:

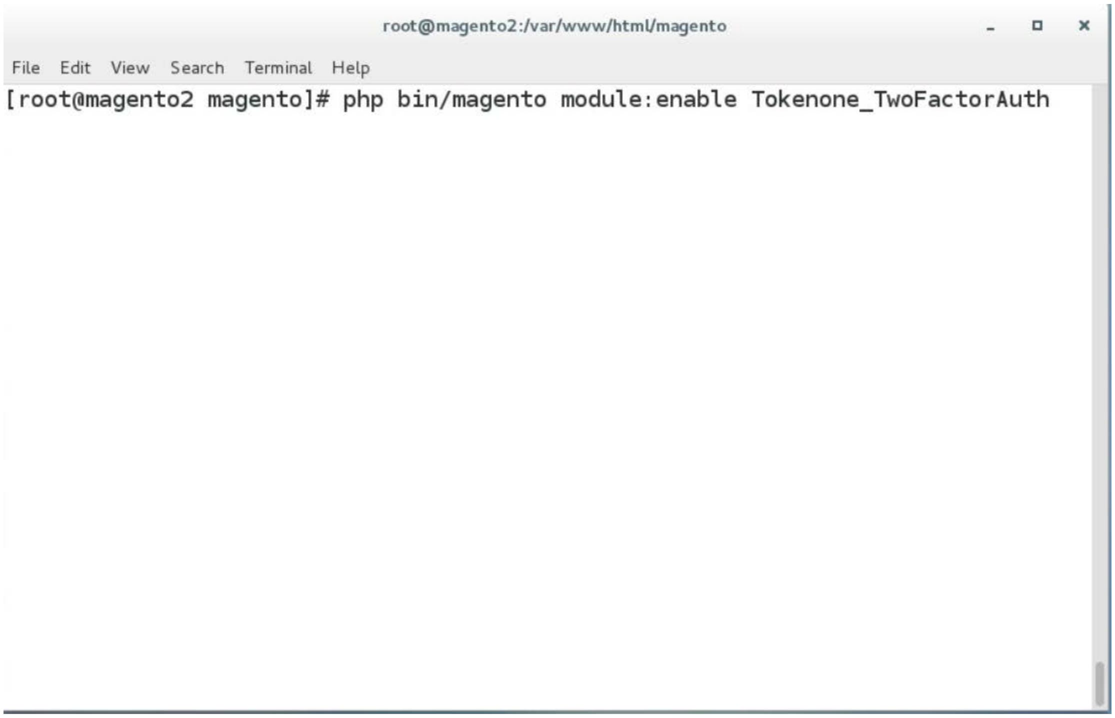
   ```
   cd /var/www/html/magento/
   ```


root@magento2:/var/www/html/magento/app/code
File Edit View Search Terminal Help

```
[root@magento2 code]# cd /var/www/html/magento/
```

8. Enable the TokenOne module by entering the following command:

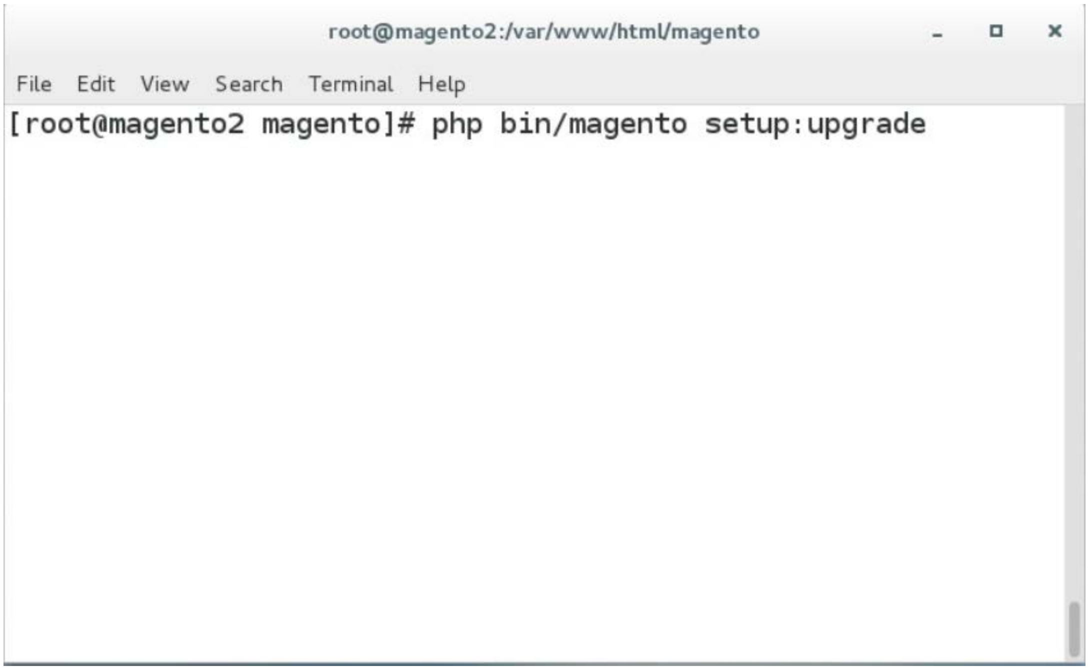
   ```
   php bin/magento module:enable Tokenone_TwoFactorAuth
   ```


root@magento2:/var/www/html/magento
File Edit View Search Terminal Help

```
[root@magento2 magento]# php bin/magento module:enable Tokenone_TwoFactorAuth
```

9. To upgrade Magento to reflect the newly enabled module, enter the following command:

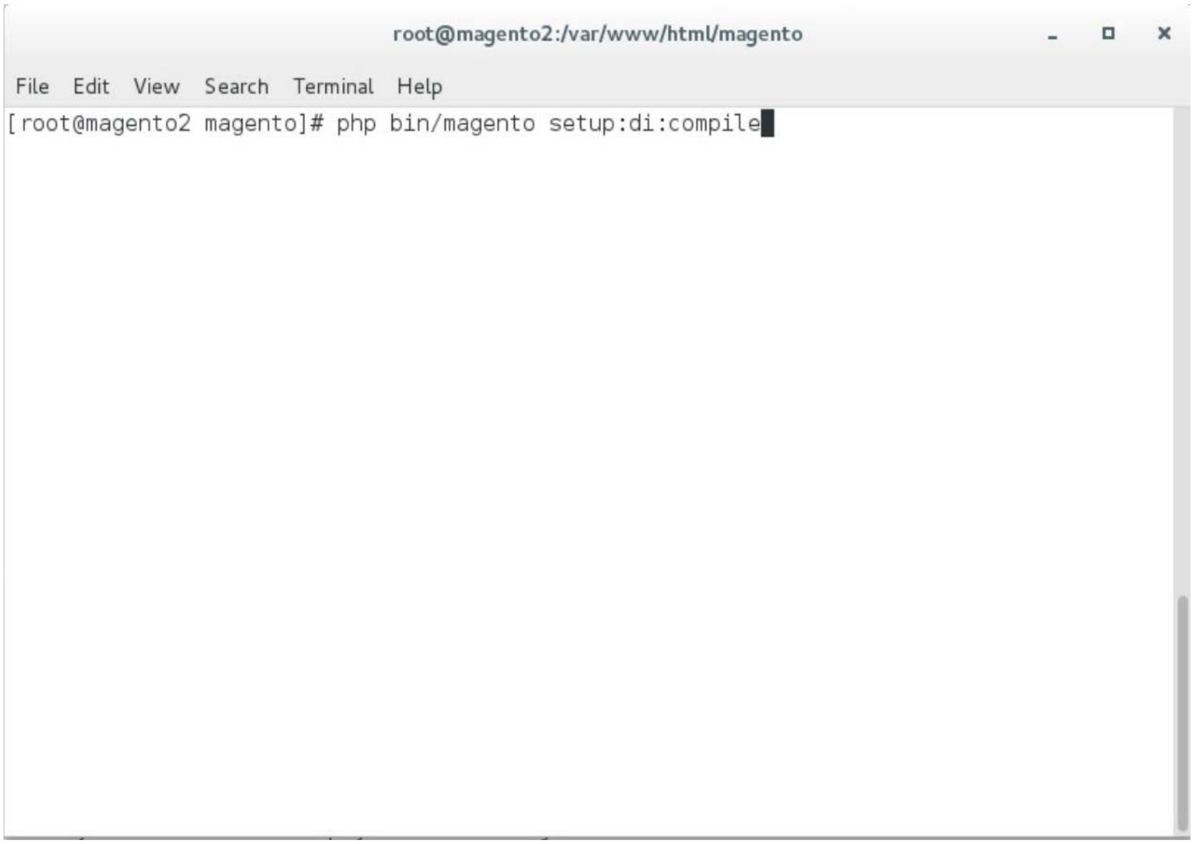
   `php bin/magento setup:upgrade`


root@magento2:/var/www/html/magento
File Edit View Search Terminal Help

```
[root@magento2 magento]# php bin/magento setup:upgrade
```

10. Recompile Magento to reflect the changes by entering the following command:

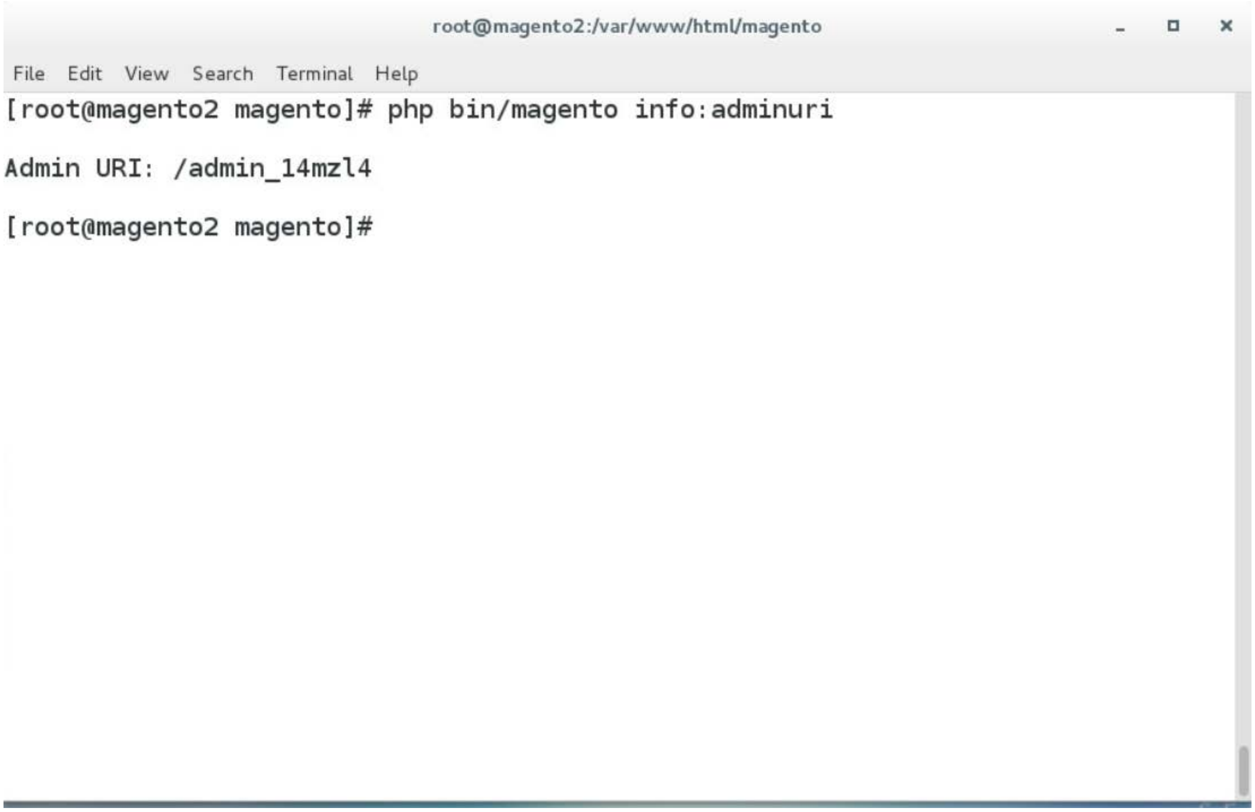
    ```
    php bin/magento setup:di:compile
    ```


root@magento2:/var/www/html/magento
File Edit View Search Terminal Help

```
[root@magento2 magento]# php bin/magento setup:di:compile
```

11. To find the Magento admin URI, enter the following command:

    ```
    php bin/magento info:adminuri
    ```


root@magento2:/var/www/html/magento
File Edit View Search Terminal Help

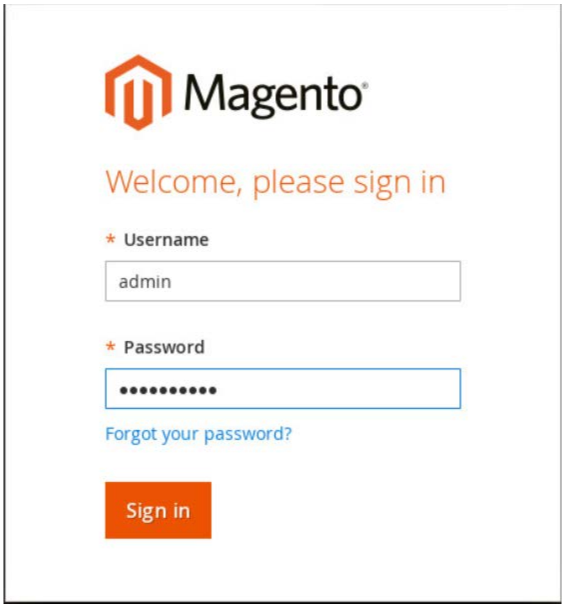
```
[root@magento2 magento]# php bin/magento info:adminuri

Admin URI: /admin_14mzl4

[root@magento2 magento]#
```

Note the URI that is output from the command. It will be used for TokenOne provisioning.

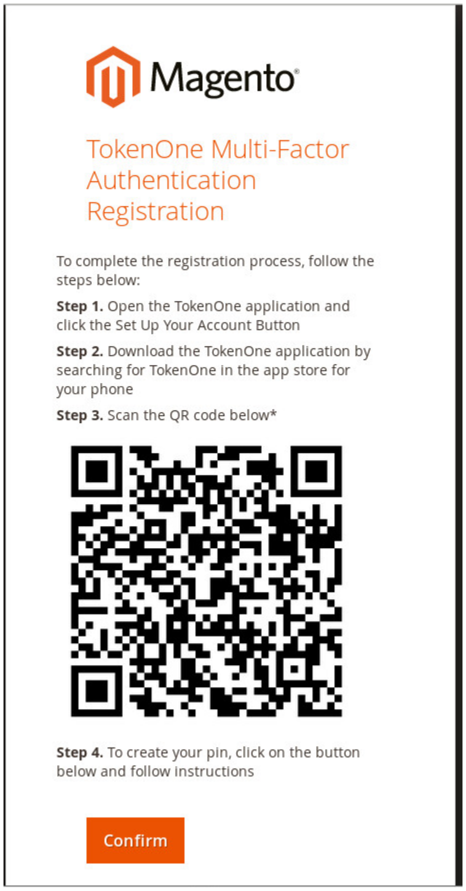
2.5.4 TokenOne Provisioning

Once TokenOne has been installed, administrators will be required to use TokenOne to log in to the administration portal. The first time that an administrator logs into the portal, they will be required to provision and link their TokenOne authenticator with the system by using the following steps:

1. Open a web browser and navigate to *https://magento2.mfa.local/magento/admin_14mzl4*.
2. Sign in to the admin portal.



3. Once the administrator has signed in to the Magento admin portal, a TokenOne splash screen will appear with steps to create an account.



TokenOne Multi-Factor Authentication Registration

To complete the registration process, follow the steps below:

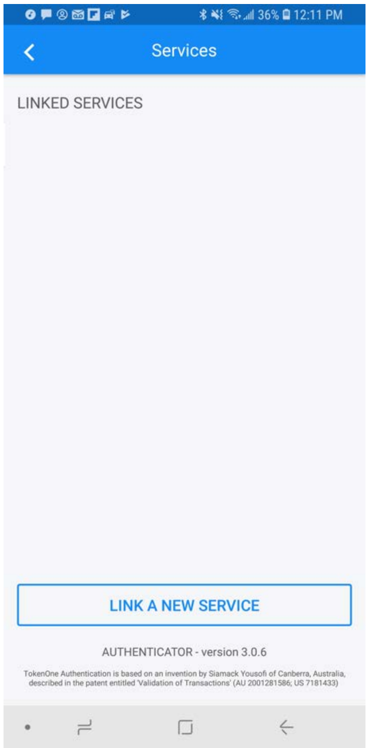
Step 1. Open the TokenOne application and click the Set Up Your Account Button

Step 2. Download the TokenOne application by searching for TokenOne in the app store for your phone

Step 3. Scan the QR code below*

Step 4. To create your pin, click on the button below and follow instructions

4. Open the TokenOne mobile application and click **LINK A NEW SERVICE.**

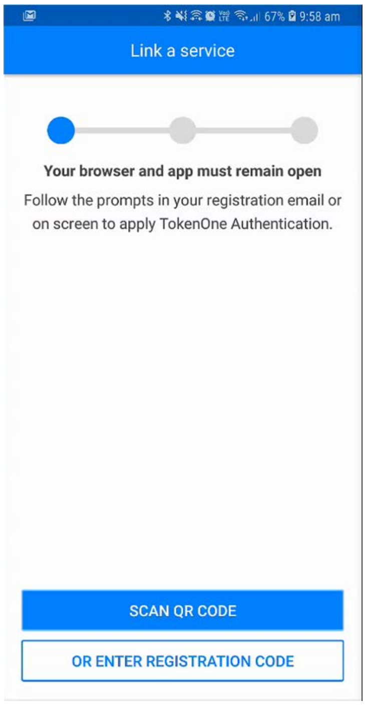


LINKED SERVICES

AUTHENTICATOR - version 3.0.6

TokenOne Authentication is based on an invention by Siamack Yousofi of Canberra, Australia, described in the patent entitled 'Validation of Transactions' (AU 2001281586; US 7181433)

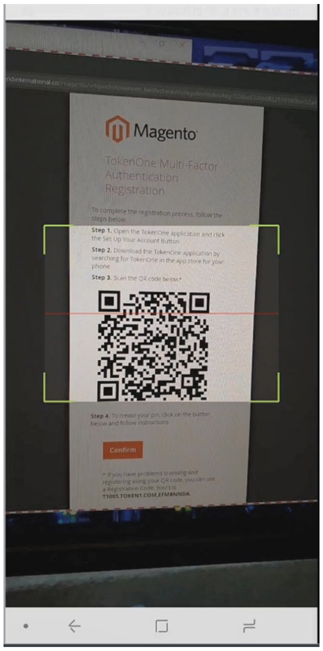
5. Click **SCAN QR CODE.**



Your browser and app must remain open

Follow the prompts in your registration email or on screen to apply TokenOne Authentication.

6. Capture the Quick Response (QR) code that is displayed on the Magento site.



Magento

TokenOne Multi-Factor Authentication Registration

To complete the registration process, follow the steps below:

Step 1. Open the TokenOne application and click the Set Up Your Account Button

Step 2. Download the TokenOne application by searching for TokenOne in the app store for your phone

Step 3. Scan the QR code below*

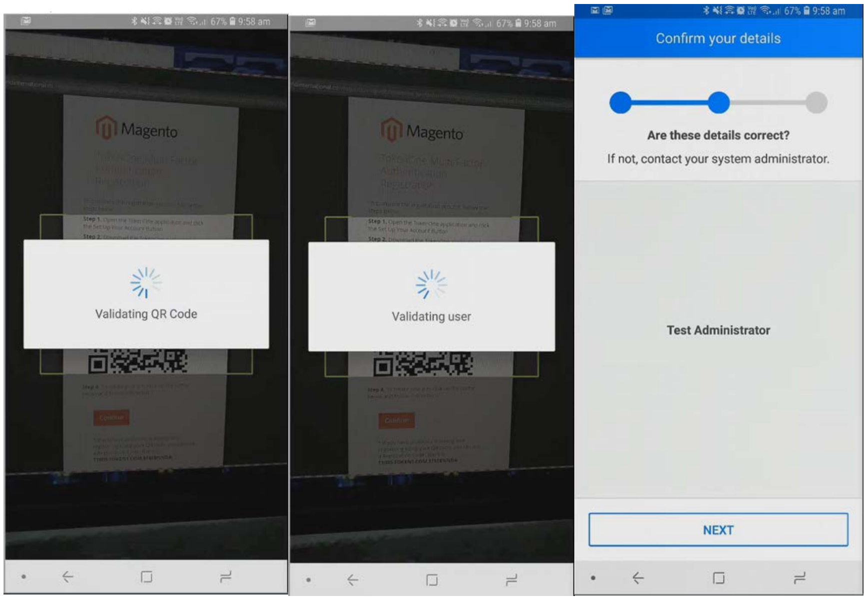
Step 4. To create your pin, click on the button below and follow instructions

Confirm

* If you have problems scanning and registering using your QR code, you can use a Registration Code. Yours is T1005.TOKEN1.COM,EFMBNNDA

7. Upon scanning the QR code, the phone will then be profiled and registered.

8. Follow the prompts on the smartphone to complete the registration.



Validating QR Code

Validating user

Confirm your details

Are these details correct?

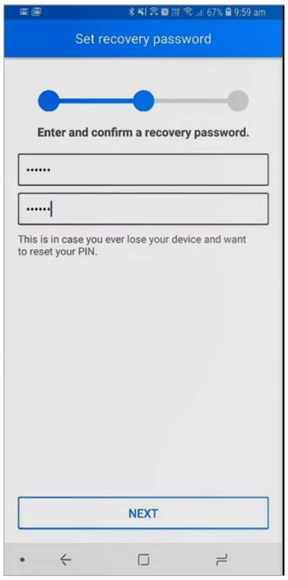
If not, contact your system administrator.

Test Administrator

NEXT

9. Click **NEXT.**

10. Create a recovery password for the account.



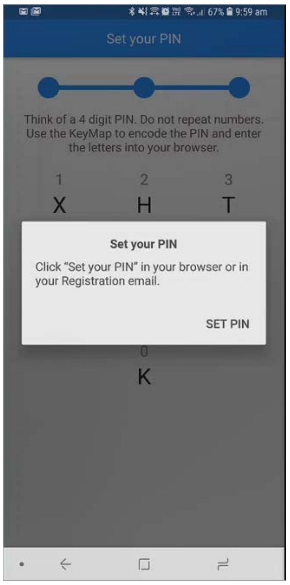
Enter and confirm a recovery password.

••••••

••••••

This is in case you ever lose your device and want to reset your PIN.

11. Click **NEXT.** Once the phone has been profiled and the account provisioned, you will be prompted to set your user PIN.

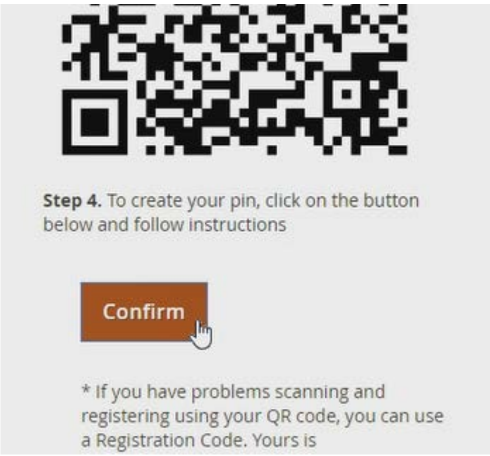


Think of a 4 digit PIN. Do not repeat numbers. Use the KeyMap to encode the PIN and enter the letters into your browser.

Set your PIN

Click "Set your PIN" in your browser or in your Registration email.

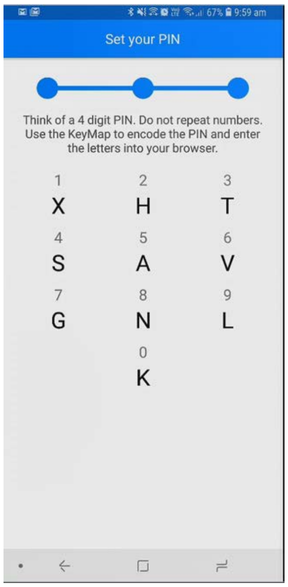
12. Click **SET PIN** on the phone, and click **Confirm** on your computer.



Step 4. To create your pin, click on the button below and follow instructions

* If you have problems scanning and registering using your QR code, you can use a Registration Code. Yours is

13. Use the KeyMap on the phone screen to encode your user PIN into a letter code. A KeyMap is simply a sheet of 10 letters, each with a corresponding number (0 to 9). Match the numbers of your PIN to the corresponding letters. This is your onetime letter code. For example, if your PIN is 2610, then your onetime letter code is HVXK.

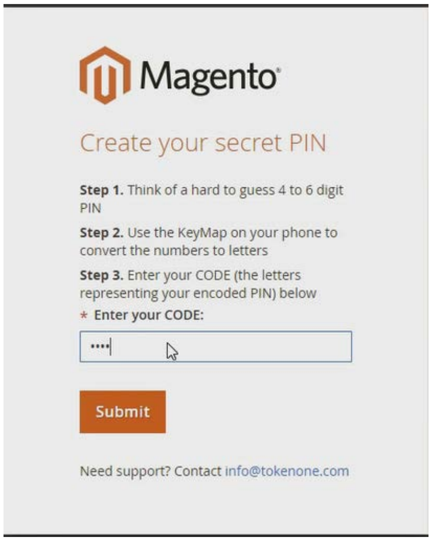


Set your PIN

Think of a 4 digit PIN. Do not repeat numbers. Use the KeyMap to encode the PIN and enter the letters into your browser.

