NIST SPECIAL PUBLICATION 1800-13C

Mobile Application Single Sign-On

Improving Authentication for Public Safety First Responders

Volume C:
How-To Guides

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April 2018

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National Institute of Standards and Technology Special Publication 1800-13C, Natl. Inst. Stand. Technol. Spec. Publ. 1800-13C, 163 pages, (April 2018), CODEN: NSPUE2

FEEDBACK

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

Comments on this publication may be submitted to: psfr-nccoe@nist.gov.

Public comment period: April 16, 2018 through June 18, 2018

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NATIONAL CYBERSECURITY CENTER OF EXCELLENCE

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NIST CYBERSECURITY PRACTICE GUIDES

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

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

ABSTRACT

On-demand access to public safety data is critical to ensuring that public safety and first responder (PSFR) personnel can deliver the proper care and support during an emergency. This requirement necessitates heavy reliance on mobile platforms while in the field, which may be used to access sensitive information, such as personally identifiable information (PII), law enforcement sensitive (LES) information, or protected health information (PHI). However, complex authentication requirements can hinder the process of providing emergency services, and any delay—even seconds—can become a matter of life or death.

In collaboration with NIST'S Public Safety Communications Research lab (PSCR) and industry stakeholders, the NCCoE aims to help PSFR personnel to efficiently and securely gain access to mission data via mobile devices and applications (apps). This practice guide describes a reference design for multifactor authentication (MFA) and mobile single sign-on (MSSO) for native and web apps, while improving interoperability between mobile platforms, apps, and identity providers, irrespective of the app development platform used in their construction. This NCCoE practice guide details a collaborative effort between the NCCoE and technology providers to demonstrate a standards-based approach using commercially available and open-source products.

This guide discusses potential security risks facing organizations, benefits that may result from the implementation of an MFA/MSSO system, and the approach that the NCCoE took in developing a reference architecture and build. This guide includes a discussion of major architecture design considerations, an explanation of the security characteristics achieved by the reference design, and a mapping of the security characteristics to applicable standards and security control families.

For parties interested in adopting all or part of the NCCoE reference architecture, this guide includes a detailed description of the installation, configuration, and integration of all components.

KEYWORDS

access control; authentication; authorization; identity; identity management; identity provider; single sign-on; relying party

ACKNOWLEDGMENTS

We are grateful to the following individuals for their generous contributions of expertise and time.

Name	Organization
Donna Dodson	NIST NCCoE
Tim McBride	NIST NCCoE
Jeff Vettraino	FirstNet
FNU Rajan	FirstNet
John Beltz	NIST Public Safety Communications Research Lab
Chris Leggett	Ping Identity

Name	Organization
Paul Madsen	Ping Identity
John Bradley	Yubico
Adam Migus	Yubico
Derek Hanson	Yubico
Adam Lewis	Motorola Solutions
Mike Korus	Motorola Solutions
Dan Griesmann	Motorola Solutions
Arshad Noor	StrongAuth
Pushkar Marathe	StrongAuth
Max Smyth	StrongAuth
Scott Wong	StrongAuth
Akhilesh Sah	Nok Nok Labs
Avinash Umap	Nok Nok Labs

The Technology Partners/Collaborators who participated in this build submitted their capabilities in response to a notice in the Federal Register. Respondents with relevant capabilities or product components were invited to sign a Cooperative Research and Development Agreement (CRADA) with NIST, allowing them to participate in a consortium to build this example solution. We worked with:

Technology Partner/Collaborator	Build Involvement
Ping Identity	Federation Server

Technology Partner/Collaborator	Build Involvement
Motorola Solutions	Mobile Apps
Yubico	External Authenticators
Nok Nok Labs	Fast Identity Online (FIDO) Universal Authentication Framework (UAF) Server
StrongAuth	FIDO Universal Second Factor (U2F) Server

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1 Introduction

The following guide demonstrates a standards-based example solution for efficiently and securely gaining access to mission-critical data via mobile devices and applications (apps). This guide demonstrates multifactor authentication (MFA) and mobile single sign-on (MSSO) solutions for native and web apps using standards-based commercially available and open-source products. We cover all of the products that we employed in our solution set. We do not recreate the product manufacturer's documentation. Instead, we provide pointers to where this documentation is available from the manufacturers. This guide shows how we incorporated the products together in our environment as a reference implementation of the proposed build architecture for doing MSSO.

Note: This is not a comprehensive tutorial. There are many possible service and security configurations for these products that are out of scope for this reference solution set.

1.1 Practice Guide Structure

This National Institute of Standards and Technology (NIST) Cybersecurity Practice Guide demonstrates a standards-based example solution and provides users with the information they need to replicate this approach to implementing our MSSO build. The example solution is modular and can be deployed in whole or in parts.

This guide contains three volumes:

- NIST SP 1800-13A: *Executive Summary*
- NIST SP 1800-13B: *Approach, Architecture, and Security Characteristics* – what we built and why
- NIST SP 1800-13C: *How-To Guides* – instructions for building the example solution **(you are here)**

See Section 2 in Volume B of this guide for a more detailed overview of the different volumes and sections, and the audiences that may be interested in each.

1.2 Build Overview

The National Cybersecurity Center of Excellence (NCCoE) worked with its build team partners to create a lab demonstration environment that includes all of the architectural components and functionality described in Section 4 of Volume B of this build guide. This includes mobile devices with sample apps, hardware and software-based authenticators to demonstrate the Fast Identity Online (FIDO) standards for MFA, the authentication server and authorization server (AS) components required to demonstrate the AppAuth authorization flows (detailed in Internet Engineering Task Force [IETF] Request for Comments [RFC] 8252) with federated authentication to a Security Assertion Markup Language (SAML) Identity Provider (IdP) and an OpenID Connect (OIDC) Provider. The complete build includes several

systems deployed in the NCCoE lab by StrongAuth, Yubico and Ping Identity as well as cloud-hosted resources made available by Motorola Solutions and by Nok Nok Labs.

This section of the build guide documents the build process and specific configurations that were used in the lab.

1.2.1 Usage Scenarios

The build architecture supports three usage scenarios. The scenarios all demonstrate single sign-on (SSO) among Motorola Solutions Public Safety Experience (PSX) apps using the AppAuth pattern, but differ in the details of the authentication process. The three authentication mechanisms are as follows:

- The OAuth AS directly authenticates the user with FIDO Universal Authentication Framework (UAF); user accounts are managed directly by the service provider.
- The OAuth AS redirects the user to a SAML IdP, which authenticates the user with a password and FIDO U2F.
- The OAuth AS redirects the user to an OIDC IdP, which authenticates the user with FIDO UAF.

In all three scenarios, once the authentication flow is completed, the user can launch multiple Motorola Solutions PSX apps without additional authentication, demonstrating SSO. These three scenarios were chosen to reflect different real-world implementation options that public safety and first responder (PSFR) organizations might choose. Larger PSFR organizations may host (or obtain from a service provider) their own IdPs, enabling them to locally manage user accounts, group memberships, and other user attributes, and to provide them to multiple Relying Parties (RPs) through federation. SAML is currently the most commonly used federation protocol, but OIDC might be preferred for new implementations. As demonstrated in this build, RPs can support both protocols more or less interchangeably. For smaller organizations, a service provider might also act in the role of “identity provider of last resort,” maintaining user accounts and attributes on behalf of organizations.

1.2.2 Architectural Overview

Figure 1-1 shows the lab build architecture.

Figure 1-1 Lab Build Architecture

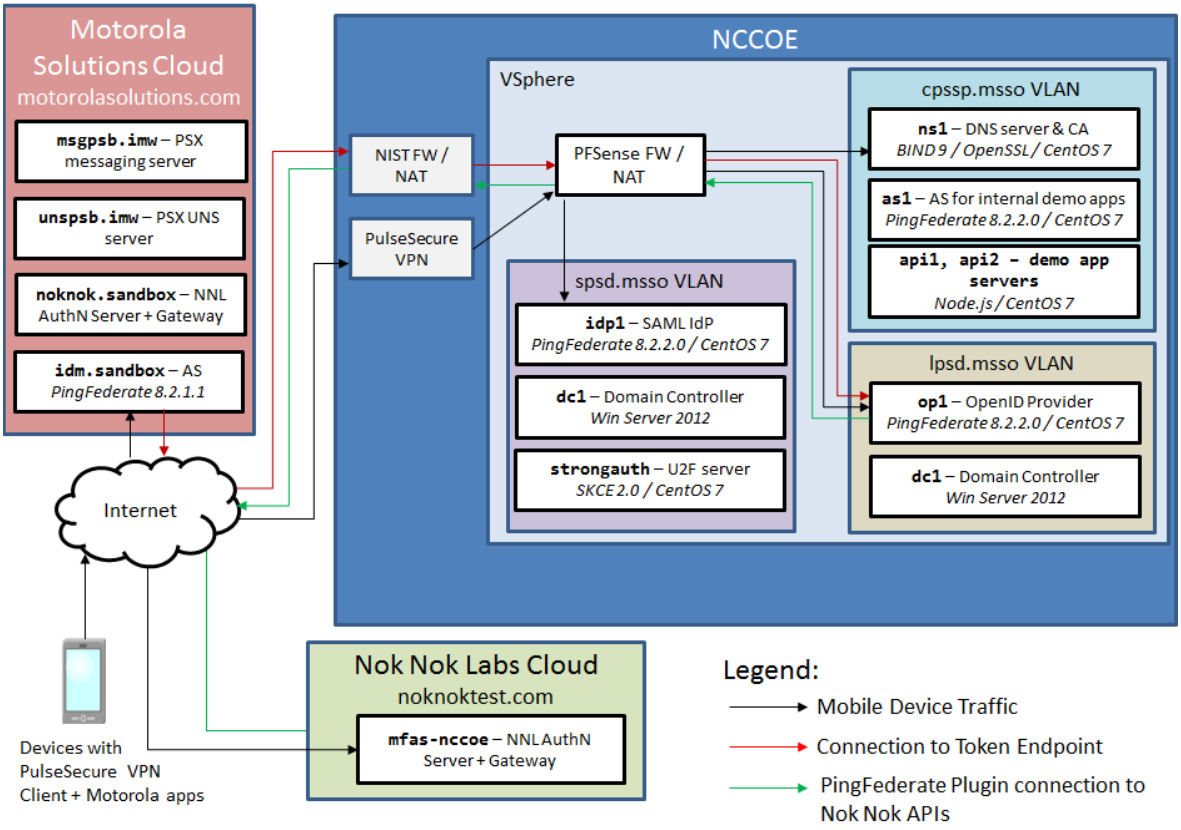


Figure 1-1 depicts the four environments that interact in the usage scenarios:

- Motorola Solutions cloud – a cloud-hosted environment providing the back-end app servers for the Motorola Solutions PSX Mapping and Messaging apps, as well as an OAuth AS that the app servers use to authorize requests from mobile devices
- Nok Nok Labs cloud – a cloud-hosted server running both the Nok Nok Authentication Server (NNAS) and the Nok Nok Labs Gateway
- NCCoE – the NCCoE lab, including several servers hosted in a vSphere environment running the IdPs and directory services that would correspond to PSFR organizations' infrastructure to support federated authentication to a service provider, like Motorola Solutions. An additional AS and some demonstration app back-ends are also hosted in the NCCoE lab for internal testing.
- mobile devices connected to public cellular networks with the required client software to authenticate to, and access, Motorola Solutions back-end apps and the NCCoE Lab systems

The names of the Virtual Local Area Networks (VLANs) in the NCCoE lab are meant to depict different organizations participating in an MSSO scheme:

- SPSD – State Public Safety Department, a PSFR organization with a SAML IdP
- LPSD – Local Public Safety Department, a PSFR organization with an OIDC IdP
- CPSSP – Central Public Safety Service Provider, a Software as a Service (SaaS) provider serving the PSFR organizations, analogous to Motorola Solutions

The fictitious *.msso* top-level domain is simply a reference to the MSSO project. The demonstration apps hosted in the CPSSP VLAN were used to initially test and validate the federation setups in the user organization; this guide mainly focuses on the integration with the Motorola Solutions AS and app back-end.

The arrows in Figure 1-1 depict traffic flows between the three different environments, to illustrate the networking requirements for cross-organizational MSSO flows. This diagram does not depict traffic flows within environments (e.g., between the IdPs and the Domain Controllers providing directory services). The depicted traffic flows are described below:

- Mobile device traffic – The PSX client apps on the device connect to the publicly-routable PSX app servers in the Motorola Solutions cloud. The mobile browser also connects to the Motorola Solutions AS, and, in the federated authentication scenarios, the browser is redirected to the IdPs in the NCCoE Lab. The mobile devices use the Pulse Secure Virtual Private Network (VPN) client to access internal lab services through Network Address Translation (NAT) addresses established on the pfSense firewall. This enables the use of the internal lab Domain Name System (DNS) server to resolve the hostnames under the *.msso* top-level domain, which is not actually registered in public DNS. To support UAF authentication at the lab-hosted OIDC IdP, the Nok Nok Passport app on the devices also connects to the publicly routable NNAS instance hosted in the Nok Nok Labs cloud environment.
- Connection to Token Endpoint – The usage scenario where the Motorola Solutions AS redirects the user to the OIDC IdP in the lab requires the AS to initiate an inbound connection to the IdP's Token Endpoint. To enable this, the PingFederate run-time port, 9031, is exposed via NAT through the NIST firewall. Note that no inbound connection is required in the SAML IdP integration, as the SAML web browser SSO does not require direct back-channel communication between the AS and the IdP. SAML authentication requests and responses are transmitted through browser redirects.
- PingFederate plugin connection to Nok Nok Application Programming Interfaces (APIs) – To support UAF authentication, the OIDC IdP includes a PingFederate adapter developed by Nok Nok Labs that needs to connect to the APIs on the NNAS.

In a typical production deployment, the NNAS would not be directly exposed to the internet; instead, mobile client interactions with the Authentication Server APIs would traverse a reverse proxy server. Nok Nok Labs provided a cloud instance of their software as a matter of expedience in completing the lab build.

Additionally, the use of a VPN client on mobile devices is optional. Many organizations directly expose their IdPs to the public internet, though some organizations prefer to keep those services internal and use a VPN to access them. Organizations can decide this based on their risk tolerance, but this build architecture can function with or without a VPN client on the mobile devices.

1.2.3 General Infrastructure Requirements

Some general infrastructure elements must be in place to support the components of this build guide. These are assumed to exist in the environment prior to the installation of the architecture components in this guide. The details of how these services are implemented are not directly relevant to the build.

- DNS – All server names are expected to be resolvable in DNS. This is especially important for FIDO functionality, as the application identification (App ID) associated with cryptographic keys is derived from the hostname used in app Uniform Resource Locators (URLs).
- Network Time Protocol (NTP) – Time synchronization among servers is important. A clock difference of five minutes or more is sufficient to cause JavaScript Object Notation (JSON) Web Token (JWT) validation, for example, to fail. All servers should be configured to synchronize time with a reliable NTP source.
- Certificate Authority (CA) – Hypertext Transfer Protocol Secure (HTTPS) connections should be used throughout the architecture. Transport Layer Security (TLS) certificates are required for all servers in the build. If an in-house CA is used to issue certificates, the root and any intermediate certificates must be provisioned to the trust stores in client mobile devices and servers.

1.3 Typographic Conventions

The following table presents typographic conventions used in this volume.

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

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

2 How to Install and Configure the Mobile Device

This section covers all of the different aspects of installing and configuring the mobile device. There are several prerequisites and different components that need to work in tandem for the entire SSO architecture to work.

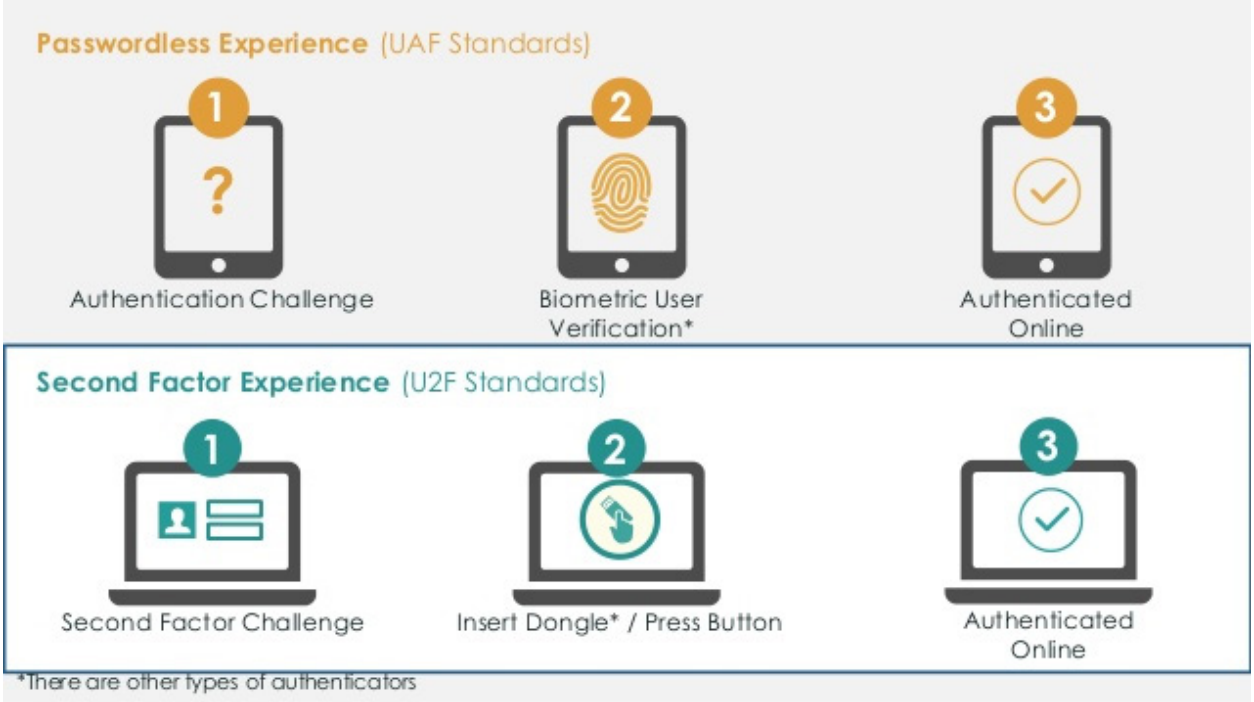
2.1 Platform and System Requirements

This section covers requirements for mobile devices—both hardware and software—for the SSO and FIDO authentication components of the architecture to work properly. The two dominant mobile platforms are Google's Android and Apple's iPhone operating system (iOS). The NCCoE reference architecture only tested Android devices and apps, but the same core architecture could support iOS.

First, for SSO support, the NCCoE reference architecture follows the guidance of the *OAuth 2.0 for Native Apps* Best Current Practice (BCP) [1]. That guidance, also known as *AppAuth*, requires that developers use an *external user-agent* (e.g., Google's Chrome for Android web browser) instead of an *embedded user-agent* (e.g., an Android WebView) for their OAuth authorization requests. Because of this, the mobile platform must support the use of external user-agents.

Second, for FIDO support, this architecture optionally includes two different types of authenticators: UAF and U2F. The *FIDO Specifications Overview* presentation [2] explains the difference, as shown in Figure 2-1.

Figure 2-1 Comparison of UAF and U2F Standards



The following subsections address Android-specific requirements to support SSO and FIDO authentication.

2.1.1 Supporting SSO

While it is not strictly required, the BCP recommends that the device provide an external user-agent that supports "in-app browser tabs," which Google describes as the *Android Custom Tab* feature. The following excerpt is from the AppAuth Android-specific guidance in Appendix B.2 of RFC 8252:

> *Apps can initiate an authorization request in the browser without the user leaving the app, through the Android Custom Tab feature which implements the in-app browser tab pattern. The user's default browser can be used to handle requests when no browser supports Custom Tabs.*
>
> *Android browser vendors should support the Custom Tabs protocol (by providing an implementation of the "CustomTabsService" class), to provide the in-app browser tab user experience optimization to their users. Chrome is one such browser that implements Custom Tabs.*

Any device manufacturer can support Custom Tabs in their Android browser. However, Google implemented this in its Chrome for Android web browser in September 2015 [3]. Because Chrome is not part of the operating system (OS) itself, but is downloaded from the Google Play Store, recent versions

of Chrome can be used on older versions of Android. In fact, the Chrome Developer website's page on Chrome Custom Tabs [4] states that it can be used on Android Jelly Bean (4.1), which was released in 2012, and up.

To demonstrate SSO, the NCCoE reference architecture utilizes the Motorola Solutions PSX App Suite, which requires Android Lollipop (5.0) or newer.

2.1.2 Supporting FIDO U2F

The device will need the following components for FIDO U2F:

- a web browser capable of understanding a U2F challenge request from an IdP
- a FIDO U2F client app capable of handling the challenge
- Near Field Communication (NFC) hardware support

Chrome for Android [5] is a browser that understands U2F challenge requests, and Google Authenticator [6] (works on Android Gingerbread [2.3.3] and up) is an app capable of handling the challenge. If NFC is unavailable, Bluetooth and Universal Serial Bus Type-C (USB-C) are also options for connecting U2F tokens. Google has added support for both options into their Play Services framework, as of November 2017. However, these other methods are less widely used and are not a focus of this guide.

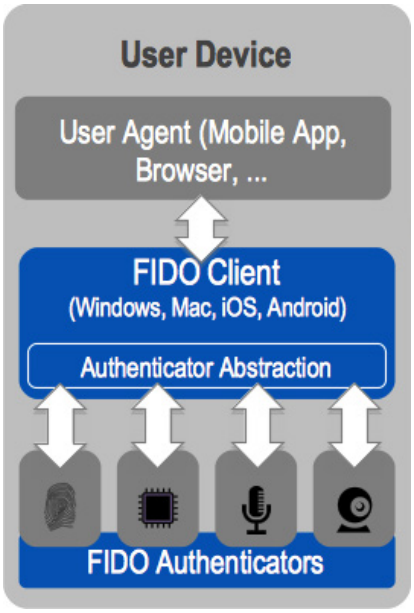
2.1.3 Supporting FIDO UAF

The device will need the following components for FIDO UAF:

- a web browser
- a FIDO UAF client app capable of handling the challenge
- a FIDO UAF authenticator

These components are pictured in Figure 2-2, which is from the *FIDO UAF Architectural Overview* [7].

363 **Figure 2-2 FIDO UAF Architectural Overview**



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365 While the overview refers to the last two components (client and authenticator) as separate
366 components, these components can—and often do—come packaged in a single app. The NCCoE
367 reference architecture utilizes the Nok Nok Passport [8] app to provide these two components. In
368 addition to the apps, the device will need to provide some hardware component to support the FIDO
369 UAF authenticator. For example, for biometric-based FIDO UAF authenticators, a camera would be
370 needed to support face or iris scanning, a microphone would be needed to support voiceprints, and a
371 fingerprint sensor would be needed to support fingerprint biometrics. Of course, if a Personal
372 Identification Number (PIN) authenticator is used, a specific hardware sensor is not required. Beyond
373 the actual input method of the FIDO UAF factor, additional (optional) hardware considerations for a UAF
374 authenticator include secure key storage for registered FIDO key pairs, storage of biometric templates,
375 and execution of matching functions (e.g., within dedicated hardware or on processor trusted execution
376 environments [TEE]).

377 2.2 How to Install and Configure the Mobile Apps

378 This section covers the installation and configuration of the mobile apps needed for various components
379 of the reference architecture: SSO, FIDO U2F, and FIDO UAF.

380 2.2.1 How to Install and Configure SSO-Enabled Apps

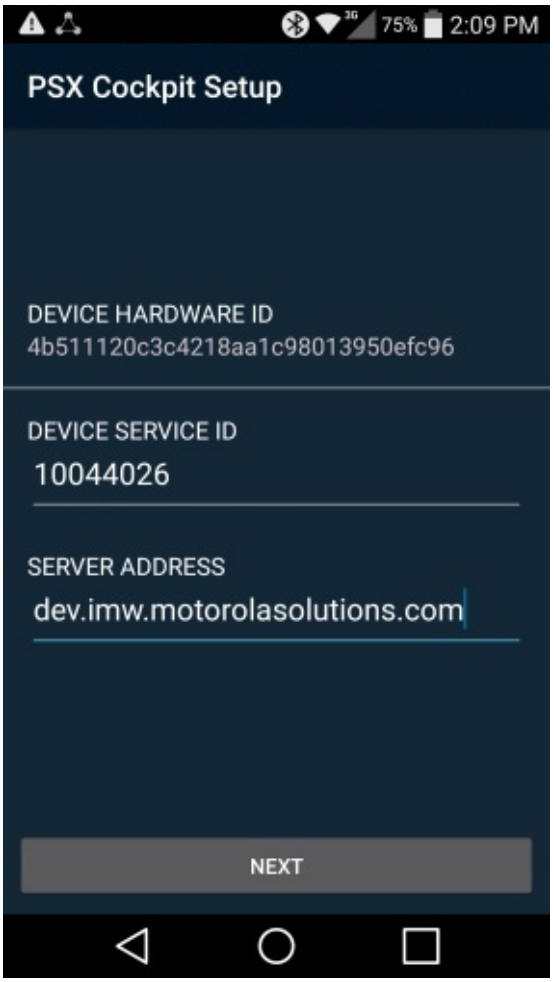
381 For SSO-enabled apps, there is no universal set of installation and configuration procedures; these will
382 vary depending on the design choices of the app manufacturer. The NCCoE reference architecture uses
383 the *Motorola Solutions PSX App Suite* [9] Version 5.4. This set of mobile apps provides several

capabilities for the public safety community. Our setup consisted of three apps: *PSX Messenger* for text, photo, and video communication; *PSX Mapping* for shared location awareness; and *PSX Cockpit* to centralize authentication and identity information across the other apps. These apps cannot be obtained from a public venue (e.g., the Google Play Store); rather, the binaries must be obtained from Motorola Solutions and installed via other means, such as a Mobile Device Management (MDM) solution or private app store.

2.2.1.1 Configuring the PSX Cockpit App

1. Open the Cockpit app. Your screen should look like Figure 2-3.

Figure 2-3 PSX Cockpit Setup

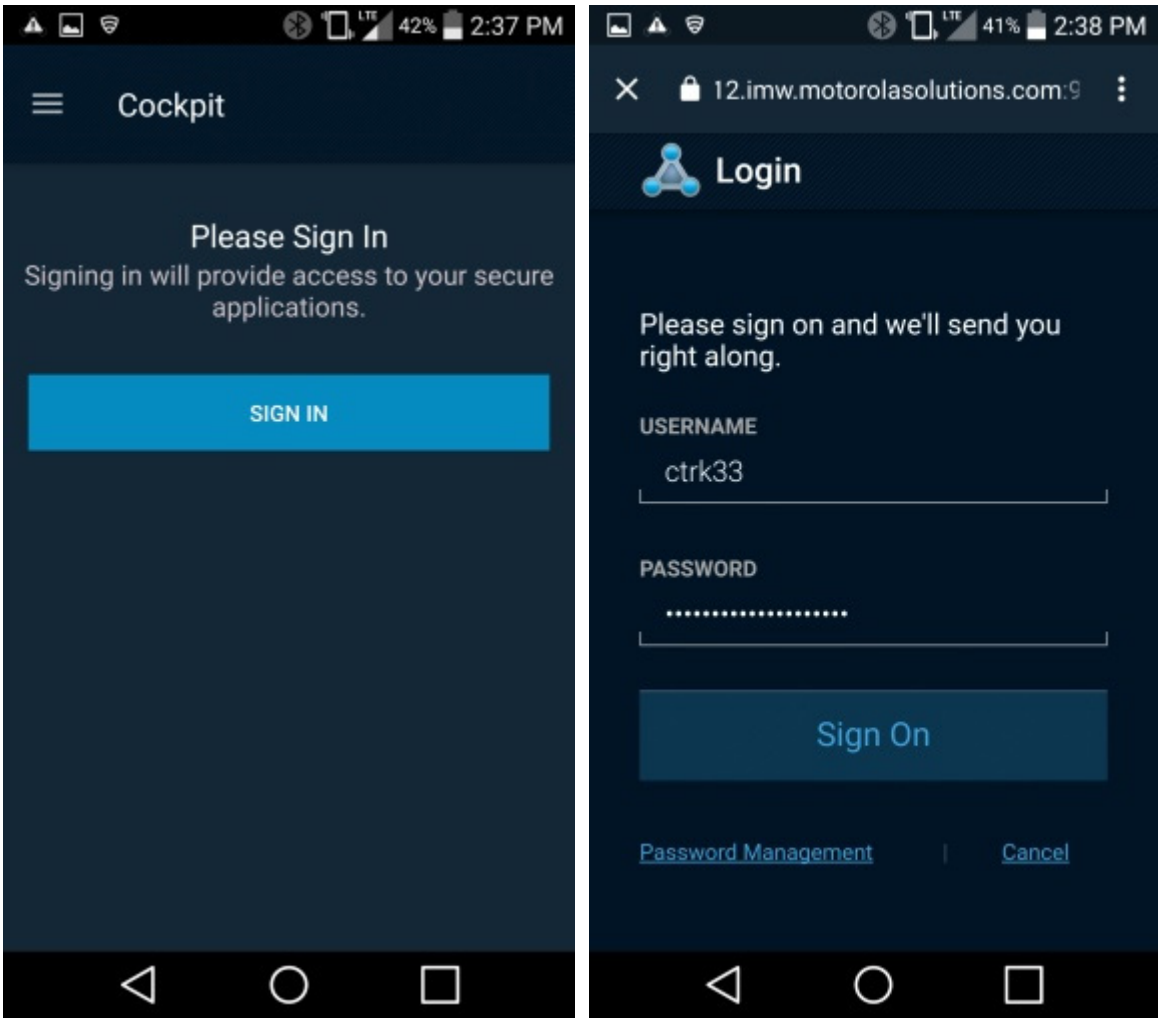


2. For **DEVICE SERVICE ID**, select a Device Service ID in the range given to you by your administrator. Note that these details would be provided by Motorola Solutions if you are using

their service offering, or by your administrator if you are hosting the PSX app servers in your own environment. Each device should be configured with a unique Device Service ID corresponding to the username from the username range. For example, the NCCoE lab used a Device Service ID of "22400" to correspond to a username of "2400."

3. For **SERVER ADDRESS**, use the Server Address given to you by your administrator. For example, the NCCoE lab used a Server Address of "uns5455.imw.motorolasolutions.com."
4. If a **Use SUPL APN** checkbox appears, leave it unchecked.
5. Tap **NEXT**. Your screen should look like Figure 2-4.