1 X	2 H	3 T
4 S	5 A	6 V
7 G	8 N	9 L
	0 K	

14. Enter the letters corresponding to your PIN into the Magento admin panel, and click **Submit.** Repeat the process to confirm your PIN.



Magento

Create your secret PIN

Step 1. Think of a hard to guess 4 to 6 digit PIN

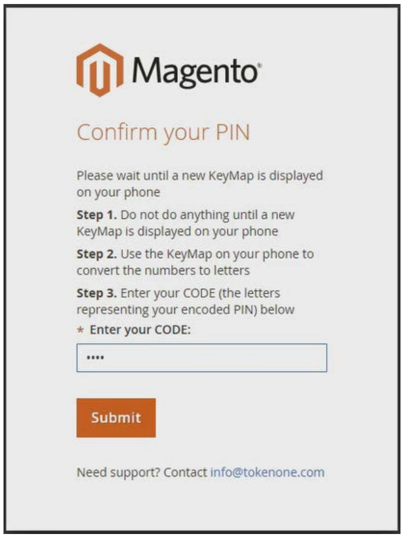
Step 2. Use the KeyMap on your phone to convert the numbers to letters

Step 3. Enter your CODE (the letters representing your encoded PIN) below

* **Enter your CODE:**

••••

Need support? Contact info@tokenone.com



Magento

Confirm your PIN

Please wait until a new KeyMap is displayed on your phone

Step 1. Do not do anything until a new KeyMap is displayed on your phone

Step 2. Use the KeyMap on your phone to convert the numbers to letters

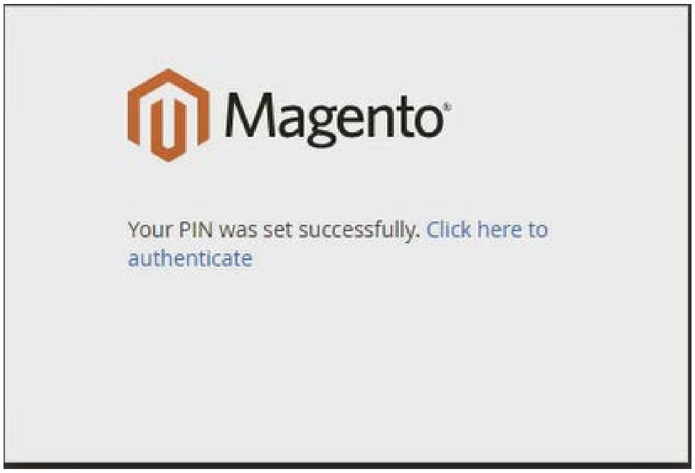
Step 3. Enter your CODE (the letters representing your encoded PIN) below

* **Enter your CODE:**

••••

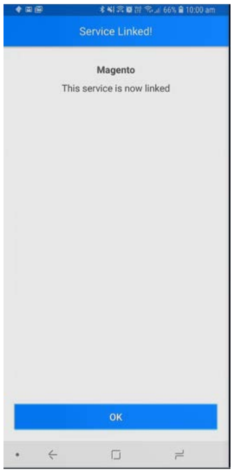
Need support? Contact info@tokenone.com

15. Do not turn off your phone during this process. Wait until the smartphone application indicates that the account has been registered.



Magento

Your PIN was set successfully. Click here to authenticate



Service Linked!

Magento

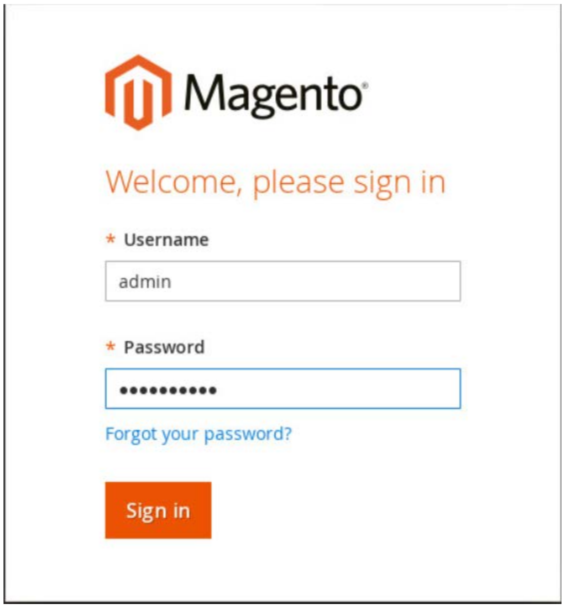
This service is now linked

2.5.5 Administrator Login with TokenOne Authentication

To log in to the Magento administration portal by using TokenOne authentication, perform the following steps:

1. Open a web browser and navigate to *https://magento2.mfa.local/magento/admin_14mzl4*.

2. Sign in to the admin portal.



Magento

Welcome, please sign in

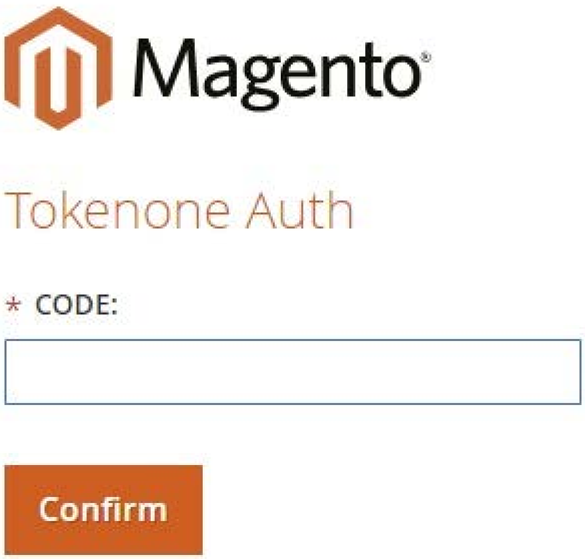
* Username

admin

* Password

•••••••••••

3. Magento will prompt for the TokenOne **CODE.**

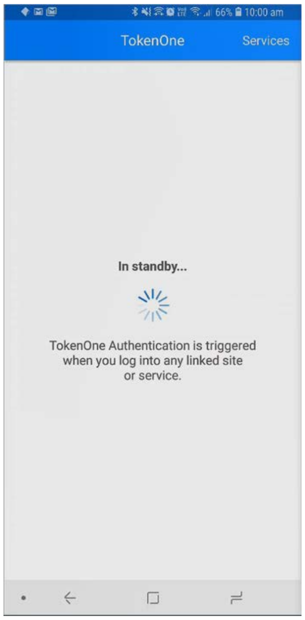


Magento

Tokenone Auth

* CODE:

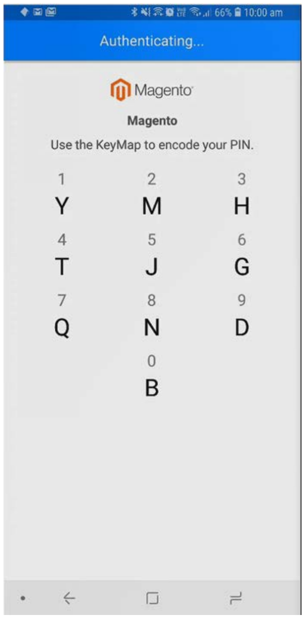
4. Open the TokenOne mobile application on your smartphone.
5. An **In standby…** screen will appear while the service verifies that you are using the correct registered device.



In standby...

TokenOne Authentication is triggered when you log into any linked site or service.

6. Once your device is verified, a unique KeyMap will appear.



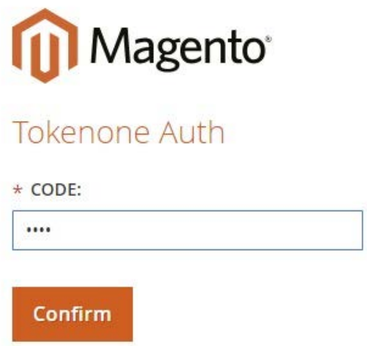
Magento

Use the KeyMap to encode your PIN.

1 Y	2 M	3 H
4 T	5 J	6 G
7 Q	8 N	9 D
	0 B	

7. Match the numbers of your PIN to the corresponding letters. This is your onetime letter code. For example, if your PIN is **2610,** then your onetime letter code is **MGYB.**

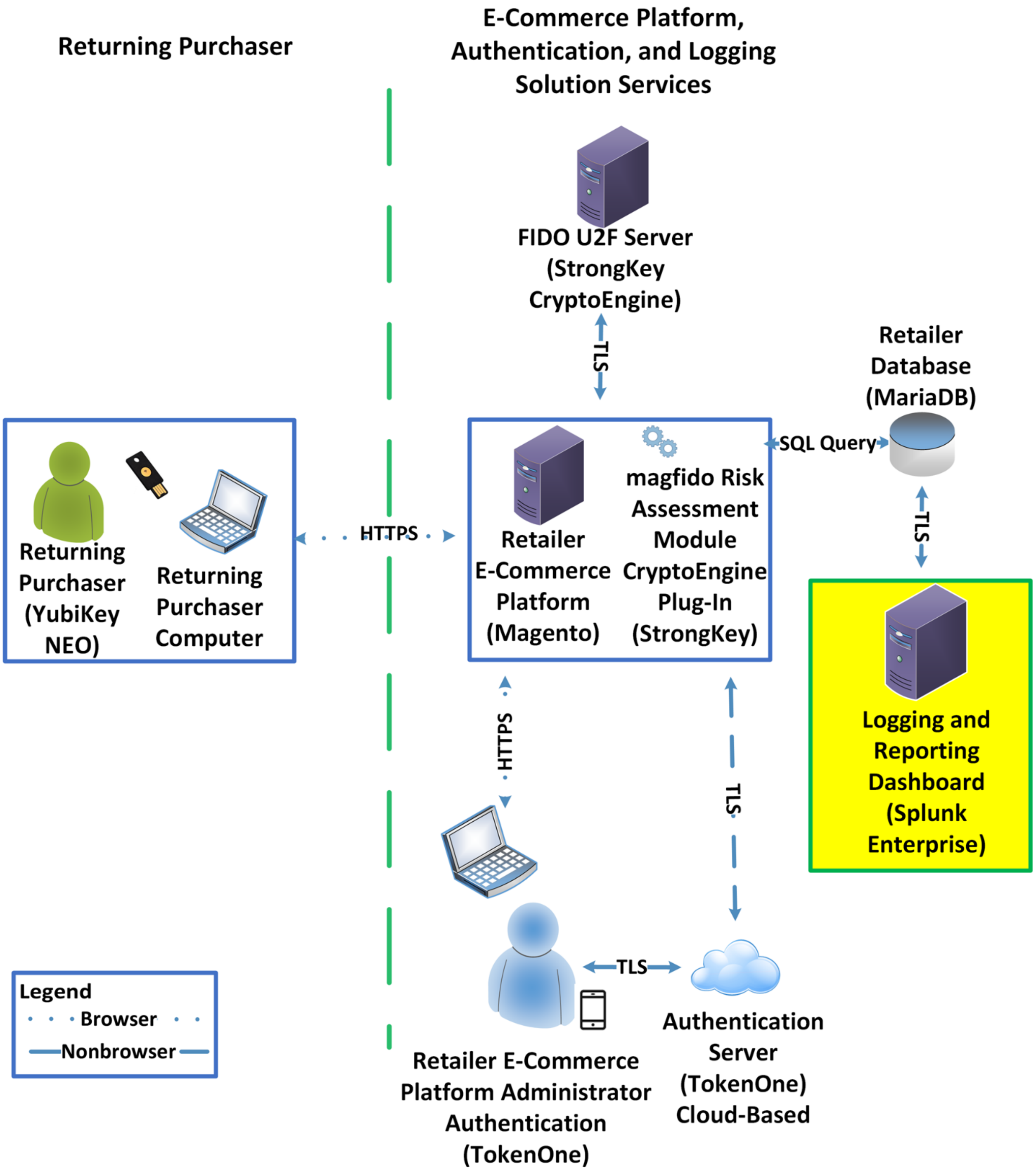
8. Enter the letter code into the administration panel, and click **Confirm.**



2.6 Splunk Enterprise

This section provides installation and configuration guidance for Splunk's Enterprise product. Splunk Enterprise is used in both the *cost threshold* and *risk engine* example implementation builds to process and display authentication logging information. In addition to installing and configuring Splunk Enterprise and its supporting components, this section also provides step-by-step guidance on developing dashboard displays of the logged information. The locations of the Splunk components that are installed by using the instructions in this section are illustrated in Figure 2-6 and are highlighted in yellow within the green box.

Figure 2-6 Splunk Enterprise Components


Returning Purchaser
E-Commerce Platform, Authentication, and Logging Solution Services
FIDO U2F Server (StrongKey CryptoEngine)
TLS
Retailer Database (MariaDB)
SQL Query
TLS
Returning Purchaser (YubiKey NEO)
Returning Purchaser Computer
HTTPS
Retailer E-Commerce Platform (Magento)
magfido Risk Assessment Module
CryptoEngine Plug-In (StrongKey)
Logging and Reporting Dashboard (Splunk Enterprise)
HTTPS
TLS
TLS
Authentication Server (TokenOne) Cloud-Based
Retailer E-Commerce Platform Administrator Authentication (TokenOne)
Legend
Browser
Nonbrowser

2.6.1 Splunk Technologies Overview

Splunk [10] technologies enable computer log and data collection, parsing, and display. Splunk Enterprise [11], along with two enabling capabilities, was used in both example implementations:

- Splunk Enterprise [11], where data was collected, parsed, and displayed by using dashboards
- Splunk Universal Forwarder [12], which was installed on systems from which we collected data, forwarding the information to Splunk Enterprise
- Splunk DB Connect [13], which was used to import structured data for analysis, indexing, and visualization into Splunk Enterprise in the example implementation

2.6.2 Splunk Enterprise

2.6.2.1 Overview

Splunk Enterprise [11] enables the monitoring and analyzing of data from multiple sources. Splunk Enterprise can receive data from many sources and then respond to data queries and provide dashboard displays of the data that has been provided to it.

For both example implementations, we used Splunk Enterprise to ingest a variety of log types from the retail e-commerce platform server. Once the data was collected by Splunk Enterprise, it could then be parsed and displayed by using prebuilt rules or custom criteria. For both example implementations, we displayed information as described in Section 2.6.5.

2.6.2.2 Splunk Enterprise: Requirements

System requirements required to support the use of Splunk Enterprise can be found here: http://docs.splunk.com/Documentation/Splunk/6.6.1/Installation/Systemrequirements.

2.6.2.3 Splunk Enterprise: Prepare for Installation

To prepare your environment for an on-premises installation, follow this guidance:

Windows:
http://docs.splunk.com/Documentation/Splunk/6.6.1/Installation/PrepareyourWindowsnetworkforaSplunkinstallation

2.6.2.4 Splunk Enterprise: Installation

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

Download Splunk Enterprise from https://www.splunk.com/en_us/download/splunk-enterprise.html. Splunk Enterprise was installed on a Windows instance. The installation instructions can be found here: http://docs.splunk.com/Documentation/Splunk/6.6.1/Installation/InstallonWindows.

2.6.3 Splunk Universal Forwarder

2.6.3.1 Splunk Universal Forwarder: Overview

The Splunk Universal Forwarder collects data to be used by Splunk Enterprise. Splunk Universal Forwarder allows Splunk Enterprise to collect data from remote sources and send it for indexing. To use this capability, Splunk Universal Forwarder must be installed on each system from which you want to collect data.

We used Splunk Universal Forwarder to collect data from Magento and forward it to Splunk Enterprise. Once the data was delivered to Splunk Enterprise, the data provided by the Splunk Universal Forwarder was used to analyze purchaser authentication trends and to populate the dashboard displays.

2.6.3.2 Splunk Universal Forwarder: Requirements

System requirements required to support the use of Splunk Universal Forwarder can be found here: http://docs.splunk.com/Documentation/Forwarder/6.6.1/Forwarder/Systemrequirements.

2.6.3.3 Splunk Universal Forwarder: Prepare for Installation

Before you can forward data to Splunk Enterprise, you must enable forwarding and receiving on Splunk Enterprise. Instructions can be found here: http://docs.splunk.com/Documentation/Forwarder/6.6.1/Forwarder/EnableaReceiver.

2.6.3.4 Splunk Universal Forwarder: Installation

The Splunk Universal Forwarder can be installed on different operating system platforms. The following subsections provide instructions for installing the Splunk Universal Forwarder on both Linux and Windows.

2.6.3.4.1 Installing Splunk Universal Forwarder on Linux

Detailed Splunk Universal Forwarder installation instructions can be found here: http://docs.splunk.com/Documentation/Forwarder/6.6.1/Forwarder/Installanixuniversalforwarder#Install_the_universal_forwarder_on_Linux.

The following steps are an abridged version of the preceding installation link:

1. You will need a splunk.com account to download the Splunk Universal Forwarder on Linux. Account setup is free and can be done here: https://www.splunk.com/page/sign_up.

2. Once you have an account, the Splunk Universal Forwarder for Linux is free and can be downloaded from here: http://www.splunk.com/en_us/download/universal-forwarder.html.

3. Having the latest operating system version is recommended for installations. For both example implementations, we used the latest CentOS version 2.6+ kernel Linux distributions (64-bit). For the example implementation, we installed on CentOS by selecting the file that ends in .tgz and placed it on the target Linux machine. This is an example:

   ```
   splunkforwader-7.0.1-2b5b15c4ee89-linux-x86_64.tgz
   ```

4. Untar the file downloaded to the opt/ directory:

   ```
   tar zxvf  <splunk_package_name.tgz> -C /opt
   ```

5. Change to the /opt/splunkforwarder/bin directory:

   ```
   cd /opt/splunkforwarder/bin
   ```

6. Start the universal forwarder:

   ```
   ./splunk start
   ```

7. Enable boot start of the universal forwarder:

   ```
   ./splunk enable boot-start
   ```

2.6.3.4.2 Configure Splunk Forwarder on Linux

More information about adding a forwarder can be found at http://docs.splunk.com/Documentation/Forwarder/6.6.1/Forwarder/Configuretheuniversalforwarder.

1. Change to the /opt/splunkforwarder/bin directory:

   ```
   cd /opt/splunkforwarder/bin
   ```

2. Run script to configure the forwarder to connect to the Splunk Enterprise server:

   ```
   ./splunk add forward-server loghost:7777 -auth admin:change
   ```

2.6.3.4.3 Installing Splunk Universal Forwarder on Windows

1. You will need a splunk.com account to download the Splunk Universal Forwarder on Windows. An account is free and can be set up here: https://www.splunk.com/page/sign_up.

2. Once you have an account, the Splunk Universal Forwarder for Windows is free and can be downloaded from here: http://www.splunk.com/en_us/download/universal-forwarder.html.

3. You want the latest version for operating system version Windows (64-bit). Because this download will be installed on Windows, select the file that ends in .msi and follow the instructions for installation and configuration. This is an example of the file name that will be downloaded:

   ```
   spunkforwarder-7.0.0-00f5bb3fa822-x64-release.msi
   ```

2.6.4 Splunk DB Connect

Splunk DB Connect facilitates database information imports, exports, lookups, and multiple data source combinations [13], [14].

2.6.4.1 Overview

Splunk DB Connect provides a solution for integrating database information with Splunk Enterprise queries and reports. It allows for structured data-collection from databases, which can be leveraged in analysis.

Splunk DB Connect was used to import structured data from Magento's MySQL database instance. This enabled us to leverage information in the database within the Splunk Enterprise deployment.

2.6.4.2 Splunk DB Connect Requirements

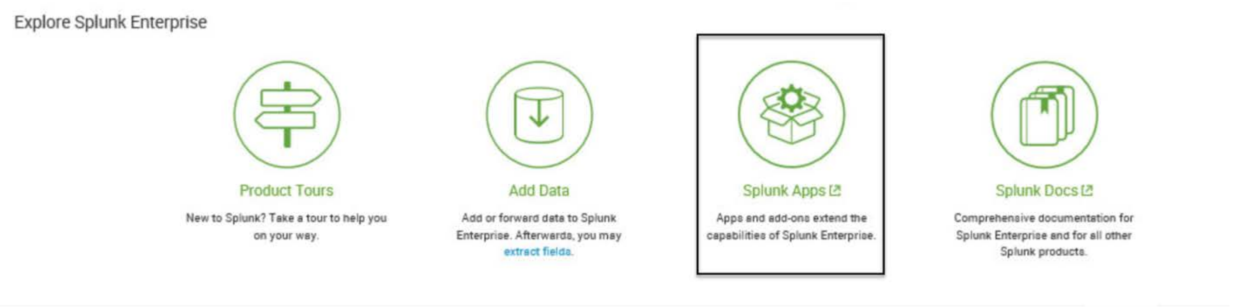
Splunk DB Connect requires that the Java Runtime Environment (JRE) is installed on the Splunk Enterprise search head. The JRE can be installed from here: http://www.oracle.com/technetwork/java/javase/downloads/jre8-downloads-2133155.html.

You must install a driver for the database that you are planning to connect to the Splunk DB Connect application. Splunk DB Connect supports a list of drivers that can define other databases. MariaDB is not included in the list of predefined databases. As MariaDB is a branch of MySQL, we downloaded the MySQL Java Connector from the following location (Section 2.6.4.4, Step 6 provides installation directions for the Java Connector.): https://dev.mysql.com/downloads/connector/j/.

2.6.4.3 Splunk DB Connect Installation

This section describes the steps required to install the Splunk DB Connect application onto your single-instance deployment of Splunk. Additional guidance can be found here: https://docs.splunk.com/Documentation/DBX/3.1.2/DeployDBX/AboutSplunkDBConnect.

1. Navigate to the Splunk Enterprise home page, and click the **Splunk Apps** icon.



Explore Splunk Enterprise

Product Tours

New to Splunk? Take a tour to help you on your way.

Add Data

Add or forward data to Splunk Enterprise. Afterwards, you may extract fields.

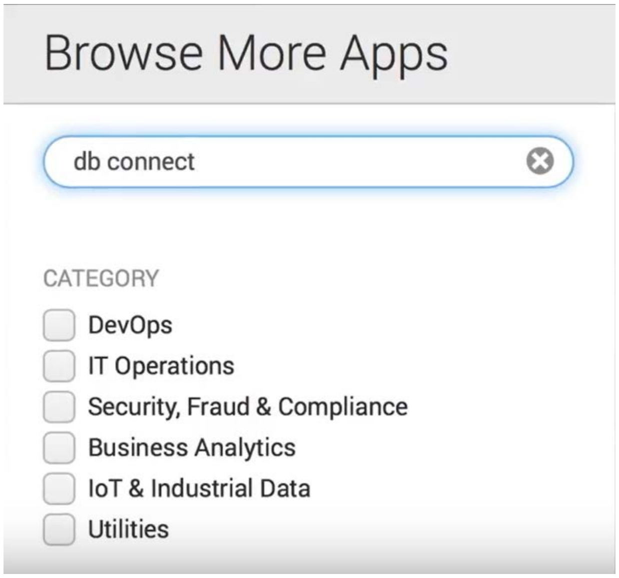
Splunk Apps

Apps and add-ons extend the capabilities of Splunk Enterprise.

Splunk Docs

Comprehensive documentation for Splunk Enterprise and for all other Splunk products.