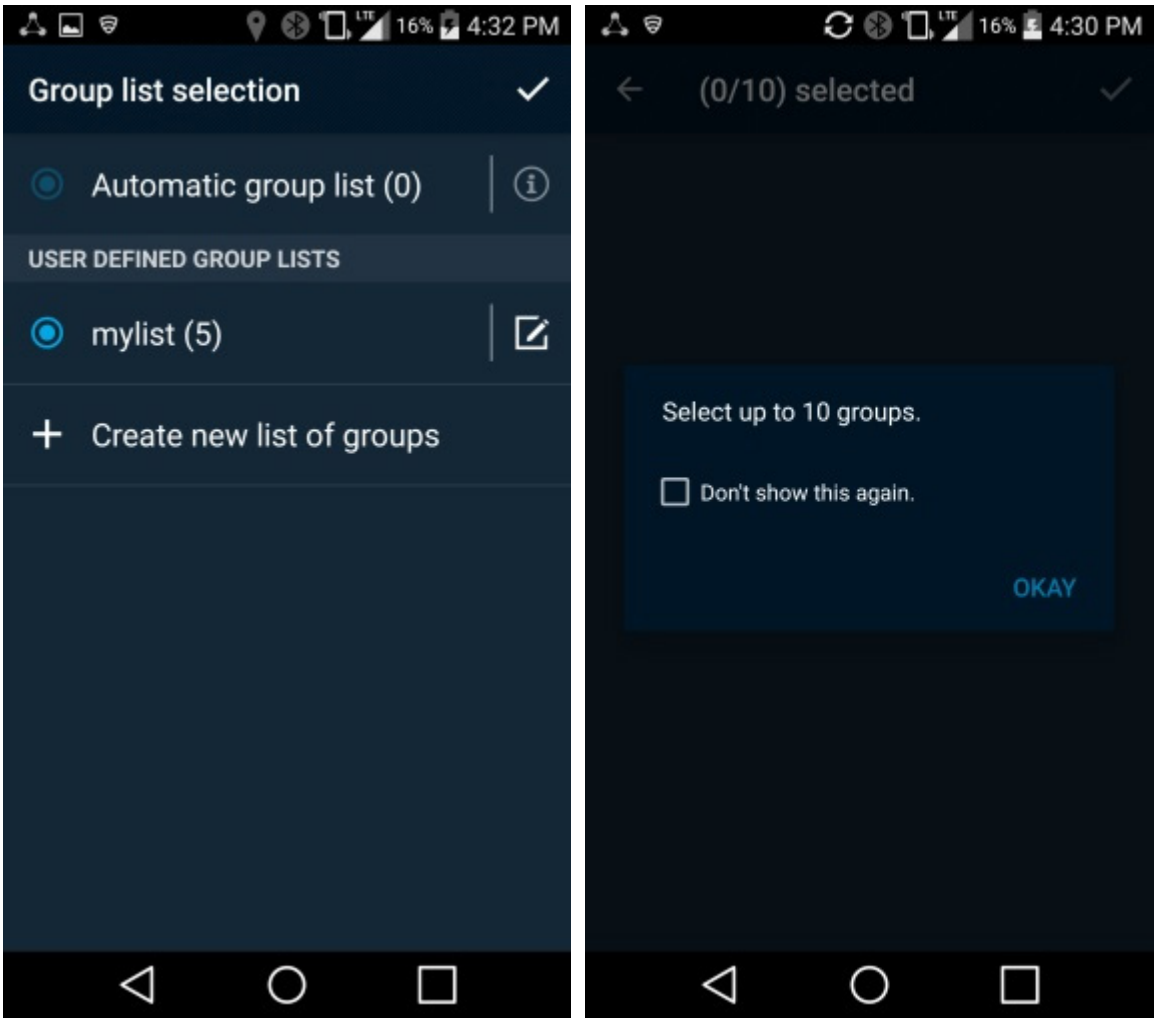
Figure 2-4 PSX Cockpit Setup, Continued



6. Tap **SIGN IN**.

7. Log in with the authentication procedure determined by the AS and IdP policies. Note that if UAF is used, a FIDO UAF authenticator must be enrolled before this step can be completed. See Section 2.2.3 for details on FIDO UAF enrollment. After you log in, your screen should look like Figure 2-5.

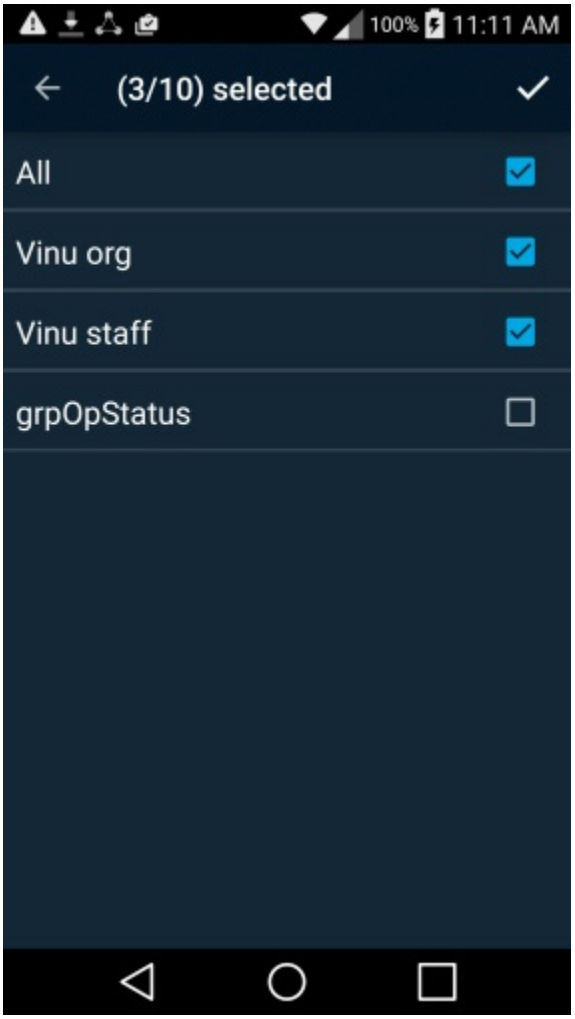
Figure 2-5 PSX Cockpit Group List Selection



8. Tap **Create new list of groups**. This is used to select which organizationally-defined groups of users you can receive data updates for in the other PSX apps.

9. Tap **OKAY**. Your screen should look like Figure 2-6.

416 **Figure 2-6 PSX Cockpit Groups**

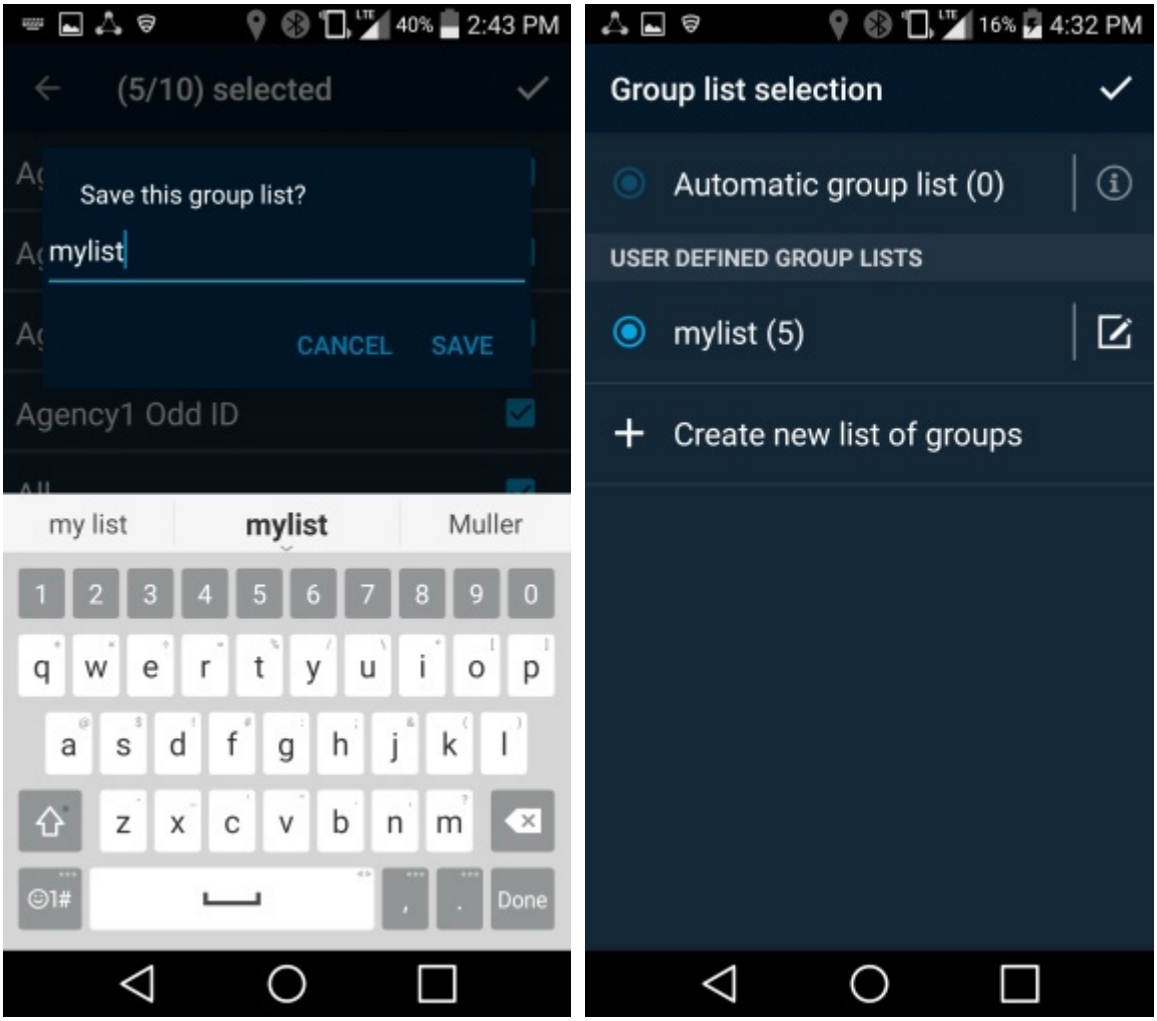


417

418 10. Check the checkboxes for the groups that you wish to use. Note that it may take a short time for
419 the groups to appear.

420 11. Tap on the upper-right checkmark. Your screen should look like Figure 2-7.

421 **Figure 2-7 PSX Cockpit Group List Setup Complete**

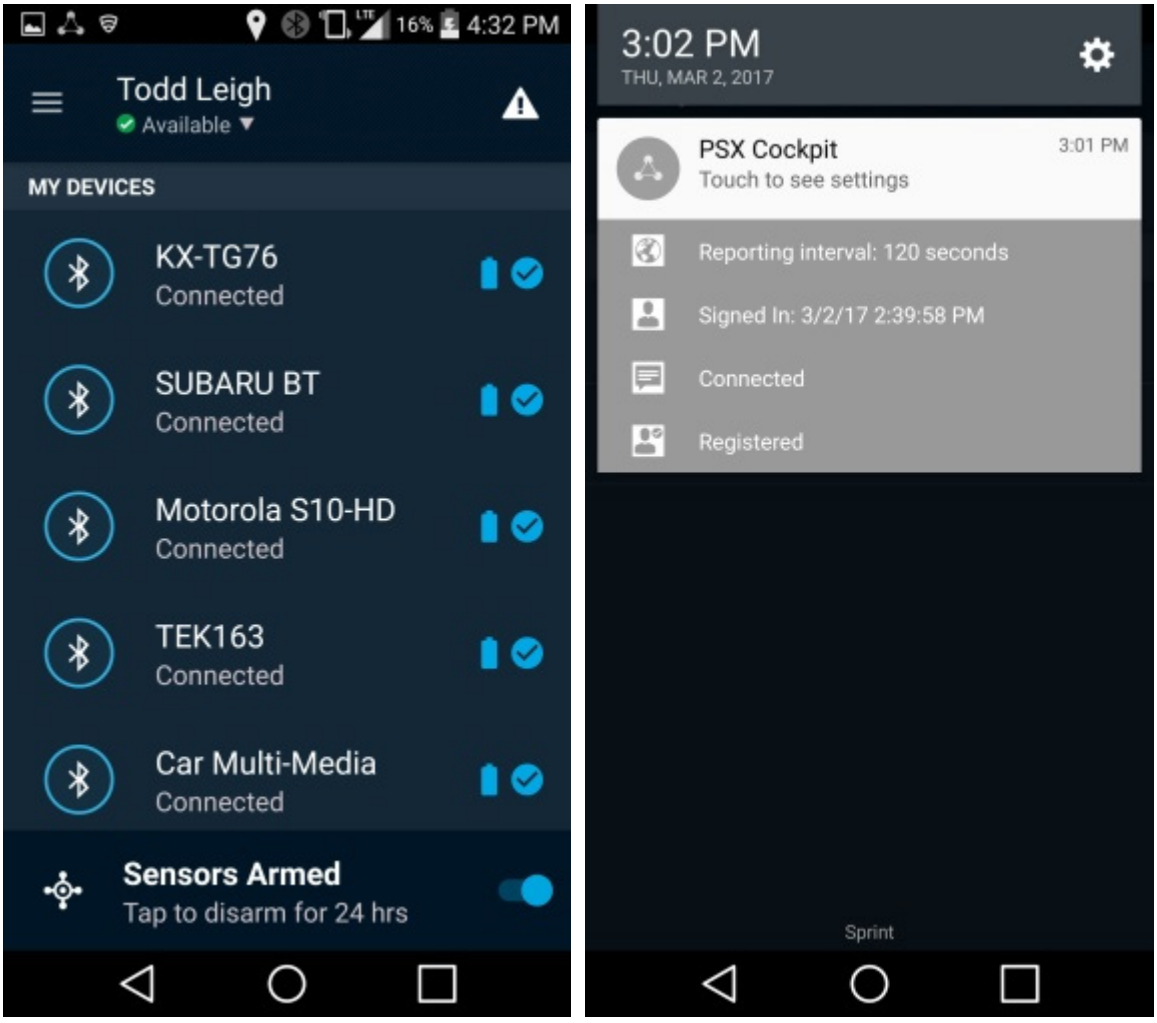


422

423 12. Enter a group list name (e.g., “mylist”), and tap **SAVE**.

424 13. Tap the upper-right checkmark to select the list. Your screen should look like Figure 2-8.

425 **Figure 2-8 PSX Cockpit User Interface**



426

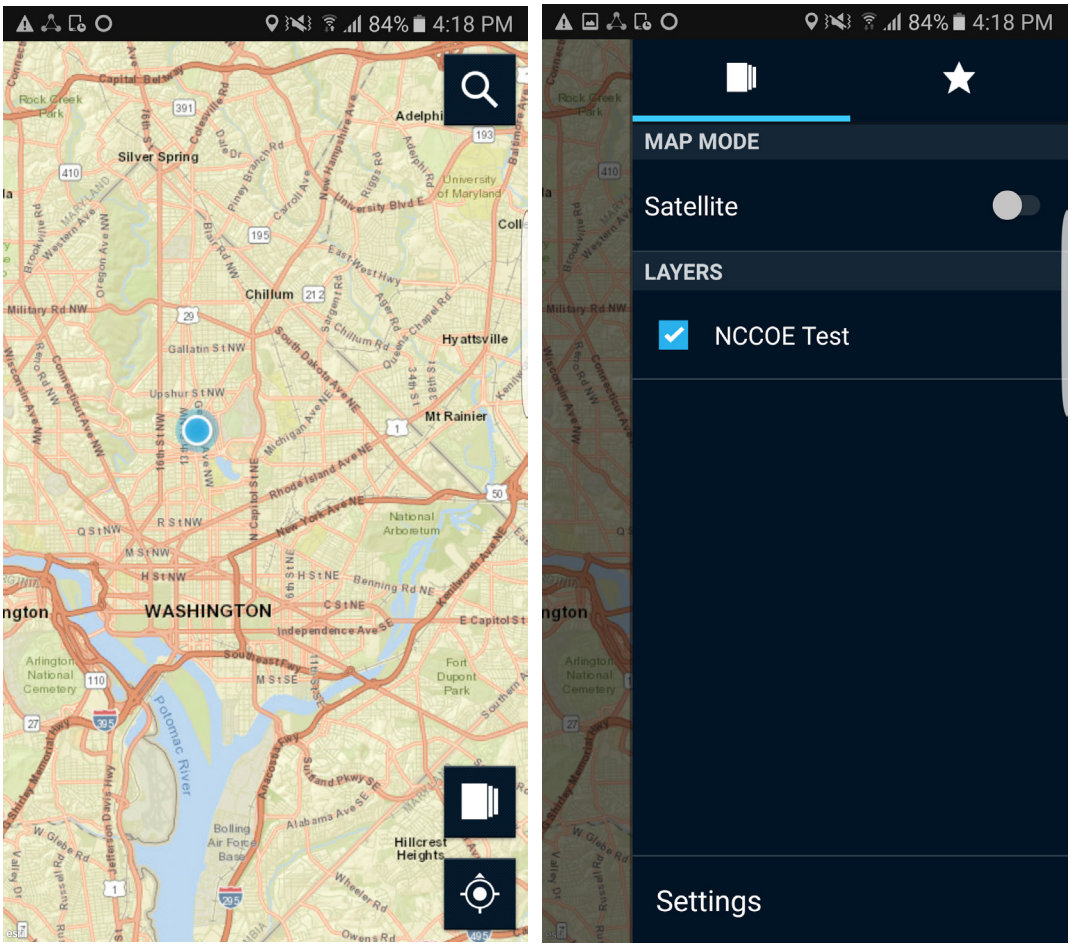
427 14. On the Cockpit screen, you can trigger an emergency (triangle icon in the upper right); set your
428 status (drop-down menu under your name); or reselect roles and groups, see configuration, and
429 sign off (hamburger menu to the left of your name, and then tap **username**).

430 15. If you pull down your notifications, you should see icons and text indicating “Reporting interval:
431 120 seconds,” “Signed In: <date> <time>,” “Connected,” and “Registered.”

2.2.1.2 Configuring the PSX Mapping App

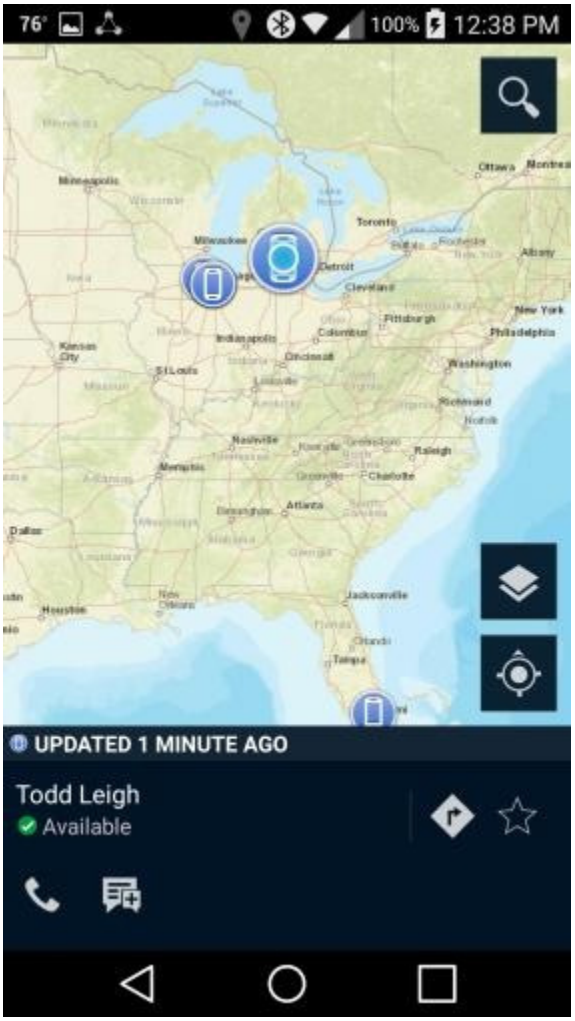
1. Open the Mapping app. You should see the screen shown in Figure 2-9.

Figure 2-9 PSX Mapping User Interface



2. Select the “Layers” icon in the lower-right corner. Group names should appear under **Layers**.
3. Select a group. Your screen should look like Figure 2-10.

438 **Figure 2-10 PSX Mapping Group Member Information**



439

440 4. The locations of the devices that are members of that group should appear as dots on the map.

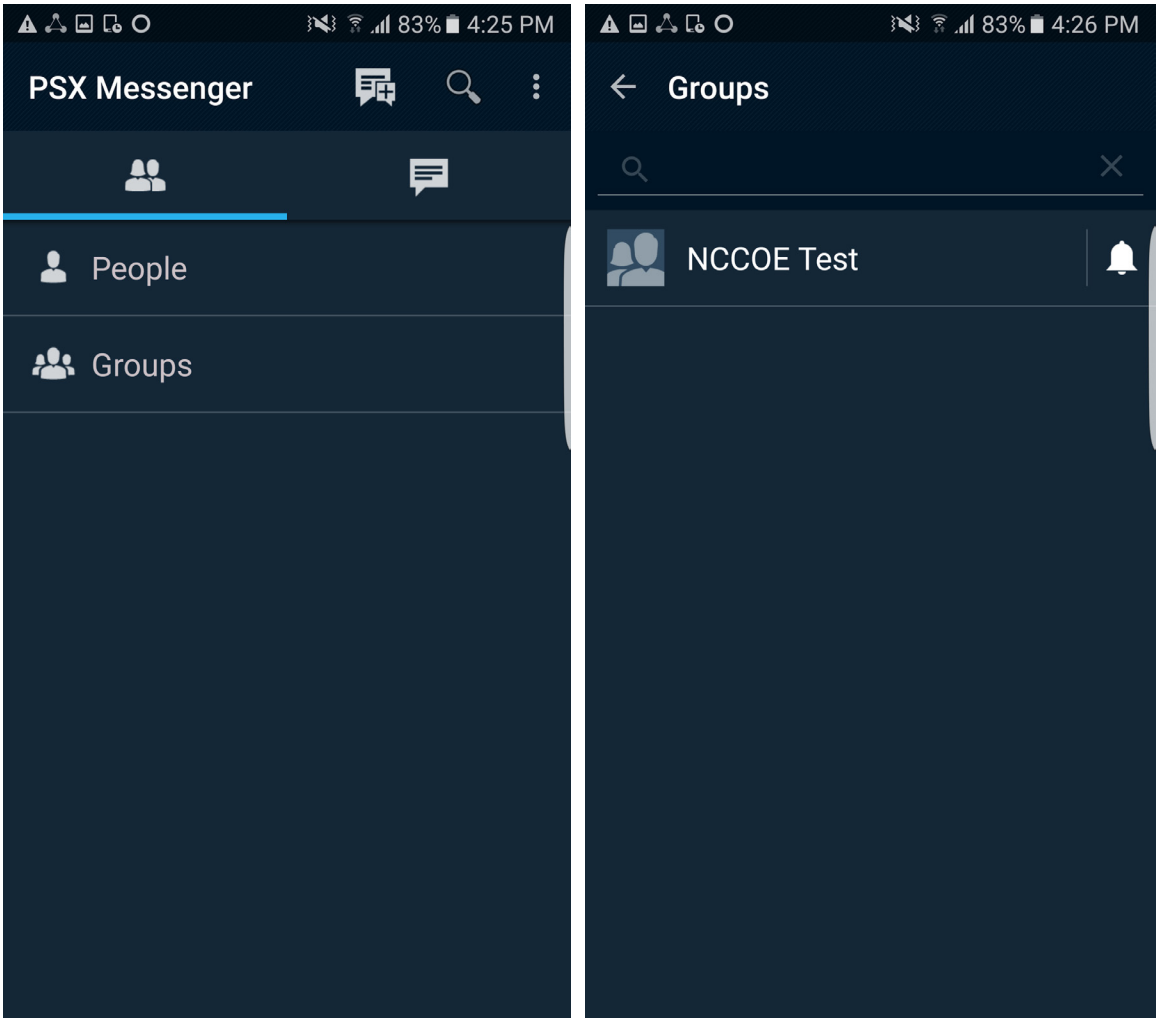
441 5. Select a device. A pop-up will show the user of the device, and icons for phoning and messaging
442 that user.

443 6. Selecting the “Messenger” icon for the selected user will take you to the Messenger app, where
444 you can send a message to the user.

2.2.1.3 Configuring the PSX Messenger App

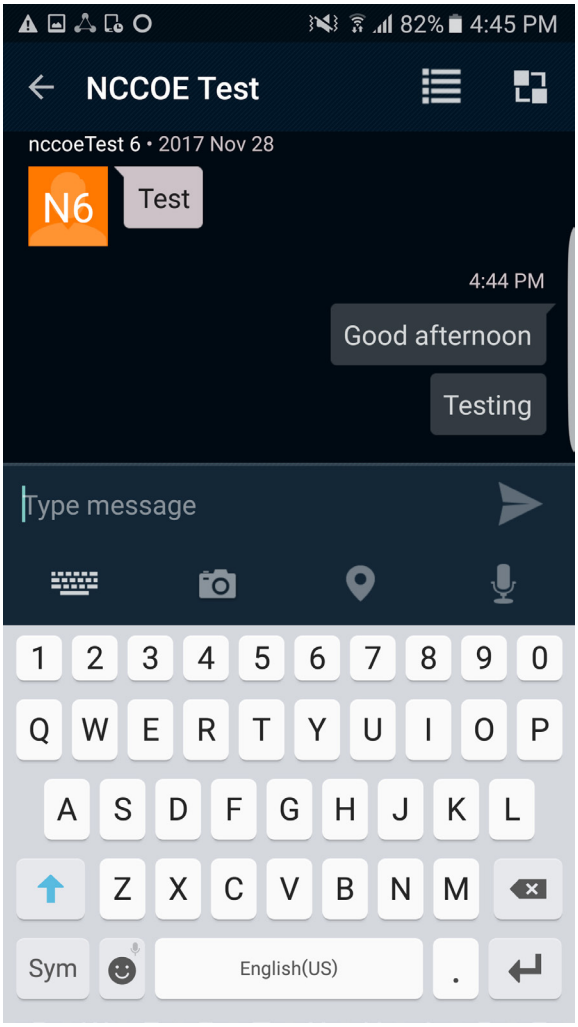
1. Open the Messenger app. Your screen should look like Figure 2-11.

Figure 2-11 PSX Messenger User Interface



2. Your screen should show **People** and **Groups**. Select one of them.
3. A list of people or groups that you can send a message to should appear. Select one of them. Your screen should look like Figure 2-12.

452 **Figure 2-12 PSX Messenger Messages**



453

454 4. You are now viewing the messaging window. You can type text for a message, and attach a
455 picture, video, voice recording, or map.

456 5. Tap the “Send” icon. The message should appear on your screen.

457 6. Tap the “Pivot” icon in the upper-right corner of the message window. Select “Locate,” and you
458 will be taken to the Mapping app with the location of the people or group you selected.

2.2.2 How to Install and Configure a FIDO U2F Authenticator

This section covers the installation and usage of a FIDO U2F authenticator on the mobile device. The NCCoE reference architecture utilizes the Google Authenticator app on the mobile device, and a Yubico YubiKey NEO as a hardware token. The app functions as the client-side U2F authenticator and is available on Google's Play Store [6].

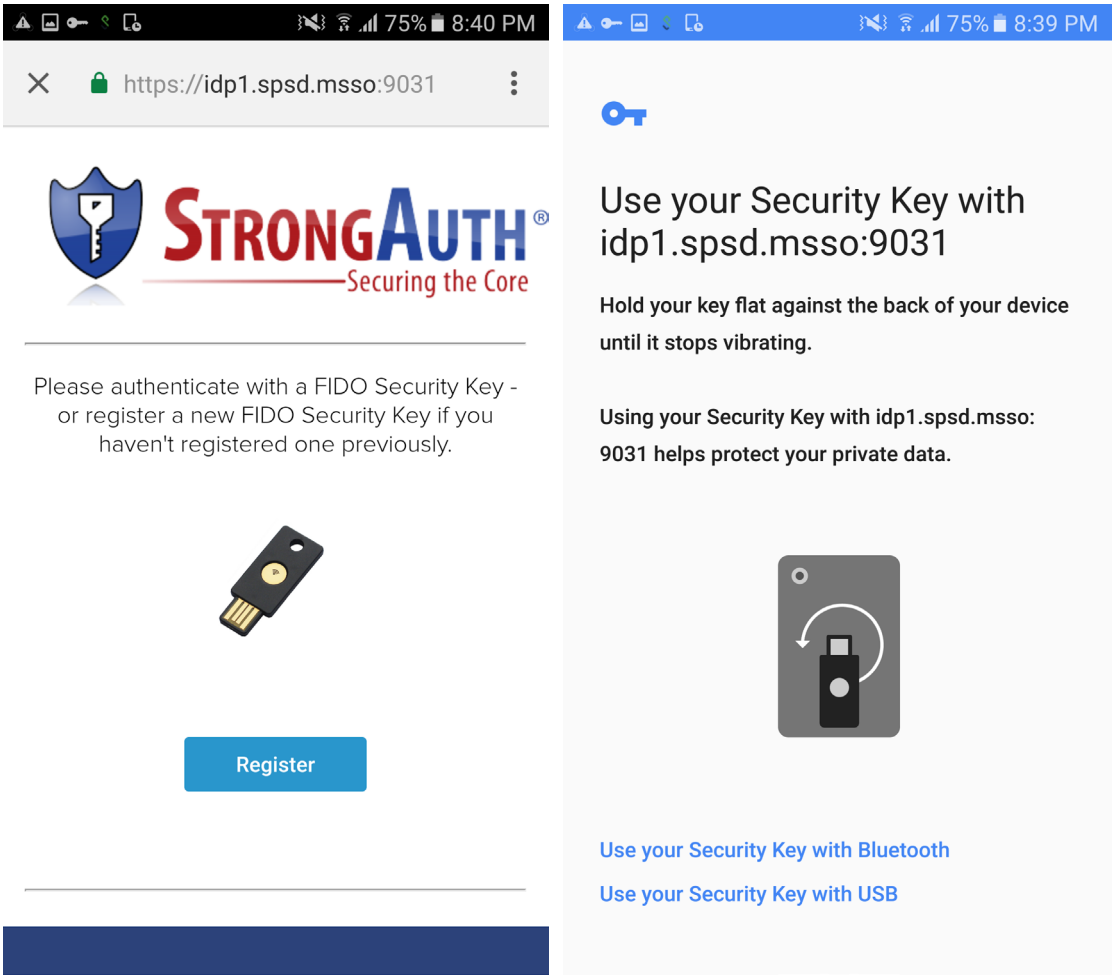
2.2.2.1 Installing Google Authenticator

1. On your Android device, open the Play Store app.
2. Search for "Google Authenticator," and install the app. There is no configuration needed until you are ready to register a FIDO U2F token with a StrongAuth server.

2.2.2.2 Registering the Token

In the architecture that is laid out in this practice guide, there is no out-of-band process to register the user's U2F token. This takes place the first time the user tries to log in with whatever SSO-enabled app they are using. For instance, when using the PSX Cockpit app, once the user tries to sign into an IdP that has U2F enabled and has successfully authenticated with a username and password, they will be presented with the screen shown in Figure 2-13.

474 **Figure 2-13 FIDO U2F Registration**



475

476 Because the user has never registered a U2F token, that is the only option the user sees.

477 1. Click **Register**, and the web page will activate the Google Authenticator app, which asks you to
478 use a U2F token to continue (Figure 2-13 above).

479 2. Hold the U2F token to your device, and then the token will be registered to your account and
480 you will be redirected to the U2F login screen again.

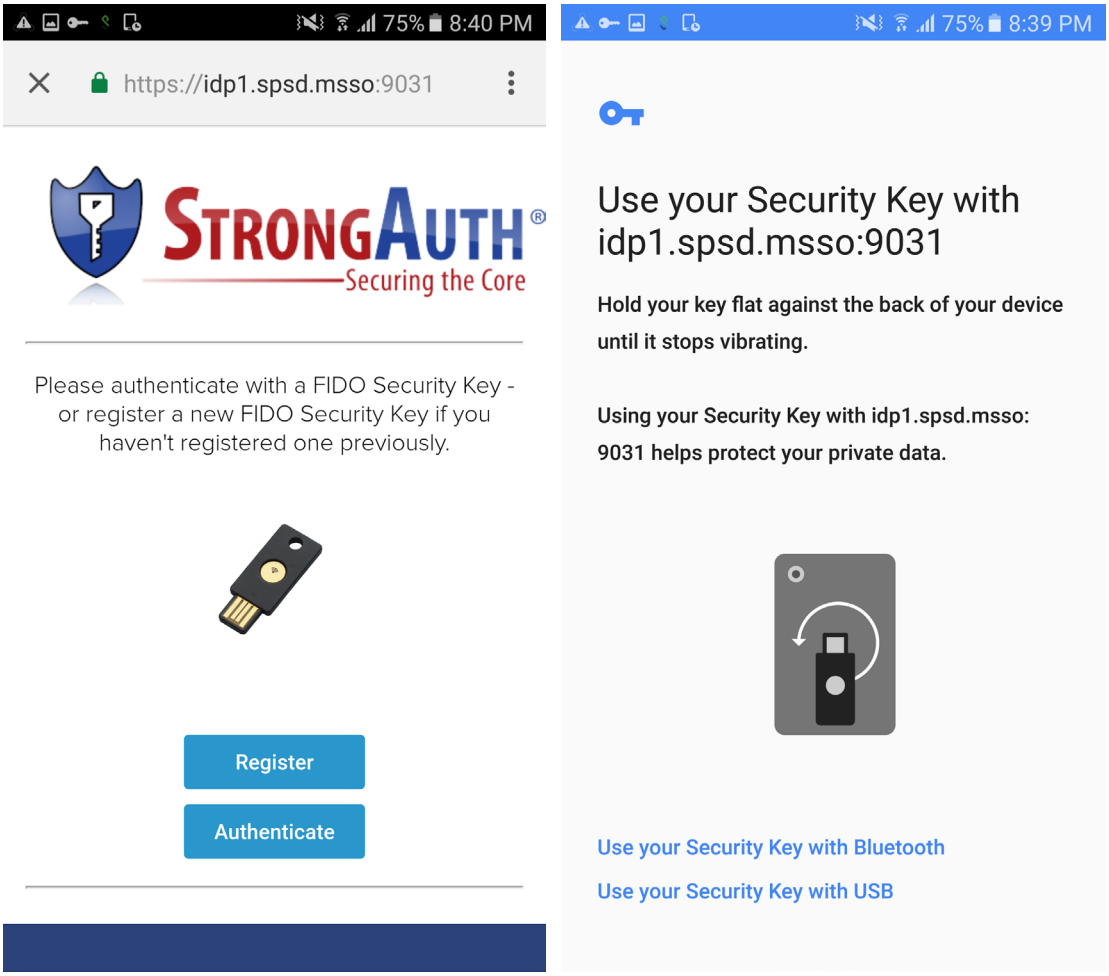
481 ### *2.2.2.3 Authenticating with the Token*

482 Now, because the system has a U2F token on file for the user, the user has the option to authenticate.

483 1. Click **Authenticate** (Figure 2-14), and the Google Authenticator app will be activated once more.

2. Hold the U2F token to your device, and then the authentication will be successful and the SSO flow will continue.

Figure 2-14 FIDO U2F Authentication



2.2.3 How to Install and Configure a FIDO UAF Client

This section covers the installation and usage of a FIDO UAF client on the mobile device. Any FIDO UAF client can be used, but the NCCoE reference architecture utilizes the Nok Nok Passport app (hereafter referred to as "Passport"). The Passport app functions as the client-side UAF app and is available on Google's Play Store [8]. The following excerpt is from the Play Store page:

> *Passport from Nok Nok Labs is an authentication app that supports the Universal Authentication Framework (UAF) protocol from the FIDO Alliance (www.fidoalliance.org).*

Passport allows you to use out-of-band authentication to authenticate to selected websites on a laptop or desktop computer. You can use the fingerprint sensor on FIDO UAF-enabled devices (such as the Samsung Galaxy S® 6, Fujitsu Arrows NX, or Sharp Aquos Zeta) or enter a simple PIN on non-FIDO enabled devices. You can enroll your Android device by using Passport to scan a QR code displayed by the website, then touch the fingerprint sensor or enter a PIN. Once enrolled, you can authenticate using a similar method. Alternatively, the website can send a push notification to your Android device and trigger the authentication.

This solution lets you use your Android device to better protect your online account, without requiring passwords or additional hardware tokens.

In our reference architecture, we use a Quick Response (QR) code to enroll the device onto Nok Nok Labs' test server.

2.2.3.1 Installing Passport

1. On your Android device, open the Play Store app.
2. Search for "Nok Nok Passport", and install the app. There is no configuration needed until you are ready to enroll the device with a Nok Nok Labs server.

Normally, the user will never need to open the Passport app during authentication; it will automatically be invoked by the SSO-enabled app (e.g., PSX Cockpit). Instead of entering a username and password into a Chrome Custom Tab, the user will be presented with the Passport screen to use the user's UAF credential.

2.2.3.2 Enrolling the Device

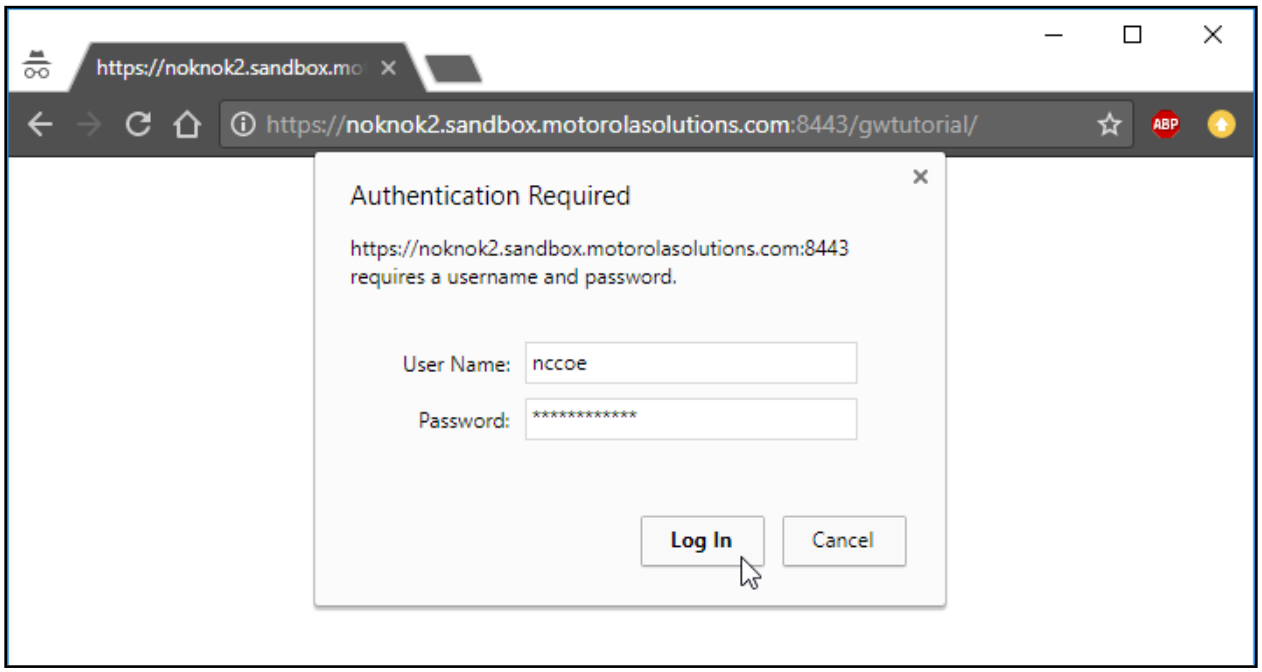
This section details the steps to enroll a device to an NNAS. First, you need a device that has Passport installed. Second, you need to use another computer (preferably a desktop or laptop) to interact with your NNAS web interface.

Note: Users are not authenticated during registration. We are using the "tutorial" app provided with the NNAS. This sample implementation does not meet the FIDO requirement of authentication prior to registration. The production version of the NNAS may require additional steps and may have a different interface.

Screenshots that demonstrate the enrollment process are shown in Figure 2-15 through Figure 2-21.

1. First, use your computer to navigate to the NNAS web interface. You will be prompted for a username and password; enter your administrator credentials, and click **Log In** (Figure 2-15).

525 **Figure 2-15 Nok Nok Labs Tutorial App Authentication**

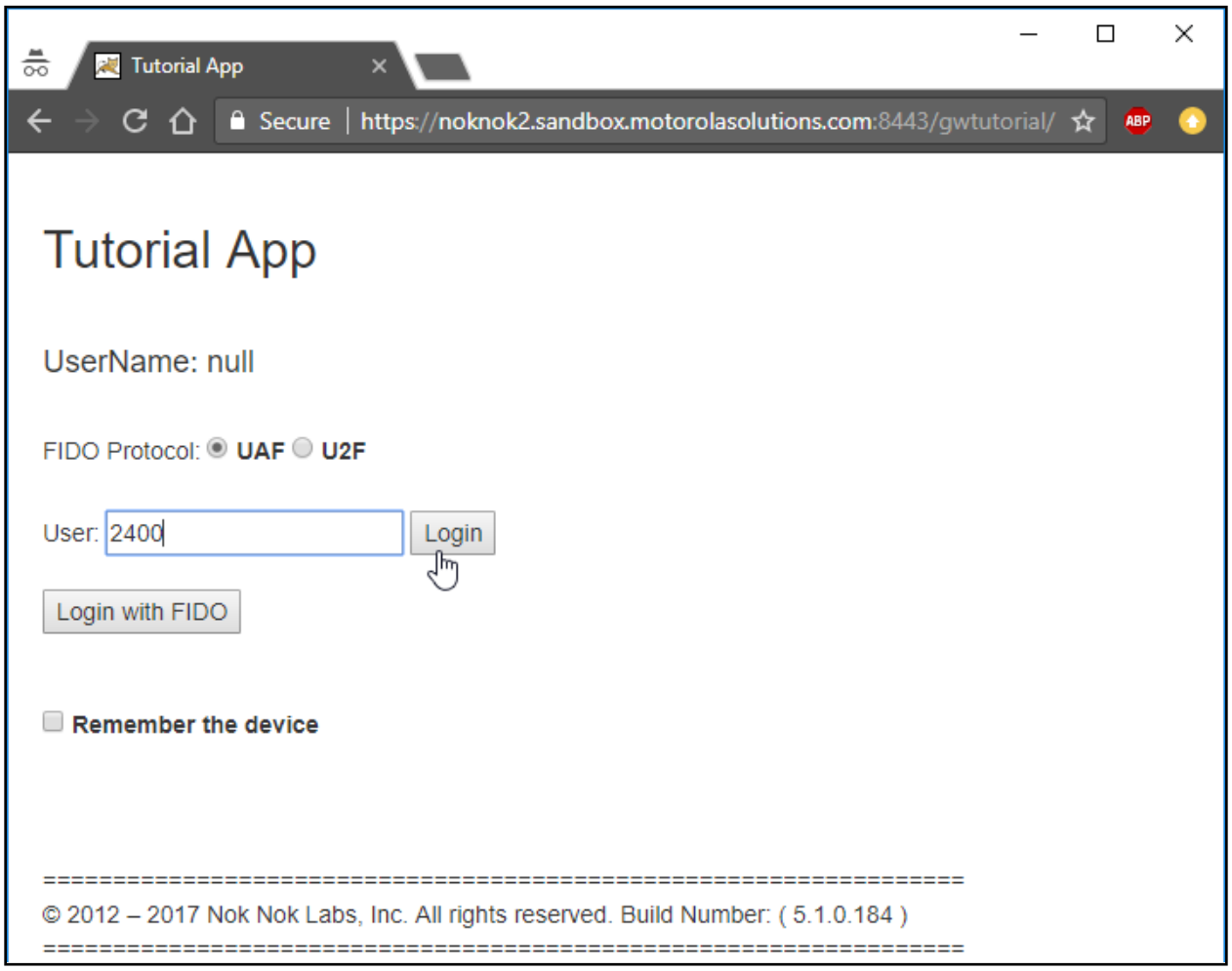


526

527 2. Once you have logged into the NNAS as an administrator, you need to identify which user you
528 want to manage. Enter the username, and click **Login with FIDO** (Figure 2-16).

529 *Note: As stated above, this is the tutorial app, so it only prompts for a username, not a*
530 *password. A production environment would require user authentication.*

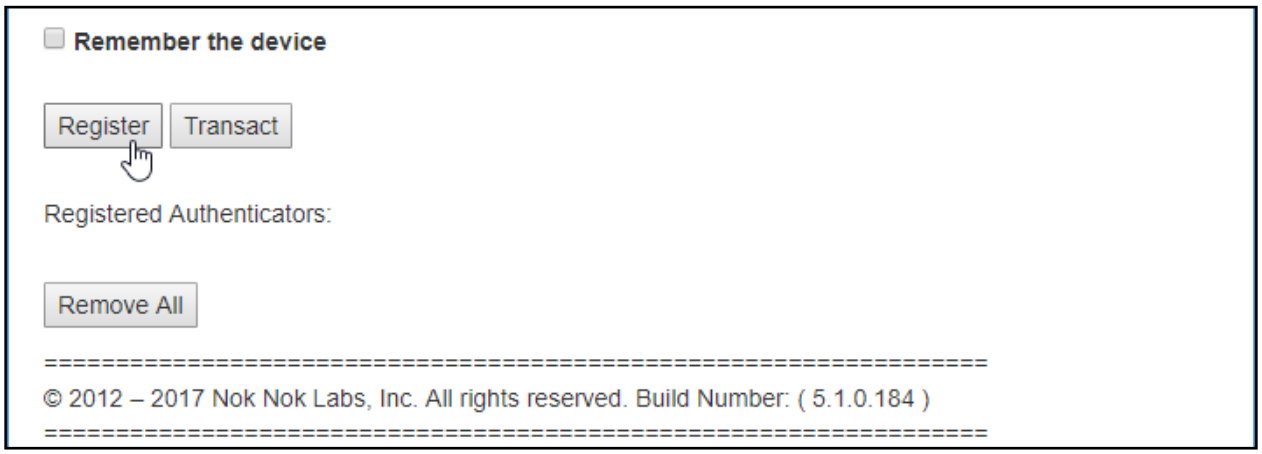
531 **Figure 2-16 Nok Nok Labs Tutorial App Login**



532

533 3. Once you have selected the user, you will need to start the FIDO UAF registration process. To
534 begin, click **Register** (Figure 2-17).

535 **Figure 2-17 FIDO UAF Registration Interface**



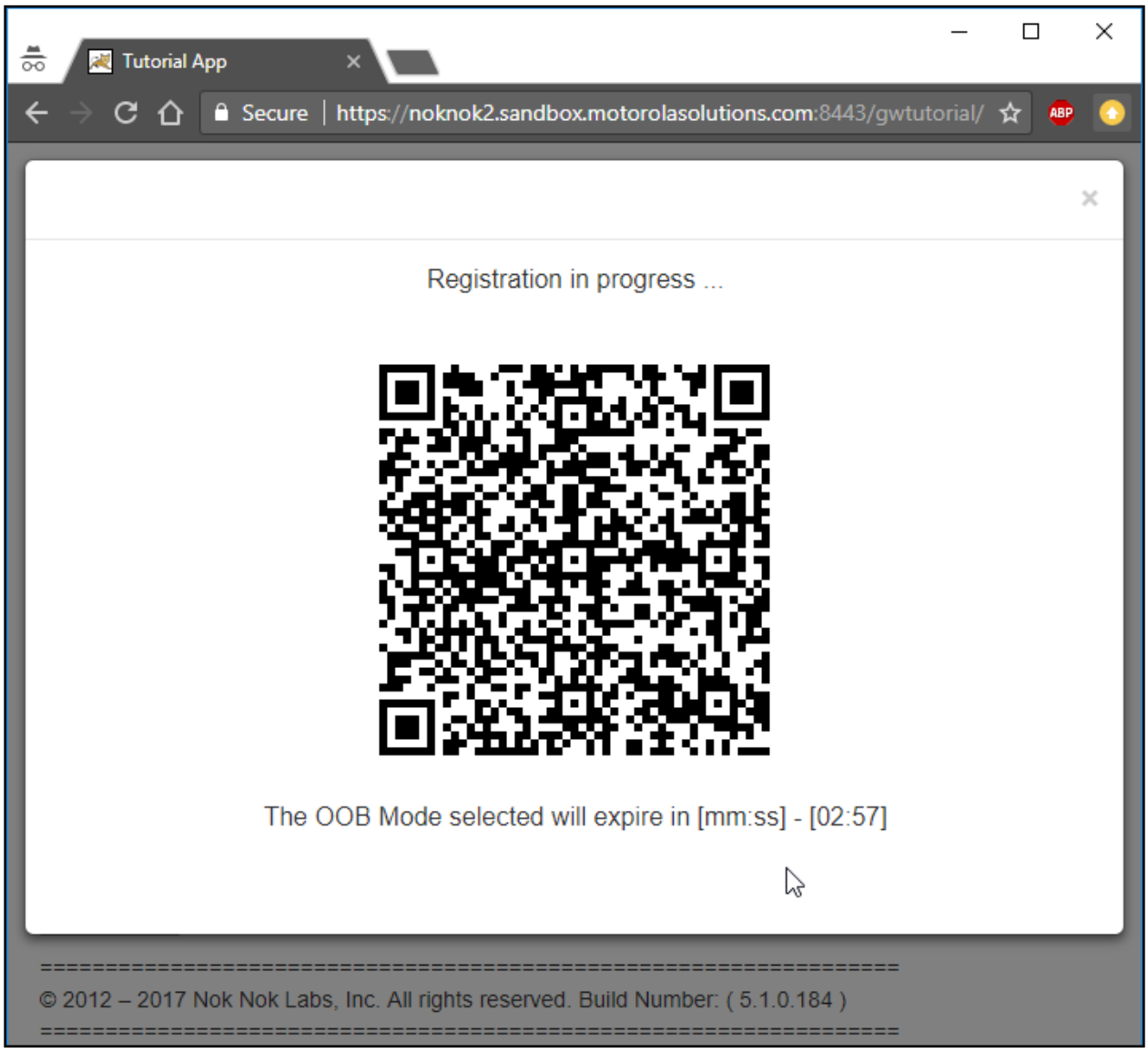
536

537 4. You will see a window with a QR code and a countdown (Figure 2-18). You have three minutes
538 to finish the registration process with your device.

539 a. Once the QR image appears, launch the Passport app on the phone. The Passport app
540 activates the device camera to enable capturing the QR code by centering the code in
541 the square frame in the middle of the screen (Figure 2-19).

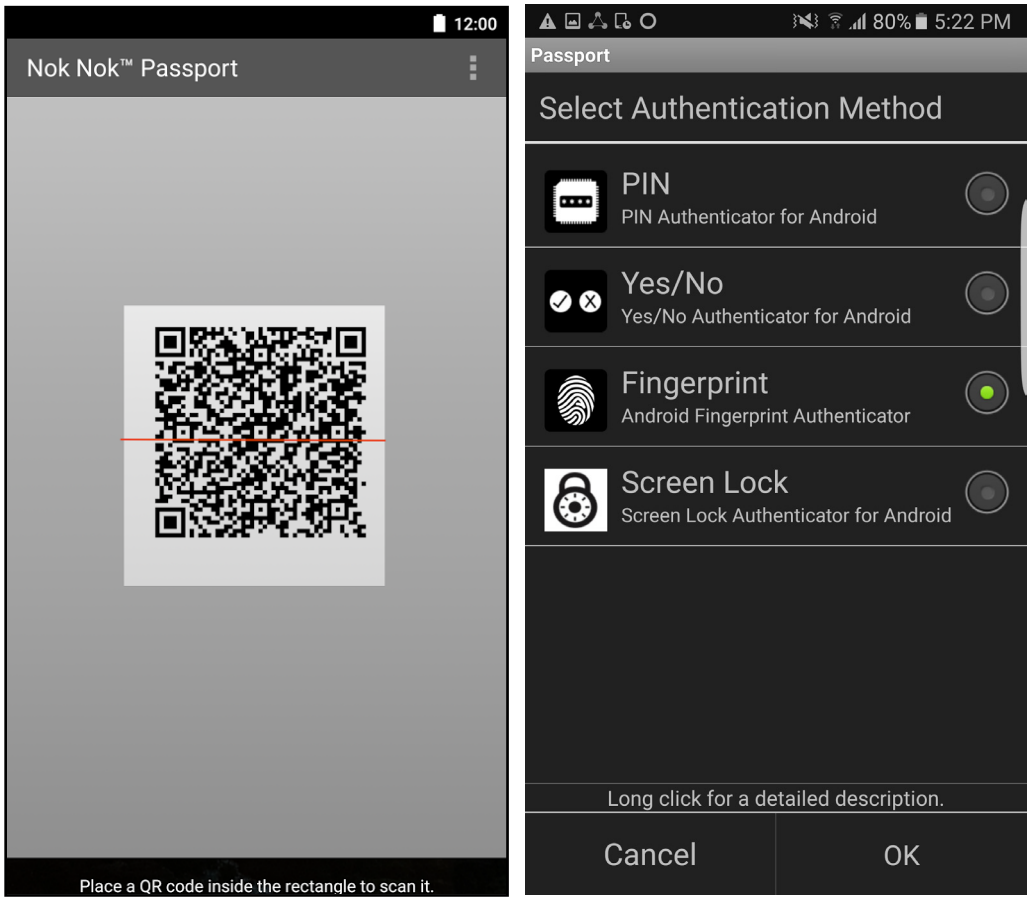
542 b. Once the QR code is scanned, the app prompts the user to select the type of verification
543 (fingerprint, PIN, etc.) to use (Figure 2-19). The selections may vary based on the au-
544 thenticator modules installed on the device.

545 **Figure 2-18 FIDO UAF Registration QR Code**



546

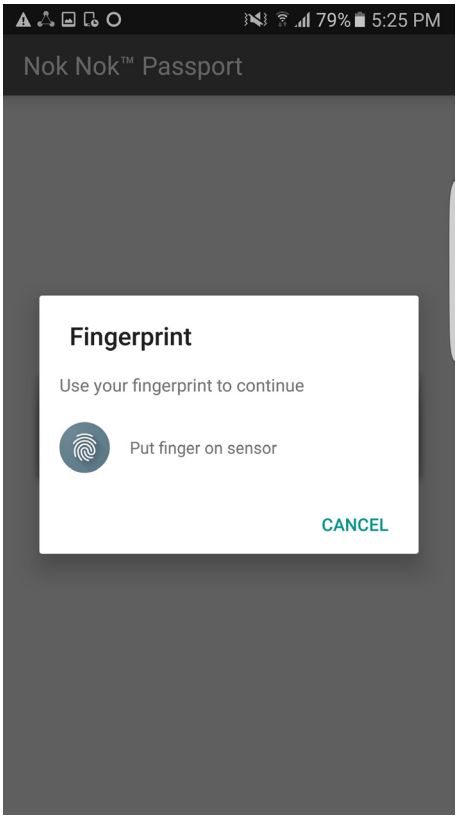
547 **Figure 2-19 FIDO UAF Registration Device Flow**



548

549 5. In this example, a fingerprint authenticator is registered. The user is prompted for a fingerprint
550 scan to complete registration (Figure 2-20). The fingerprint authenticator uses a fingerprint
551 previously registered in the Android screen-lock settings. If a PIN authenticator were registered,
552 the user would be prompted to set a PIN instead.

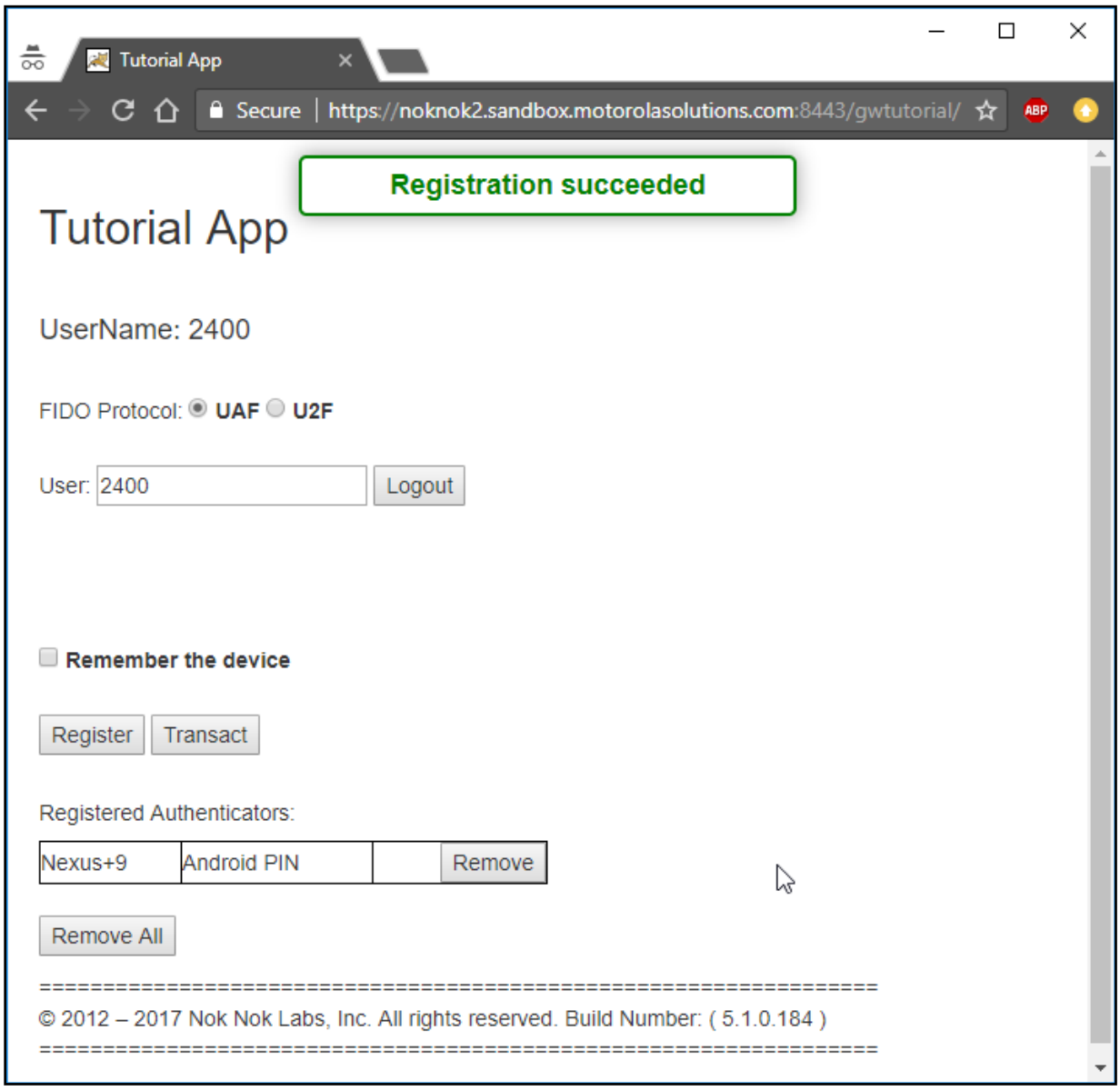
553 **Figure 2-20 FIDO UAF Fingerprint Authenticator**



554

555 6. If the fingerprint scan matches the user's registered fingerprint, then a new UAF key pair is
556 generated, the public key is sent to the server, and registration is completed (Figure 2-21).

557 **Figure 2-21 FIDO UAF Registration Success**



558

559 2.3 How App Developers Must Integrate AppAuth for SSO

560 App developers can easily integrate AppAuth to add SSO capabilities to their app. The first step to doing
561 this is reading through the AppAuth for Android documentation on GitHub [10]. After doing so, an app
562 developer can begin the integration of AppAuth. The degree of this integration can vary—for instance,

563 you may choose to utilize user attributes to personalize the user's app experience. Each separate step
564 will be displayed here.