2. Type “db connect” into the search bar to locate the Splunk DB Connect application.



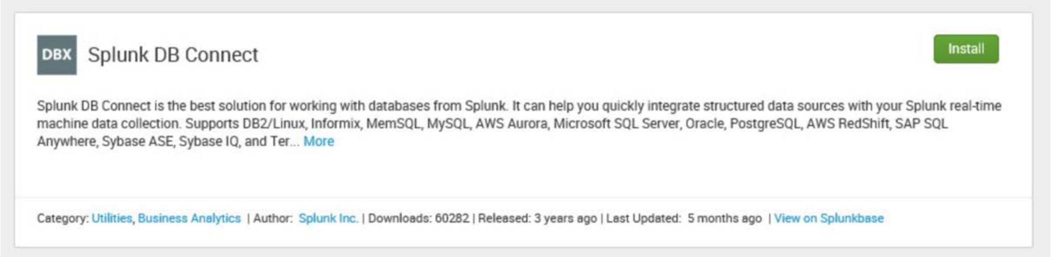
Browse More Apps

db connect

CATEGORY

□ DevOps
□ IT Operations
□ Security, Fraud & Compliance
□ Business Analytics
□ IoT & Industrial Data
□ Utilities

3. Once the **Splunk DB Connect** application is located, click **Install.**

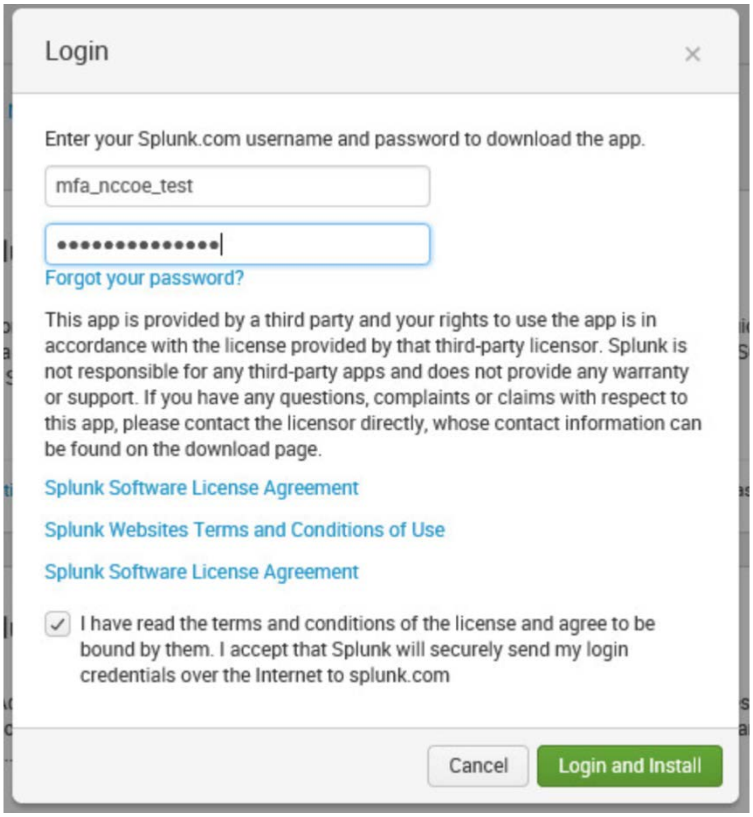


Splunk DB Connect

Splunk DB Connect is the best solution for working with databases from Splunk. It can help you quickly integrate structured data sources with your Splunk real-time machine data collection. Supports DB2/Linux, Informix, MemSQL, MySQL, AWS Aurora, Microsoft SQL Server, Oracle, PostgreSQL, AWS RedShift, SAP SQL Anywhere, Sybase ASE, Sybase IQ, and Ter... More

Category: Utilities, Business Analytics | Author: Splunk Inc. | Downloads: 60282 | Released: 3 years ago | Last Updated: 5 months ago | View on Splunkbase

4. Log in and accept the terms and conditions by using your splunk.com user account and credentials (not the Splunk Enterprise instance credentials) and then by clicking **Login and Install.**



Login

Enter your Splunk.com username and password to download the app.

mfa_nccoe_test

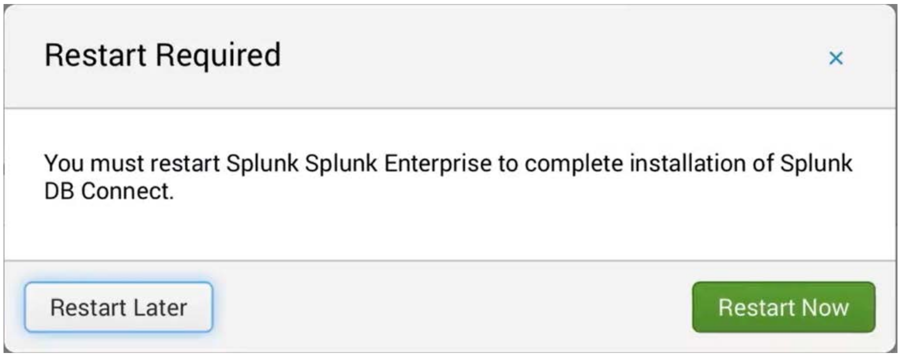
•••••••••••••••

This app is provided by a third party and your rights to use the app is in accordance with the license provided by that third-party licensor. Splunk is not responsible for any third-party apps and does not provide any warranty or support. If you have any questions, complaints or claims with respect to this app, please contact the licensor directly, whose contact information can be found on the download page.

Splunk Software License Agreement
Splunk Websites Terms and Conditions of Use
Splunk Software License Agreement

☑ I have read the terms and conditions of the license and agree to be bound by them. I accept that Splunk will securely send my login credentials over the Internet to splunk.com

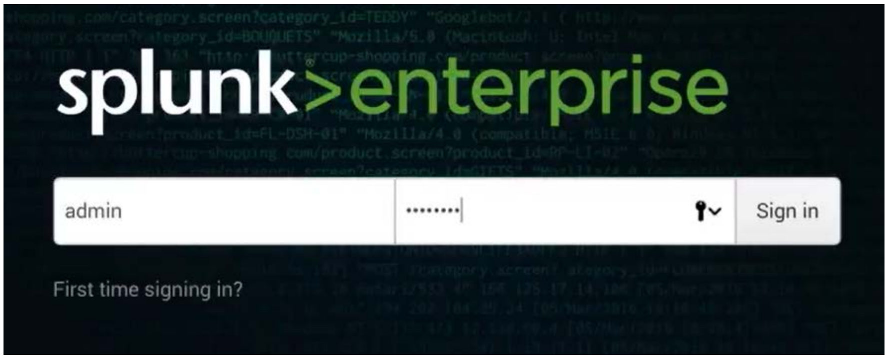
5. Click **Restart Now.**



Restart Required

You must restart Splunk Splunk Enterprise to complete installation of Splunk DB Connect.

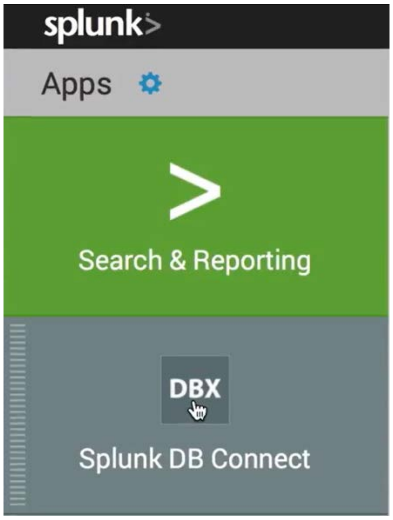
6. Log in after reboot with the Splunk Enterprise instance credentials that were created during installation of Splunk Enterprise.



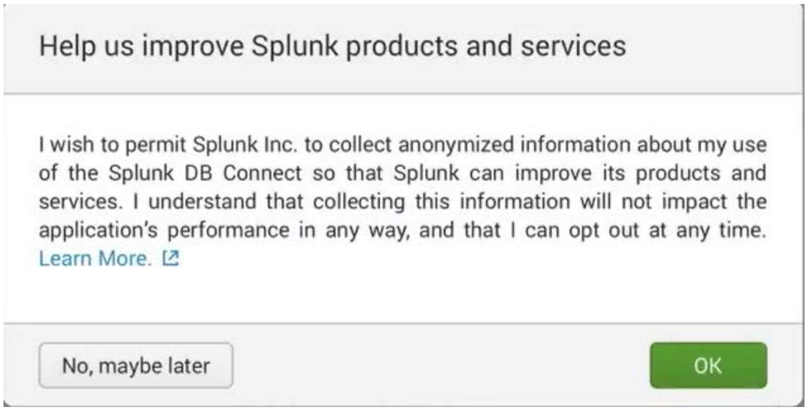
2.6.4.4 Setup

This section describes the initial setup process that will follow installation of Splunk DB Connect.

1. On the home page, navigate to **Splunk DB Connect** in the **Apps** sidebar.



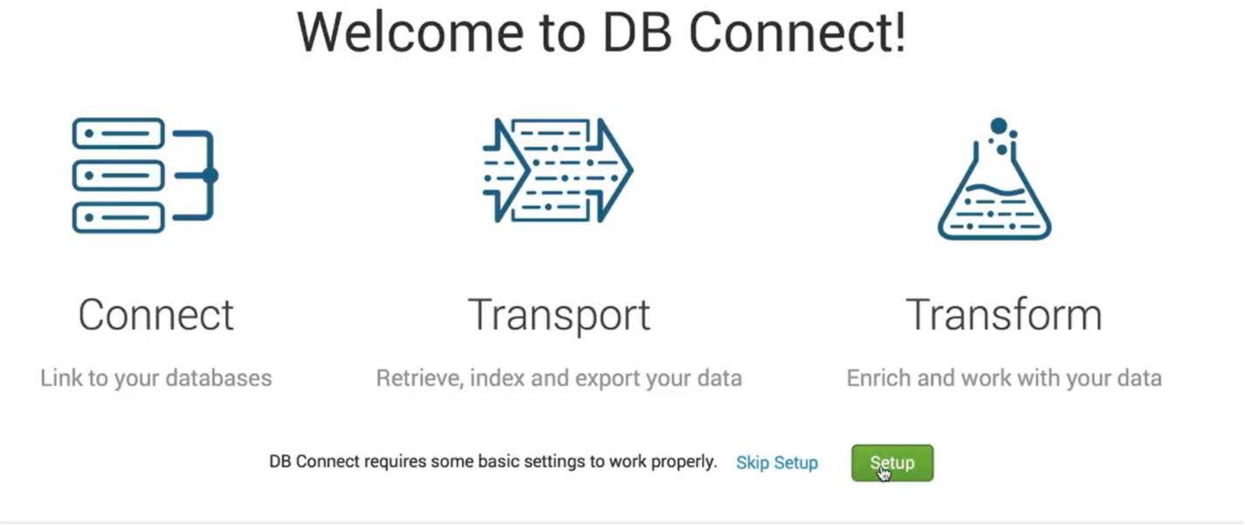
2. Select whether to send Splunk information about your use of Splunk DB Connect.



Help us improve Splunk products and services

I wish to permit Splunk Inc. to collect anonymized information about my use of the Splunk DB Connect so that Splunk can improve its products and services. I understand that collecting this information will not impact the application's performance in any way, and that I can opt out at any time. Learn More.

3. Click **Setup** to begin the configuration process.

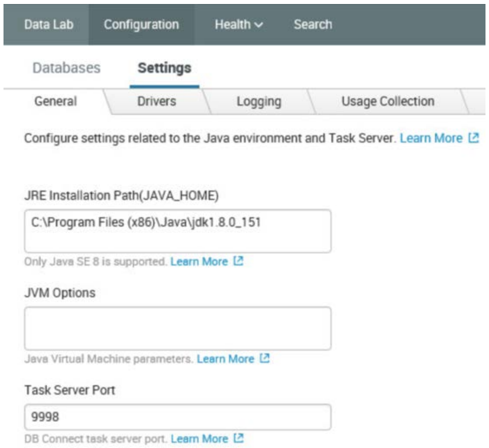


Welcome to DB Connect!

Connect
Link to your databases
Transport
Retrieve, index and export your data
Transform
Enrich and work with your data

DB Connect requires some basic settings to work properly.

4. Specify the **JRE Installation Path (JAVA_HOME).**



Configure settings related to the Java environment and Task Server. Learn More

JRE Installation Path(JAVA_HOME)

C:\Program Files (x86)\Java\jdk1.8.0_151

Only Java SE 8 is supported. Learn More

JVM Options

Java Virtual Machine parameters. Learn More

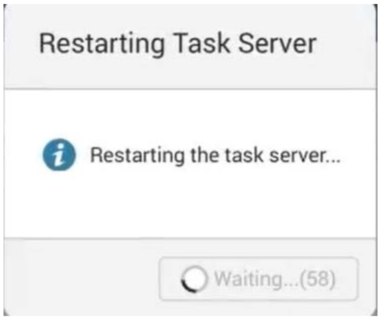
Task Server Port

9998

DB Connect task server port. Learn More

a. Click **Save** to confirm general configurations.

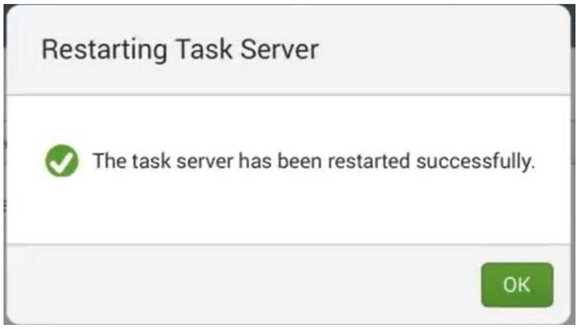
b. Task server restart will occur.



Restarting Task Server

Restarting the task server...

c. Once the restart completes, click **OK.**

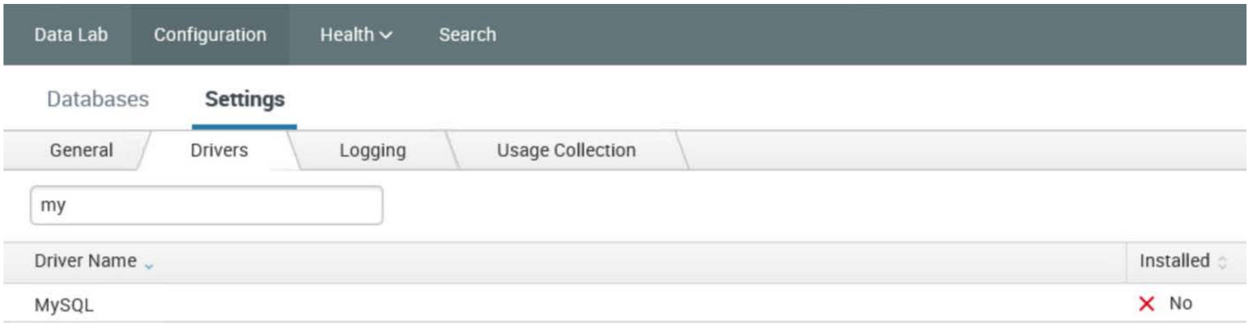


Restarting Task Server

The task server has been restarted successfully.

5. Proceed to set up drivers for the database in the **Drivers** tab: **Configuration > Settings > Drivers.**

6. Search for the database that you are using.



Driver Name	Installed
MySQL	✗ No

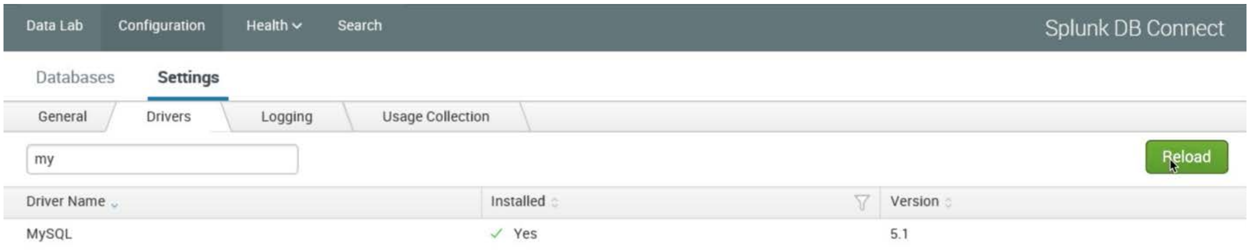
a. If your driver is not installed, Splunk DB Connect will show **No** for **Installed.** If that is the case, perform Step i below to move the connector into a new directory to enable configuring Splunk DB Connect.

   i. Move the MySQL Java Connector downloaded in Section 2.6.4.2 to the following directory:

   ```
   C:\Program Files\Splunk\etc\apps\splunk_app_db_connect\drivers
   ```

b. To specify a database that is not predefined, follow the Splunk documentation located here: https://docs.splunk.com/Documentation/DBX/3.1.2/DeployDBX/AboutSplunkDBConnect.

7. Click **Reload.** The status of the driver should reflect that it was installed.



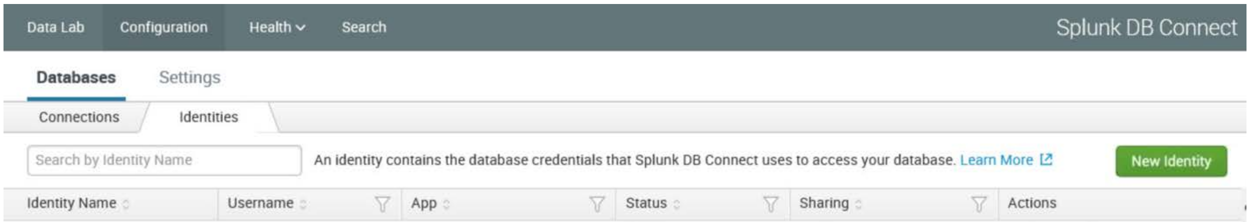
Driver Name	Installed	Version
MySQL	✓ Yes	5.1

2.6.4.5 Creating Identities

Before connecting Splunk DB Connect to your database, an identity is needed to establish the connection. This section details creating an identity that leverages database credentials, which will be used by Splunk DB Connect to access your database.

1. Navigate to the **Identities** tab: **Configuration > Databases > Identities.**

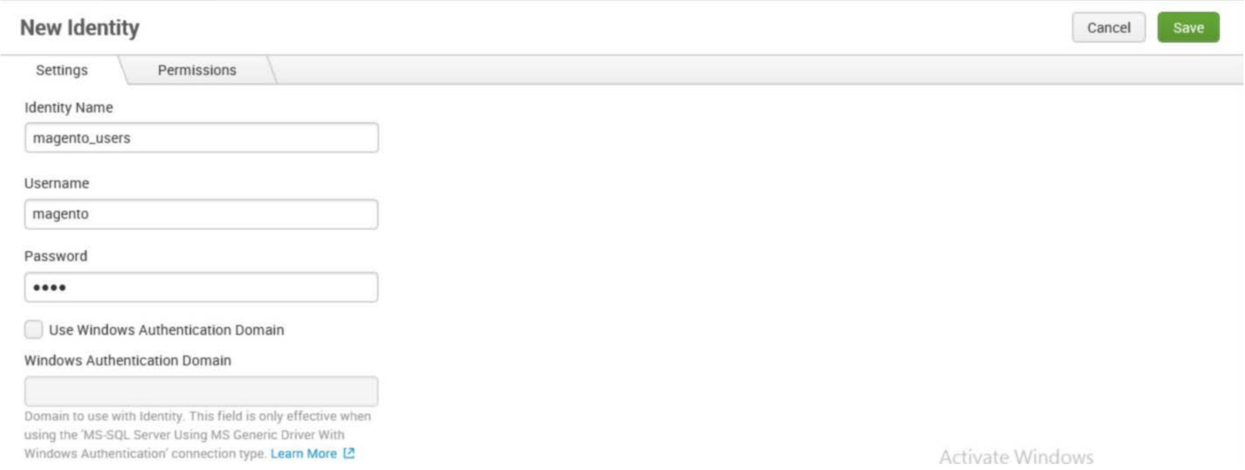
2. Click **New Identity.**



An identity contains the database credentials that Splunk DB Connect uses to access your database. Learn More

Identity Name	Username	App	Status	Sharing	Actions

3. Configure the **Settings** for your **New Identity.**



Identity Name: magento_users

Username: magento

Password: ••••

□ Use Windows Authentication Domain

Windows Authentication Domain:

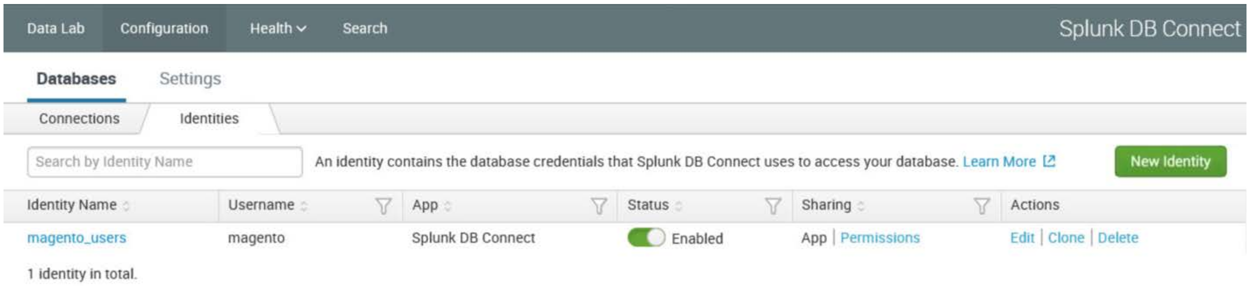
Domain to use with Identity. This field is only effective when using the 'MS-SQL Server Using MS Generic Driver With Windows Authentication' connection type. Learn More

   a. Specify a unique **Identity Name.**

   b. Enter the **Username** and **Password** that are used to access your database.

   c. Click **Save.**

4. You will now see the new identity that you created, listed in the table of identities.



An identity contains the database credentials that Splunk DB Connect uses to access your database. Learn More

Identity Name	Username	App	Status	Sharing	Actions
magento_users	magento	Splunk DB Connect	Enabled	App | Permissions	Edit | Clone | Delete

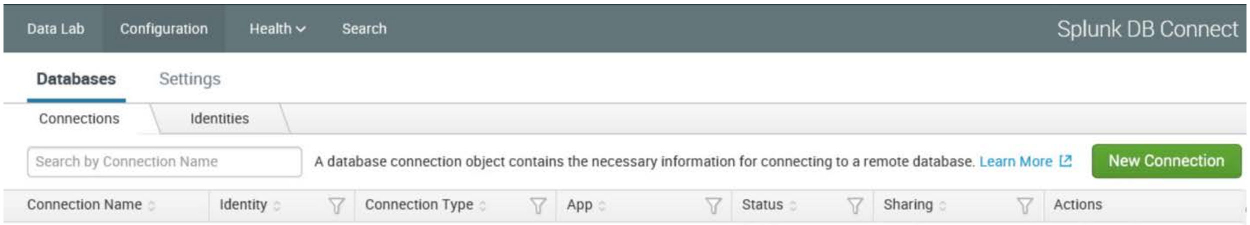
1 identity in total.

2.6.4.6 Creating Connections

This section details how to create a database connection for Splunk DB Connect to use. This provides the information that the software needs to connect to your remote database.

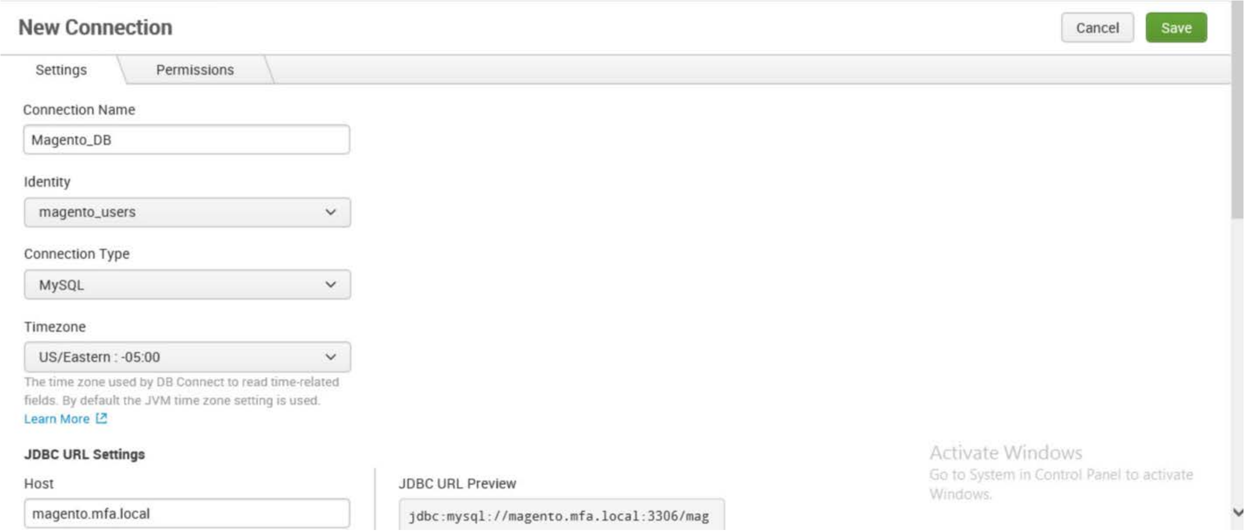
1. Navigate to the **Connections** tab: **Configuration > Databases > Connections.**

2. Click **New Connection.**



A database connection object contains the necessary information for connecting to a remote database.

3. Configure the **Settings** for your **New Connection.**



Connection Name: Magento_DB

Identity: magento_users

Connection Type: MySQL

Timezone: US/Eastern : -05:00

The time zone used by DB Connect to read time-related fields. By default the JVM time zone setting is used.

JDBC URL Settings

Host: magento.mfa.local

JDBC URL Preview:

```
jdbc:mysql://magento.mfa.local:3306/mag
```

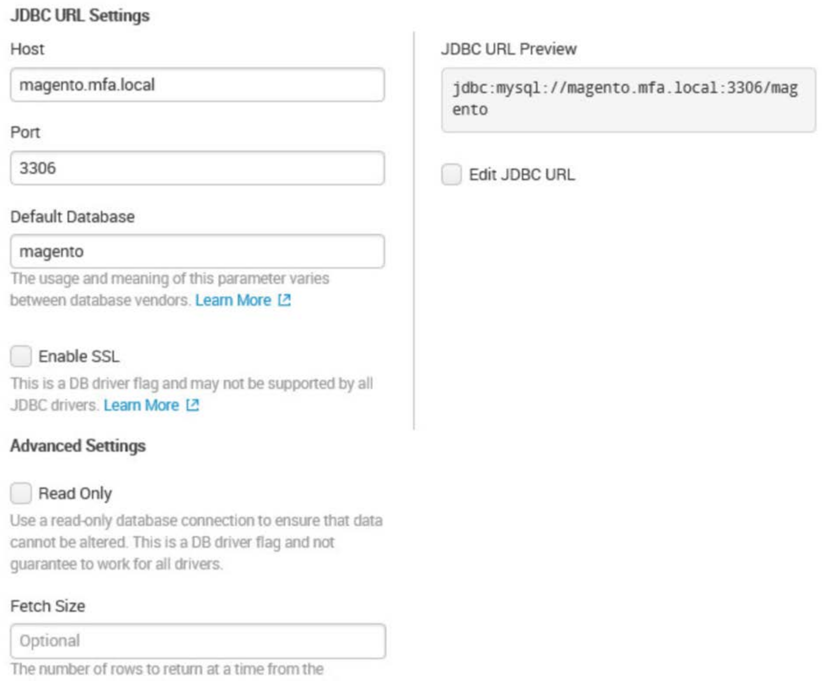
   a. Uniquely name your connection in the **Connection Name** field.

   b. Select the **Identity** created in Section 2.6.4.5.

   c. In the **Connection Type** field, select the type of database being connected.

   d. Specify the **Timezone.**

4. Configure the **JDBC URL Settings.**



JDBC URL Settings

Host: magento.mfa.local

Port: 3306

Default Database: magento

The usage and meaning of this parameter varies between database vendors. Learn More

□ Enable SSL

This is a DB driver flag and may not be supported by all JDBC drivers. Learn More

Advanced Settings

□ Read Only

Use a read-only database connection to ensure that data cannot be altered. This is a DB driver flag and not guarantee to work for all drivers.

Fetch Size: Optional

The number of rows to return at a time from the

JDBC URL Preview

```
jdbc:mysql://magento.mfa.local:3306/mag
ento
```

□ Edit JDBC URL

a. Enter the database’s host name in the **Host** field.

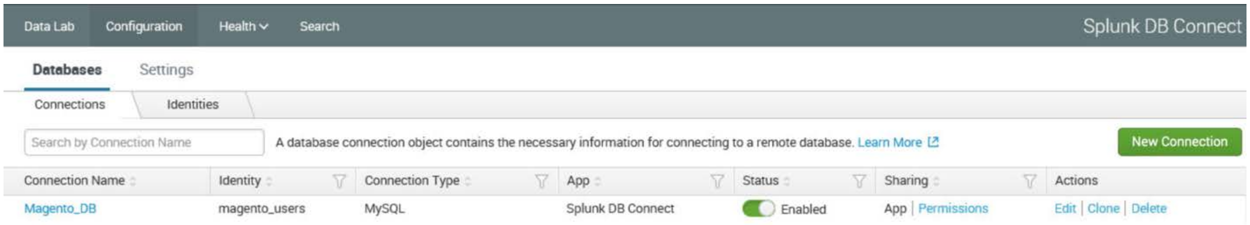
b. Specify the **Port** that your database uses for remote connections.

c. Specify the **Default Database** to be used.

d. Click **Save.**

Note: If you receive an error when attempting to save the connection, be sure to check that the database to which you are attempting to connect is configured for remote connections.

5. You will now see the new connection that you created, listed in the table of connections.



A database connection object contains the necessary information for connecting to a remote database. Learn More

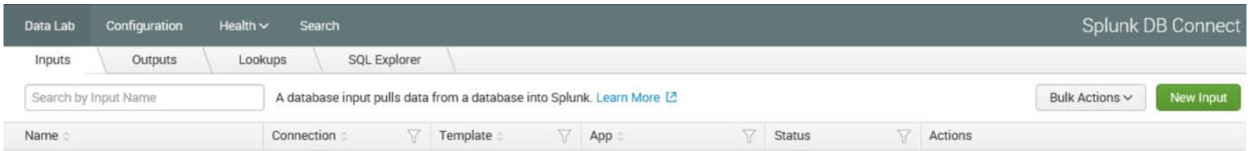
Connection Name	Identity	Connection Type	App	Status	Sharing	Actions
Magento_DB	magento_users	MySQL	Splunk DB Connect	Enabled	App | Permissions	Edit | Clone | Delete

2.6.4.7 Creating Inputs

This section details how to ingest data from your database by using inputs. We demonstrated creation of an input that pulled customer account information from the Magento database.

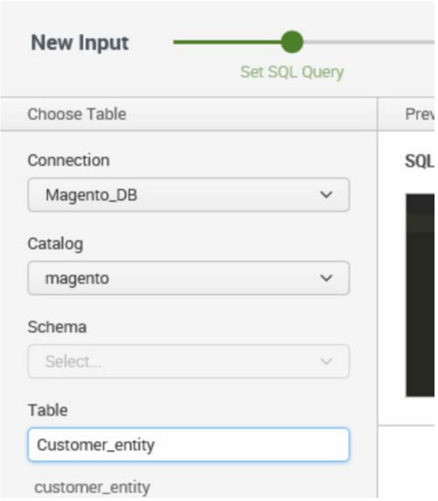
1. Navigate to the **Inputs** tab: **Data Lab > Inputs.**

2. Click **New Input.**



A database input pulls data from a database into Splunk. Learn More

3. Choose the table for your **New Input.**



Connection: Magento_DB

Catalog: magento

Schema: Select...

Table: Customer_entity

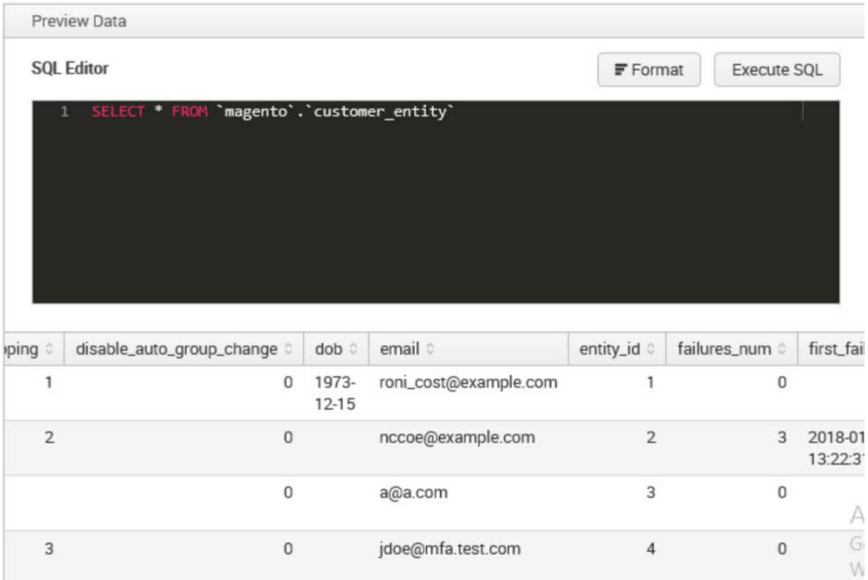
customer_entity

   a. Select the **Connection** created in Section 2.6.4.6.

   b. Select the Default Database created in Section 2.6.4.6, Step 4c, as the **Catalog.**

   c. Search for and select the **Table** from which input is to pull data. We selected the **Customer_entity** table.

4. Preview the data.

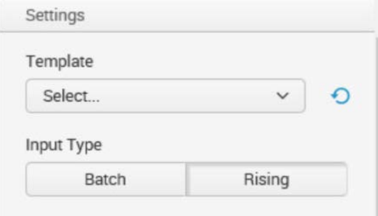


```
SELECT * FROM `magento`.`customer_entity`
```

ping	disable_auto_group_change	dob	email	entity_id	failures_num	first_fai
1	0	1973-12-15	roni_cost@example.com	1	0	
2	0		nccoe@example.com	2	3	2018-01 13:22:3
	0		a@a.com	3	0	
3	0		jdoe@mfa.test.com	4	0	

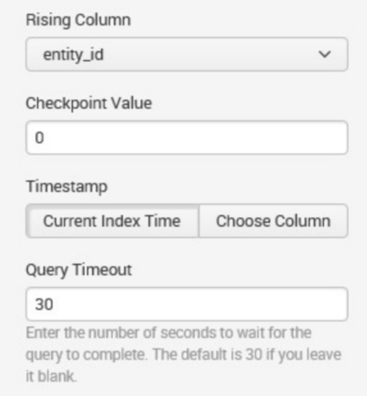
5. Click **Execute SQL** to review the results of the query.

6. Select the **Input Type.**



Batch or **Rising: Batch** indexes all of the table's data every time that it runs, whereas **Rising** uses a checkpoint to update the data that it collects from the table. We selected **Rising.**

7. Configure the settings for the Rising input type.



Rising Column: entity_id

Checkpoint Value: 0

Timestamp: Current Index Time | Choose Column

Query Timeout: 30

Enter the number of seconds to wait for the query to complete. The default is 30 if you leave it blank.

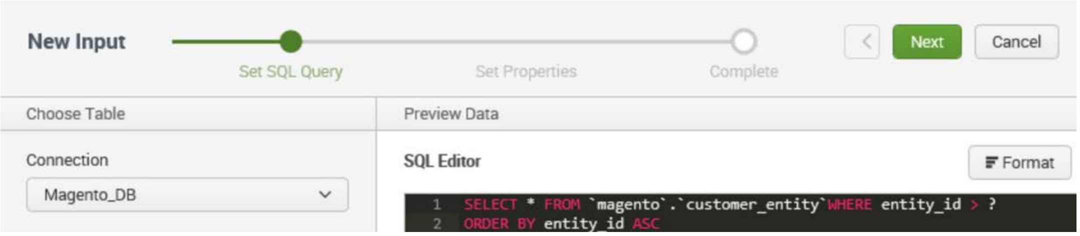
   a. Specify the column of your table to be used as the **Rising Column.** We selected **entity_id.**

   b. Enter the **Checkpoint Value** of the entry where you want your Rising Input to begin updating. This will dynamically update as the query is executed over time. We entered **0** to begin input at the first entity created.

   c. Select the **Timestamp** for Splunk to index this data. We selected **Current Index Time.**

   d. **Query Timeout:** Enter the number of seconds to wait for the query to complete. We entered **30.**

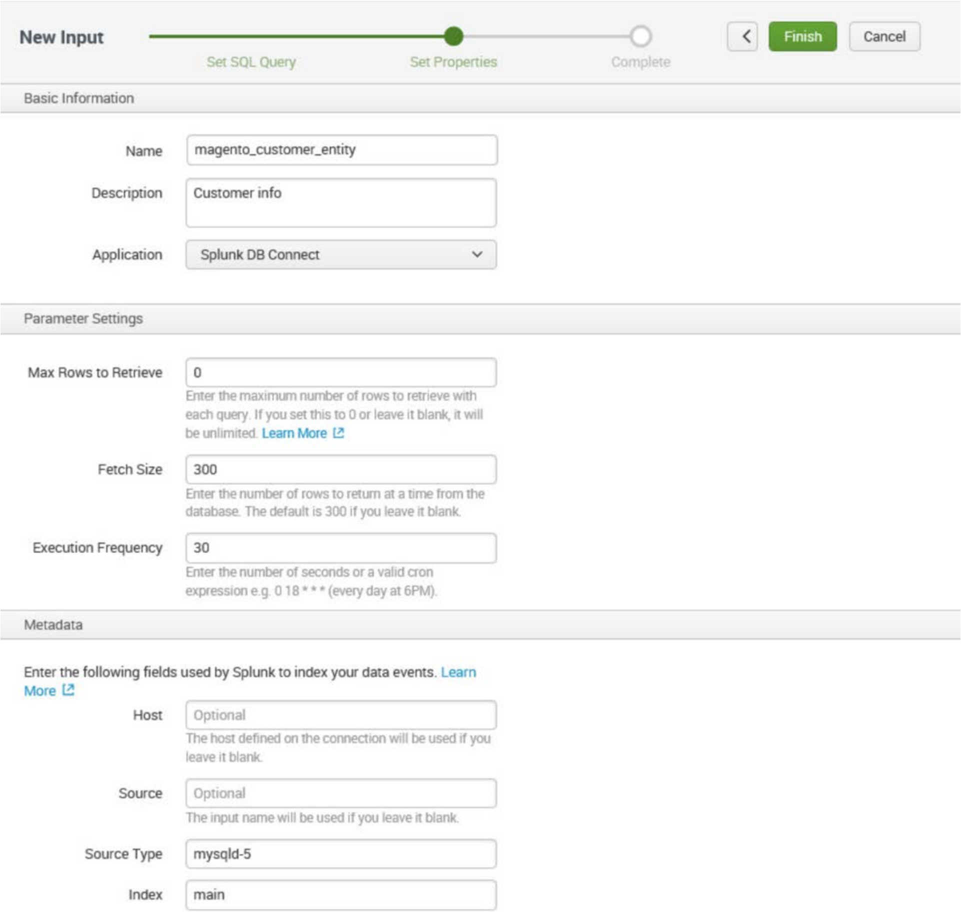
8. Click **Next.**



Connection: Magento_DB

```
SELECT * FROM `magento`.`customer_entity`WHERE entity_id > ?
ORDER BY entity_id ASC
```

9. **Set Properties** for the **New Input.**



Basic Information

Name: magento_customer_entity

Description: Customer info

Application: Splunk DB Connect

Parameter Settings

Max Rows to Retrieve: 0

Enter the maximum number of rows to retrieve with each query. If you set this to 0 or leave it blank, it will be unlimited. Learn More

Fetch Size: 300

Enter the number of rows to return at a time from the database. The default is 300 if you leave it blank.

Execution Frequency: 30

Enter the number of seconds or a valid cron expression e.g. 0 18 * * * (every day at 6PM).

Metadata

Enter the following fields used by Splunk to index your data events. Learn More

Host: Optional

The host defined on the connection will be used if you leave it blank.

Source: Optional

The input name will be used if you leave it blank.

Source Type: mysqld-5

Index: main

a. Enter a unique **Name** for the input. We named our instance **magento_customer_entity.**

b. Enter a **Description** for the type of data being input from the table.

c. Select the **Application** context. We selected **Splunk DB Connect.**

d. Enter the **Max Rows to Retrieve** with each query. We entered the default, **0.**

e. Enter the **Fetch Size.** This specifies the number of rows to be returned with each input query. We entered the default, **300.**

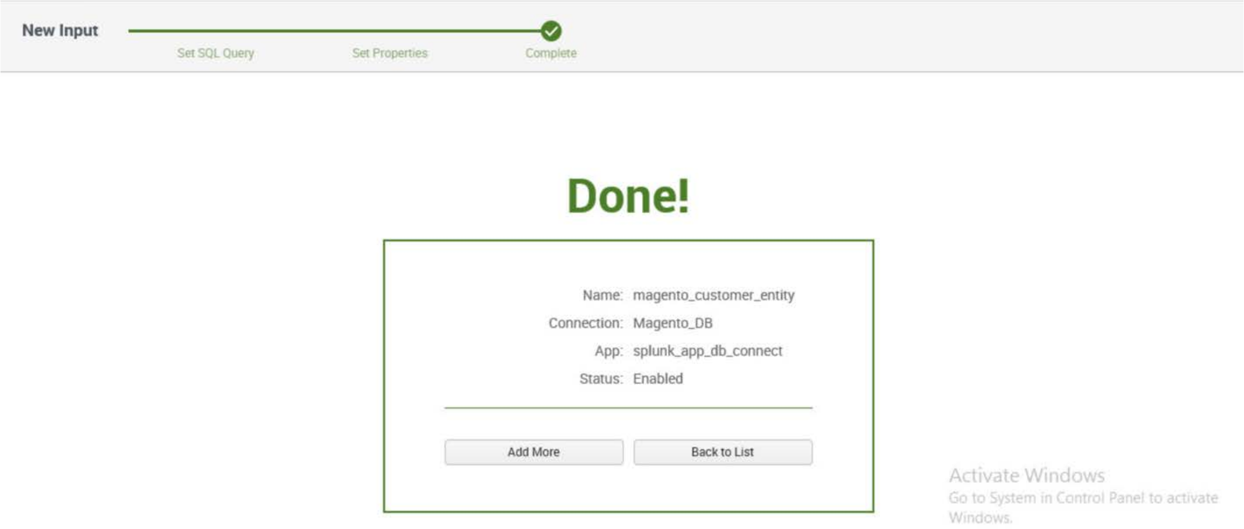
f. Enter the **Execution Frequency.** This specifies how frequently, in seconds, to execute the query for this input. We entered **30.**

g. Enter a **Source Type** for the data being queried by this input. Note: This can be predefined, or a new type can be created in this field. We entered the predefined **mysqld-5.**

h. Select the **Index** field, and enter **main.**

i. Click **Finish.**

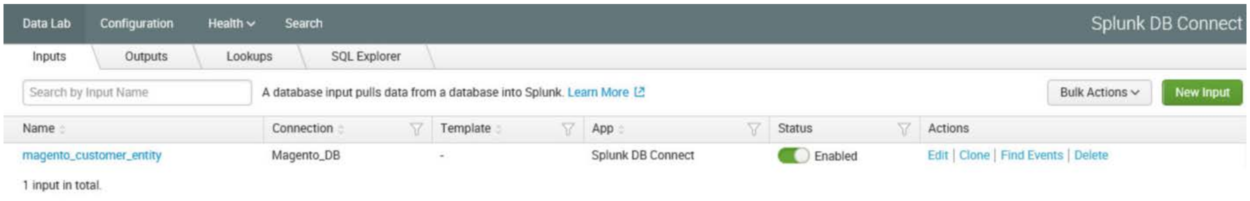
10. The following screen will appear upon completion. Click **Back to List.**



Done!

Name: magento_customer_entity
Connection: Magento_DB
App: splunk_app_db_connect
Status: Enabled

11. You will now see the new input that you created, listed in the table of inputs.



A database input pulls data from a database into Splunk.

Name	Connection	Template	App	Status	Actions
magento_customer_entity	Magento_DB	-	Splunk DB Connect	Enabled	Edit | Clone | Find Events | Delete

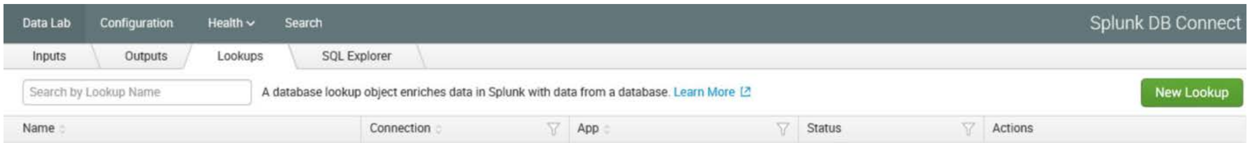
1 input in total.

2.6.4.8 Creating Database Lookups

This section describes creating a new database lookup. Database lookups allow you to extend the data being input from your external database into the Splunk Search Processing Language (SPL) queries. It allows events gathered from logs to be correlated with the information pulled from your database. This example correlates the entity_id returned in SPL queries to user emails stored in the database.

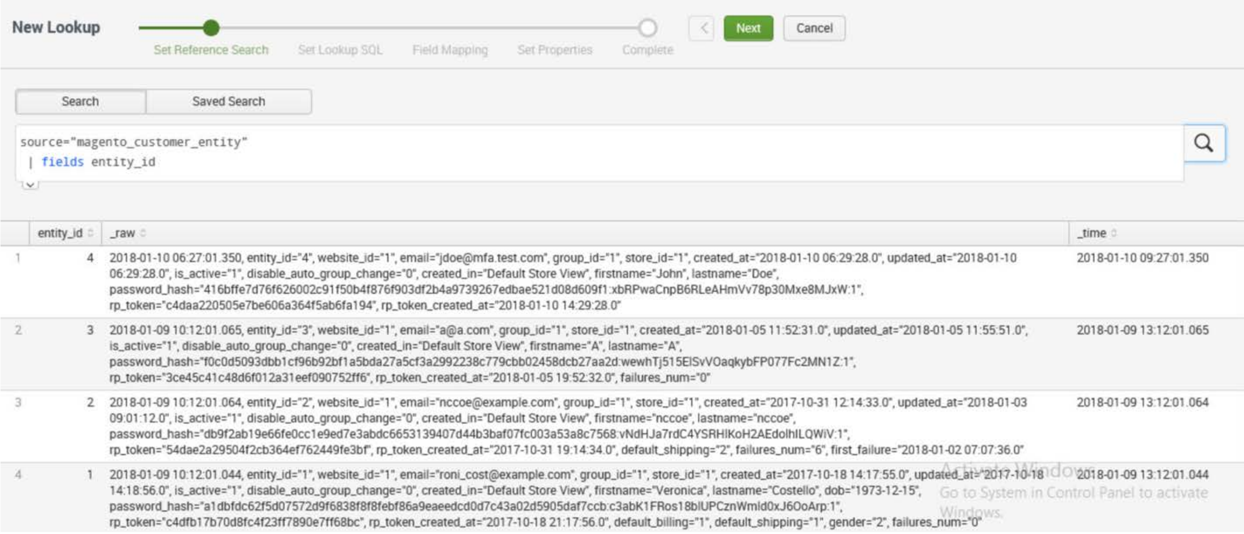
1. Navigate to the **Lookups** tab: **Data Lab > Lookups.**

2. Click **New Lookup.**



A database lookup object enriches data in Splunk with data from a database.

3. Navigate to **Set Reference Search,** and select the field of interest to be mapped to the lookup.



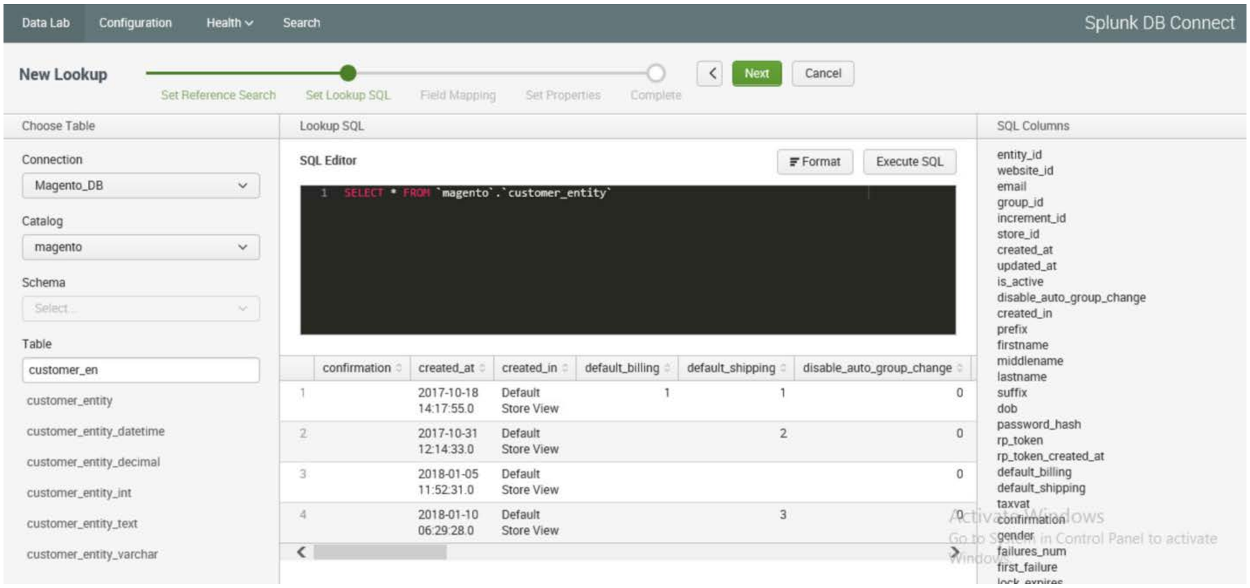
```
source="magento_customer_entity"
 | fields entity_id
```

	entity_id	_raw	_time
1	4	2018-01-10 06:27:01.350, entity_id="4", website_id="1", email="jdoe@mfa.test.com", group_id="1", store_id="1", created_at="2018-01-10 06:29:28.0", updated_at="2018-01-10 06:29:28.0", is_active="1", disable_auto_group_change="0", created_in="Default Store View", firstname="John", lastname="Doe", password_hash="416bffe7d76f626002c91f50b4f876f903df2b4a9739267edbae521d08d609f1:xbRPwaCnpB6RLeAHmVv78p30Mxe8MJxW:1", rp_token="c4daa220505e7be606a364f5ab6fa194", rp_token_created_at="2018-01-10 14:29:28.0"	2018-01-10 09:27:01.350
2	3	2018-01-09 10:12:01.065, entity_id="3", website_id="1", email="a@a.com", group_id="1", store_id="1", created_at="2018-01-05 11:52:31.0", updated_at="2018-01-05 11:55:51.0", is_active="1", disable_auto_group_change="0", created_in="Default Store View", firstname="A", lastname="A", password_hash="f0c0d5093dbb1cf96b92bf1a5bda27a5cf3a2992238c779cbb02458dcb27aa2d:wewhTj515ElSvVOaqkybFP077Fc2MN1Z:1", rp_token="3ce45c41c48d6f012a31eef090752ff6", rp_token_created_at="2018-01-05 19:52:32.0", failures_num="0"	2018-01-09 13:12:01.065
3	2	2018-01-09 10:12:01.064, entity_id="2", website_id="1", email="nccoe@example.com", group_id="1", store_id="1", created_at="2017-10-31 12:14:33.0", updated_at="2018-01-03 09:01:12.0", is_active="1", disable_auto_group_change="0", created_in="Default Store View", firstname="nccoe", lastname="nccoe", password_hash="db9f2ab19e66fe0cc1e9ed7e3abdc6653139407d44b3baf07fc003a53a8c7568:vNdHJa7rdC4YSRHlKoH2AEdolhILQWiV:1", rp_token="54dae2a29504f2cb364ef762449fe3bf", rp_token_created_at="2017-10-31 19:14:34.0", default_shipping="2", failures_num="6", first_failure="2018-01-02 07:07:36.0"	2018-01-09 13:12:01.064
4	1	2018-01-09 10:12:01.044, entity_id="1", website_id="1", email="roni_cost@example.com", group_id="1", store_id="1", created_at="2017-10-18 14:17:55.0", updated_at="2017-10-18 14:18:56.0", is_active="1", disable_auto_group_change="0", created_in="Default Store View", firstname="Veronica", lastname="Costello", dob="1973-12-15", password_hash="a1dbfdc62f5d07572d9f6838f8f8febf86a9eaeedcd0d7c43a02d5905daf7ccb:c3abK1FRos18blUPCznWmld0xJ6OoArp:1", rp_token="c4dfb17b70d8fc4f23ff7890e7ff68bc", rp_token_created_at="2017-10-18 21:17:56.0", default_billing="1", default_shipping="1", gender="2", failures_num="0"	2018-01-09 13:12:01.044

a. We entered a new **Search.**

b. Click **Next.**

4. Navigate to **Set Lookup SQL.**



Connection: Magento_DB

Catalog: magento

Schema: Select...