565 *Note: In this example, we use Android Studio 3.0, Android Software Development Kit (SDK) 25, and*
566 *Gradle 2.14.1. In addition, before beginning this, you must register your app with your AS and obtain a*
567 *client ID, which will be needed in Section 2.3.4.*

568 ### 2.3.1 Adding the Library Dependency

569 1. Edit your app's *build.gradle* file, and add this line to its dependencies (note that the AppAuth
570 library will most likely be updated in the future, so you should use the most recent version for
571 your dependency, not necessarily the one in this document):

572 ```
    ==
573 dependencies {
574 ...
575   compile 'net.openid:appauth:0.7.0'
576 }
577 ==
```

578 ### 2.3.2 Adding Activities to the Manifest

579 1. First, you need to identify your AS's hostname, OAuth redirect path, and what scheme was set
580 when you registered your app. The scheme here is contrived, but it is common practice to use
581 reverse DNS style names; you should choose whatever aligns with your organization's common
582 practices. Another alternative to custom schemes is to use App Links.

583 2. Edit your *AndroidManifest.xml* file, and add these lines:

584 ```
    ================================================================================
585 <manifest xmlns:android="http://schemas.android.com/apk/res/android"
586     xmlns:tools="http://schemas.android.com/tools"
587     package="com.example.app">
588 ...
589         <activity
590             android:name="net.openid.appauth.RedirectUriReceiverActivity"
591             tools:node="replace">
592             <intent-filter>
593                 <action android:name="android.intent.action.VIEW" />
```

```
                    <category android:name="android.intent.category.DEFAULT" />
                    <category android:name="android.intent.category.BROWSABLE" />
                    <data
                        android:host="as.example.com"
                        android:path="/oauth2redirect"
                        android:scheme="myappscheme" />
                </intent-filter>
            </activity>
            <activity android:name=".activity.AuthResultHandlerActivity" />
            <activity android:name=".activity.AuthCanceledHandlerActivity" />
        </application>
    </manifest>
    ================================================================================
```

2.3.3 Create Activities to Handle Authorization Responses

1. Create a utility class for reusable code (**Utility**), and create activities to handle successful authorizations (**AuthResultHandlerActivity**) and canceled authorizations (**AuthCanceledHandlerActivity**):

```
    ================================================================================
    public class Utility {
        public static AuthorizationService getAuthorizationService(Context context)
    {
            AppAuthConfiguration appAuthConfig = new AppAuthConfiguration.Builder()
                    .setBrowserMatcher(new BrowserWhitelist(
                            VersionedBrowserMatcher.CHROME_CUSTOM_TAB,
                            VersionedBrowserMatcher.SAMSUNG_CUSTOM_TAB))
                    // the browser matcher above allows you to choose which in-app
    browser
                    // tab providers will be supported by your app in its OAuth2 flow
                    .setConnectionBuilder(new ConnectionBuilder() {
                        @NonNull
                        public HttpURLConnection openConnection(@NonNull Uri uri)
```

```
                            throws IOException {
                        URL url = new URL(uri.toString());
                        HttpURLConnection connection =
                                (HttpURLConnection) url.openConnection();
                        if (connection instanceof HttpsURLConnection) {
                            // optional: use your own trust manager to set a custom
                            // SSLSocketFactory on the HttpsURLConnection
                        }
                        return connection;
                    }
                }).build();

        return new AuthorizationService(context, appAuthConfig);
    }

    public static AuthState restoreAuthState(Context context) {
        // we use SharedPreferences to store a String version of the JSON
        // Auth State, and here we retrieve it to convert it back to a POJO
        SharedPreferences sharedPreferences =
                PreferenceManager.getDefaultSharedPreferences(context);
        String jsonString = sharedPreferences.getString("AUTHSTATE", null);
        if (!TextUtils.isEmpty(jsonString)) {
            try {
                return AuthState.jsonDeserialize(jsonString);
            } catch (JSONException jsonException) {
                // handle this appropriately
            }
        }
        return null;
    }
```

```
655         }
656         ================================================================================
657         public class AuthResultHandlerActivity extends Activity {
658
659             private static final String TAG = AuthResultHandlerActivity.class.getName();
660
661             private AuthState mAuthState;
662             private AuthorizationService mAuthService;
663
664             @Override
665             protected void onCreate(Bundle savedInstanceState) {
666                 super.onCreate(savedInstanceState);
667
668                 AuthorizationResponse res =
669         AuthorizationResponse.fromIntent(getIntent());
670                 AuthorizationException ex =
671         AuthorizationException.fromIntent(getIntent());
672                 mAuthState = new AuthState(res, ex);
673                 mAuthService = Utility.getAuthorizationService(this);
674
675                 if (res != null) {
676                     Log.d(TAG, "Received AuthorizationResponse");
677                     performTokenRequest(res.createTokenExchangeRequest());
678                 } else {
679                     Log.d(TAG, "Authorization failed: " + ex);
680                 }
681             }
682
683             @Override
684             protected void onDestroy() {
685                 super.onDestroy();
```

```
686             mAuthService.dispose();
687         }
688
689         private void performTokenRequest(TokenRequest request) {
690             TokenResponseCallback callback = new TokenResponseCallback() {
691                 @Override
692                 public void onTokenRequestCompleted(
693                         TokenResponse tokenResponse,
694                         AuthorizationException authException) {
695                     receivedTokenResponse(tokenResponse, authException);
696                 }
697             };
698             mAuthService.performTokenRequest(request, callback);
699         }
700
701         private void receivedTokenResponse(TokenResponse tokenResponse,
702                                            AuthorizationException authException) {
703             Log.d(TAG, "Token request complete");
704             if (tokenResponse != null) {
705                 mAuthState.update(tokenResponse, authException);
706
707                 // persist auth state to SharedPreferences
708                 PreferenceManager.getDefaultSharedPreferences(this)
709                         .edit()
710                         .putString("AUTHSTATE", mAuthState.jsonSerializeString())
711                         .commit();
712
713                 String accessToken = mAuthState.getAccessToken();
714                 if (accessToken != null) {
715                     // optional: pull claims out of JWT (name, etc.)
```

```
            }
        } else {
            Log.d(TAG, "  ", authException);
        }
    }
}
```

```
================================================================================
public class AuthCanceledHandlerActivity extends Activity {

    private static final String TAG =
AuthCanceledHandlerActivity.class.getName();

    @Override
    protected void onCreate(Bundle savedInstanceState) {
        super.onCreate(savedInstanceState);

        Log.d(TAG, "OpenID Connect authorization flow canceled");

        // go back to MainActivity
        finish();
    }
}
================================================================================
```

2.3.4 Executing the OAuth 2 Authorization Flow

1. In whatever activity you are using to initiate authentication, add in the necessary code to use the AppAuth SDK to execute the OAuth 2 authorization flow:

```
================================================================================
...

// some method, usually a "login" button, activates the OAuth2 flow

String OAUTH_AUTH_ENDPOINT =
"https://as.example.com:9031/as/authorization.oauth2";
```

```
String OAUTH_TOKEN_ENDPOINT = "https://as.example.com:9031/as/token.oauth2";
String OAUTH_REDIRECT_URI = "myappscheme://app.example.com/oauth2redirect";
String OAUTH_CLIENT_ID = "myapp";
String OAUTH_PKCE_CHALLENGE_METHOD = "S256"; // options are "S256" and "plain"

// CREATE THE SERVICE CONFIGURATION
AuthorizationServiceConfiguration config = new
AuthorizationServiceConfiguration(
       Uri.parse(OAUTH_AUTH_ENDPOINT), // auth endpoint
       Uri.parse(OAUTH_TOKEN_ENDPOINT), // token endpoint
       null // registration endpoint
);

// OPTIONAL: Add any additional parameters to the authorization request
HashMap<String, String> additionalParams = new HashMap<>();
additionalParams.put("acr_values", "urn:acr:form");

// BUILD THE AUTHORIZATION REQUEST
AuthorizationRequest.Builder builder = new AuthorizationRequest.Builder(
       config,
       OAUTH_CLIENT_ID,
       ResponseTypeValues.CODE,
       Uri.parse(OAUTH_REDIRECT_URI))
       .setScopes("profile") // scope is optional, set whatever is needed by
your app
       .setAdditionalParameters(additionalParams);

// SET UP PKCE CODE VERIFIER
String codeVerifier = CodeVerifierUtil.generateRandomCodeVerifier();
String codeVerifierChallenge =
CodeVerifierUtil.deriveCodeVerifierChallenge(codeVerifier);
builder.setCodeVerifier(codeVerifier, codeVerifierChallenge,
       OAUTH_PKCE_CHALLENGE_METHOD);

AuthorizationRequest request = builder.build();

// PERFORM THE AUTHORIZATION REQUEST
// this pauses and leaves the current activity
Intent postAuthIntent = new Intent(this, AuthResultHandlerActivity.class);
Intent authCanceledIntent = new Intent(this,
AuthCanceledHandlerActivity.class);
mAuthService.performAuthorizationRequest(
       request,
       PendingIntent.getActivity(this, request.hashCode(), postAuthIntent, 0),
       PendingIntent.getActivity(this, request.hashCode(), authCanceledIntent,
0));

...

// when the activity resumes, check if the OAuth2 flow was successful
```

```
@Override
protected void onResume() {
   super.onResume();

   AuthState authState = Utility.restoreAuthState(this);
   if (authState != null) {

      // we are authorized!
      // proceed to the next activity that requires an access token
   }
}

...

================================================================================
```

2.3.5 Fetching and Using the Access Token

1. After you have proceeded from the prior activity, you can fetch your access token. If some time has passed since you obtained the access token, you may need to use your refresh token to get a new access token. AppAuth handles both cases the same way. Implement the following code wherever you need to use the access token:

```
================================================================================

...


// assuming we have an instance of a Context as mContext...

// ensure we have a fresh access token to perform any future actions
final AuthorizationService authService =
Utility.getAuthorizationService(mContext);
AuthState authState = Utility.restoreAuthState(mContext);
authState.performActionWithFreshTokens(authService, new
AuthState.AuthStateAction() {
   @Override
   public void execute(String accessToken, String idToken,

         AuthorizationException ex) {
      JWT jwt = null;
      if (ex != null) {
         // negotiation for fresh tokens failed, check ex for more details
      } else {
         // we can now use accessToken to access remote services

         // this is typically done by including the token in an HTTP header,

         // or in a handshake transaction if another transport protocol is
used
      }
      authService.dispose();
```

```
            }
        });

        ...

        ================================================================================
```

3 How to Install and Configure the OAuth 2 AS

3.1 Platform and System Requirements

Ping Identity is used as the AS for this build. The AS issues access tokens to the client after successfully authenticating the resource owner and obtaining authorization [11].

The requirements for Ping Identity can be categorized into three groups: software, hardware, and network.

3.1.1 Software Requirements

The software requirements are as follows:

- OS: Microsoft Windows Server, Oracle Enterprise Linux, Oracle Solaris, Red Hat Enterprise, SUSE Linux Enterprise
- Virtual systems: VMware, Xen, Windows Hyper-V
- Java environment: Oracle Java Standard Edition (SE)
- Data integration: Ping Directory, Microsoft Active Directory (AD), Oracle Directory Server, Microsoft Structured Query Language (SQL) Server, Oracle Database, Oracle MySQL 5.7, PostgreSQL

3.1.2 Hardware Requirements

The minimum hardware requirements are as follows:

- Intel Pentium 4, 1.8-gigahertz (GHz) processor
- 1 gigabyte (GB) of Random Access Memory (RAM)
- 1 GB of available hard drive space

A detailed discussion on this topic and additional information can be found at https://documentation.pingidentity.com/pingfederate/pf82/index.shtml#gettingStartedGuide/concept/systemRequirements.html.

3.1.3 Network Requirements

Ping Identity identifies several ports to be open for different purposes. These purposes can include communication with the administrative console, runtime engine, cluster engine, and Kerberos engine.

A detailed discussion on each port can be found at https://documentation.pingidentity.com/pingfederate/pf84/index.shtml#gettingStartedGuide/pf_t_installPingFederateRedHatEnterpriseLinux.html.

In this implementation, we needed ports to be opened to communicate with the administrative console and the runtime engine.

For this experimentation, we have used the configuration identified in the following subsections.

3.1.3.1 Software Configuration

The software configuration is as follows:

- OS: CentOS Linux Release 7.3.1611 (Core)
- Virtual systems: Vmware ESXI 6.5
- Java environment: OpenJDK Version 1.8.0_131
- Data integration: Active Directory (AD)

3.1.3.2 Hardware Configuration

The hardware configuration is as follows:

- Processor: Intel(R) Xeon(R) central processing unit (CPU) E5-2420 0 at 1.90 GHz
- Memory: 2 GB
- Hard drive: 25 GB

3.1.3.3 Network Configuration

The network configuration is as follows:

- 9031: This port allows access to the runtime engine; this port must be accessible to client devices and federation partners.
- 9999: This port allows the traffic to the administrative console; only PingFederate administrators need access.

3.2 How to Install the OAuth 2 AS

Before the installation of Ping Identity AS, the prerequisites identified in the following subsections need to be fulfilled.

3.2.1 Java Installation

Java 8 can be installed in several ways on CentOS 7 using *yum*. Yum is a package manager on the CentOS 7 platform that automates software processes, such as installation, upgrade, and removal, in a consistent way.

1. Download the Java Development Kit (JDK) in the appropriate format for your environment, from Oracle's website; for CentOS, the Red Hat Package Manager (RPM) download can be used: http://www.oracle.com/technetwork/java/javase/downloads/jdk8-downloads-2133151.html.

2. As root, install the RPM by using the following command, substituting the actual version of the downloaded file:

   ```
   rpm -ivh jdk-8u151-linux-x64.rpm
   ```

3. Alternatively, the JDK can be downloaded in *.tar.gz* format and unzipped in the appropriate location (i.e., */usr/share* on CentOS 7).

3.2.2 Java Post Installation

The `alternatives` command maintains symbolic links determining default commands. This command can be used to select the default Java command. This is helpful even in cases where there are multiple installations of Java on the system.

1. Use the following command to select the default Java command:

   ```
   alternatives --config java
   ```

   There are 3 programs which provide 'java'.

   ```
     Selection    Command
   -----------------------------------------------
      1           /usr/java/jre1.8.0_111/bin/java
   *+ 2           java-1.8.0-openjdk.x86_64 (/usr/lib/jvm/java-1.8.0-openjdk-
   1.8.0.131-3.b12.el7_3.x86_64/jre/bin/java)
      3           /usr/java/jdk1.8.0_131/jre/bin/java
   Enter to keep the current selection[+], or type selection number:
   ```

   This presents the user with a configuration menu for choosing a Java instance. Once a selection is made, the link becomes the default command system wide.

2. To make Java available to all users, the JAVA_HOME environment variable was set by using the following command:

```
echo export JAVA_HOME="/usr/java/latest" > /etc/profile.d/javaenv.sh
```

3. For cryptographic functions, download the *Java Cryptography Extension (JCE) Unlimited Strength Jurisdiction Policy Files 8* from http://www.oracle.com/technetwork/java/javase/downloads/jce8-download-2133166.html.

4. Uncompress and extract the downloaded file. The installation procedure is described in the Readme document. In the lab, *local_policy.jar* was extracted to the default location, *<java-home>/lib/security.Network Configuration*.

5. Check if the firewall is running or not by using the command below. If it is up, it will return a status that shows it is running:

```
firewall-cmd --state
```

   a. If it is not running, activate the firewall by using the following command:

```
sudo systemctl start firewalld.service
```

6. Check if the required ports, 9031 and 9999, are open by using the following command:

```
firewall-cmd --list-ports
```

   a. This command will return the following values:

```
6031/tcp 9999/udp 9031/tcp 6031/udp 9998/udp 9031/udp 9999/tcp 9998/tcp
8080/tcp
```

   From the returned ports, we can determine which ports and protocols are open.

   b. In case the required ports are not open, issue the command below. It should return `success`.

```
firewall-cmd --zone=public --permanent --add-port=9031/tcp
success
```

7. Reload the firewall by using the following command to make the rule change take effect:

```
firewall-cmd --reload
Success
```

   a. Now, when the open ports are listed, the required ports should show up:

```
firewall-cmd --zone=public --list-ports
6031/tcp 9999/udp 9031/tcp 6031/udp 9998/udp 9031/udp 9999/tcp 9998/tcp
8080/tcp 5000/tcp
```

3.2.3 PingFederate Installation

Ping installation documentation is available at https://docs.pingidentity.com/bundle/pf_sm_installPingFederate_pf82/page/pf_t_installPingFederateRedHatEnterpriseLinux.html?#.

Some important points are listed below:

- Obtain a Ping Identity license. It can be acquired from https://www.pingidentity.com/en/account/sign-on.html.
- For this experiment, installation was done using the zip file. Installation was done at */usr/share*.
- The license was updated.
- The PingFederate service can be configured as a service that automatically starts at system boot. PingFederate provides instructions for doing this on different OSs. In the lab, the Linux instructions at the link provided below were used. Note that, while the instructions were written for an *init.d*-based system, these instructions will also work on a systemd-based system.

  https://docs.pingidentity.com/bundle/pf_sm_installPingFederate_pf82/page/pf_t_installPingFederateServiceLinuxManually.html?#

The following configuration procedures are completed in the PingFederate administrative console, which is available at *https://<ping-server-hostname>:9999/pingfederate/app.*

3.2.4 Certificate Installation

During installation, PingFederate generates a self-signed TLS certificate, which is not trusted by desktop or mobile device browsers. A certificate should be obtained from a trusted internal or external CA, and should be installed on the PingFederate server. The private key and signed certificate can be uploaded and activated for use on the run-time server port and the admin port by navigating to **Server Settings** in the console and clicking on **SSL Server Certificates**.

In addition, most server roles described in this guide will require the creation of a signing certificate. This is required for a SAML or OIDC IdP, and for an OAuth AS if access tokens will be issued as JWTs. To create or import a signing certificate, under **Server Configuration – Certificate Management**, click **Signing & Decryption Keys & Certificates**. A self-signed certificate can be created, or a trusted certificate can be obtained and uploaded there.

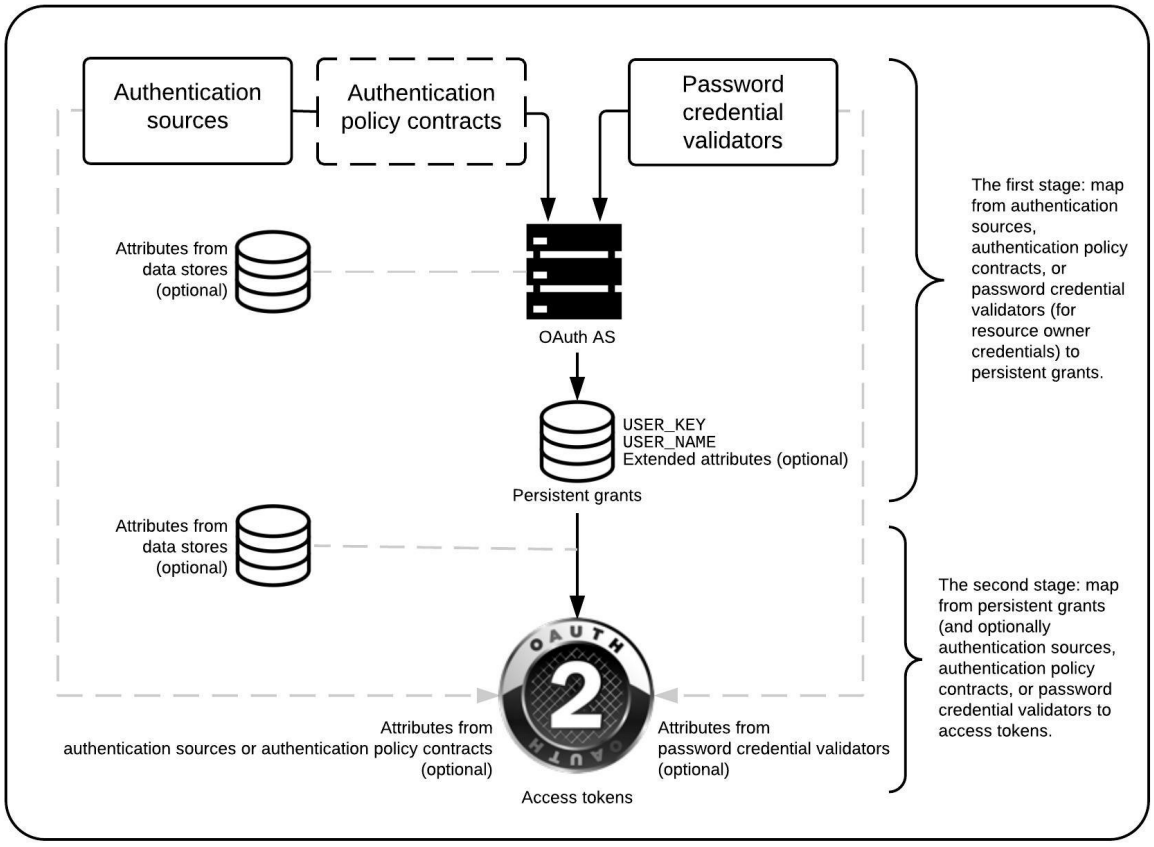
3.3 How to Configure the OAuth 2 AS

Configuration of a Ping OAuth 2 AS is described at https://documentation.pingidentity.com/pingfederate/pf82/index.shtml#concept_usingOauthMenuSelections.html#concept_usingOauthMenuSelections.

This guide documents the configuration for an AS serving the role of the *idm.sandbox* server hosted in the Motorola Solutions cloud instance, as depicted in Figure 1-1. This AS is configured to support the three usage scenarios—local user authentication at the AS, redirection to a SAML IdP, and redirection to an OIDC IdP—and to initiate the correct login flow based on an IdP discovery mechanism.

An understanding of the PingFederate OAuth implementation helps provide context for the configurations documented in this guide. PingFederate supports several different authentication flows and mechanisms, but there is a common framework for how user attributes are mapped into OAuth tokens. This framework is depicted in Figure 3-1, which is taken from PingFederate's documentation at https://documentation.pingidentity.com/pingfederate/pf83/index.shtml#concept_mappingOauthAttributes.html#concept_mappingOauthAttributes.

Figure 3-1 Access Token Attribute Mapping Framework



The overall OAuth processing flow at the AS is as follows:

1. The AS receives an OAuth authorization request from an unauthenticated user.

2. The AS authenticates the user through the configured authentication adapters, IdP connections, and/or authentication policies.
3. Information from adapters or policy contracts, optionally combined with user information retrieved from data stores such as Lightweight Directory Access Protocol (LDAP), are used to build a persistent grant context. The two mandatory attributes in the persistent grant context are listed below:
    - **USER_KEY** – This is a globally unique user identifier. For ASs that interact with multiple IdPs, this name should be resistant to naming collisions across user organizations (e.g., email address or distinguished name).
    - **USER_NAME** – If the user is prompted to authorize the request, this name will be displayed on the page, so a user-friendly name, such as [givenName lastName], could be used here; the name does not need to be unique.
4. If authorization prompts are enabled, the user is prompted to approve the authorization request; for this lab build, these prompts were disabled on the assumption that fast access to apps is a high priority for the PSFR community.
5. If the request is authorized, a second mapping process takes place to populate the access token with information from the persistent grant and, optionally, from adapters, policy contracts, or data stores.

Note that persistent grant attributes are stored and can be retrieved and reused when the client uses a refresh token to obtain a new access token, whereas attributes that are looked up in the second stage would be looked up again during the token refresh request. Storing attributes in the persistent grant can therefore reduce the need for repeated directory queries; however, it may be preferable to always query some attributes that are subject to change (like account status) again when a new access token is requested. In addition, it is important to note that storing persistent grant attributes requires a supported relational database or LDAP data store. Refer to the following documentation for a list of supported data stores: https://documentation.pingidentity.com/pingfederate/pf82/index.shtml#gettingStartedGuide/task/installingPingFederate.html.

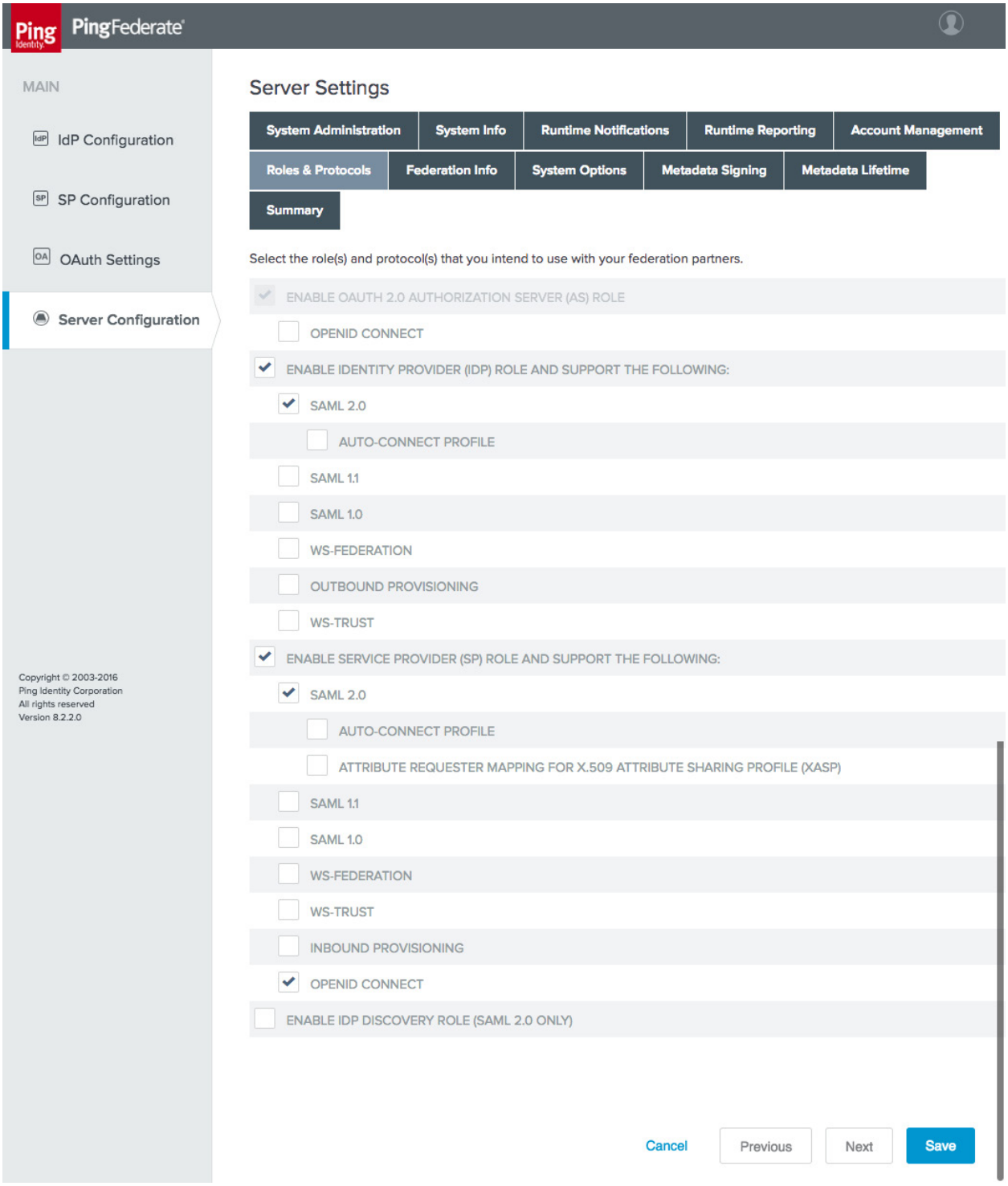
The following steps go through the configuration of the AS.

1. Enable the PingFederate installation to work as an AS. This can be done in the following steps:
    a. Under **Main**, click the **Server Configuration** section tab, and then click **Server Settings**.
    b. In **Server Settings**, click the **Roles & Protocols** tab. The Roles & Protocols screen will appear as shown in Figure 3-2.
        i. Click **ENABLE OAUTH 2.0 AUTHORIZATION SERVER (AS) ROLE**.

ii. Click **ENABLE IDENTITY PROVIDER (IDP) ROLE AND SUPPORT THE FOLLOWING**, and then under it, click **SAML 2.0**. Although this server does not act as a SAML IdP, it is necessary to enable the IdP role and at least one protocol to configure the local user authentication use case.

iii. Click **ENABLE SERVICE PROVIDER (SP) ROLE AND SUPPORT THE FOLLOWING**, and then under it, click **SAML 2.0** and **OPENID CONNECT**; this enables integration with both types of IdPs.

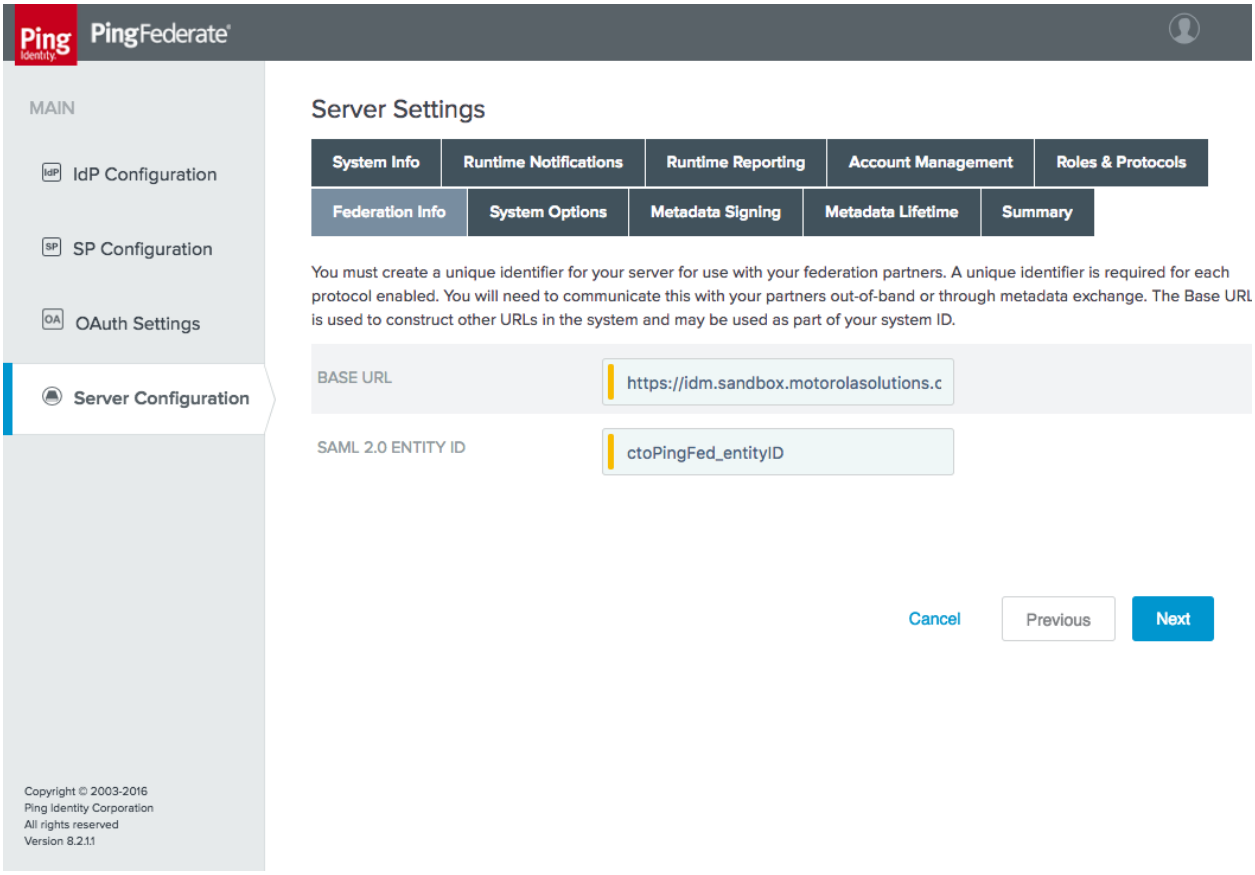
1044 **Figure 3-2 Server Roles for AS**



1045

c. Also under **Server Settings**, on the **Federation Info** tab, enter the **BASE URL** and **SAML 2.0 ENTITY ID** (Figure 3-3). The **BASE URL** should use a public DNS name that is resolvable by any federation partners. The **SAML 2.0 ENTITY ID** is simply an identifier string that must be unique among federation partners; it is recommended to be a Uniform Resource Identifier (URI), per the SAML 2.0 Core specification [12].