Table: customer_en

customer_entity
customer_entity_datetime
customer_entity_decimal
customer_entity_int
customer_entity_text
customer_entity_varchar

```
SELECT * FROM `magento`.`customer_entity`
```

	confirmation	created_at	created_in	default_billing	default_shipping	disable_auto_group_change
1		2017-10-18 14:17:55.0	Default Store View	1	1	0
2		2017-10-31 12:14:33.0	Default Store View		2	0
3		2018-01-05 11:52:31.0	Default Store View			0
4		2018-01-10 06:29:28.0	Default Store View		3	0

SQL Columns:

entity_id
website_id
email
group_id
increment_id
store_id
created_at
updated_at
is_active
disable_auto_group_change
created_in
prefix
firstname
middlename
lastname
suffix
dob
password_hash
rp_token
rp_token_created_at
default_billing
default_shipping
taxvat
confirmation
gender
failures_num
first_failure
lock_expires

Activate Windows
Go to System in Control Panel to activate Windows.

a. Specify a **Connection** by using information from the connection, which was created in Section 2.6.4.6.

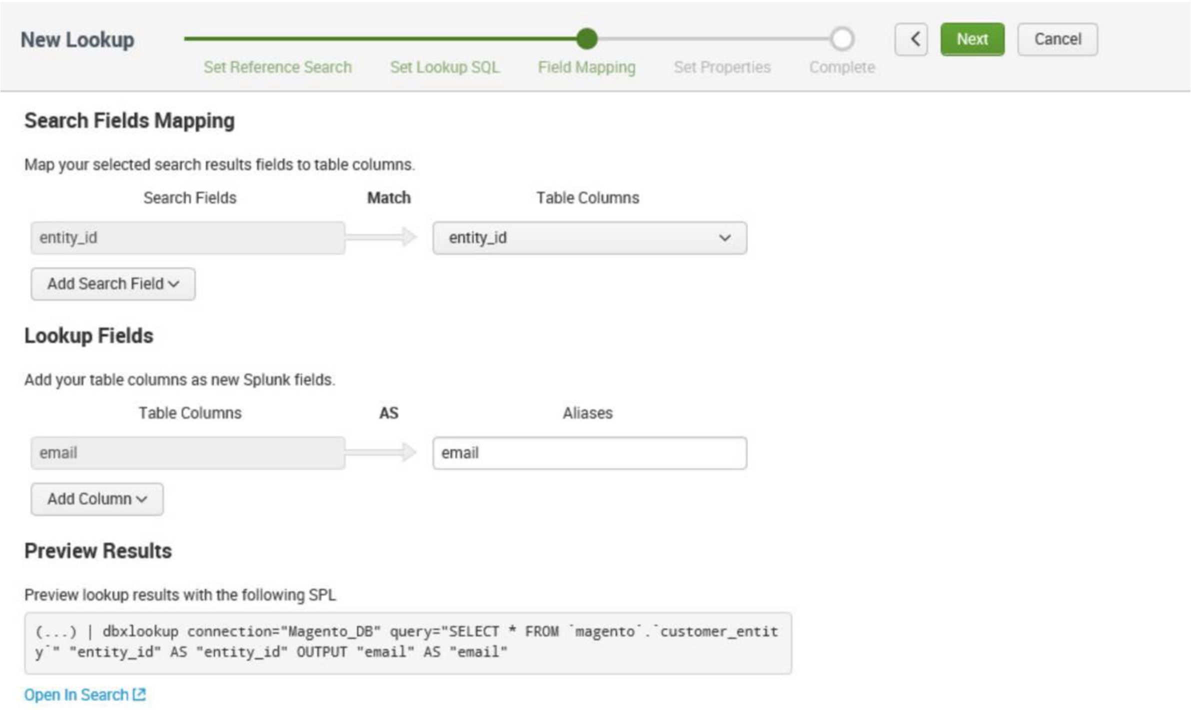
b. Specify the **Catalog.**

c. Enter the **Table.**

d. Click **Execute SQL** to view the results of the query created.

e. Click **Next.**

5. Navigate to **Field Mapping.**



Search Fields Mapping

Map your selected search results fields to table columns.

Search Fields	Match	Table Columns
entity_id	→	entity_id

Lookup Fields

Add your table columns as new Splunk fields.

Table Columns	AS	Aliases
email	→	email

Preview Results

Preview lookup results with the following SPL

```
(...) | dbxlookup connection="Magento_DB" query="SELECT * FROM `magento`.`customer_entit
y`" "entity_id" AS "entity_id" OUTPUT "email" AS "email"
```

a. Click **Add Search Field.**

b. Select the **Search Fields** to be mapped to the database. We selected **entity_id.**

c. Select the **Table Columns** to which the field maps in the database. We selected **entity_id.**

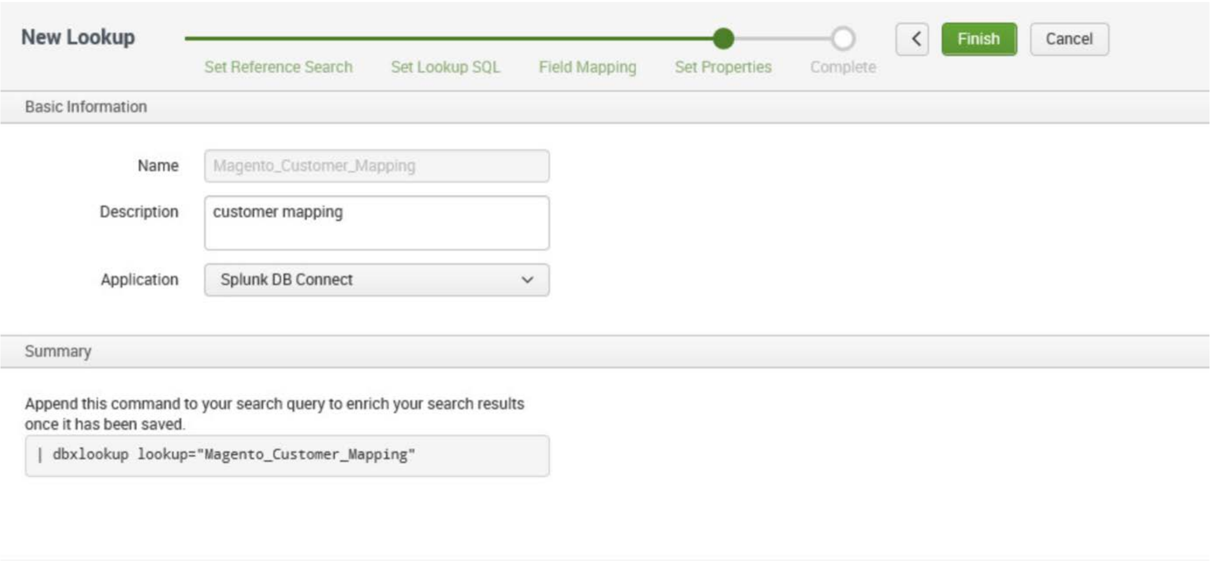
d. Click **Add Column.**

e. Select the **Table Columns** to be returned as Splunk fields. We selected **email.**

f. Enter an **Alias** for the field. We chose to leave the name of the field as **email.**

g. Click **Next.**

6. Navigate to **Set Properties.**



Name: Magento_Customer_Mapping

Description: customer mapping

Application: Splunk DB Connect

Append this command to your search query to enrich your search results once it has been saved.

```
| dbxlookup lookup="Magento_Customer_Mapping"
```

a. Enter a unique **Name** for the lookup. We named our instance **Magento_Customer_Mapping.**

b. Enter a **Description** for the type of new lookup being created.

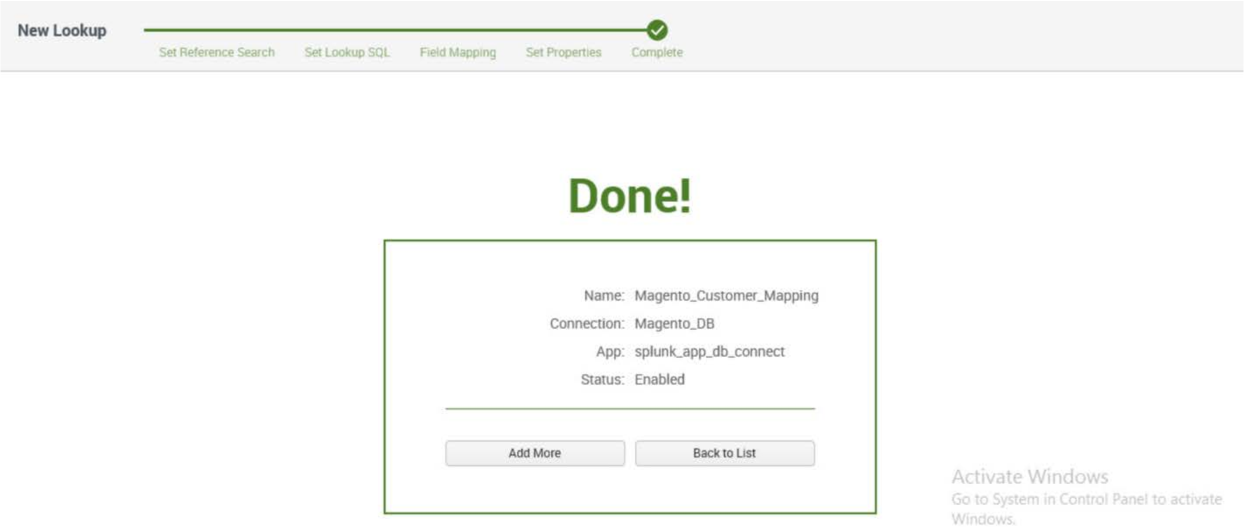
c. Select the **Application** context. We selected **Splunk DB Connect.**

d. The **Summary** contains the command to be appended to your SPL searches to leverage the lookup:

```
| dbxlookup lookup=“Magento_Customer_Mapping”
```

e. Click **Finish.**

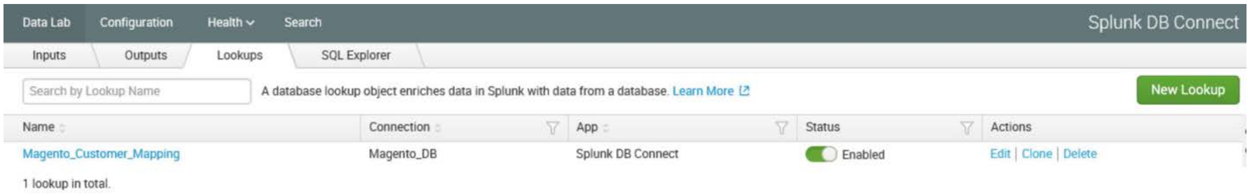
7. The following screen will appear upon completion. Click **Back to List.**



Done!

Name: Magento_Customer_Mapping
Connection: Magento_DB
App: splunk_app_db_connect
Status: Enabled

8. You will now see the new lookup that you created, listed in the table of lookups.



A database lookup object enriches data in Splunk with data from a database. Learn More

Name	Connection	App	Status	Actions
Magento_Customer_Mapping	Magento_DB	Splunk DB Connect	Enabled	Edit | Clone | Delete

1 lookup in total.

2.6.5 Splunk Enterprise Queries and Dashboards

Splunk Enterprise reports, alerts, and dashboards are powered by queries written in the Splunk SPL. These queries are used to perform the analytics responsible for capturing events, identifying trends, and detecting anomalies. Once a query is written, it can be saved as a report, an alert, or a dashboard panel. The following queries were developed for both example implementations and were also saved as Splunk Enterprise dashboards to provide a central viewing location.

2.6.5.1 Query: Total Attempted Single-Factor Authentications

The following search query traverses the logs aggregated from the Magento server. The query uses multiple data sources relating to the same access log to detect when access to a customer account is attempted via single-factor credentials. The output of the query shows the total events per hour.

```
host="magento.mfa.local"  source ="/var/log/httpd/*" sourcetype=access_common 302
"/fidodemo/customer/account/loginPost"  earliest=1 latest=now | stats count by
date_hour
```

2.6.5.2 Query: Failed Single-Factor Authentications Within Past Five Minutes

The following search query traverses the logs aggregated from the Magento server, specifically the database logs. This log returns information, including failed login attempts per entity ID. With the database lookup created in Section 2.6.4.8, the query below maps the entity ID to the respective email address reporting when a customer account has failed to be logged in via single-factor credentials. The output of the query shows failed logins, per email address, within a five-minute interval.

```
source="/usr/local/strongauth/mariadb-10.1.22/log/mysqld.log" failures_num!="'0'" |
rex field=entity_id "\'?(?<entity_id>[\d\.]+)\'?" | dbxlookup
lookup="Magento_Customer_Mapping" earliest=-5m latest=now | eventstats |  stats count
by email
```

2.6.5.3 Query: Attempted Single-Factor Authentications in Past Five Minutes

The following search query traverses the logs aggregated from the Magento server. The query uses multiple data sources relating to the same access log to detect when access to a customer account is attempted via single-factor credentials. The output of the query shows the failed login, per IP address, within a five-minute interval.

```
host="magento.mfa.local"  source ="/var/log/httpd/*" sourcetype=access_common 302
"/fidodemo/customer/account/loginPost"  earliest=-5m latest=now | stats count by IP
```

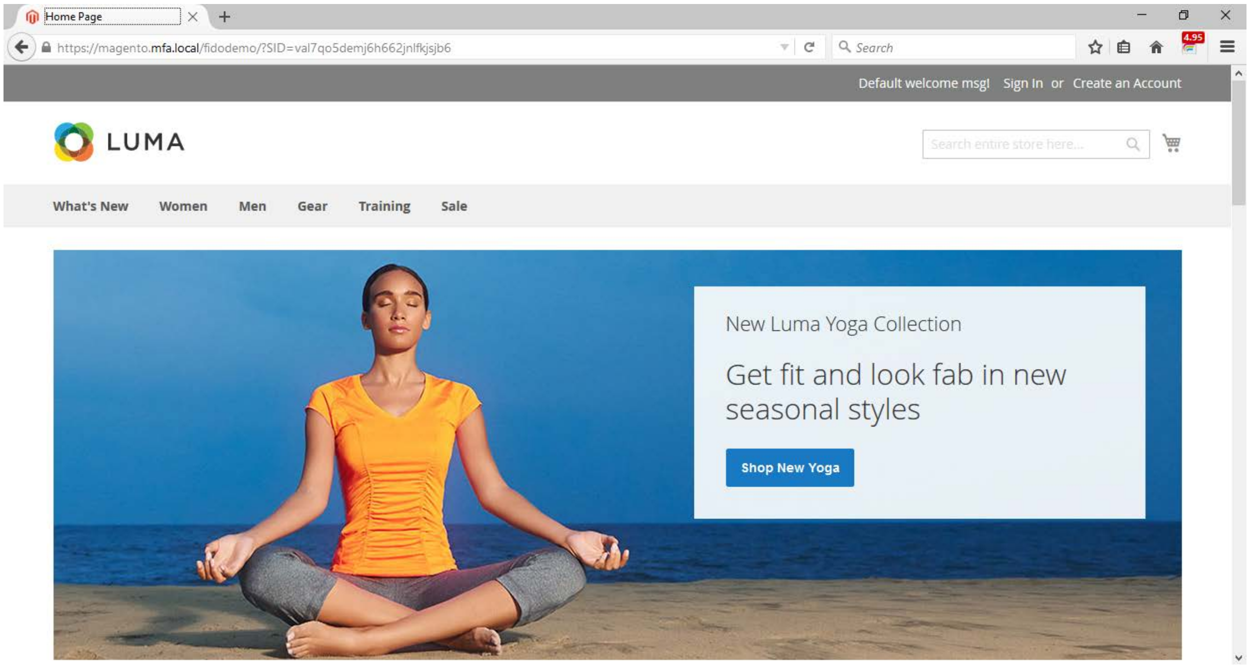
2.7 Testing FIDO Key Registration and Checkout

Once installed and configured, the example implementation can configure accounts, and the build can be tested. To test the implementation, an example customer account was created. Example processes for customer account creation, FIDO key registration, and FIDO checkout are detailed in the following subsections.

2.7.1 Creating an Example Magento Customer Account

This section outlines how to create example customer accounts. The accounts are created using a web browser interface.

1. To begin, **open a web browser** and navigate to *https://magento.mfa.local/fidodemo*.


Home Page
https://magento.mfa.local/fidodemo/?SID=val7qo5demj6h662jnlfkjsjb6
Search
Default welcome msg! Sign In or Create an Account
LUMA
Search entire store here...
What's New
Women
Men
Gear
Training
Sale
New Luma Yoga Collection
Get fit and look fab in new seasonal styles
Shop New Yoga

2. Click **Create an Account.**

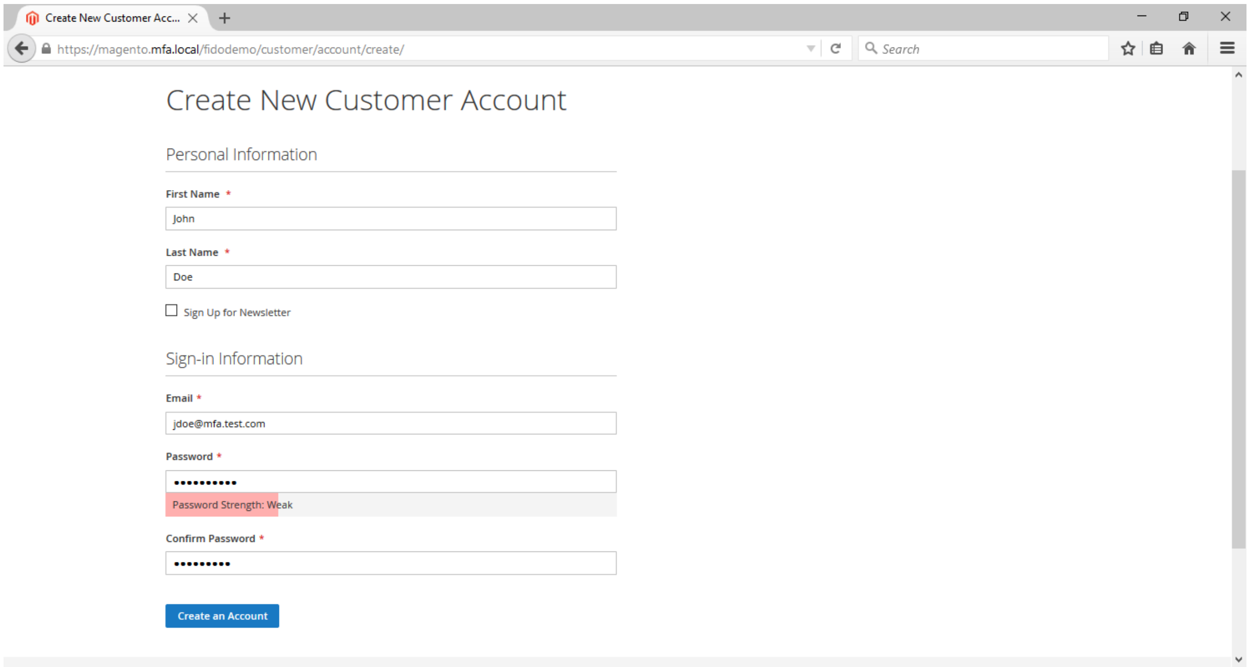
3. Fill out the form as shown in the example below.

    a. **First Name:** John

    b. **Last Name:** Doe

    c. **Email:** jdoe@mfa.test.com

    d. **Password:** <password>


Create New Customer Acc...
https://magento.mfa.local/fidodemo/customer/account/create/
Search

Create New Customer Account

Personal Information

First Name *
John

Last Name *
Doe

□ Sign Up for Newsletter

Sign-in Information

Email *
jdoe@mfa.test.com

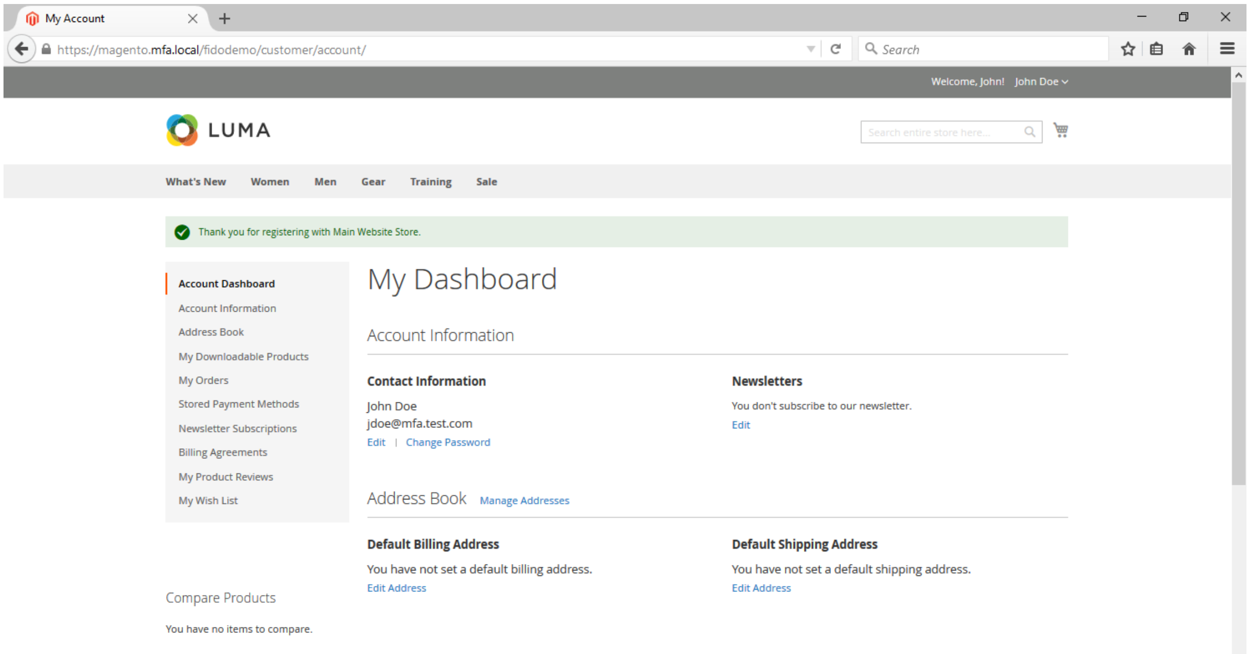
Password *
••••••••••
Password Strength: Weak

Confirm Password *
•••••••••

Create an Account

4. After entering the required information, click **Create an Account.**

5. Upon successful account creation, you will be taken to the **Account Dashboard** page, where details of the account that was created are visible.



Thank you for registering with Main Website Store.

My Dashboard

Account Information

Contact Information
John Doe
jdoe@mfa.test.com
Edit | Change Password

Newsletters
You don't subscribe to our newsletter.
Edit

Address Book Manage Addresses

Default Billing Address
You have not set a default billing address.
Edit Address

Default Shipping Address
You have not set a default shipping address.
Edit Address

Compare Products
You have no items to compare.

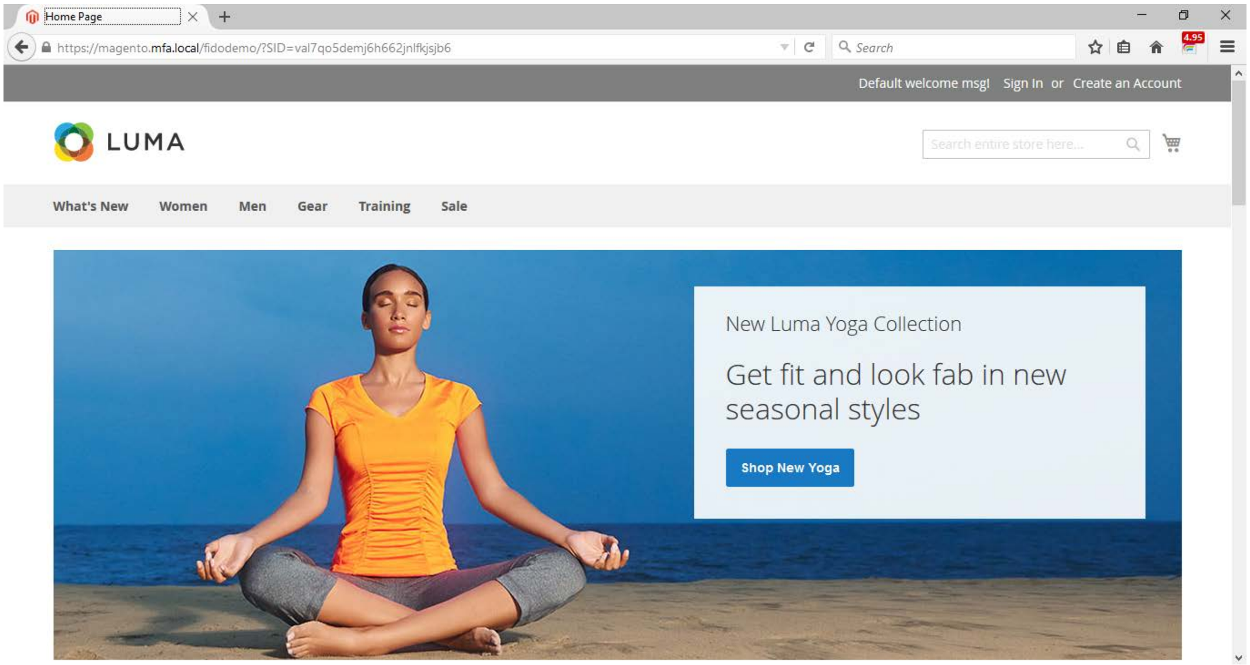
2.7.2 FIDO Key Registration

This section provides information for associating the FIDO key with the purchaser's account that was created in Section 2.7.1. The account holder will need their FIDO key to complete the registration process.