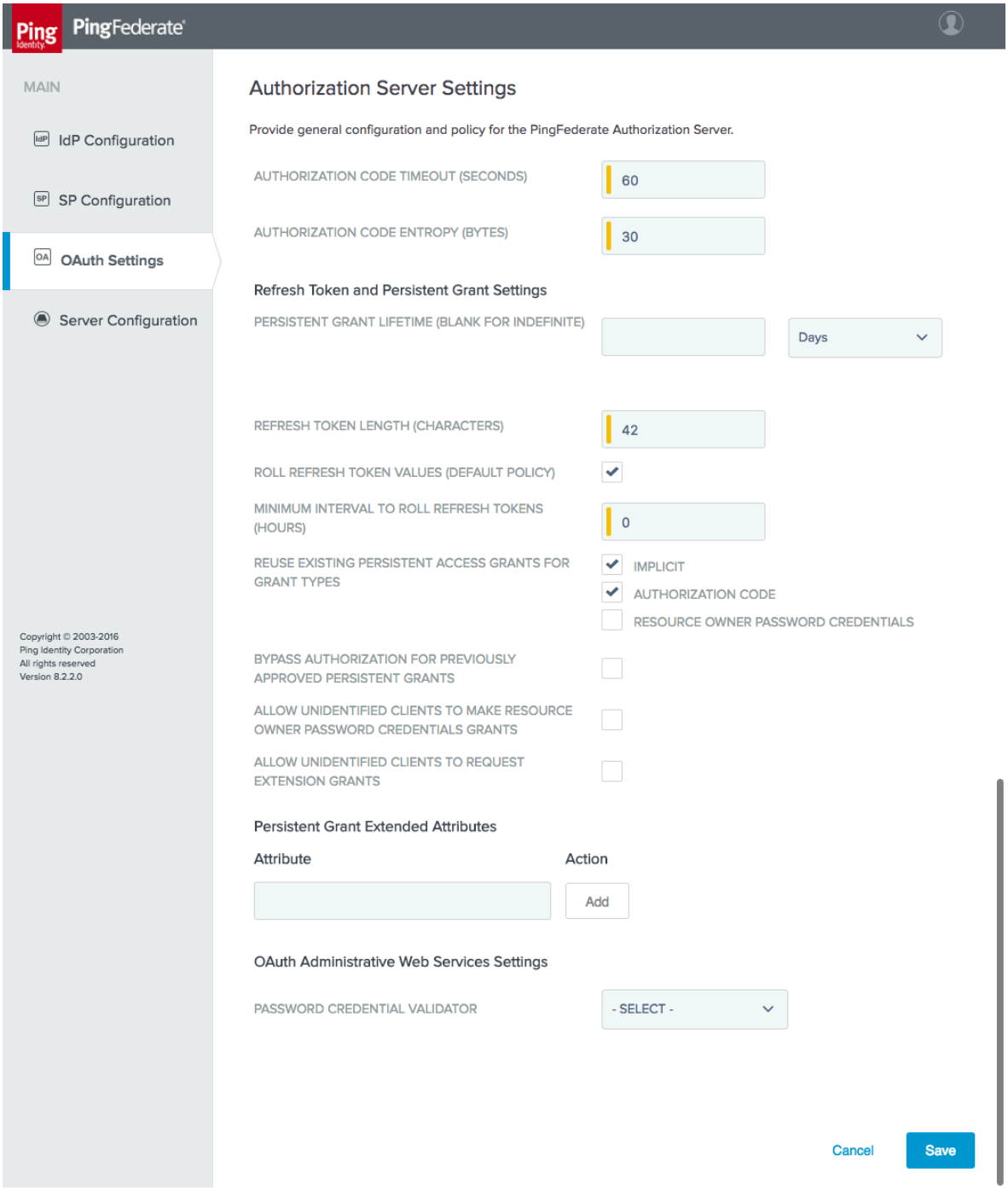
Figure 3-3 Federation Info



2. The next step is to configure the OAuth AS. Click the **OAuth Settings** section tab under **Main**.

a. Click **Authorization Server Settings** under the **Authorization Server** header. This displays the **Authorization Server Settings** (Figure 3-4).

1056 **Figure 3-4 AS Settings**



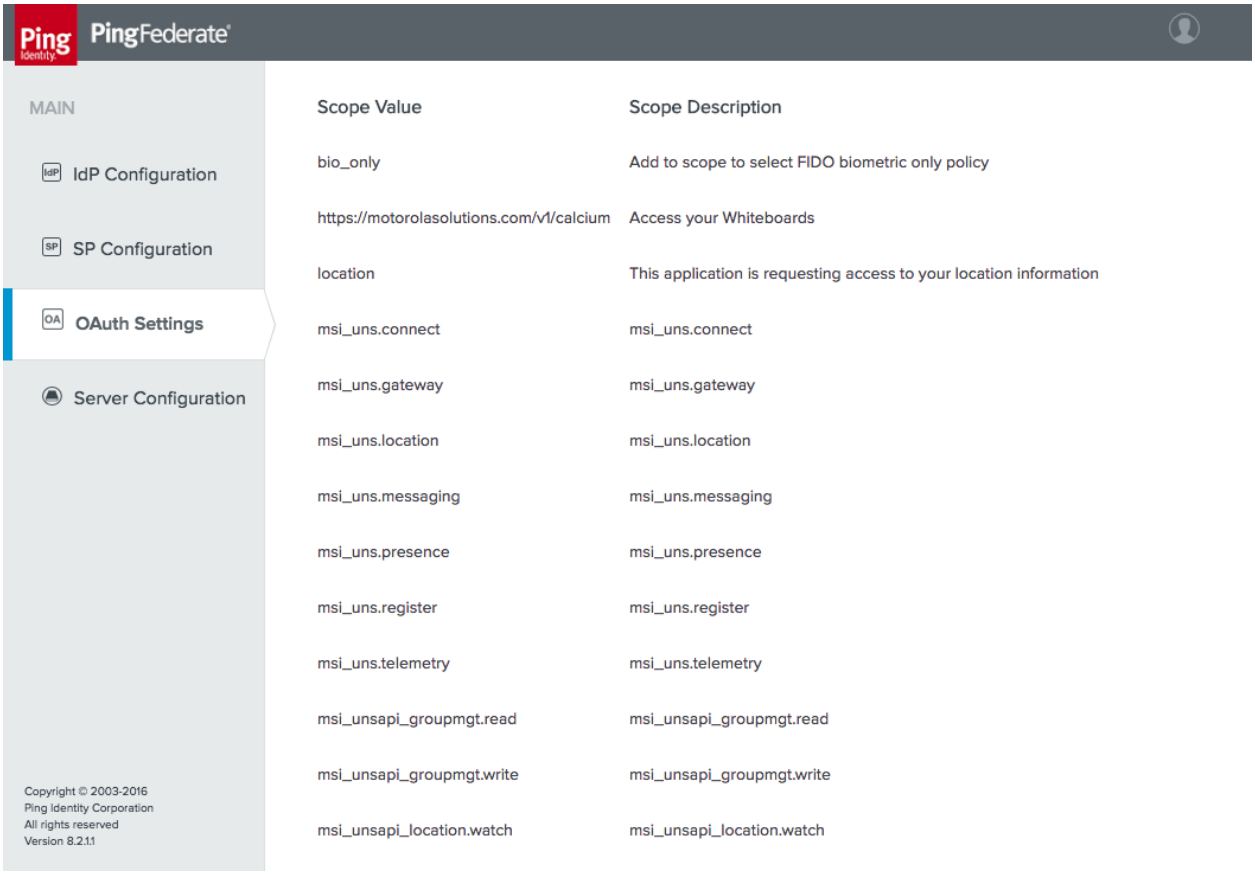
1057

The default settings are suitable for the lab build architecture; organizations may wish to customize these default settings in accordance with organizational security policy or usage requirements. Some notes on individual settings are provided below:

- **AUTHORIZATION CODE TIMEOUT (SECONDS)**: Once an authorization code has been returned to a client, it must be exchanged for an access token within this interval. This reduces the risk of an unauthorized client obtaining an access token through brute-force guessing or intercepting a valid client's code. *Proof Key for Code Exchange (PKCE)* [13], as implemented by the AppAuth library, is another useful mechanism to protect the authorization code.
- **AUTHORIZATION CODE ENTROPY (BYTES)**: Length of the authorization code returned by the AS to the client, in bytes
- **REFRESH TOKEN LENGTH (CHARACTERS)**: Length of the refresh token, in characters
- **ROLL REFRESH TOKEN VALUES (DEFAULT POLICY)**: When selected, the OAuth AS generates a new refresh token value when a new access token is obtained.
- **MINIMUM INTERVAL TO ROLL REFRESH TOKENS (HOURS)**: The minimum number of hours that must pass before a new refresh token value can be issued.
- **REUSE EXISTING PERSISTENT ACCESS GRANTS FOR GRANT TYPES**:
  - **IMPLICIT**: Consent from the user is requested only for the first OAuth resource request associated with the grant.
  - **AUTHORIZATION CODE**: Same as above if the **BYPASS AUTHORIZATION FOR PREVIOUSLY APPROVED PERSISTENT GRANTS** is selected; this can be used to prompt the user for authorization only once to avoid repeated prompts for the same client.
- **PASSWORD CREDENTIAL VALIDATOR**: Required for Hypertext Transfer Protocol (HTTP) Basic authentication if the OAuth Representational State Transfer (REST) Web Service is used for managing client apps; this functionality was not used for this build.

3. Next, configure scopes, as required, for the app. Click the **OAuth Settings** section tab, and then click **Scope Management**. The specific scope values will be determined by the client app developer. Generally speaking, scopes refer to different authorizations that can be requested by the client and granted by the user. Access tokens are associated with the scopes for which they are authorized, which can limit the authorities granted to clients. Figure 3-5 shows several scopes that were added to the AS for this lab build that have specific meanings in the PSX apps suite.

1093 **Figure 3-5 Scopes**



1094

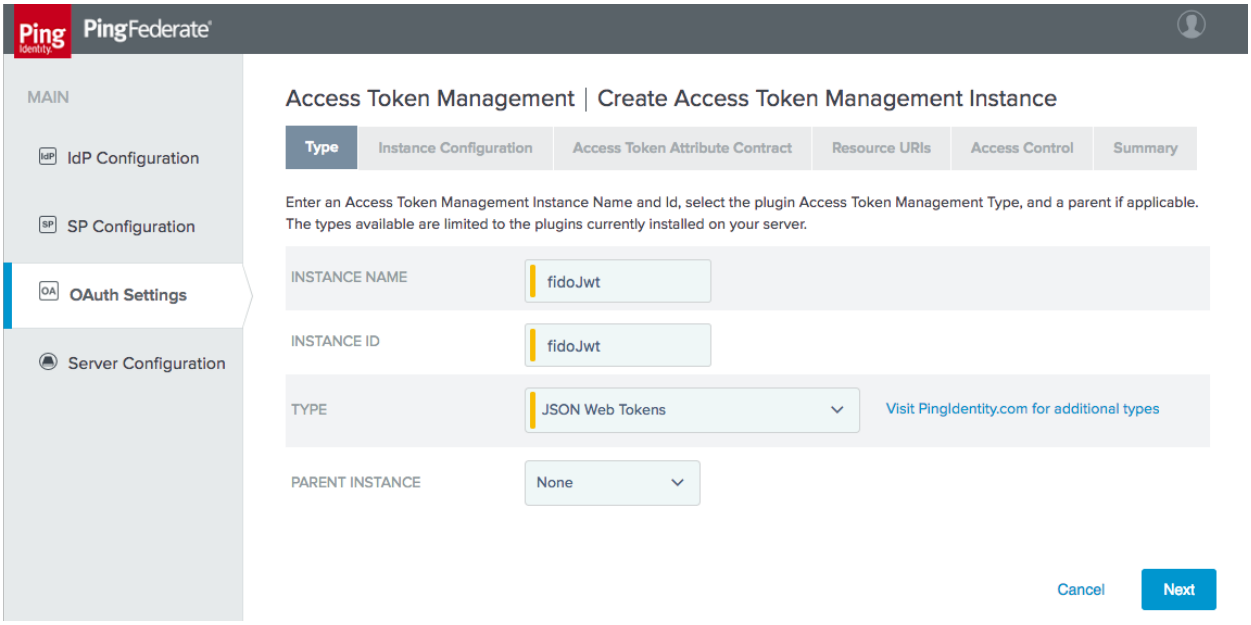
1095 4. Define an Access Token Management profile. This profile determines whether access tokens are
1096 issued as simple reference token strings or as JWTs. For this lab build, JWTs were used. JWTs are
1097 signed and optionally encrypted, so resource servers can validate them locally and they can
1098 contain user attributes and other information. Reference tokens are also a viable option, but
1099 resource servers must contact the AS's introspection endpoint to determine whether they are
1100 valid, and must obtain the granted scopes and any other information associated with them. The
1101 Access Token Management Profile also defines any additional attributes that will be associated
1102 with the token.

1103 a. Create an Access Token Manager by following these steps:

1104 i. Click the **OAuth Settings** section tab, click **Access Token Management**, and then
1105 click **Create New Instance**.

1106 ii. On the **Type** tab, give the instance a meaningful name and ID, and select the to-
1107 ken type (Figure 3-6).

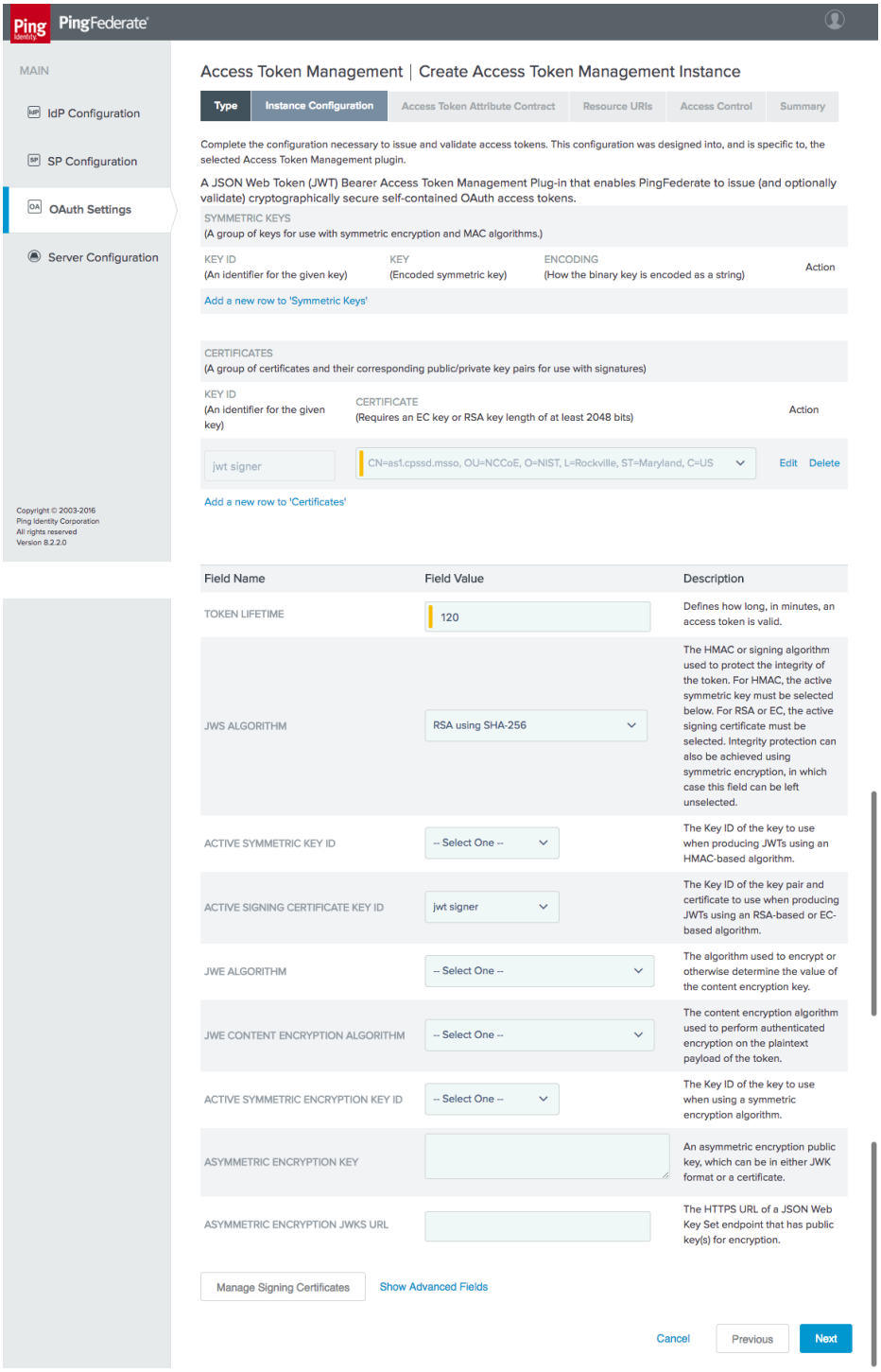
1108 **Figure 3-6 Access Token Management Instance**



1109

1110 5. On the next tab, **Instance Configuration**, select a symmetric key or certificate to use for JWT
1111 signing (Figure 3-7). In this instance, a signing certificate was created as described in
1112 Section 3.2.4. Tokens can also optionally be encrypted using JSON Web Encryption (JWE) [14]; in
1113 this case, the client developer would provide a certificate in order to receive encrypted
1114 messages. JWE was not used in the lab build.

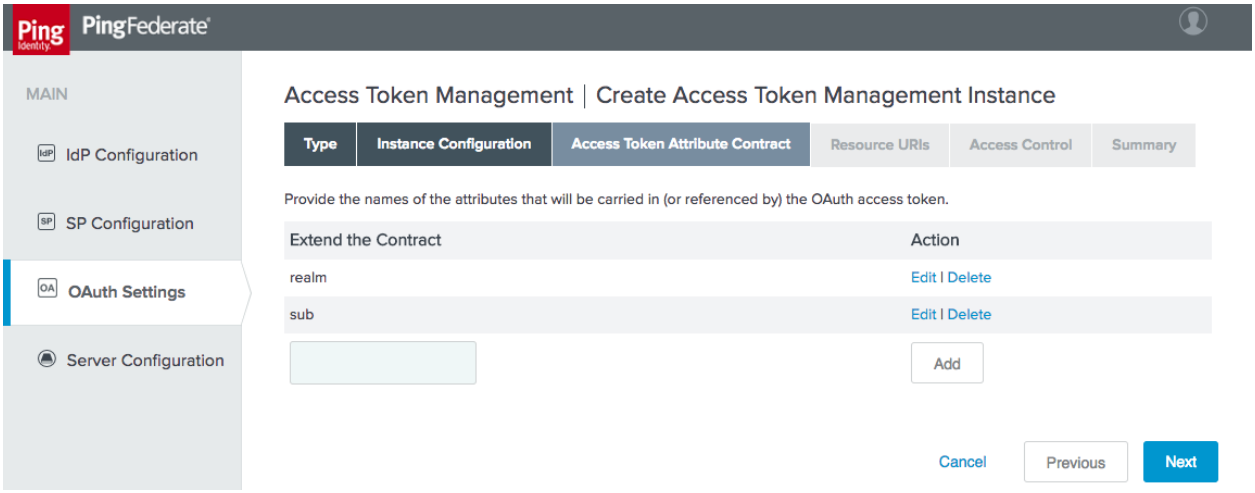
1115 **Figure 3-7 Access Token Manager Instance Configuration**



1116

6. On the **Access Token Attribute Contract** tab, add the two values **realm** and **sub** to the attribute contract (Figure 3-8).

Figure 3-8 Access Token Manager Attribute Contract

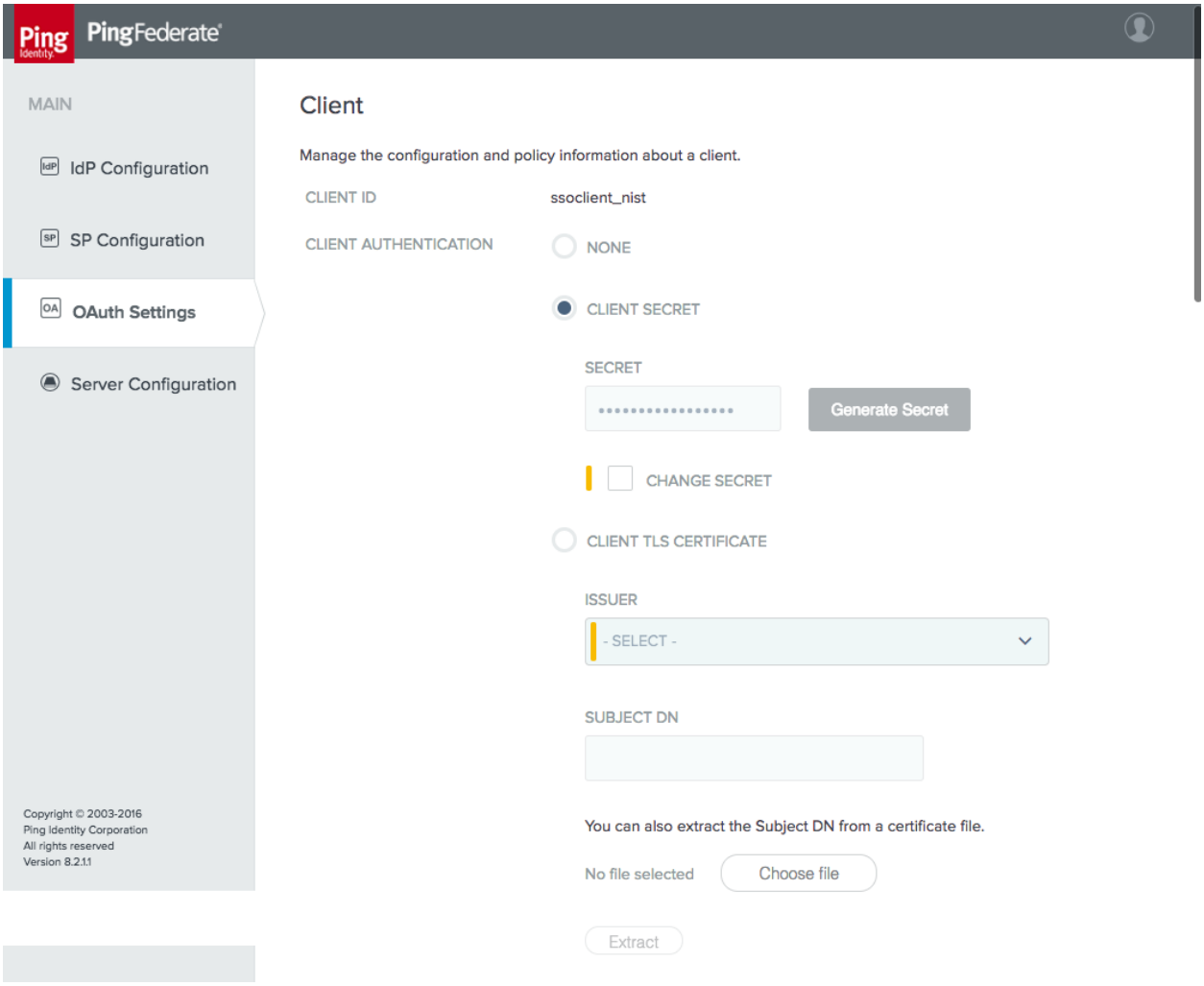


7. The **Resource URIs** and **Access Control** tabs were not used for this build. Click **Save** to complete the Access Token Manager.

8. Next, one or more OAuth clients need to be registered with the AS. In the Motorola Solutions use case, the PSX Cockpit app is registered as a client. OAuth Client registration is described for PingFederate at: https://documentation.pingidentity.com/pingfederate/pf82/index.shtml#concept_configuringClient.html.

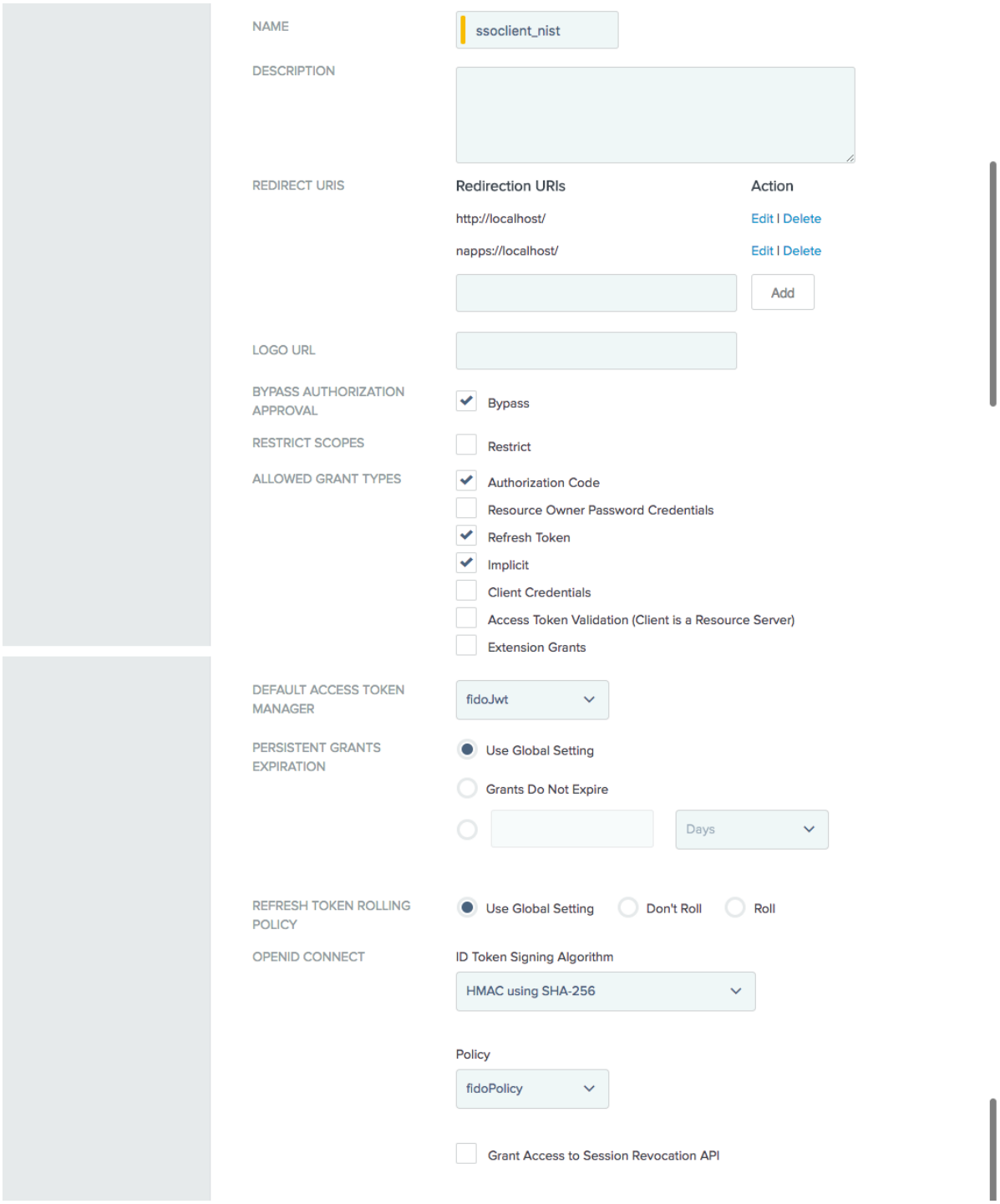
   To create a new client, click the **OAuth Settings** section tab, click **Clients**, and then click **Create New**. Clients are displayed on the rightmost side of the screen in the **OAuth Settings** window. Once **Create New** is clicked, the screen shown in Figure 3-9 and Figure 3-10 will appear. Due to the vertical size of the pages of this document, the screenshot is divided into two parts for legibility.

1133 **Figure 3-9 OAuth Client Registration, Part 1**



1134

1135 **Figure 3-10 OAuth Client Registration, Part 2**



1136

The following are notes on the parameters on this screen:

- **CLIENT ID**: This is a required parameter. This is the unique identifier accompanied with each request that is presented to the AS's token and authorization endpoints. For this lab build, Motorola Solutions assigned a client ID of "ssoclient_nist" for the instances of their apps on the test devices.
- **CLIENT AUTHENTICATION**: May be set to **NONE**, **CLIENT SECRET** (for HTTP basic authentication), or **CLIENT TLS CERTIFICATE**. For native mobile app clients, there is no way to protect a client secret or private key and provide it to all instances of the app with any guarantee of confidentiality, as a user might be able to reverse-engineer the app to obtain any secrets delivered with it, or to debug the app to capture any secrets delivered at run-time. Therefore, a value of **NONE** is acceptable for native mobile apps, when mitigated with the use of PKCE. For web clients, servers are capable of protecting secrets; therefore, some form of client authentication should be required.
- **REDIRECT URIS**: Redirection URIs are the URIs to which the OAuth AS may redirect the resource owner's user agent after authorization is obtained. A redirect URI is used with the **Authorization Code** and **Implicit** grant types. This value is typically provided by the app developer to the AS administrator.
- **ALLOWED GRANT TYPES**: These are the allowed grant types for the client. For this lab build, the **Authorization Code** grant type was used exclusively.
- **DEFAULT ACCESS TOKEN MANAGER**: This is the Access Token Manager profile to be used for this client.
- **PERSISTENT GRANTS EXPIRATION**: This setting offers the option to override the global AS persistent grants settings for this client.
- **REFRESH TOKEN ROLLING POLICY**: This setting offers the option to override the global AS token rolling policy settings for this client.

Once these values are set, click **Save** to store the client.

This completes the required configuration for the AS's interactions with OAuth clients. The following section outlines the steps to set up the AS to authenticate users.

3.4 How to Configure the OAuth 2 AS for Authentication

In this section, the AS is configured to authenticate users locally or through federation with a SAML or OIDC IdP. These settings depend on the selection of roles and protocols, as shown in Figure 3-2, therefore, ensure that has been completed before proceeding.

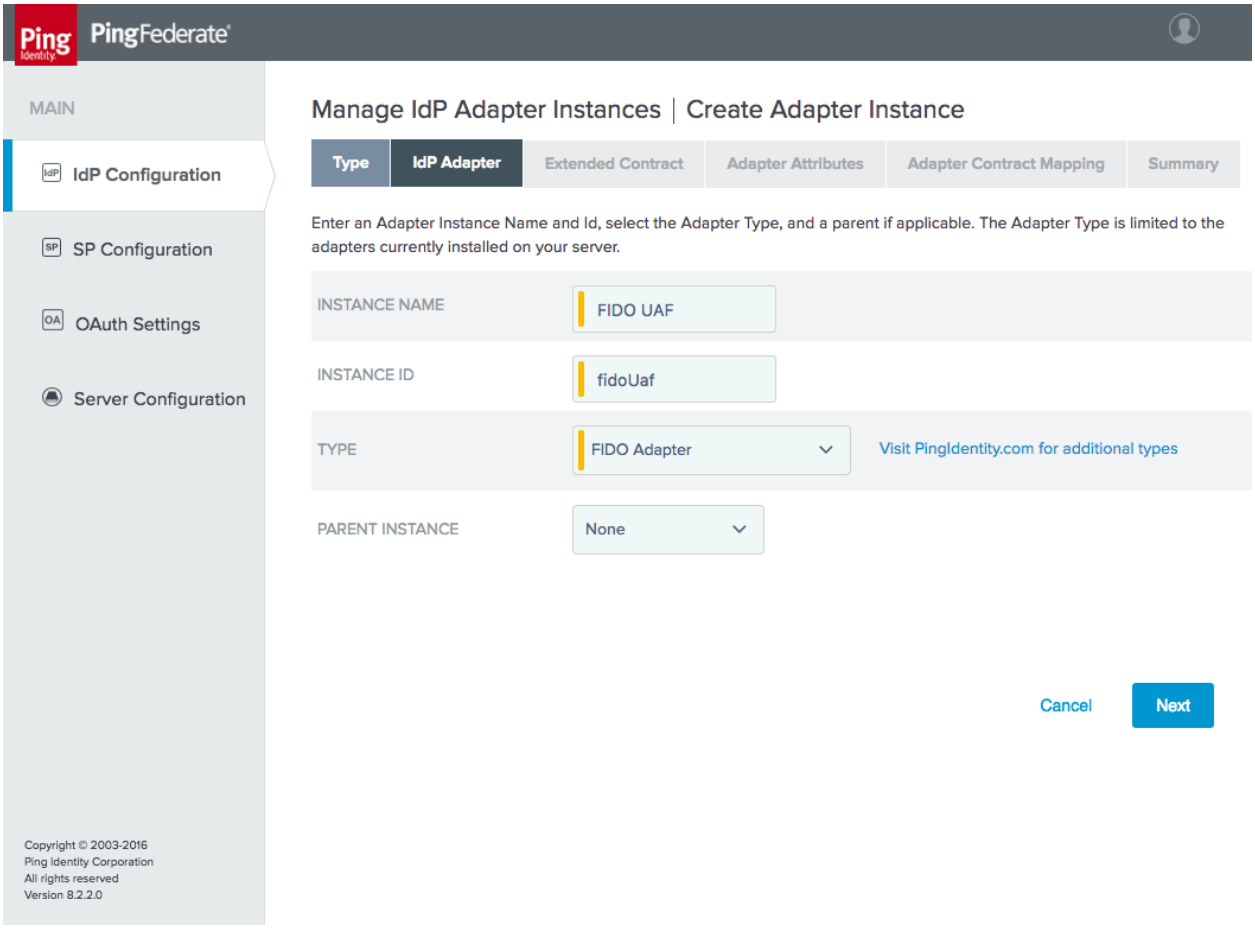
3.4.1 How to Configure Direct Authentication

The AS was configured to authenticate users with FIDO UAF authentication. This depends on the NNAS, Nok Nok Labs Gateway, and Nok Nok Labs UAF Plugin for PingFederate. See Section 5 for the installation and configuration instructions for those components. This section assumes that those components have already been installed and configured.

3.4.1.1 Configure Adapter Instance

1. First, an instance of the FIDO UAF adapter must be configured. Click the **IdP Configuration** section tab, and then click **Adapters** under **Application Integration**.
2. Click **Create New Instance** to create an IdP adapter instance. This will bring up the new tabbed screen shown in Figure 3-11.
    a. On the **Type** tab, the **INSTANCE NAME** and **INSTANCE ID** are internal identifiers and can be set to any meaningful values. The **TYPE** selection, “FIDO Adapter,” will not appear until the Nok Nok Labs UAF plugin has been successfully installed on the PingFederate server as described in Section 5.

1183 **Figure 3-11 Create Adapter Instance**

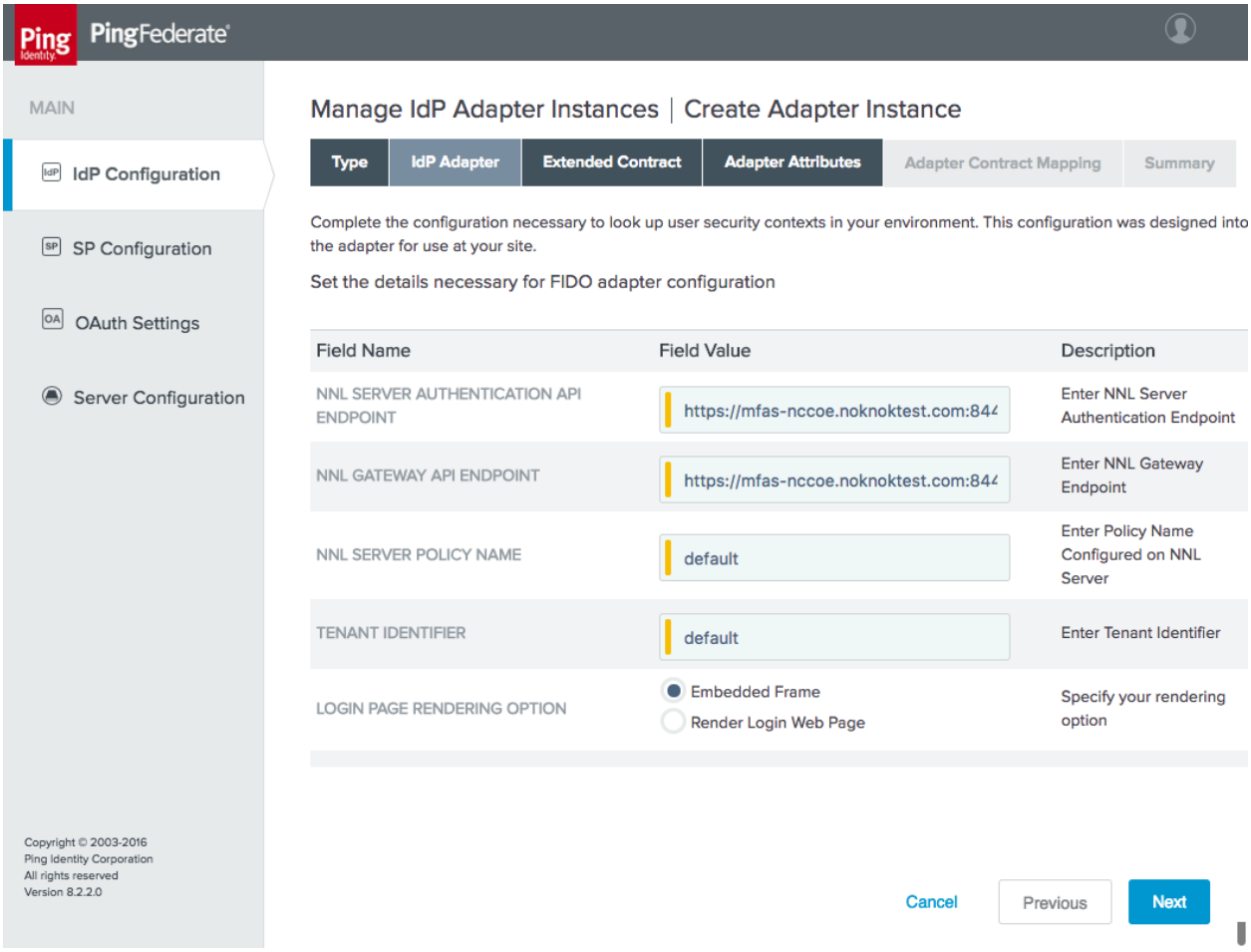


1184

1185 b. On the **IdP Adapter** tab, specify the URLs for the Nok Nok Labs API and Gateway end-
1186 points (Figure 3-12).

1187 i. The **NNL SERVER POLICY NAME** field can be used to select a custom policy, if
1188 one has been defined on the Nok Nok Labs server; for this build, the default pol-
1189 icy was used.

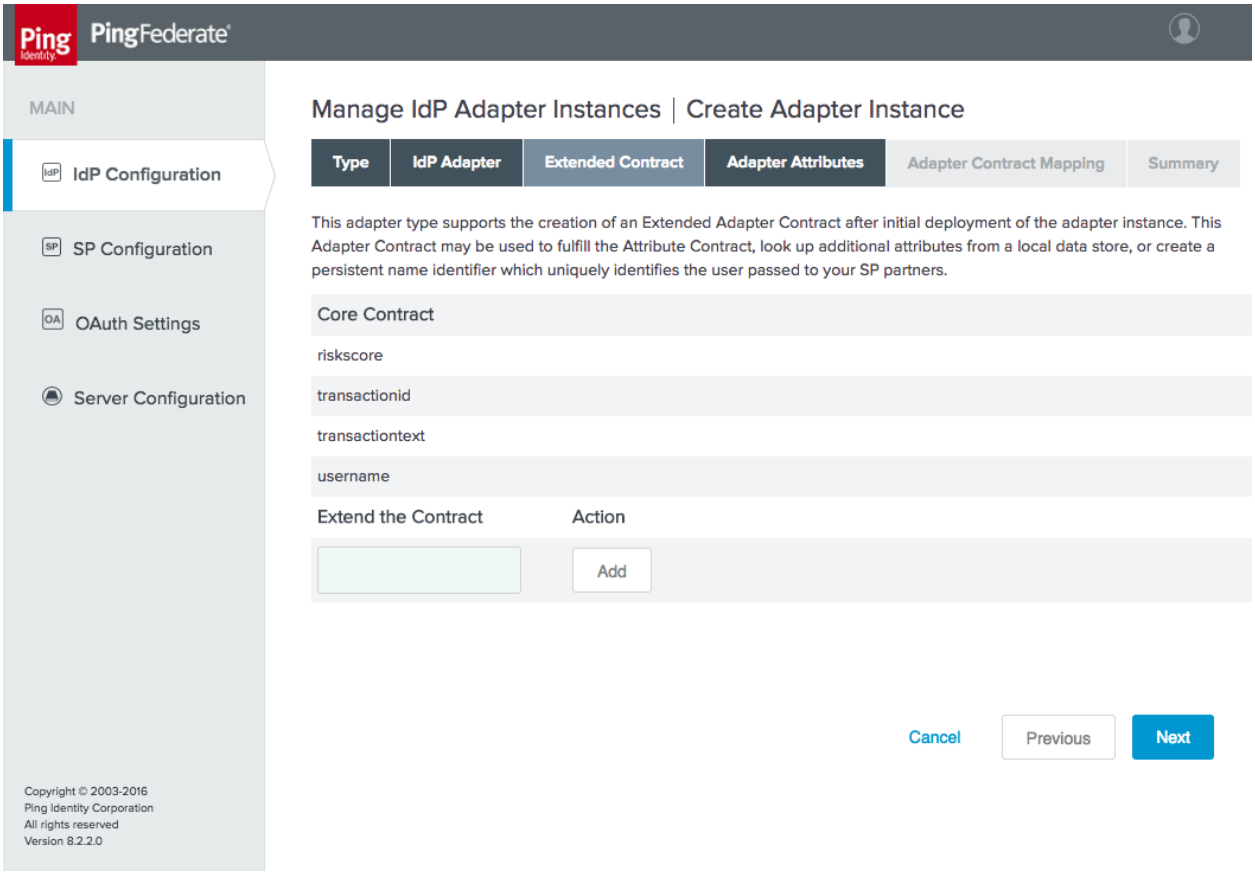
1190 **Figure 3-12 FIDO Adapter Settings**



1191

1192 c. The **Extended Contract** tab was also left as the default for the adapter, which provides
1193 the **riskscore**, **transactionid**, **transactiontext**, and **username** values (Figure 3-13). If de-
1194 sired, additional attributes could be added to the contract and looked up in a user direc-
1195 tory, based on the username returned from the adapter.

1196 **Figure 3-13 FIDO Adapter Contract**

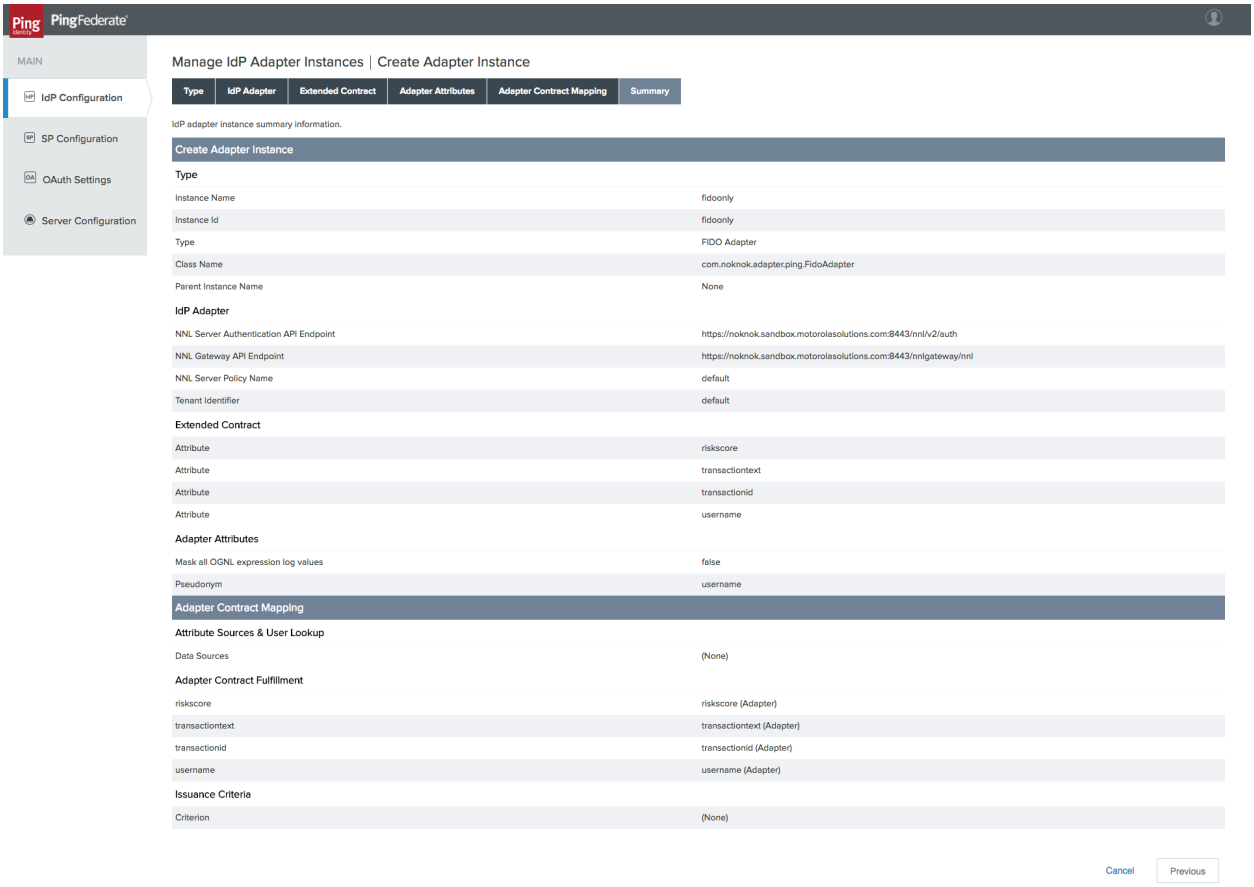


1197

1198 d. On the **Adapter Attributes** tab, select the **Pseudonym** checkbox for **username**. Pseudo-
1199 nyms were not used in the lab build, but a selection is required on this tab.

1200 e. There is no need to configure an adapter contract, unless attributes have been added on
1201 the **Extended Contract** tab. Clicking **Done** and then **Save** completes the configuration of
1202 the adapter. Clicking the adapter name in the list of adapters brings up the Adapter In-
1203 stance **Summary** tab, which lists all of the configured settings (Figure 3-14).

1204 **Figure 3-14 FIDO Adapter Instance Summary**



1205

1206 Some additional configurations are needed to tie this authentication adapter to the issuance of an
1207 OAuth token. It is possible to directly map the adapter to the access token context, but because the
1208 adapter will be incorporated into an authentication policy in this case, an Authentication Policy Contract
1209 Mapping is used instead.

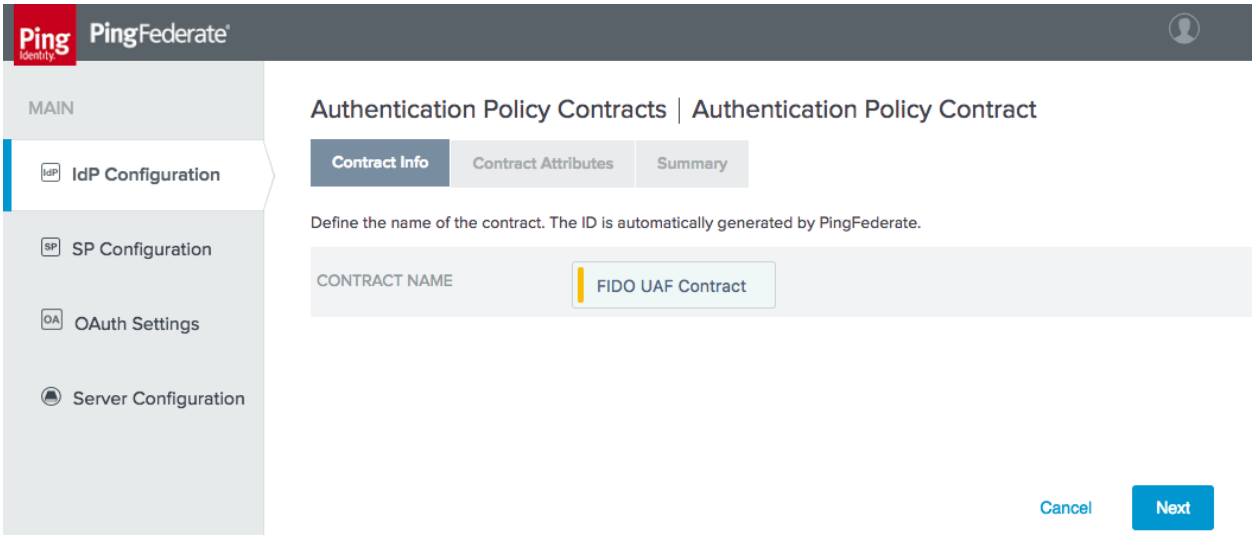
1210 ### *3.4.1.2 Create Policy Contract*

1211 1. To create a Policy Contract, navigate to the **IdP Configuration** section tab, and select **Policy**
1212 **Contracts** under **Authentication Policies**. A policy contract defines the set of attributes that will
1213 be provided by an authentication policy.

1214 2. Click **Create New Contract**.

1215 a. On the **Contract Info** tab, give the contract a meaningful name (Figure 3-15).

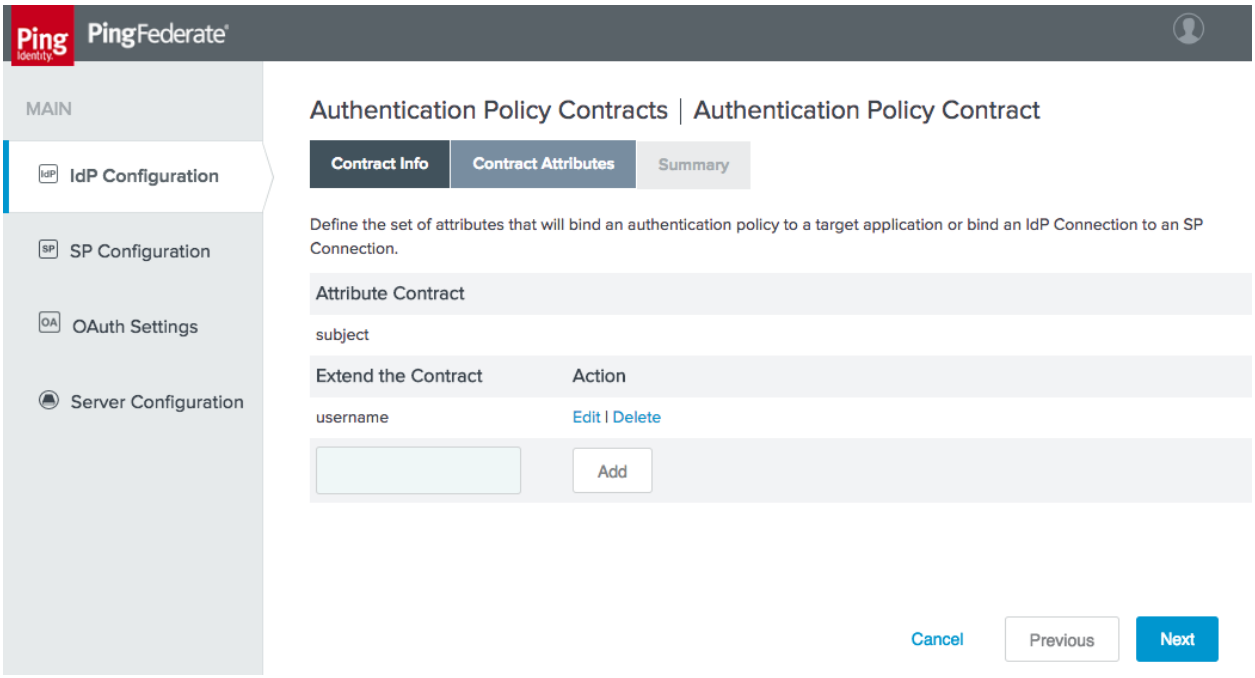
1216 **Figure 3-15 Policy Contract Information**



1217

1218 b. On the **Contract Attributes** tab, add a value called **username** (Figure 3-16).

1219 **Figure 3-16 Policy Contract Attributes**



1220

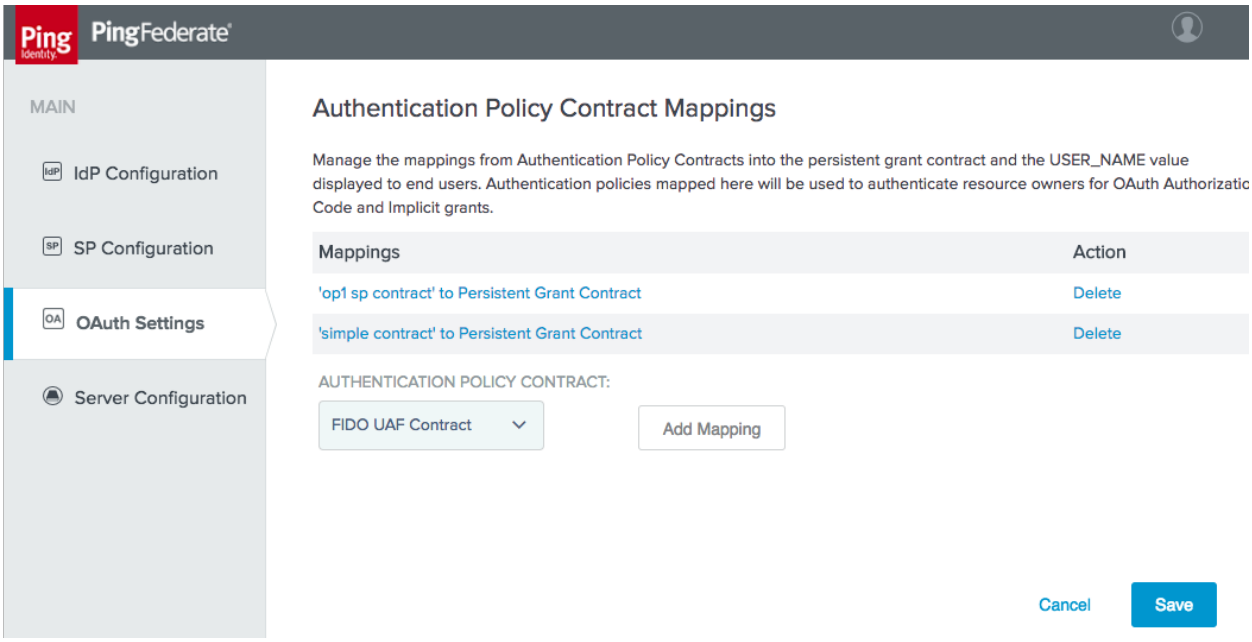
1221 c. Click **Done**, and then click **Save** to save the new contract.

3.4.1.3 Create Policy Contract Mapping

1. Create a mapping from the policy contract to the OAuth persistent grant. Click the **OAuth Settings** section tab, and then click **Authentication Policy Contract Mapping** under **Token & Attribute Mapping**.

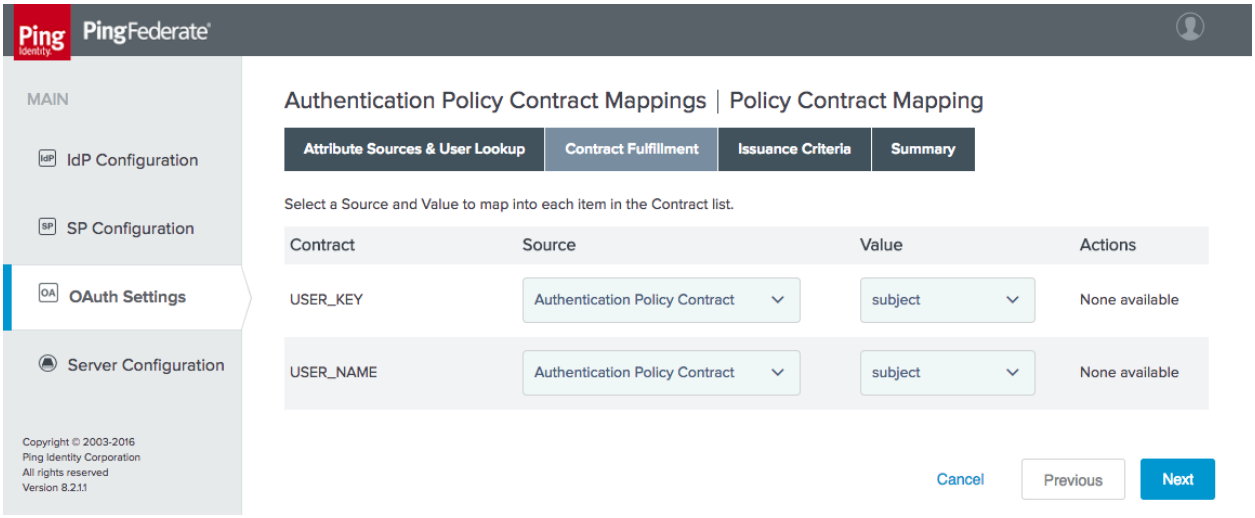
    a. Select the newly-created policy contract, and then click **Add Mapping** (Figure 3-17).

Figure 3-17 Create Authentication Policy Contract Mapping



2. An attribute source could be added at this point to look up additional user attributes, but this is not necessary. Click **Save**.
3. Skip the **Attribute Sources & User Lookup** tab.
4. On the **Contract Fulfillment** tab, map both **USER_KEY** and **USER_NAME** to the **subject** value returned from the policy contract (Figure 3-18).

1234 **Figure 3-18 Authentication Policy Contract Fulfillment**



1235

1236 5. No issuance criteria were specified. Click **Next**, and then click **Save** to complete the mapping.

1237 ### *3.4.1.4 Create Access Token Mapping*

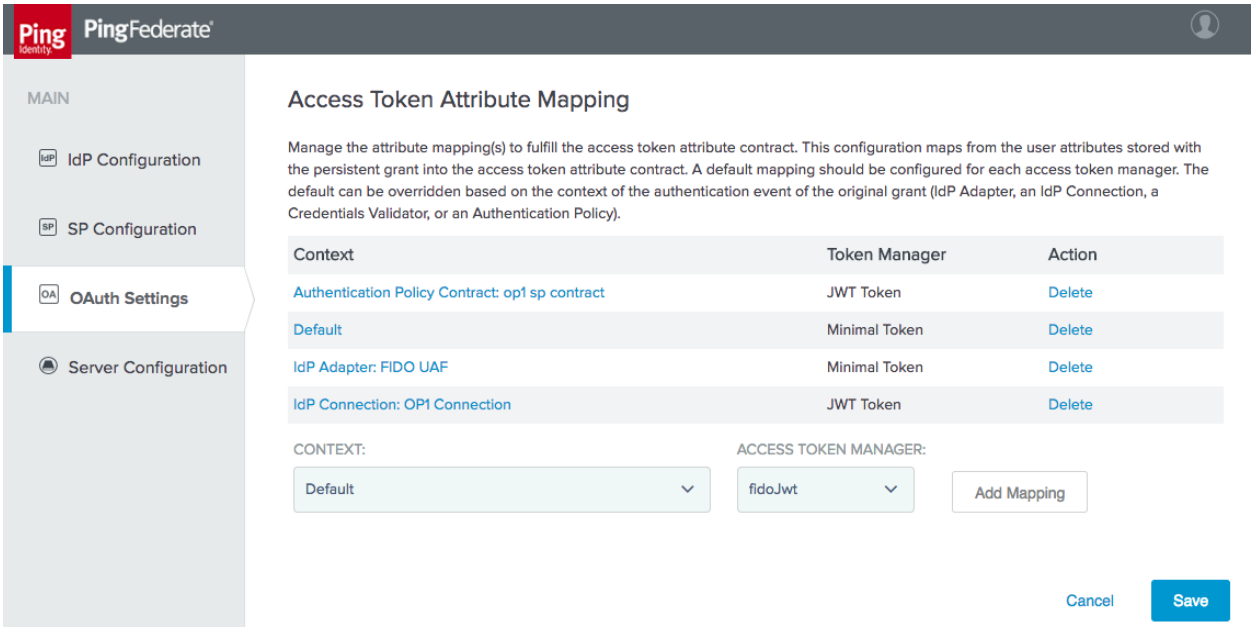
1238 Finally, an access token mapping needs to be created. In this simple case, the adapter only provides a
1239 single attribute (username) and it is stored in the persistent grant, so a default attribute mapping can be
1240 used.