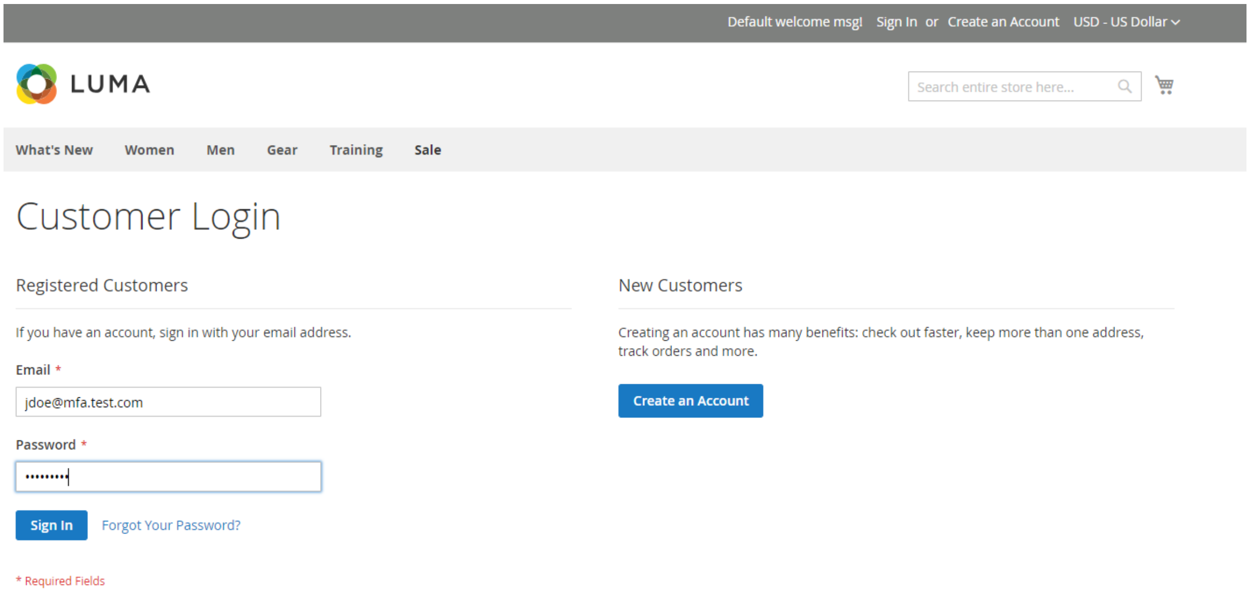
1. To begin, open a web browser and navigate to *https://magento.mfa.local/fidodemo*.

   Note: You need to have already created a Magento Example Customer Account. If you have not done so, please refer to Section 2.7.1.

2. Click **Sign In.**



3. Fill out the **Email** and **Password** for the example customer account that was created in Section 2.7.1.



Default welcome msg! Sign In or Create an Account USD - US Dollar

LUMA

Search entire store here...

What's New Women Men Gear Training Sale

Customer Login

Registered Customers

If you have an account, sign in with your email address.

Email *

jdoe@mfa.test.com

Password *

•••••••••

Sign In Forgot Your Password?

* Required Fields

New Customers

Creating an account has many benefits: check out faster, keep more than one address, track orders and more.

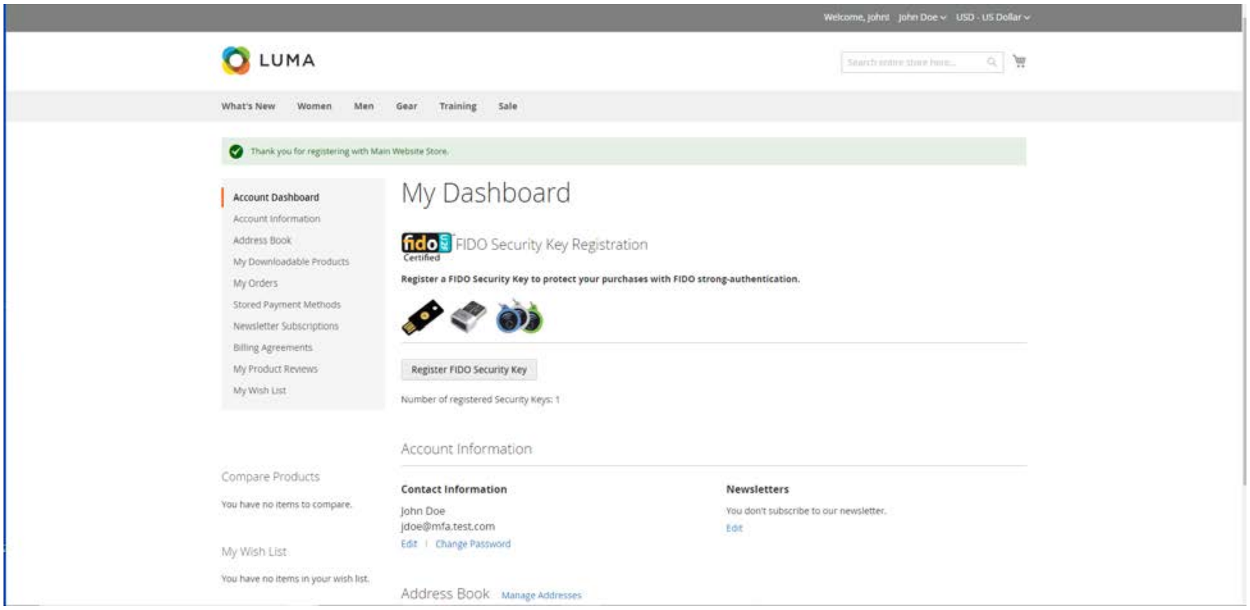
Create an Account

a. **Email:** jdoe@mfa.test.com

b. **Password:** <password>

4. Click **Sign In.**

5. On the **Account Dashboard** page, click **Register FIDO Security Key.**



Welcome, John! John Doe USD - US Dollar

LUMA

Search entire store here...

What's New Women Men Gear Training Sale

Thank you for registering with Main Website Store.

Account Dashboard
Account Information
Address Book
My Downloadable Products
My Orders
Stored Payment Methods
Newsletter Subscriptions
Billing Agreements
My Product Reviews
My Wish List

My Dashboard

fido Certified FIDO Security Key Registration

Register a FIDO Security Key to protect your purchases with FIDO strong-authentication.

Register FIDO Security Key

Number of registered Security Keys: 1

Account Information

Contact Information

John Doe
jdoe@mfa.test.com
Edit | Change Password

Newsletters

You don't subscribe to our newsletter.
Edit

Compare Products

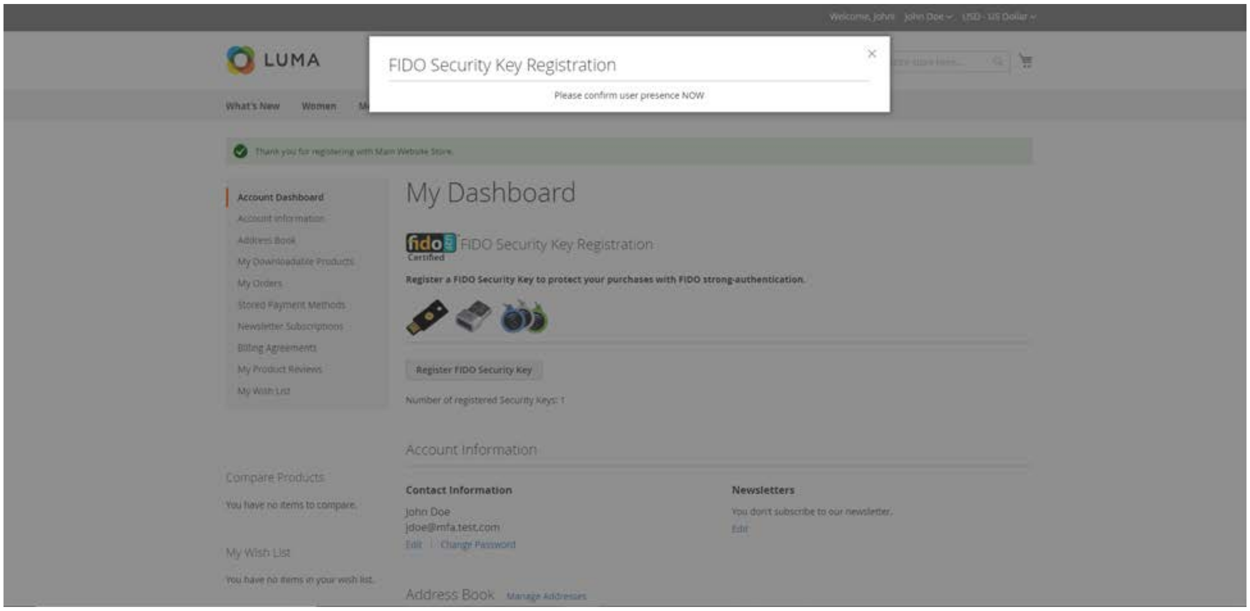
You have no items to compare.

My Wish List

You have no items in your wish list.

Address Book Manage Addresses

6. The FIDO Authentication Engine will prompt “Please confirm user presence NOW.”



FIDO Security Key Registration

Please confirm user presence NOW

Thank you for registering with Main Website Store.

My Dashboard

FIDO Security Key Registration

Register a FIDO Security Key to protect your purchases with FIDO strong-authentication.

Number of registered Security Keys: 1

Account Information

Contact Information

John Doe
jdoe@mfa.test.com

Newsletters

You don't subscribe to our newsletter.

Compare Products

You have no items to compare.

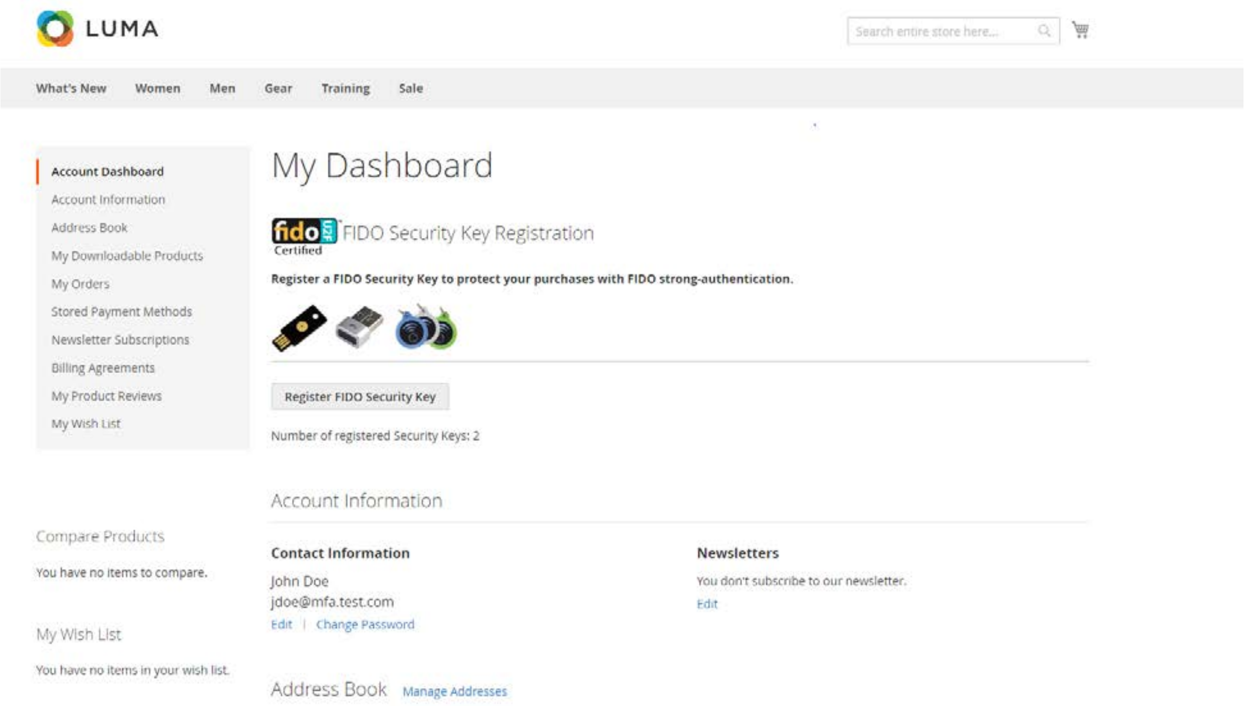
My Wish List

You have no items in your wish list.

Address Book

Insert the Yubico YubiKey NEO Security Key [15], [16] into an available Universal Serial Bus (USB) slot on the computer, and then place a finger on the gold contact pad.

7. Successful key registration will result in returning to the **Account Dashboard** page.



My Dashboard

FIDO Security Key Registration

Register a FIDO Security Key to protect your purchases with FIDO strong-authentication.

Number of registered Security Keys: 2

Account Information

Contact Information

John Doe
jdoe@mfa.test.com

Newsletters

You don't subscribe to our newsletter.

Address Book

Compare Products

You have no items to compare.

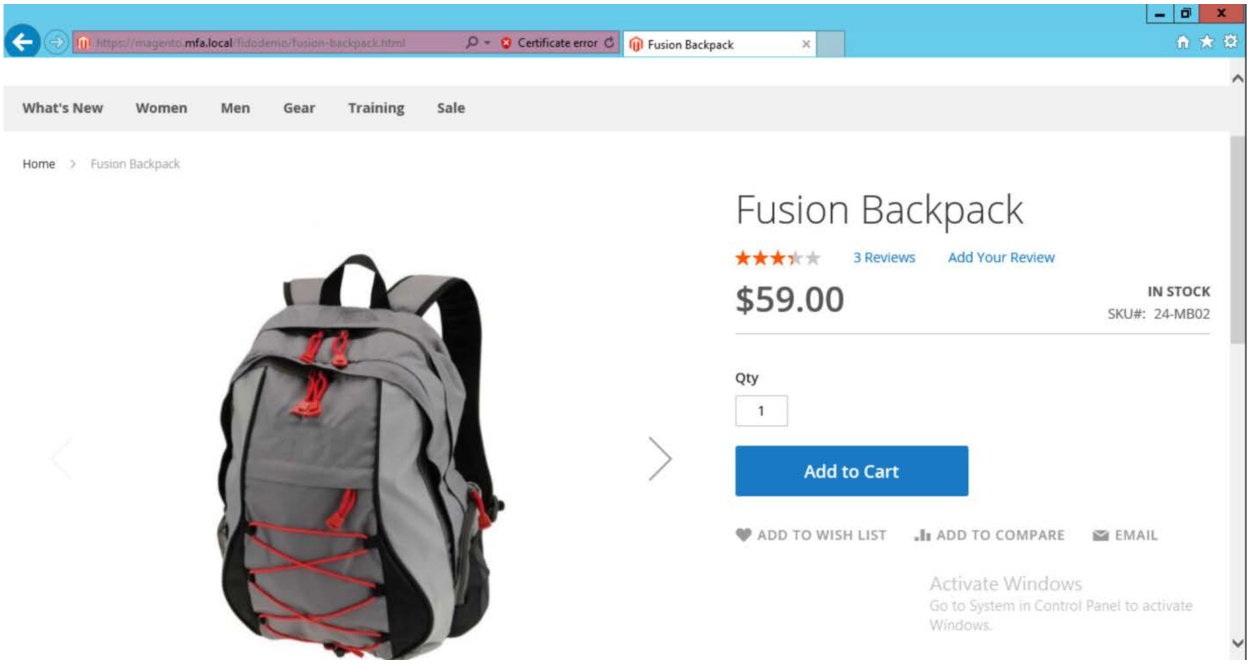
My Wish List

You have no items in your wish list.

2.7.3 Testing Customer Checkout

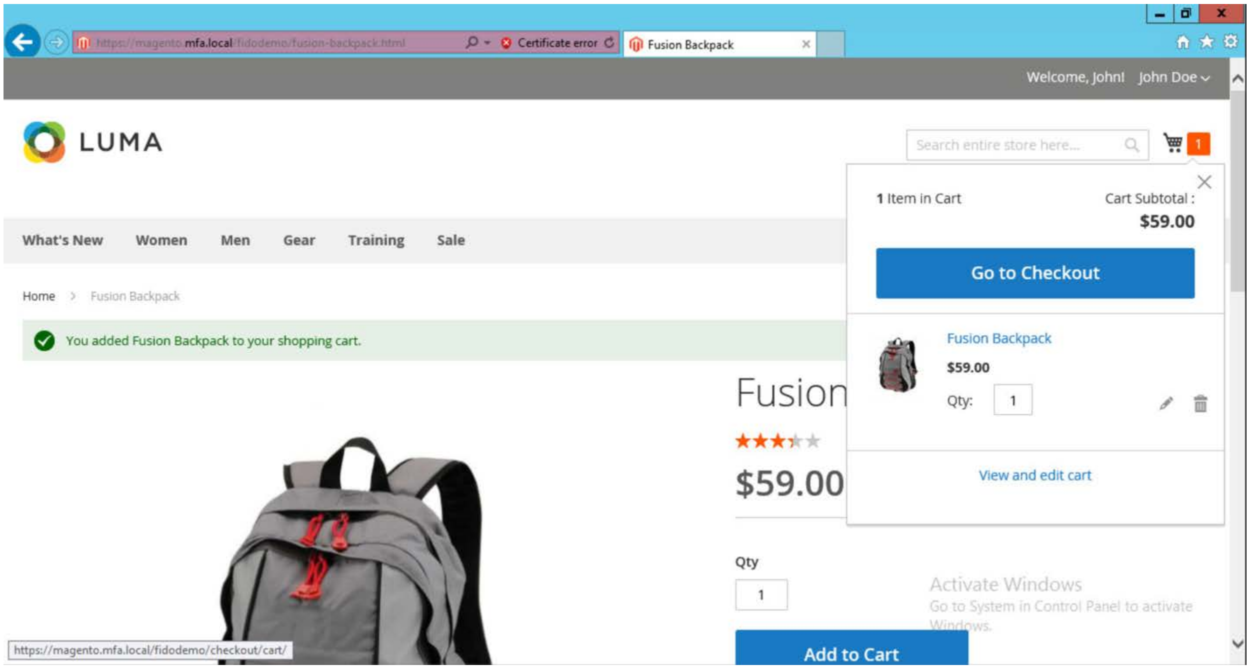
This section provides information for testing that the FIDO server is prompting for a second form of authentication for purchases above $25. This section assumes that an example customer account has been created with a registered FIDO Security Key (Section 2.7.1 and Section 2.7.2).

1. Open a web browser and navigate to *https://magento.mfa.local/fidodemo*.
2. If not already logged in to an example customer account, select **Sign In** from the Magento home page and log in with the following credentials:
   a. **Email:** jdoe@mfa.test.com
   b. **Password:** <password>
3. You will be taken to the **Account Dashboard** page.
4. From there, navigate back to *https://magento.mfa.local/fidodemo*.
5. Scroll down the page and select any item over $25. For our demonstration, we have selected the Fusion Backpack.

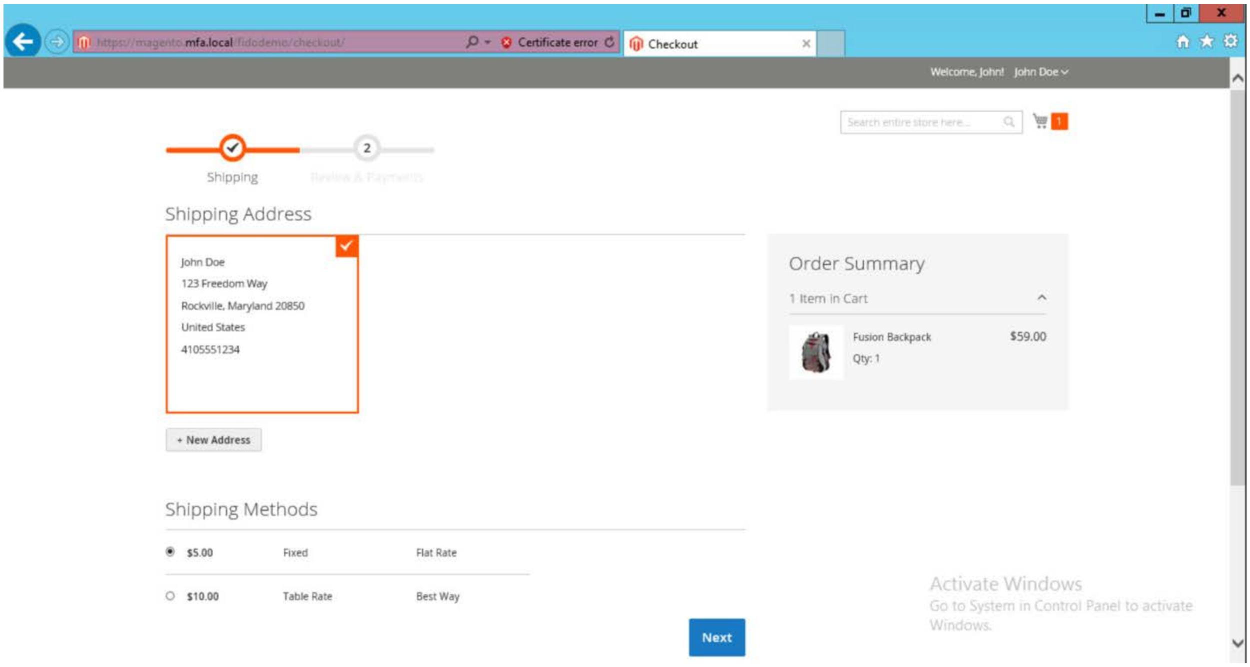


6. Click **Add to Cart.**

7. Click the shopping-basket icon, and then click **Go to Checkout.**



8. Under **Shipping Methods,** select the **Fixed–Flat Rate** radio bubble.



https://magento.mfa.local/fidodemo/checkout/ Certificate error Checkout

Welcome, John! John Doe

Search entire store here... 1

Shipping Review & Payments

Shipping Address

John Doe
123 Freedom Way
Rockville, Maryland 20850
United States
4105551234

+ New Address

Order Summary

1 Item in Cart

Fusion Backpack Qty: 1	$59.00

Shipping Methods

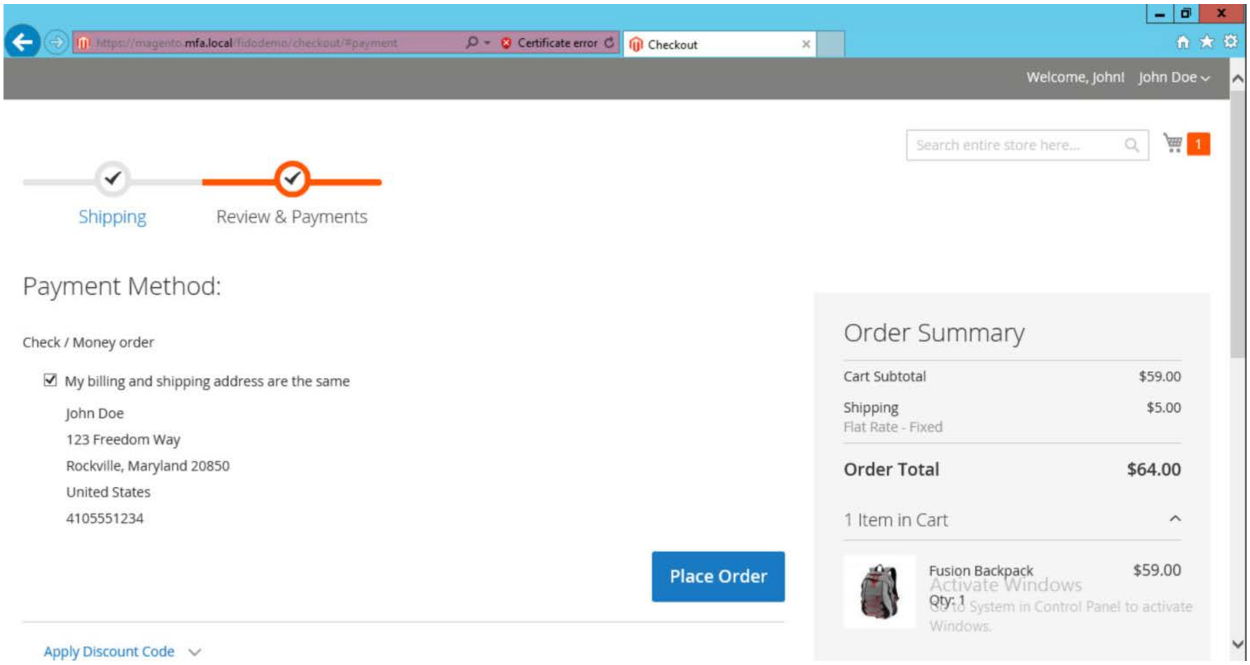
● $5.00	Fixed	Flat Rate
○ $10.00	Table Rate	Best Way

Next

Activate Windows
Go to System in Control Panel to activate Windows.

9. Click **Next.**

10. On the following page, select **Place Order.**



https://magento.mfa.local/fidodemo/checkout/#payment Certificate error Checkout

Welcome, John! John Doe

Search entire store here... 1

Shipping Review & Payments

Payment Method:

Check / Money order

☑ My billing and shipping address are the same

John Doe
123 Freedom Way
Rockville, Maryland 20850
United States
4105551234

Place Order

Apply Discount Code

Order Summary

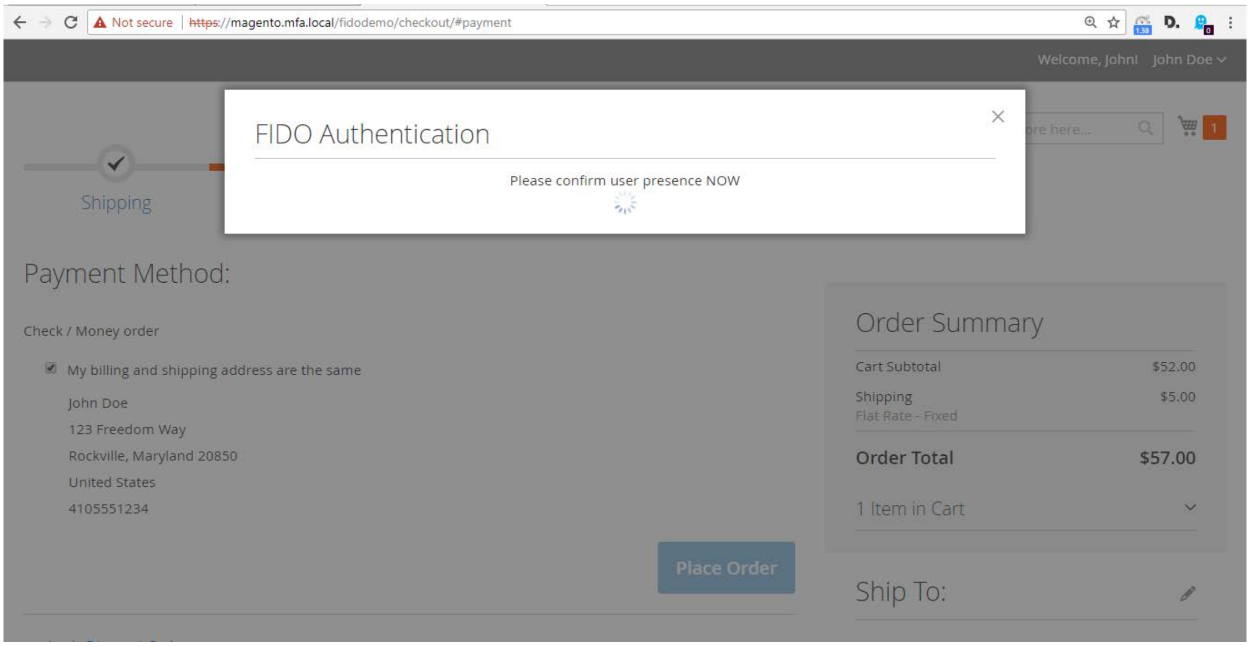
Cart Subtotal	$59.00
Shipping Flat Rate - Fixed	$5.00
Order Total	**$64.00**

1 Item in Cart

Fusion Backpack Qty: 1	$59.00

Activate Windows
Go to System in Control Panel to activate Windows.

11. The FIDO Authentication Engine will prompt “Please confirm user presence NOW.”



Not secure | https://magento.mfa.local/fidodemo/checkout/#payment
Welcome, John! John Doe
Shipping

FIDO Authentication

Please confirm user presence NOW

Payment Method:

Check / Money order

☑ My billing and shipping address are the same

John Doe
123 Freedom Way
Rockville, Maryland 20850
United States
4105551234

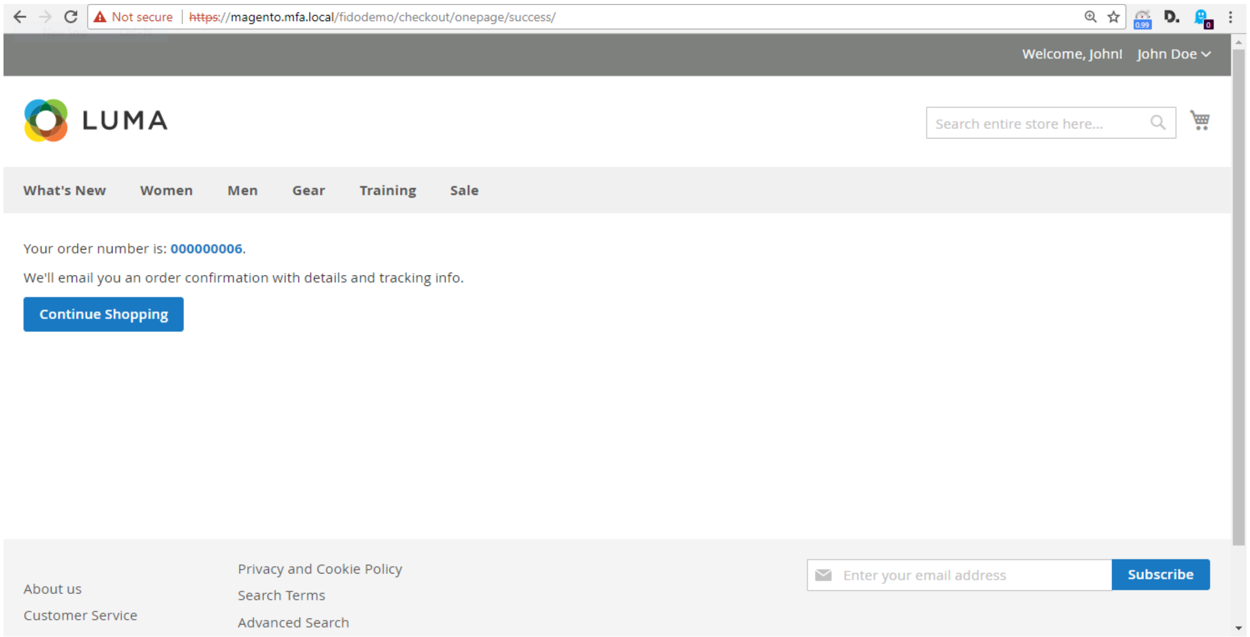
Order Summary	
Cart Subtotal	$52.00
Shipping Flat Rate - Fixed	$5.00
Order Total	$57.00

1 Item in Cart

Ship To:

12. Insert the Yubico YubiKey NEO Security Key into an available USB slot on the computer, and then place a finger on the gold contact pad.

13. Successfully activating the FIDO token will result in the order confirmation page.



Not secure | https://magento.mfa.local/fidodemo/checkout/onepage/success/
Welcome, John! John Doe
LUMA
Search entire store here...
What's New
Women
Men
Gear
Training
Sale

Your order number is: 000000006.

We'll email you an order confirmation with details and tracking info.

Appendix A FIDO U2F Security Key Registration

Fast IDentity Online (FIDO) authentication requires registering one or more *FIDOU2FAuthenticators,* also known as FIDO Universal Second Factor (U2F) Security Keys, or security keys. Security keys can be used for authentication on multiple information systems or websites. If the purchaser already has a U2F, then they can use that same U2F as their multifactor authenticator for the electronic commerce (e-commerce) example implementations depicted in this guide.

FIDO authentication in these example implementations is accomplished by using the magfido *FIDOU2FAuthenticator* module created by StrongKey for the Magento Open Source platform. When deploying the example implementations, there are three parts to the process. While these three parts all execute in sequence without the purchaser being aware of each part, it is helpful to explain each part so that developers understand the workflow.

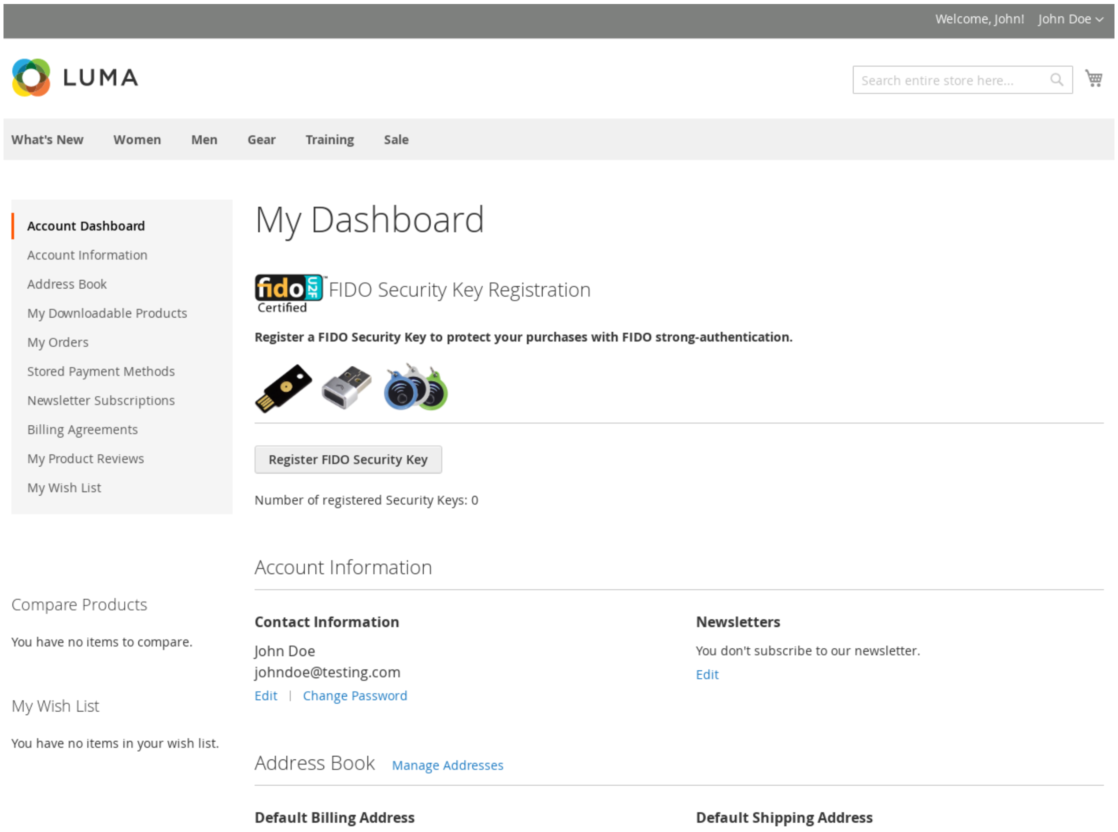
A.1 Display Function

In this part of the process, the Magento layout file *customer_account_index.xml* loads code from the *fido_register.phtml* file on the server side to perform these two functions:

1. Generate Hypertext Markup Language (HTML) that displays FIDO registration purchaser-interface components in the browser, along with summary information of the number of security keys that a purchaser may have registered. The summary information on registered keys is shown above the Recent (Magento) Orders section, which normally appears at the top of the dashboard.
2. Execute the FIDO registration process to register a new FIDO Security Key, using JavaScript embedded in the *fido_register.phtml* file.

If a purchaser has not yet registered a FIDO Security Key within Magento, then the HTML displays a zero (0) value for the number of registered keys, and a button to register a new security key (Figure A-1).

Figure A-1 Browser Display Without Any Security Keys Registered



Welcome, John! John Doe

LUMA

Search entire store here...

What's New Women Men Gear Training Sale

Account Dashboard
Account Information
Address Book
My Downloadable Products
My Orders
Stored Payment Methods
Newsletter Subscriptions
Billing Agreements
My Product Reviews
My Wish List

Compare Products

You have no items to compare.

My Wish List

You have no items in your wish list.

My Dashboard

fido U2F Certified FIDO Security Key Registration

Register a FIDO Security Key to protect your purchases with FIDO strong-authentication.

Register FIDO Security Key

Number of registered Security Keys: 0

Account Information

Contact Information

John Doe
johndoe@testing.com
Edit | Change Password

Newsletters

You don't subscribe to our newsletter.
Edit

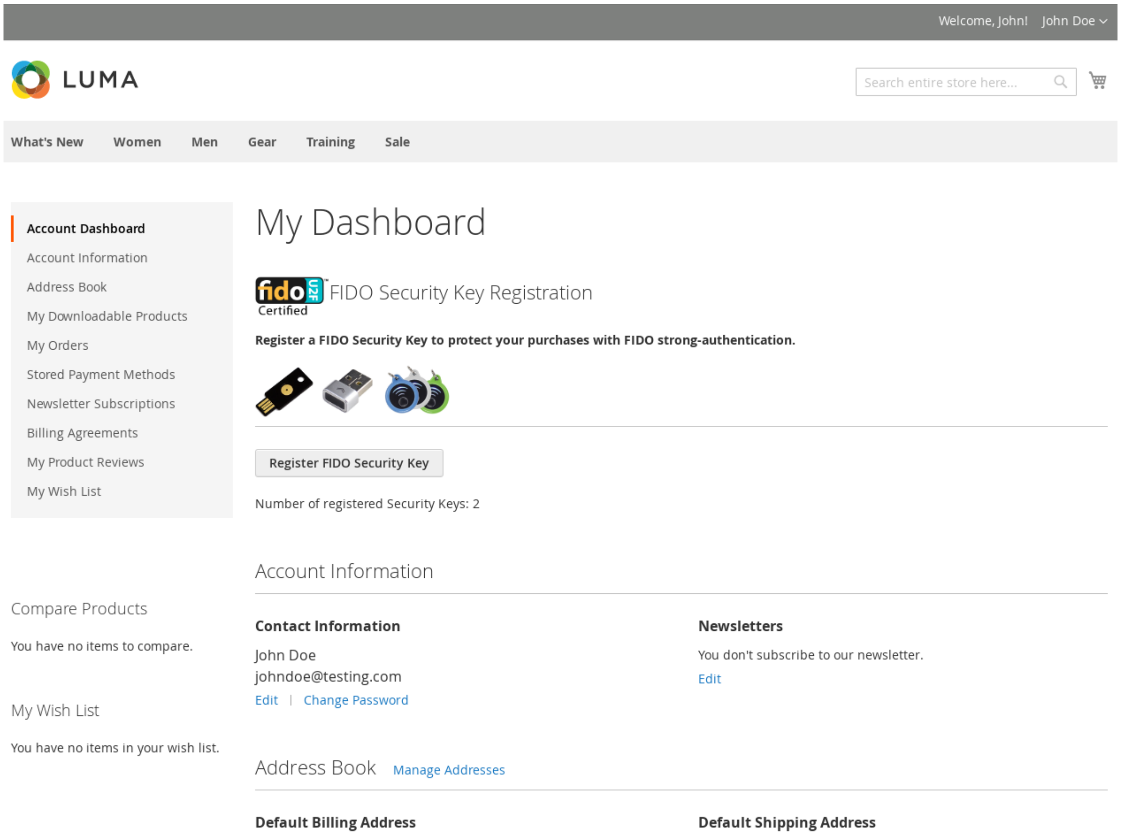
Address Book Manage Addresses

Default Billing Address

Default Shipping Address

If a purchaser has registered one or more security keys to their account—which the FIDO U2F protocol allows—then the *FIDOU2FAuthenticator* module displays the number of security keys registered by the purchaser. Otherwise, it displays 0. The HTML display for such a purchaser's registered keys resembles the depiction shown in Figure A-2.

Figure A-2 Browser Display with Two Security Keys Registered



My Dashboard

FIDO Security Key Registration

Register a FIDO Security Key to protect your purchases with FIDO strong-authentication.

Number of registered Security Keys: 2

Account Information

Contact Information

John Doe
johndoe@testing.com

Newsletters

You don't subscribe to our newsletter.

Compare Products

You have no items to compare.

My Wish List

You have no items in your wish list.

Address Book

Default Billing Address

Default Shipping Address

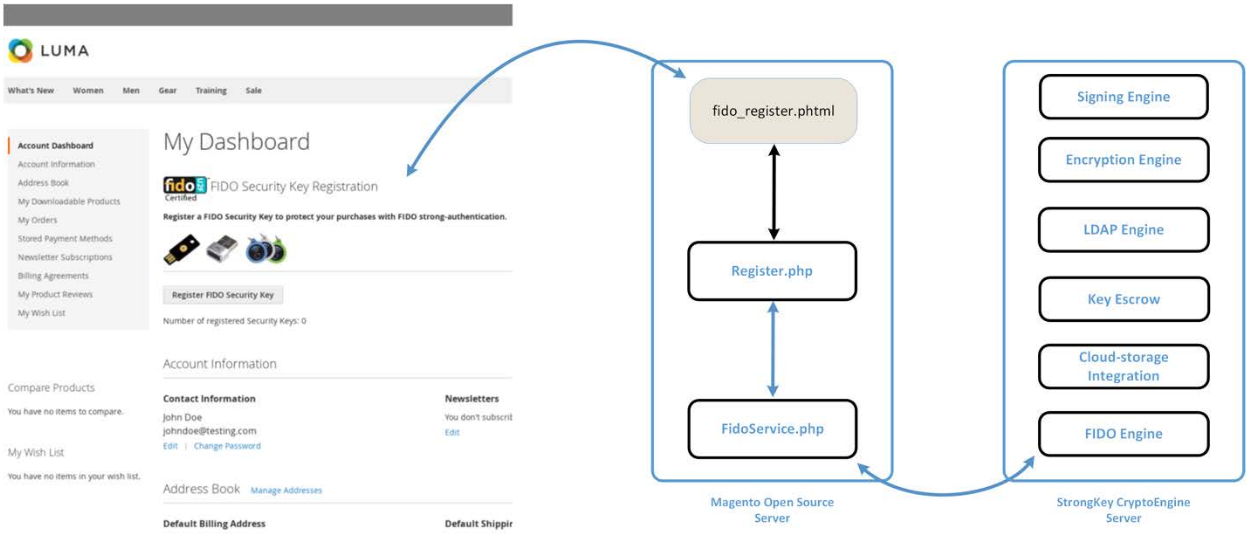
To determine the number of FIDO Security Keys registered by a purchaser within their account, the server code in *fido_register.phtml* calls the "block" file, *Register.php*. This Hypertext Preprocessor (PHP) file, in turn, invokes *FidoService.php* to call a web service (also sometimes known as "consume a web service") on a previously configured FIDO U2F server (implemented in StrongKey CryptoEngine [SKCE]) known to the Magento instance. The web-service request retrieves security-key-related information for the specific purchaser from the FIDO server.

FidoService.php parses the retrieved number of registered keys and returns the value to *Register.php*, which, in turn, returns the number to *fido_register.phtml* that generates HTML for the browser to display.

> Note: In this example implementation, *Register.php* is executed only when the purchaser navigates to their purchaser-dashboard page. If a new security key is registered while on that page, then the page is automatically refreshed upon completion of the transaction to display the correct number of registered security keys.

An overview diagram of the first part of the registration process—that displays the current number of registered security keys, if any—is shown in Figure A-3.

Figure A-3 Display Function Part of the FIDO Registration Process



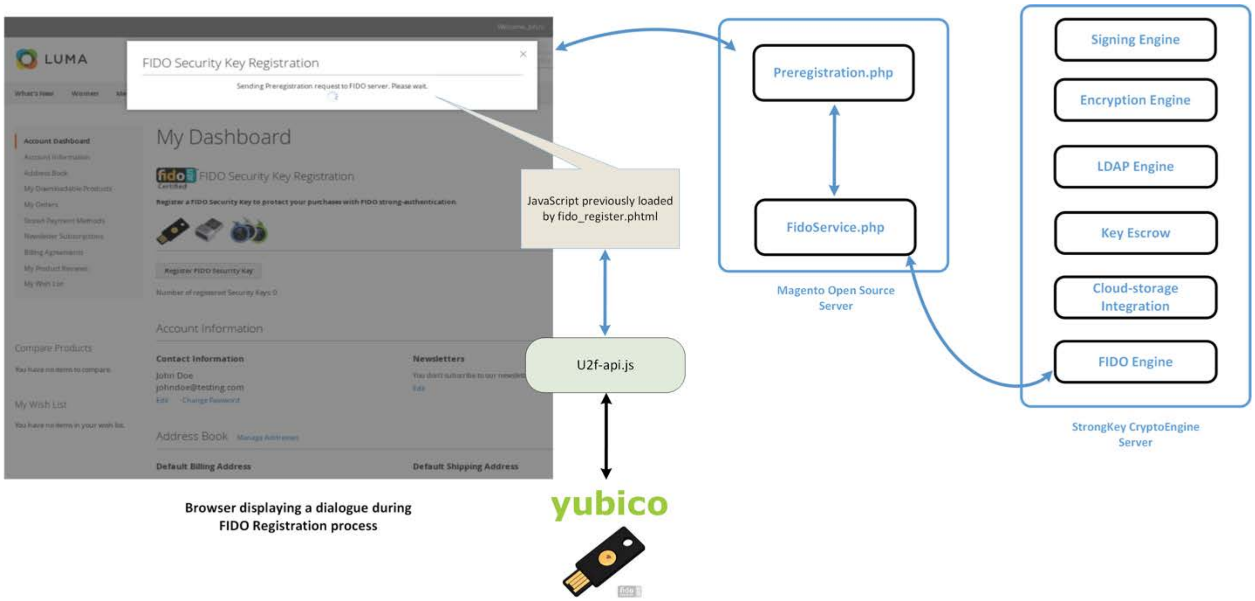
A.2 Preregister Function

The second part of the FIDO registration process acquires a challenge from the FIDO U2F server (SKCE) for processing within the purchaser's FIDO Security Key (Figure A-4).

When the **Register FIDO Security Key** button on the browser is clicked by the purchaser, JavaScript that was loaded earlier in the web page (by *fido_register.phtml*) makes an Asynchronous JavaScript and XML (Extensible Markup Language) (AJAX) call to *Preregistration.php* on the Magento server, which, in turn, invokes *FidoService.php* to call the ***preregister*** web-service operation on the SKCE. SKCE returns a nonce, along with a list of previously registered FIDO Security Keys, if any. If this is the first security key being registered, then this list is empty.

Note: In the FIDO U2F protocol, currently registered security keys, if any, are returned by the FIDO server to safeguard that security keys do not attempt to generate a duplicate key for purchasers on the same device. This implies that manufacturers of FIDO Security Keys must implement logic to ensure that they check for an existing key pair for a purchaser for the specific website. A FIDO Certified Authenticator will always have this logic implemented because it is part of the protocol-conformance testing to achieve the FIDO Certified label.

Figure A-4 Preregistration Part of the FIDO Registration Process


LUMA
FIDO Security Key Registration
Sending Preregistration request to FIDO server. Please wait.
My Dashboard
Account Dashboard
FIDO Security Key Registration
Register a FIDO Security Key to protect your purchases with FIDO strong-authentication
Register FIDO Security Key
Account Information
Contact Information
John Doe
johndoe@testing.com
Newsletters
Compare Products
My Wish List
Address Book
Default Billing Address
Default Shipping Address
JavaScript previously loaded by fido_register.phtml
U2f-api.js
Browser displaying a dialogue during FIDO Registration process
yubico
Preregistration.php
FidoService.php
Magento Open Source Server
Signing Engine
Encryption Engine
LDAP Engine
Key Escrow
Cloud-storage Integration
FIDO Engine
StrongKey CryptoEngine Server

Upon receiving the challenge, the browser and the security key interact with each other by using the *u2f-api.js* library to perform FIDO U2F-specified protocol functions. If the security key does not already have a cryptographic key pair for this specific website domain, then it requires the purchaser to perform an action to prove their presence in front of the computer. Upon the purchaser doing so, it generates a new Elliptic Curve Digital Signature Algorithm (ECDSA) key pair.

The "purchaser action" may be something chosen by the manufacturer of the security key, such as these actions:

- touching a metallic component or pressing a button that has a blinking light-emitting diode
- removing and reinserting a USB-based security key
- bringing a near field communication (NFC)-based security key near the NFC-enabled computer/mobile device
- scanning their finger or iris on a mobile device enabled with biometric capabilities
- additional manufacturer choices

FIDO protocols do not mandate any specific user/purchaser action for testing human presence. Manufacturers are at liberty to choose whatever complies with the protocol.

A.3 Register Function

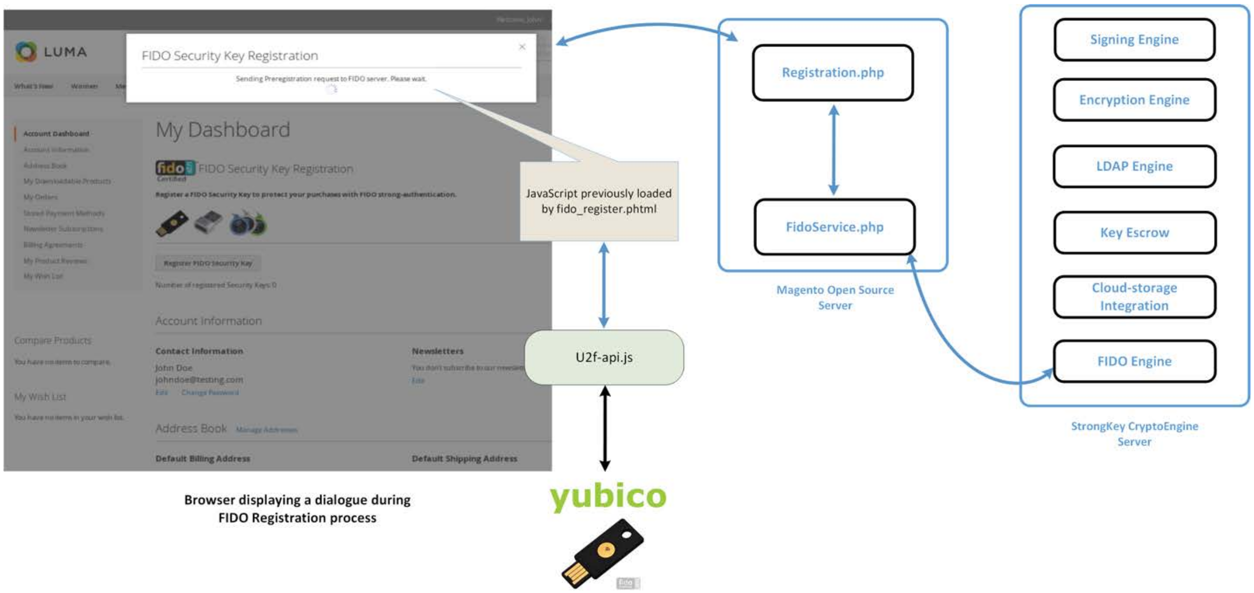
The third and last part of the FIDO registration process generates a new key pair for the purchaser for the specific website domain on the purchaser's FIDO Security Key, digitally signs the challenge from the FIDO U2F server (SKCE), and then submits a package of the response to SKCE for processing.