1241 1. On the **OAuth Settings** section tab, under **Token & Attribute Mapping**, click **Access Token**
1242 **Mapping**.

1243 a. Select **Default** for the **CONTEXT** (Figure 3-19).

1244 b. Select the **ACCESS TOKEN MANAGER** created previously (Figure 3-19).

1245 **Figure 3-19 Create Access Token Attribute Mapping**



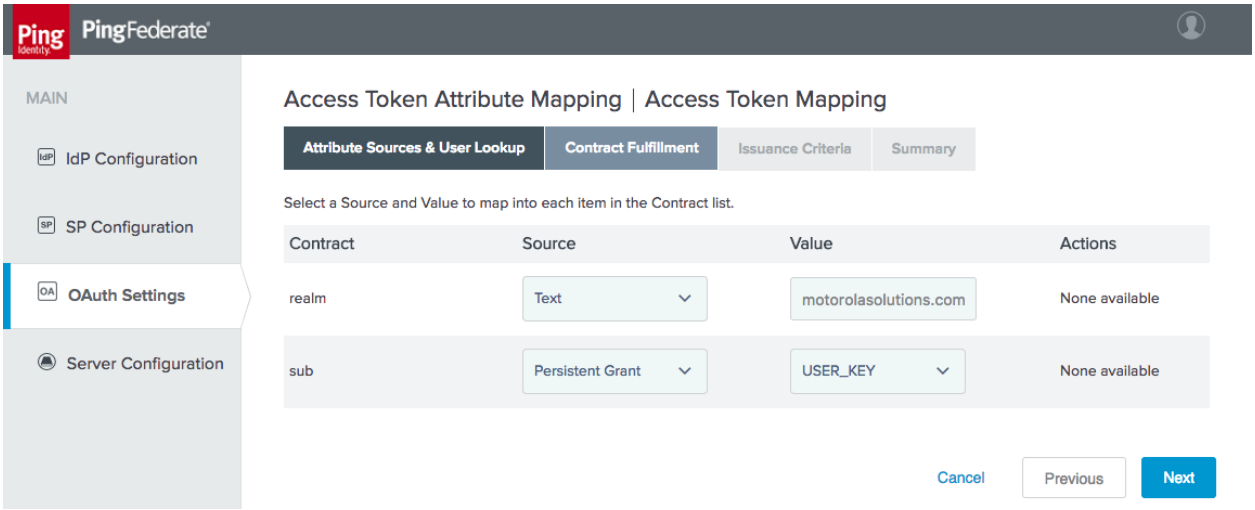
1246

1247 c. Click **Add Mapping**.

1248 d. Click **Next** to Skip the **Attribute Sources & User Lookup** tab.

1249 e. On the **Contract Fulfillment** tab, configure sources and values for the **realm** and **sub**
1250 contracts (Figure 3-20). In this case, **realm** is set to the text string **motorolasolu-**
1251 **tions.com**. Click **Next**.

1252 **Figure 3-20 Access Token Mapping Contract Fulfillment**



1253

f. Click **Next** through the **Issuance Criteria** tab, and then click **Save**.

2. To complete the setup for direct authentication, the FIDO UAF adapter needs to be included in an authentication policy as described in Section 3.4.4.2.

3.4.2 How to Configure SAML Authentication

This section explains how to configure the AS to accept SAML authentication assertions from a SAML 2.0 IdP. This configuration is for RP-initiated SAML web browser SSO, where the authentication flow begins at the AS and the user is redirected to the IdP. Here, it is assumed that all of the steps outlined in Section 3.4 have been completed, particularly enabling the SP role and protocols.

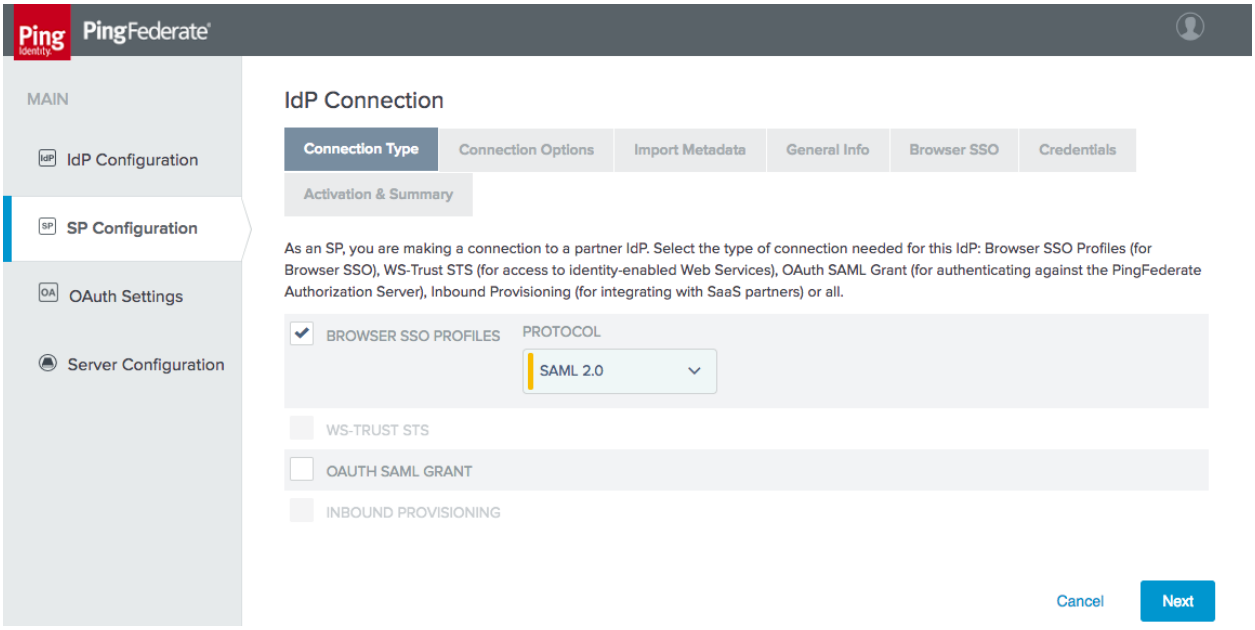
3.4.2.1 Create IdP Connection

Establishing the relationship between the AS and IdP requires coordination between the administrators of the two servers, which will typically belong to two separate organizations. The administrators of the SAML IdP and RP will need to exchange their **BASE URL** and **SAML 2.0 ENTITY ID** values (available on the **Federation Info** tab under **Server Settings**) to complete the configuration. The IdP administrator must also provide the signing certificate of the IdP. If assertions will be encrypted, the AS administrator will need to provide the IdP administrator with the certificate to be used for the public key. Alternatively, administrators can export their SAML metadata and provide it to the other party to automate parts of the setup.

1. On the **SP Configuration** section tab, click **Create New** under **IdP Connections**.

    a. On the **Connection Type** tab, select **BROWSER SSO PROFILES**, and choose **SAML 2.0** for the **PROTOCOL** (Figure 3-21). If these options are not present, ensure that the roles are selected correctly in **Server Settings**.

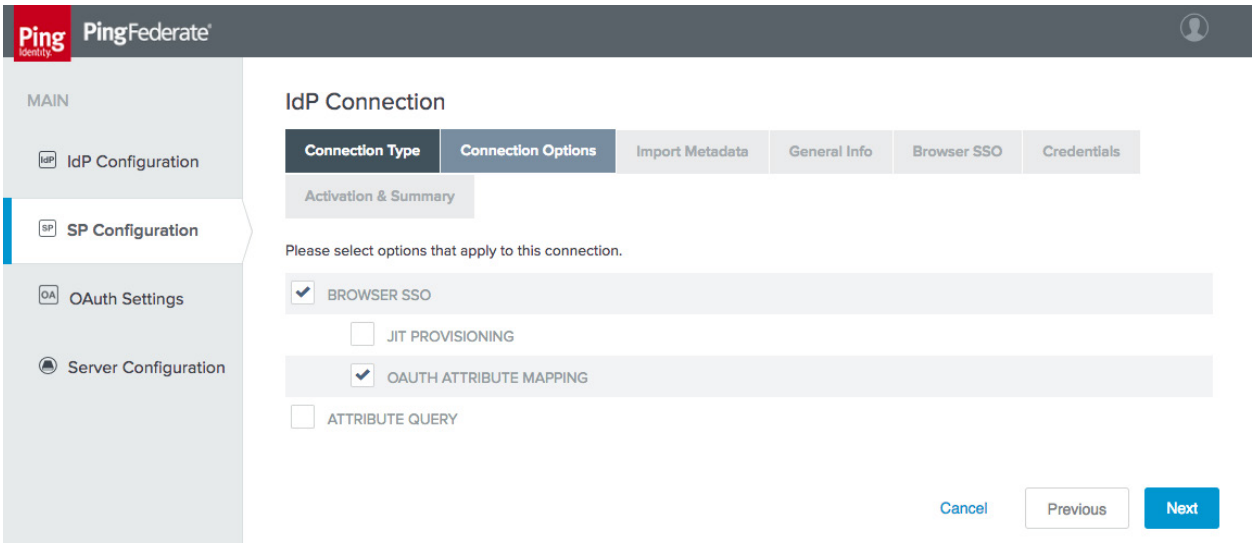
1275 **Figure 3-21 Create IdP Connection**



1276

1277 b. On the **Connection Options** tab, select **BROWSER SSO**, and then under it, **OAUTH AT-**
1278 **TRIBUTE MAPPING** (Figure 3-22).

1279 **Figure 3-22 IdP Connection Options**

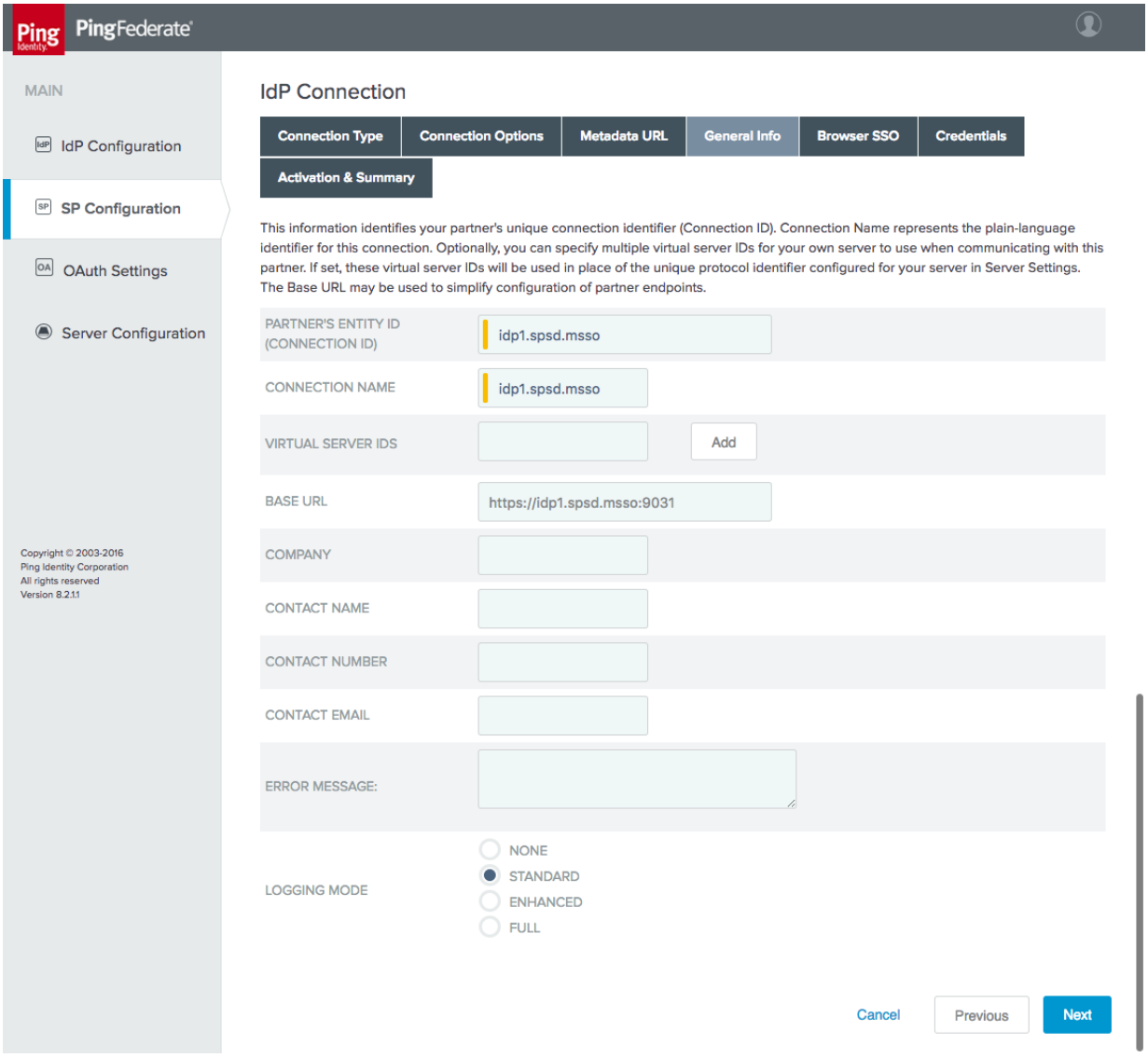


1280

1281 c. Metadata import was not configured for the lab build; therefore, skip the **Import**
1282 **Metadata** tab.

d. On the **General Info** tab, enter the **PARTNER'S ENTITY ID (CONNECTION ID)** and **BASE URL** of the IdP, and provide a **CONNECTION NAME** (Figure 3-23).

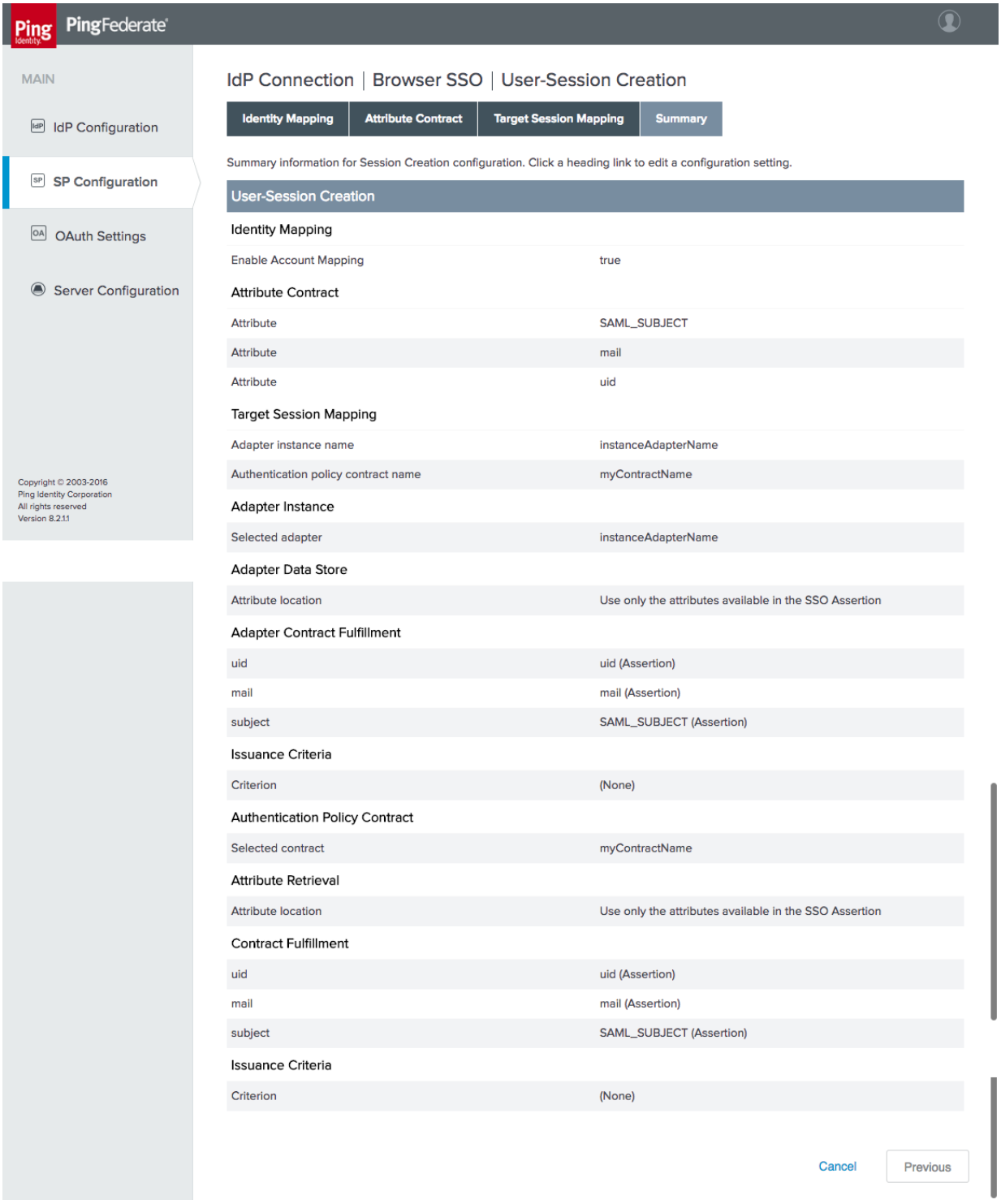
Figure 3-23 IdP Connection General Info



e. On the **Browser SSO** tab, click **Configure Browser SSO**. The Browser SSO setup has multiple sub-pages.

i. On the **SAML Profiles** tab, select **SP-Initiated SSO**. The **User-Session Creation** settings are summarized on the **Summary** tab; they extract the user ID and email address from the SAML assertion (Figure 3-24).

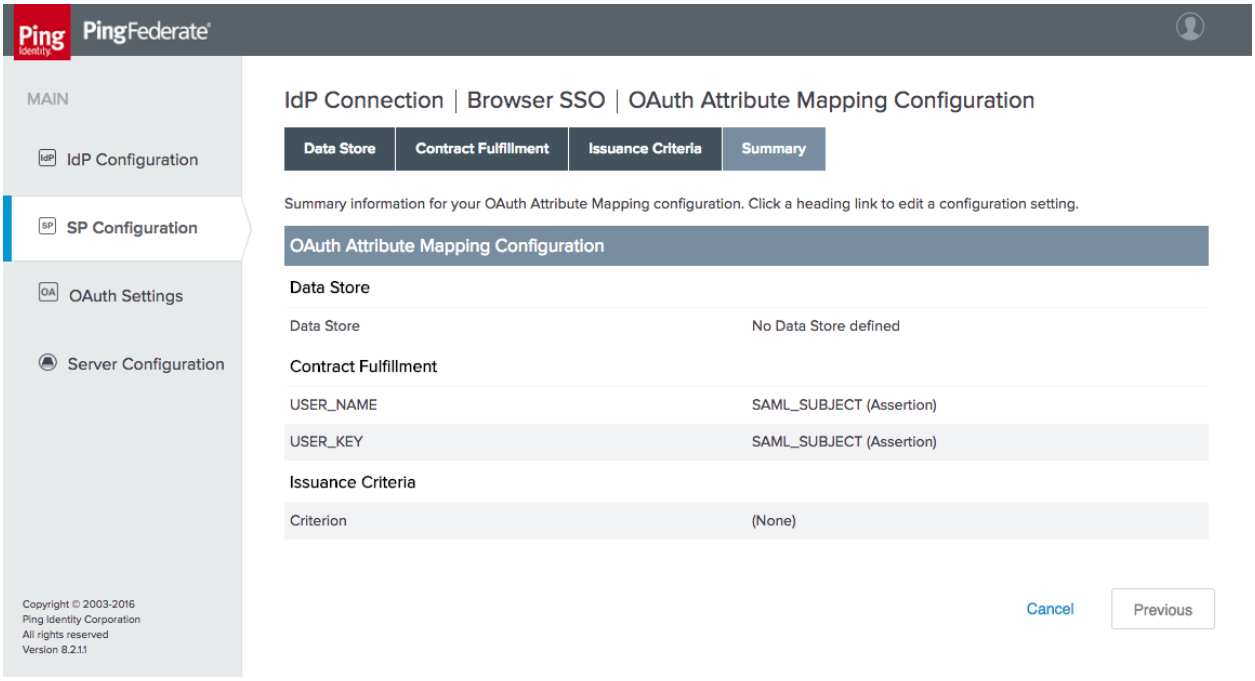
1292 **Figure 3-24 IdP Connection – User-Session Creation**



1293

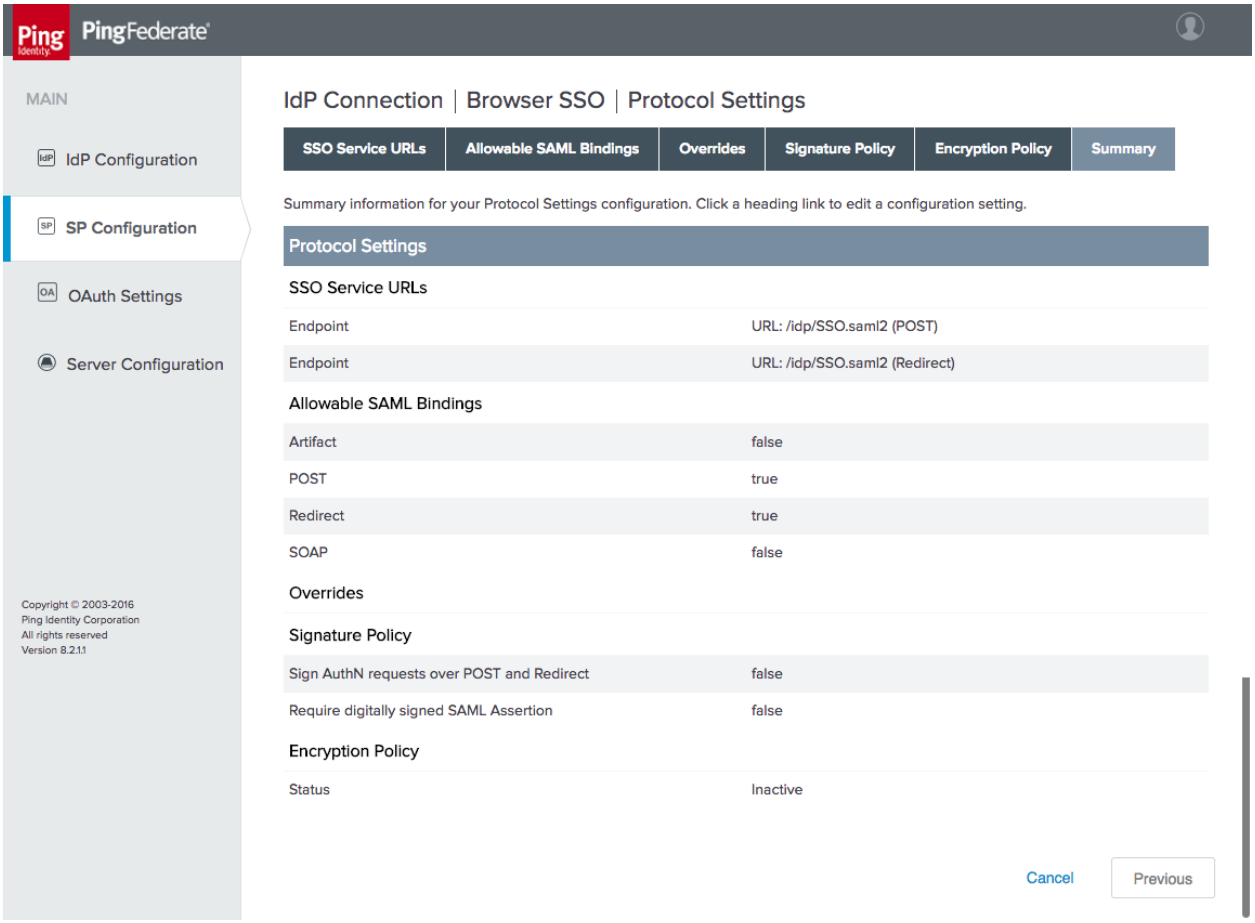
ii. On the **OAuth Attribute Mapping Configuration** tab, select **MAP DIRECTLY INTO PERSISTENT GRANT**. Configure the OAuth attribute mapping as shown in Figure 3-25. This maps both required values in the persistent grant context to the SAML subject. Click **Next**, then **Next** again to skip the **Issuance Criteria** tab. Click **Save.**

Figure 3-25 IdP Connection OAuth Attribute Mapping



iii. Click **Next** to proceed to the **Protocol Settings** tab. The **Protocol Settings** configure specifics of the SAML protocol, such as the allowed bindings. Configure these as shown in Figure 3-26. When finished, click **Save**, which will return you to the **Browser SSO** tab of the **IdP Connection** settings.

1305 **Figure 3-26 IdP Connection – Protocol Settings**



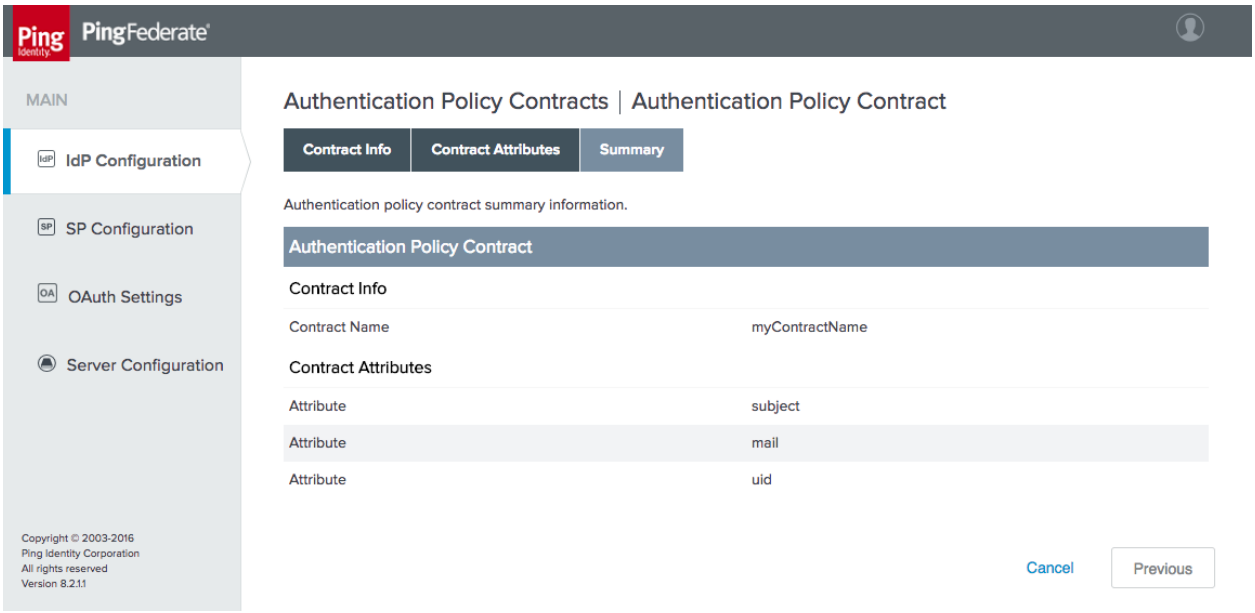
1306

1307 f. Click **Next**. On the **Credentials** tab, the IdP's signing certificate can be uploaded. This is
1308 not necessary if the certificate is signed by a trusted CA.

3.4.2.2 Create Policy Contract

1. Create a policy contract as described in Section 3.4.1.2, with the attributes **subject**, **mail**, and **uid** (Figure 3-27).

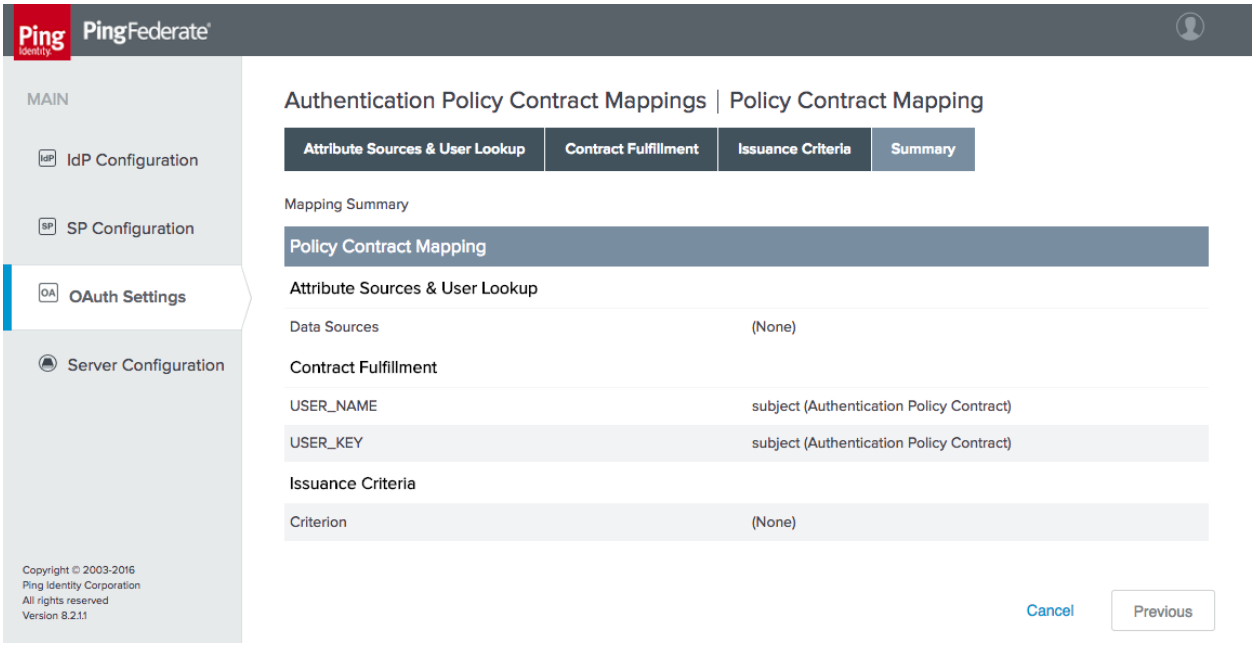
Figure 3-27 Policy Contract for SAML RP



3.4.2.3 Create Policy Contract Mapping

1. Create an OAuth policy contract mapping for the newly created policy as described in Section 3.4.1.3, mapping **USER_NAME** and **USER_KEY** to **subject** (Figure 3-28).