When the purchaser has "activated" their FIDO Security Key by using the mechanism that the manufacturer designed into the process, the security key generates a new ECDSA key pair, uses the newly generated private key from the key pair to digitally sign the nonce, and assembles a package of information to return to the browser. The browser sends the package to *Registration.php*, which, in turn, sends the package to *FidoService.php*, which finally calls the *register* web-service operation on SKCE to register the newly generated public key with the FIDO server.

During this process, *fido_register.phtml* displays a modal dialogue to notify purchasers of progress and/or error messages, should something go wrong. Any interaction with the modal dialogue, such as closing it, does not affect the operation. The operation continues until it succeeds or fails.

This last step of the registration process is shown in Figure A-5.

Figure A-5 Third and Final Step of the FIDO Registration Process



FIDO Security Key Registration

Sending Preregistration request to FIDO server. Please wait.

A.3.1 The Checkout Process

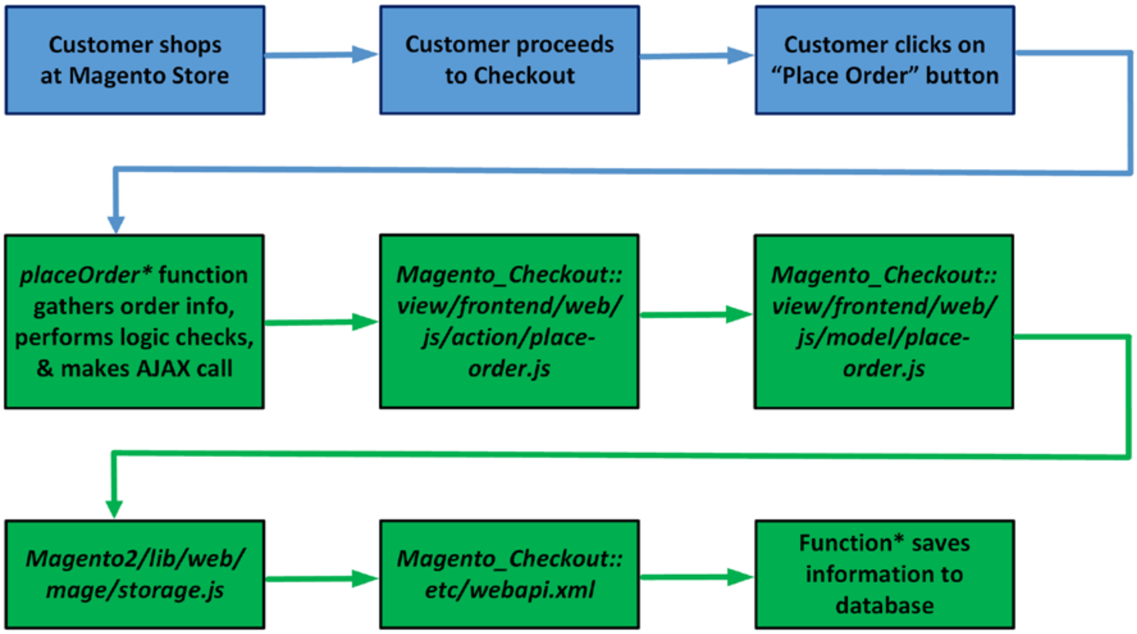
The *FIDOU2FAuthenticator* module must integrate with Magento's default checkout workflow.

Before describing the FIDO authentication process, a brief background of the default checkout workflow is presented below.

1. Purchasers browse the e-commerce website to purchase one or more items.
2. Purchasers place and remove items in and out of their shopping cart until they decide to purchase the items in their shopping cart.
3. Purchasers click **Proceed to Checkout.**
4. At this point, the checkout process requires the purchaser to fill out billing and shipping information and then to click **Place Order.**
5. This causes the browser to run JavaScript code, which makes an AJAX call to submit the shopping cart, billing address, and payment information to the Magento server.
6. The Magento server processes the information and saves it to its database—or returns an error if there is an exception—confirming the conclusion of the transaction.

The checkout workflow is displayed in Figure A-6.

Figure A-6 Magento Checkout Workflow


Customer shops at Magento Store
Customer proceeds to Checkout
Customer clicks on "Place Order" button
*placeOrder** function gathers order info, performs logic checks, & makes AJAX call
Magento_Checkout::view/frontend/web/js/action/place-order.js
Magento_Checkout::view/frontend/web/js/model/place-order.js
Magento2/lib/web/mage/storage.js
Magento_Checkout::etc/webapi.xml
Function* saves information to database

Note: In Figure A-6,

* placeOrder is in Magento_Checkout::view/frontend/web/js/view/payment/default.js

# savePaymentInformationAndPlaceOrder is in Magento_Checkout::PaymentInformationManagement

By understanding the above Magento default checkout workflow, you can better understand how the example implementations' FIDO authentication flow is implemented.

A.3.2 The FIDO Authentication Flow for the Example Implementations

The *FIDOU2FAuthenticator* module, when installed, will inject itself into the workflow described above. The primary modification that FIDO authentication makes to the checkout process is to override the *placeOrder* function of *Magento_Checkout/view/payment/default.js.*

1. The new *placeOrder* function makes an AJAX call to the *RiskAssessor.php* on the Magento server to determine whether FIDO authentication is required (based on this example implementation's rule to check whether the total order is greater than $25).

2. If the total is $25 or less, then the checkout data is sent to the Magento server to be persisted directly without any FIDO actions. However, if the order total exceeds $25, then another AJAX call is made to *FidoService.php* to request a FIDO challenge from SKCE. This is accomplished by *FidoService.php* making a *preauthenticate* web-service request to SKCE, the FIDO U2F server. *FidoService.php* returns the challenge nonce to the calling JavaScript in the customer's browser.

3. Upon receiving the challenge, the browser interacts with *u2f-api.js* to prompt the customer to digitally sign the challenge by using their FIDO Security Key.

4. Once the challenge nonce has been signed by using the FIDO Security Key, the digital signature is appended to checkout data that is normally sent to the Magento server.

5. On the server, where the *Magento_Checkout/Model/PaymentInformationManagement savePaymentInformationAndPlaceOrder* function has been overridden, Magento receives the checkout data and checks again if FIDO authentication is required. This is to ensure that web-service requests to the back-end services are not manipulated to bypass FIDO strong authentication.

6. If FIDO strong authentication is not required, then Magento goes through the standard checkout flow and persists the transaction. If FIDO strong authentication is required, then the overridden code in *PIMOverrideFidoAuthenticate.php* checks for the digital signature bytes appended to the checkout data.

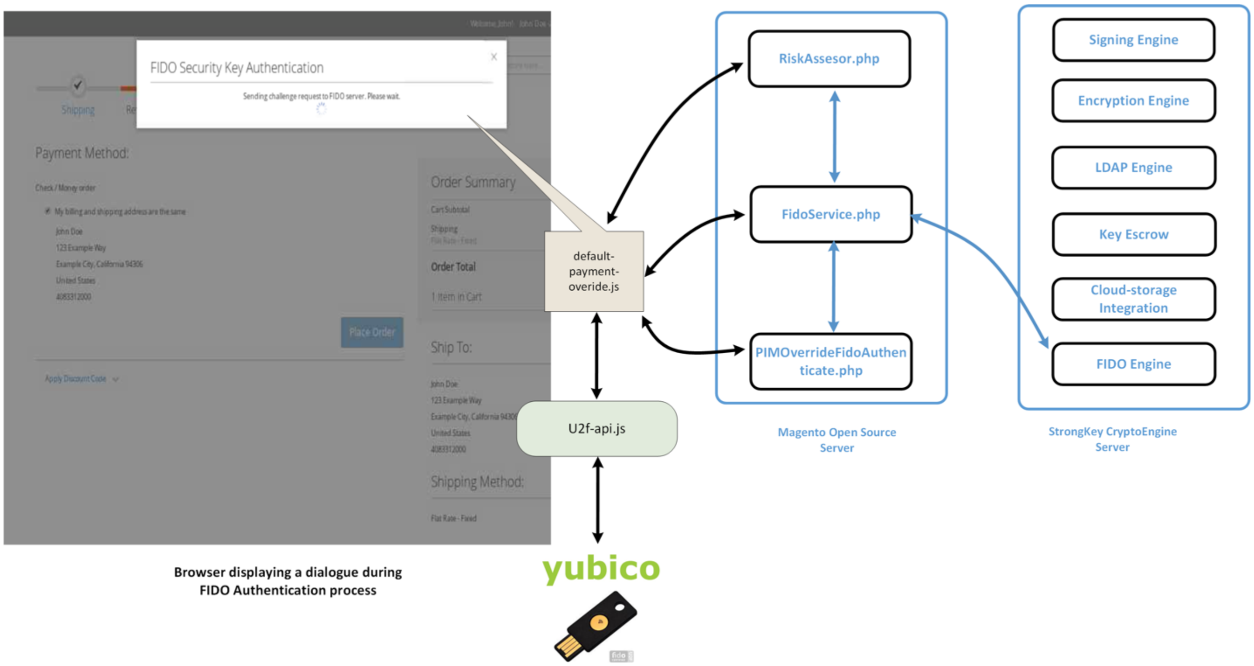
7. If the signature bytes are present, then *PIMOverrideFidoAuthenticate.php* calls the *authenticate* web-service operation (by using *FidoService.php*) on SKCE with the signature bytes.

8. If the *authenticate* web service returns successfully, then *PIMOverrideFidoAuthenticate.php* continues with the checkout process, persists transaction data to the database, and confirms the transaction to the customer. A failed response to the *authenticate* web service returns an error to the customer, and the checkout fails.

In the browser, a modal dialogue provides status messages on the FIDO strong-authentication process executing in the background (if FIDO strong authentication is determined to be necessary); otherwise, the FIDO dialogue does not display itself. As in the FIDO registration workflow, closing the modal dialogue does not stop the FIDO authentication process, and interacting with the browser window in any way does not change the behavior.

Figure A-7 provides an overview of the FIDO authentication process at a high level.

Figure A-7 Overview of the FIDO Authentication Process


FIDO Security Key Authentication
Sending challenge request to FIDO server. Please wait.
Shipping
Payment Method:
Check / Money order
My billing and shipping address are the same
John Doe
123 Example Way
Example City, California 94306
United States
Place Order
Apply Discount Code
Order Summary
Cart Subtotal
Shipping
Order Total
1 Item in Cart
Ship To:
Shipping Method:
Flat Rate - Fixed
default-payment-overide.js
U2f-api.js
yubico
RiskAssesor.php
FidoService.php
PIMOverrideFidoAuthenticate.php
Magento Open Source Server
Signing Engine
Encryption Engine
LDAP Engine
Key Escrow
Cloud-storage Integration
FIDO Engine
StrongKey CryptoEngine Server
Browser displaying a dialogue during FIDO Authentication process

A.3.3 Information About the magfido Files and Directories

This section provides additional information regarding files referenced and/or modified by StrongKey to implement FIDO U2F MFA for these example implementations. If you are familiar with Magento, then you may skip this section; others may find this section to be helpful in understanding what must be done to integrate FIDO U2F into their Magento instance in a production environment.

Magento includes several boilerplate/configuration files: *composer.json* and *registration.php* are those that must be included in every Magento module because they identify the module to the Magento system.

The *etc* folder contains configuration files:

- *module.xml* is a boilerplate file.

- *di.xml* tells Magento to override the default *PaymentInformationManagement.php* file with StrongKey's custom version (named *PIMOverrideFidoAuthenticate.php*).
- *extension_attributes.xml* tells Magento that purchase-transaction data sent to the server may have signature data appended to it, which can be identified by the attribute name *signature*.
- *etc/frontend/di.xml* adds an *AdditionalConfigProvider* that supplies the MFA modal dialogue with the file name *loading.gif*.
- *routes.xml* tells Magento that this module defines controllers that will handle uniform resource locator (URL) requests to fidou2fauthenticator.

The *api* folder contains interface files describing valid functions of the models *FidoService* and *RiskAssessor*. The interface files are named *FidoServiceInterface.php* and *RiskAssessorInterface.php*.

The *block* folder contains server-side logic to generate views displayed by the browser. Specifically, it contains the file *Register.php* that provides the base URL for AJAX calls in the registration workflow and returns the number of security keys registered to the online customer.

The *controller* folder contains controllers to handle AJAX calls from the browser. The controllers map to SKCE web services, such as *preregistration*, *registration*, and *preauthentication*. Because FIDO authentication is part of the checkout process and is performed in conjunction with payment data, an explicit controller for FIDO authentication is not defined here but is included as part of *PIMOverrideFidoAuthentication*. It also contains the *RiskAssessor.php* controller to call the *RiskAssessor.php* code in the *model* folder (see below), which performs the actual risk assessment.

The *model* folder contains the following server-side logic files:

- *AdditionalConfigProvider.php* retrieves the static URL of the *loading.gif* image and adds it to variables for the browser client to deliver a better user experience.
- *FidoService.php* makes the actual web-service calls to the FIDO U2F server, SKCE.
- *RiskAssessor.php* makes the risk decision in this example implementation—to check if the order's total value is greater than $25—and returns a *Boolean* value indicating if FIDO multifactor authentication (MFA) is necessary.
- *PIMOverrideFidoAuthentication.php* implements the server-side logic to check, once again, if FIDO MFA is necessary, checking if signature bytes are appended to payment data, verifying if the supplied digital signature is valid (through *FidoService.php*), and persisting the order transaction.

The *view* folder contains the client-side logic. Because all FIDO-related workflows in this example implementation are intended for customer interaction only, there is a *frontend* folder inside the *view* folder (as opposed to an *adminhtml* folder, which would normally define views for administrators). Within the *frontend* folder, there are four groups of files:

- The first group contains files related to the registration workflow: *layout/customer_account_index.xml* directs Magento to load *templates/fido_register.phtml* above the Recent Orders section of the Customer dashboard in the browser. *fido_register.phtml* coordinates the entire FIDO registration workflow.
- The second group contains files related to the modal dialogue: *layout/checkout_index_index.xml* appends JavaScript from *web/js/view/checkout-modal.js* to JavaScript normally loaded on checkout pages. *checkout-modal.js*, in turn, loads *web/template/checkout-modal.html* with HTML that is rendered on the checkout page.
- The third group of files provides client-side logic to perform FIDO authentication. *requirejs-config.js* is a configuration file to load JavaScript libraries found in *web/js/lib*—including *u2f.js* and *common.js*, which are part of the standard distribution for FIDO U2F from Google for use with the Chrome browser—and overrides the default JavaScript in *Magento_Checkout/js/view/payment/default.js* with *web/js/default-override.js*. The latter file—*default-override.js*—provides client-side logic, including requesting the challenge nonce, getting the challenge nonce digitally signed by the FIDO Security Key, returning the digital signature, and updating the modal dialogue with progress information.
- The last group of files found in the *view/frontend* folder contains image files found in *web/images/*.

A.3.4 Solutions to Common Challenges When Configuring Magento and magfido

The following subsections provide solutions to common challenges when the magfido module is configured with Magento.

A.3.4.1 Code Was Modified but Change Did Not Take Effect

The most common reason for this issue is that Magento's cache was not cleared. Clear the browser cache from the browser's admin console, or open a terminal, change to the Magento directory (*/var/www/html/fidodemo),* and run this command:

```
php bin/magento cache:flush
```

A.3.4.2 Magento Is Unable to Read the WSDL of the FIDO Server

Possible reasons for Magento being unable to read the FIDO server's Web Services Description Language (WSDL), and thus being unable to complete the action, are explained below.

- The Fully Qualified Domain Name of the FIDO server was defined incorrectly. This can be fixed by modifying the WSDL constant in *StrongAuth_FidoValidator/Model/FidoService.php*.
- The FIDO server has a self-signed certificate that Hypertext Transfer Protocol Daemon (HTTPD) does not trust. This can be fixed by adding the self-signed certificate to the trusted certificate store located in */etc/pki/tls/certs/ca-bundle.crt*.

- The Security-Enhanced Linux (SELinux) security policy is blocking the outbound port used by HTTPD to connect to the FIDO server. This can be fixed by disabling SELinux for testing purposes. In production environments, it is recommended that SELinux rules be modified to permit HTTPD to connect to the FIDO server.

A.3.4.3 Error 500 When Attempting to Access the Home Page

This is not a FIDO-related issue but can manifest itself as a Magento-HTTPD misconfiguration. While there are many possible ways that this error can occur, the most common reason is incorrect file permissions. For testing purposes, running the following command should fix the problem to make the Magento home page accessible:

```
cd /var/www/html/fidodemo && find var vendor pub/static pub/media app/etc -type f -
exec chmod 777 {} \; && find var vendor pub/static pub/media app/etc -type d -exec
chmod 777 {} \; && chmod 777 bin/magento
```

In production environments, consider the security ramifications before adjusting permissions to the directory structure and files, and before making modifications. Please note that the command shown above is a concatenation of multiple commands executed as a single command, so either execute them in a single command (as shown above) or execute them as multiple commands in sequence:

```
cd /var/www/html/fidodemo

find var vendor pub/static pub/media app/etc -type f -exec chmod 777 {} \;

find var vendor pub/static pub/media app/etc -type d -exec chmod 777 {} \;

chmod 777 bin/magento
```

Appendix B List of Acronyms

AJAX	Asynchronous JavaScript and XML
API	Application Programming Interface
CentOS	Community Enterprise Operating System
DNS	Domain Name System
ECDSA	Elliptic Curve Digital Signature Algorithm
e-commerce	Electronic Commerce
FIDO	Fast IDentity Online
FQDN	Fully Qualified Domain Name
GB	Gigabyte(s)
HTML	Hypertext Markup Language
HTTPD	Hypertext Transfer Protocol Daemon
HTTPS	Hypertext Transfer Protocol Secure
ID	Identifier
IP	Internet Protocol
IT	Information Technology
JDK	Java Development Kit
JRE	Java Runtime Environment
LAMP	Linux, Apache, MySQL, PHP
LDAP	Lightweight Directory Access Protocol
MFA	Multifactor Authentication
NCCoE	National Cybersecurity Center of Excellence
NFC	Near Field Communication
NIST	National Institute of Standards and Technology
PHP	Hypertext Preprocessor
PIN	Personal Identification Number

QR	Quick Response
RAM	Random Access Memory
SELinux	Security-Enhanced Linux
SKCE	StrongKey CryptoEngine
SP	Special Publication
SPL	Splunk Search Processing Language
SQL	Structured Query Language
SSL	Secure Sockets Layer
TCP	Transmission Control Protocol
TLS	Transport Layer Security
U2F	Universal Second Factor
URI	Uniform Resource Identifier
URL	Uniform Resource Locator
USB	Universal Serial Bus
WSDL	Web Services Description Language
XML	Extensible Markup Language
YUM	Yellowdog Updater Modified

Appendix C Glossary

Authentication
Verifying the identity of a user, process, or device, often as a prerequisite to allowing access to a system's resources [17]

Authenticator
Something the claimant possesses and controls (typically a cryptographic module or password) that is used to authenticate the claimant's identity [17]

Credential
An object or data structure that authoritatively binds an identity–via an identifier or identifiers–and (optionally) additional attributes to at least one authenticator possessed and controlled by a subscriber

While common usage often assumes that the subscriber maintains the credential, these guidelines also use the term to refer to electronic records maintained by the Credential Service Providers that establish binding between the subscriber's authenticator(s) and identity [17].

Credential Service Provider
A trusted entity that issues or registers subscriber authenticators and issues electronic credentials to subscribers. A Credential Service Provider may be an independent third party or issue credentials for its own use [17].

Identity
An attribute, or set of attributes, that uniquely describes a subject within a given context [17]

Multifactor
A characteristic of an authentication system or an authenticator that requires more than one distinct authentication factor for successful authentication. MFA can be performed by using a single authenticator that provides more than one factor or by using a combination of authenticators that provide different factors. The three authentication factors are something you know, something you have, and something you are [17].

Multifactor Authentication (MFA)
An authentication system that requires more than one distinct authentication factor for successful authentication. Multifactor authentication can be performed by using a multifactor authenticator or by using a combination of authenticators that provide different factors. The three authentication factors are something you know, something you have, and something you are [17].

Personal Identification Number
A memorized secret typically consisting of only decimal digits [17]

Private Key The secret part of an asymmetric key pair that is used to digitally sign or decrypt data [17]

Public Key The public part of an asymmetric key pair that is used to verify signatures or encrypt data [17]

Public Key Certificate A digital document issued and digitally signed by the private key of a certificate authority that binds an identifier to a subscriber to a public key. The certificate indicates that the subscriber identified in the certificate has sole control and access to the private key. See also RFC 5280 [17].

Relying Party An entity that relies upon the subscriber's authenticator(s) and credentials or a verifier's assertion of a claimant's identity, typically to process a transaction or grant access to information or a system [17]

Risk The level of impact on organizational operations (including mission, functions, image, or reputation), organizational assets, or individuals resulting from the operation of an information system, given the potential effect of a threat and the likelihood of that threat occurring [18]

Session A persistent interaction between a subscriber and an endpoint, either a relying party or a Credential Service Provider. A session begins with an authentication event and ends with a session termination event. A session is bound by use of a session secret that the subscriber's software (a browser, application, or OS) can present to the relying party or the Credential Service Provider, in lieu of the subscriber's authentication credentials [17].

Single Factor A characteristic of an authentication system or an authenticator that requires only one authentication factor (something you know, something you have, or something you are) for successful authentication [17]

Subscriber A party who has received a credential or authenticator from a Credential Service Provider [17]

Token See Authenticator [17].

Transaction A discrete event between a user and a system that supports a business or programmatic purpose. A government digital system may have multiple categories or types of transactions, which may require separate analysis within the overall digital identity risk assessment [17].

Appendix D References

[1] FIDO Alliance. (n.d.). *Specifications Overview* [Online]. Available: https://fidoalliance.org/specifications/overview/.

[2] FIDO Alliance. (n.d.). FIDO Alliance [Online]. Available: https://fidoalliance.org/.

[3] StrongKey. (n.d.). Home–StrongKey [Online]. Available: https://www.strongkey.com/.

[4] Magento, Inc. (n.d.). *eCommerce Platform|Best eCommerce Software for Selling Online* [Online]. Available: https://magento.com/.

[5] Magento, Inc. (n.d.). *Magento Open Source* [Online]. Available: https://magento.com/products/open-source.

[6] A. Noor and A. de Leon. (Feb. 20, 2018). *FIDO U2F Integration for Magento 2* [Online]. Available: https://sourceforge.net/projects/magfido/?source=navbar.

[7] RSA. (n.d.). *RSA|Security Solutions to Address Cyber Threats* [Online]. Available: https://www.rsa.com/.

[8] RSA Security LLC. (n.d.). *Adaptive Authentication|Fraud Detection–RSA* [Online]. Available: https://www.rsa.com/en-us/products/fraud-prevention/secure-consumer-access.

[9] TokenOne. (n.d.). *TokenOne|Secure Authentication|Sydney* [Online]. Available: https://www.tokenone.com.

[10] Splunk Inc. (n.d.). Splunk [Online]. Available: https://www.splunk.com/.

[11] Splunk Inc. (n.d.). *Splunk® Enterprise* [Online]. Available: https://www.splunk.com/en_us/products/splunk-enterprise.html.

[12] Splunk Inc. (n.d.). *Splunk® Universal Forwarder: Forwarder Manual* [Online]. Available: http://docs.splunk.com/Documentation/Forwarder/7.0.2/Forwarder/Abouttheuniversalforwarder.

[13] Splunk Inc. (n.d.). *Splunk DB Connect* [Online]. Available: https://splunkbase.splunk.com/app/2686/.

[14] Splunk Inc. (n.d.). *Splunk DB Connect Details* [Online]. Available: https://splunkbase.splunk.com/app/2686/#/details.

[15] Yubico. (n.d.). *Yubico NEO* [Online]. Available: https://www.yubico.com/products/yubikey-hardware/.

[16] Yubico. (n.d.). *Yubico|YubiKey Strong Two Factor Authentication for Business and Individual Use* [Online]. Available: https://www.yubico.com/.

[17] National Institute of Standards and Technology (NIST) Special Publication 800-63-3, *Digital Identity Guidelines.* (June 2017). [Online]. Available: https://pages.nist.gov/800-63-3/.

[18] NIST Interagency/Internal Report 7298, Rev. 2, *Glossary of Key Information Security Terms.* (May 2013). [Online]. Available: https://www.nist.gov/publications/glossary-key-information-security-terms-1.