1317 **Figure 3-28 Contract Mapping for SAML RP**



1318

1319 2. To complete the setup for SAML authentication, the FIDO UAF adapter needs to be included in
1320 an authentication policy as described in Section 3.4.4.2.

1321 ## 3.4.3 How to Configure OIDC Authentication

1322 As with the configuration of a SAML IdP connection, integrating the AS with an OIDC IdP requires
1323 coordination between the administrators of the two systems. The administrator of the IdP must create
1324 an OIDC client registration before the connection can be configured on the AS side. The AS administrator
1325 must provide the redirect URI and, if encryption of the ID Token is desired, a public key. Unlike with
1326 SAML, there is no metadata file to exchange; however, if the IdP supports the OIDC discovery endpoint,
1327 the client can automatically obtain many of the required configuration settings from the discovery URL.

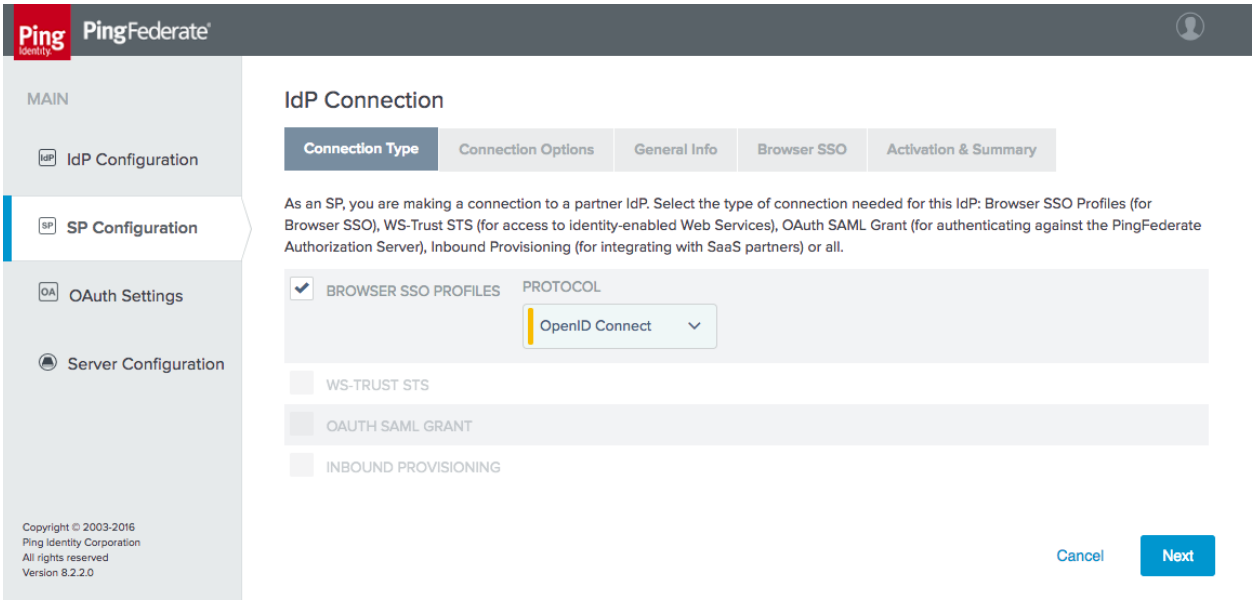
1328 This section assumes that the AS role and OIDC SP support have been enabled via **Server Settings**, as
1329 described in Section 3.4. This section also uses the same authentication policy contract as the SAML
1330 authentication implementation. Create the policy contract as described in Section 3.4.2.2, if it does not
1331 already exist.

1332 ### *3.4.3.1 Create IdP Connection*

1333 1. On the **SP Configuration** section tab, click **Create New** under **IdP Connections**.

1334 a. On the **Connection Type** tab, select **BROWSER SSO PROFILES**, and then under it, select
1335 **OpenID Connect** for the **PROTOCOL** (Figure 3-29).

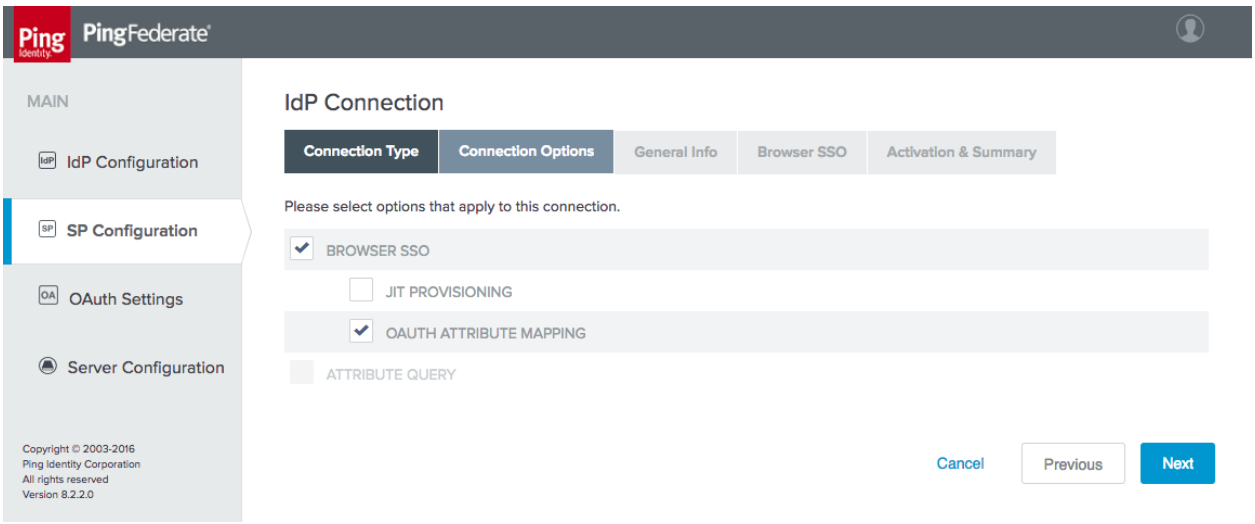
1336 **Figure 3-29 IdP Connection Type**



1337

1338 b. On the **Connection Options** tab, select **BROWSER SSO**, and then under it, select **OAUTH**
1339 **ATTRIBUTE MAPPING** (Figure 3-30).

1340 **Figure 3-30 IdP Connection Options**

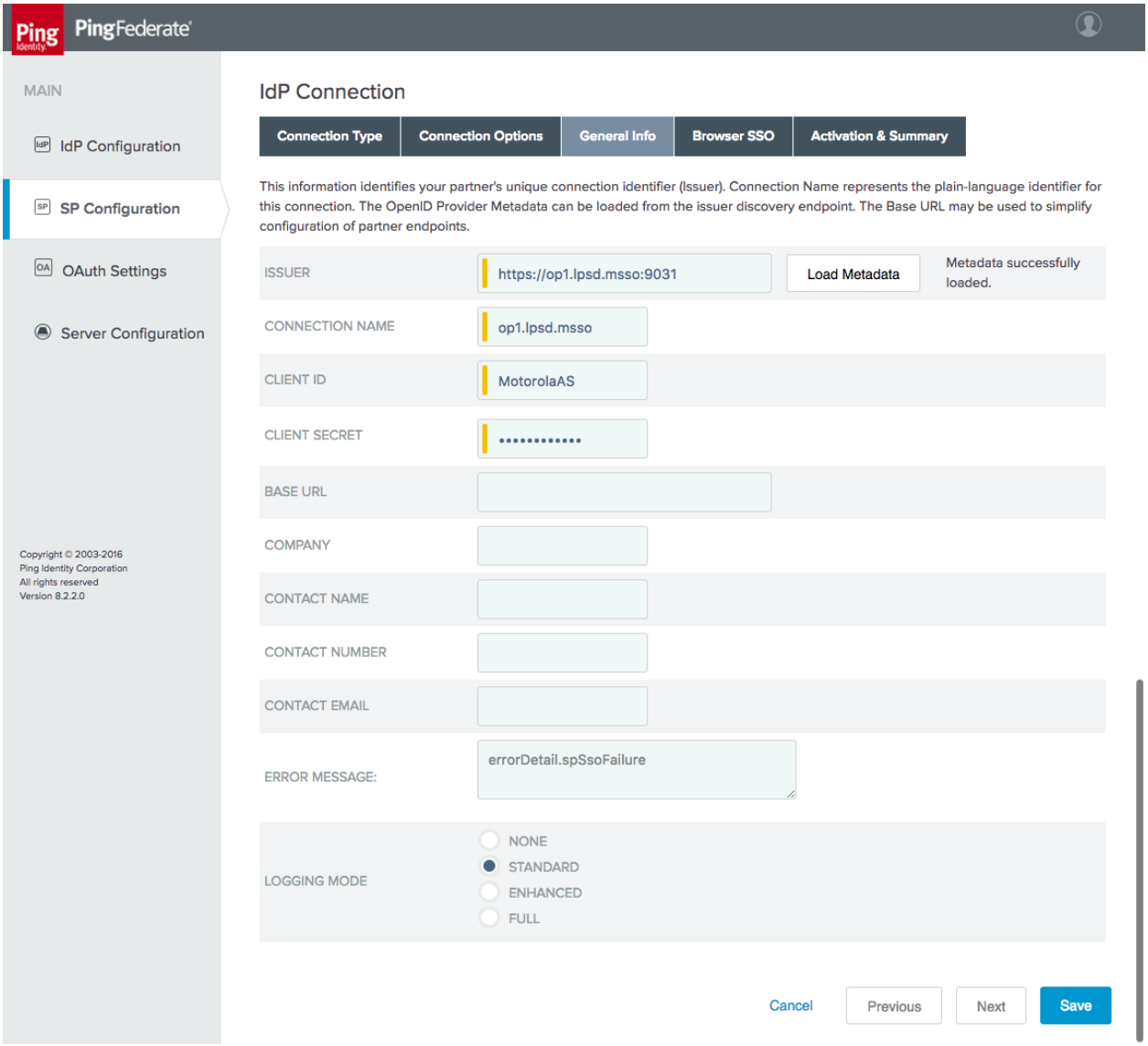


1341

1342 c. On the **General Info** tab, enter the **ISSUER** value for the IdP (Figure 3-31). This is the
1343 **BASE URL** setting available on the **Federation Info** tab, under the **Server Configuration**
1344 section tab on the IdP. Then click **Load Metadata**, which causes the AS to query the IdP's

discovery endpoint. The message “Metadata successfully loaded” should appear. Provide a **CONNECTION NAME**, and enter the **CLIENT ID** and **CLIENT SECRET** provided by the IdP administrator.

Figure 3-31 IdP Connection General Info

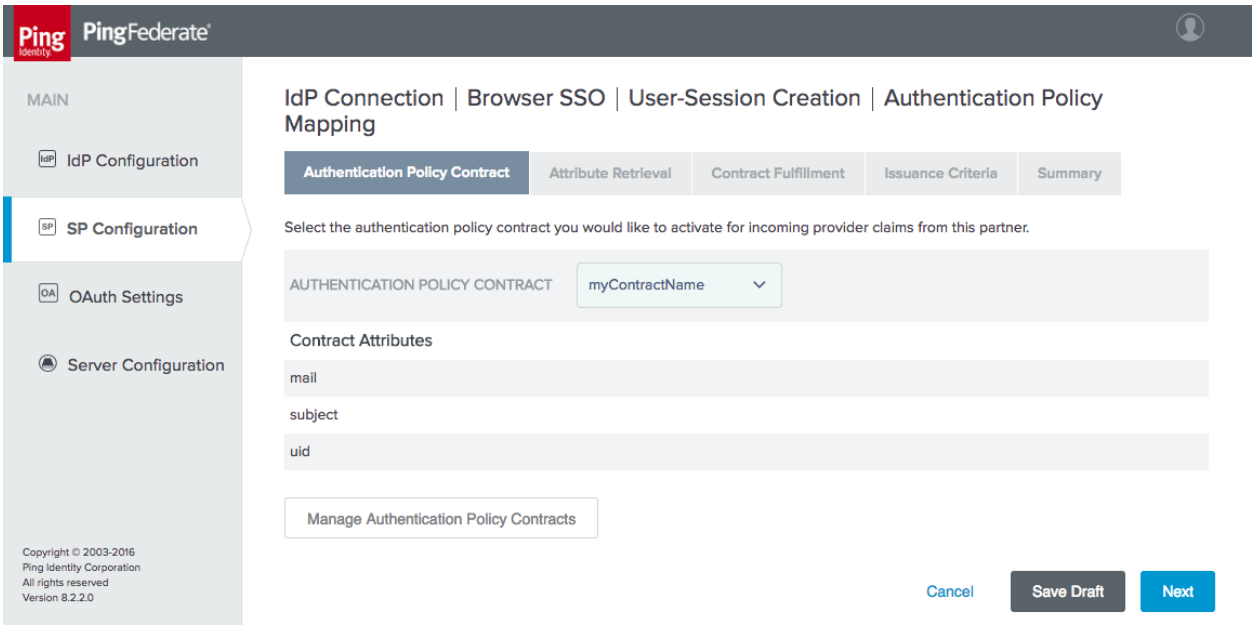


d. On the **Browser SSO** tab, click **Configure Browser SSO**, then click **Configure User-Session Creation**. The **User-Session Creation** page will appear.

i. On the **Target Session Mapping** tab, click **Map New Authentication Policy**.

ii. On the **Authentication Policy Contract** tab, select the **AUTHENTICATION POLICY CONTRACT** created in Section 3.4.2.2 (in the example shown in Figure 3-32, it is called **myContractName**). If the policy contract has not been created, click **Manage Authentication Policy Contracts**, and create it now.

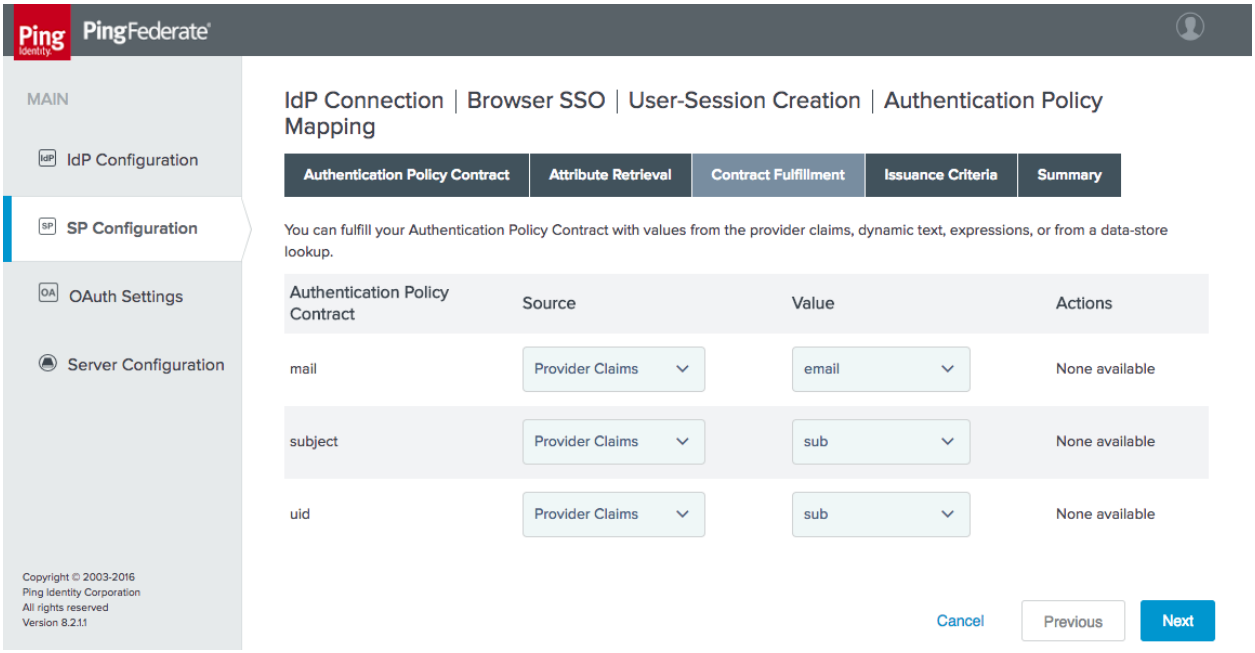
Figure 3-32 IdP Connection Authentication Policy Contract



iii. On the **Attribute Retrieval** tab, leave the default setting (use only the attributes available in the provider claims).

iv. On the **Contract Fulfillment** tab, map the **mail**, **subject**, and **uid** attributes to the **email**, **sub**, and **sub** provider claims (Figure 3-33).

1363 **Figure 3-33 IdP Connection Policy Contract Mapping**



1364

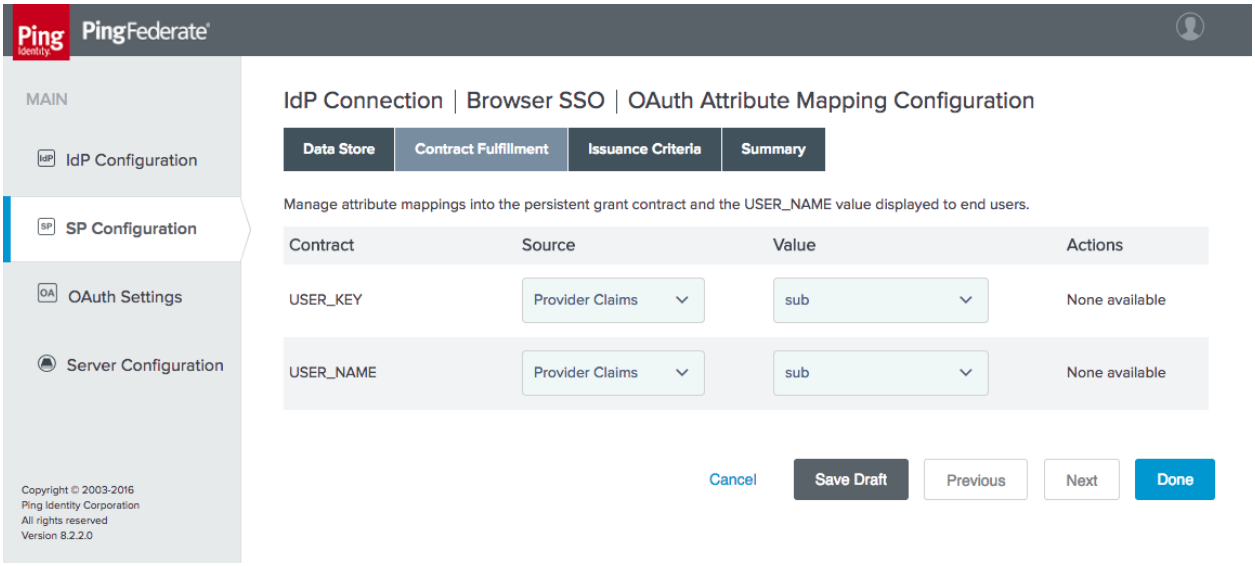
1365 v. No **Issuance Criteria** were configured; therefore, skip the **Issuance Criteria** tab.

1366 vi. Click **Next**, then **Done**, and then click **Done** again to exit the **User-Session Crea-**
1367 **tion** tab.

1368 vii. On the **OAuth Attribute Mapping Configuration** tab, select **Map Directly into**
1369 **Persistent Grant**, and then click **Configure OAuth Attribute Mapping**.

1370 viii. Click **Next** to skip the Data Store tab. On the **Contract Fulfillment** tab, map both
1371 **USER_NAME** and **USER_KEY** to the **sub** provider claim (Figure 3-34).

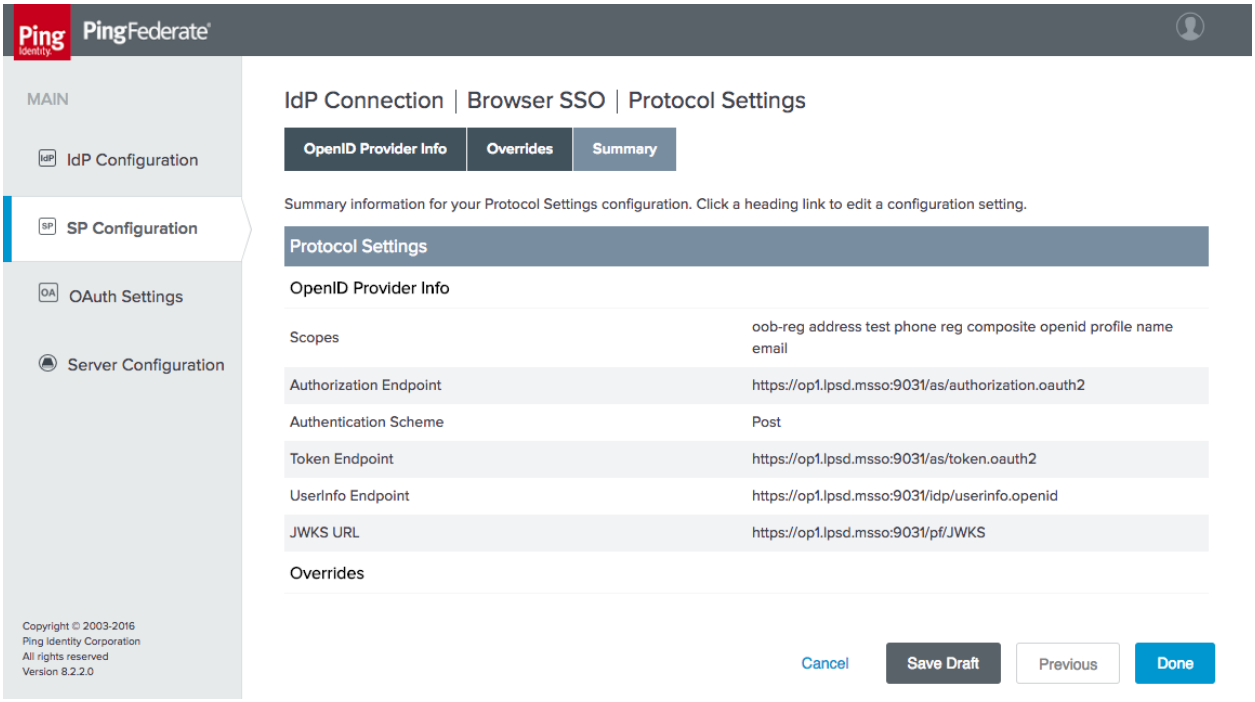
1372 **Figure 3-34 IdP Connection OAuth Attribute Mapping**



1373

1374 ix. Click **Done** to exit the **OAuth Attribute Mapping Configuration** setup. The **Pro-**
1375 **tocol Settings** should be automatically populated through the information gath-
1376 ered from the discovery endpoint (Figure 3-35). If necessary, the scopes to be
1377 requested can be customized on the **Protocol Settings** tab; in the lab, these set-
1378 tings were left at the default.

1379 **Figure 3-35 IdP Connection Protocol Settings**



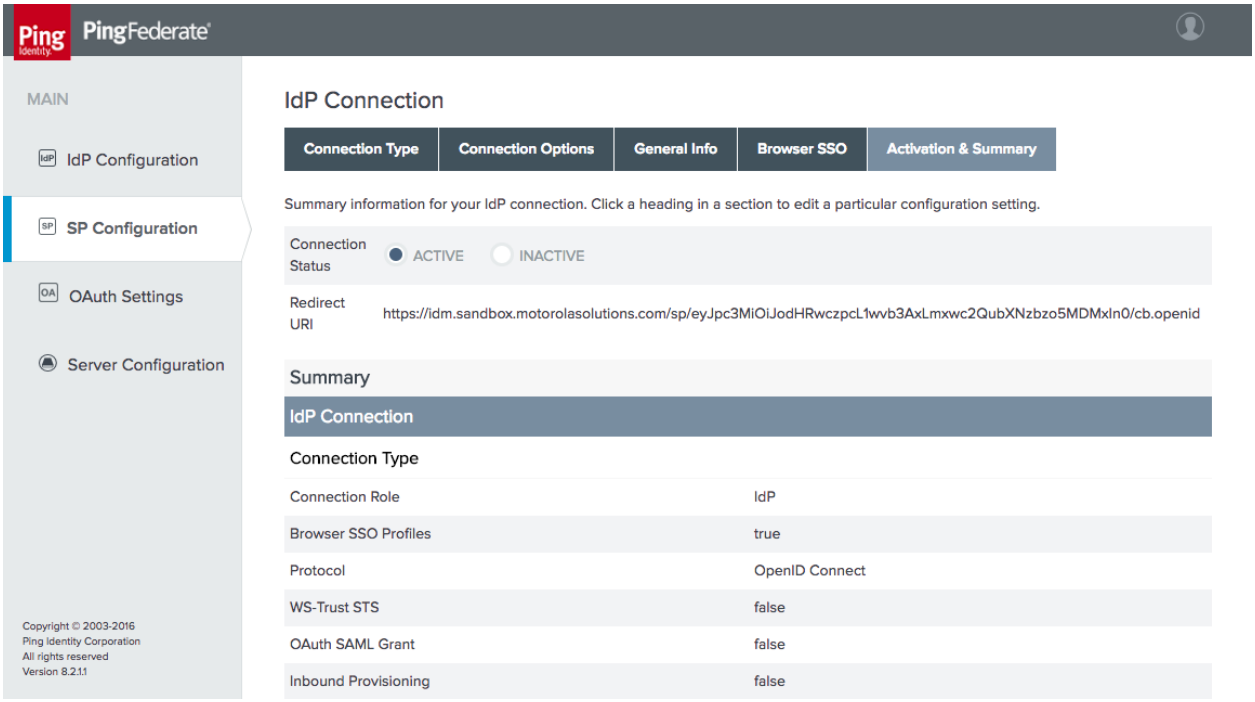
1380

1381 x. Click **Done** to exit the **Browser SSO** configuration setup.

1382 e. On the **Activation & Summary** tab, a **Redirect URI** will be generated (Figure 3-36). Pro-
1383 vide this information to the IdP administrator, as it needs to be configured in the
1384 OpenID Client settings on the IdP side.

1385 i. The **Connection Status** can also be configured to **ACTIVE** or **INACTIVE** on this
1386 tab.

1387 **Figure 3-36 IdP Connection Activation and Summary**



1388

1389 f. Click **Save** to complete the **IdP Connection** setup.

1390 ### *3.4.3.2 Create the Policy Contract Mapping*

1391 The same policy contract mapping created earlier for the SAML integration can also be used for OIDC
1392 integration, as the attribute names are identical. If this policy contract mapping has not already been
1393 created, refer to Section 3.4.2.3 to create it.

1394 ## 3.4.4 How to Configure the Authentication Policy

1395 ### *3.4.4.1 Install the Domain Selector Plugin*

1396 When a single AS is integrated with multiple IdPs, it needs a means of determining which IdP can
1397 authenticate each user. In the lab build, a domain selector is used to determine whether the AS should
1398 authenticate the user locally, redirect to the SAML IdP, or redirect to the OIDC IdP. The domain selector
1399 prompts the user to enter the user's email address or domain. The specified domain is used to select
1400 which branch of the authentication policy should be applied. Upon successful authentication, the
1401 domain selector sets a cookie in the browser to persist the domain selection to avoid prompting the
1402 user each time that the user authenticates.

PingFederate includes sample code for a Domain Selector plugin. Before the Domain Selector can be used in an authentication policy, it must be built. The source code for the selector is located under the PingFederate directory, in the directory `sdk/plugin-src/authentication-selector-example`.

1. Complete the following steps to build the selector:

    a. Edit the `build.local.properties` file in the PingFederate SDK directory to set the target plugin as follows:

    ```
    target-plugin.name=authentication-selector-example
    ```

    b. Run the following commands to build and install the plugin:

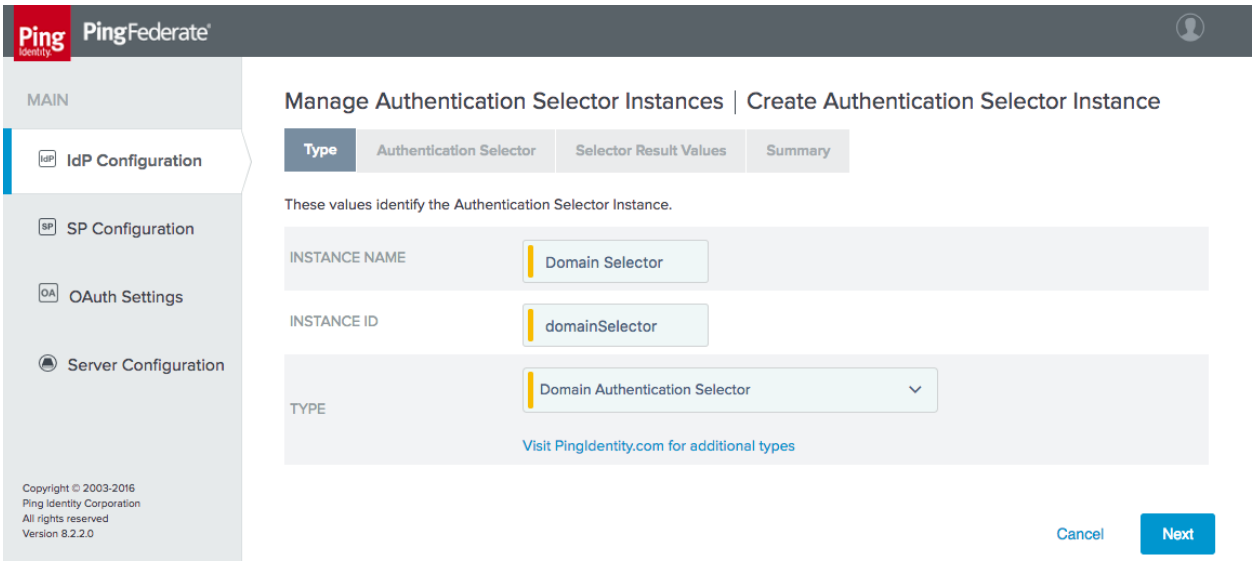
    ```
    $ ant clean-plugin
    $ ant jar-plugin
    $ ant deploy-plugin
    $ sudo service pingfederate restart
    ```

2. Once installed, the Domain Selector can be configured with the required values. On the **IdP Configuration** section tab, click **Selectors** under **Authentication Policies**.

3. Click **Create New Instance**.

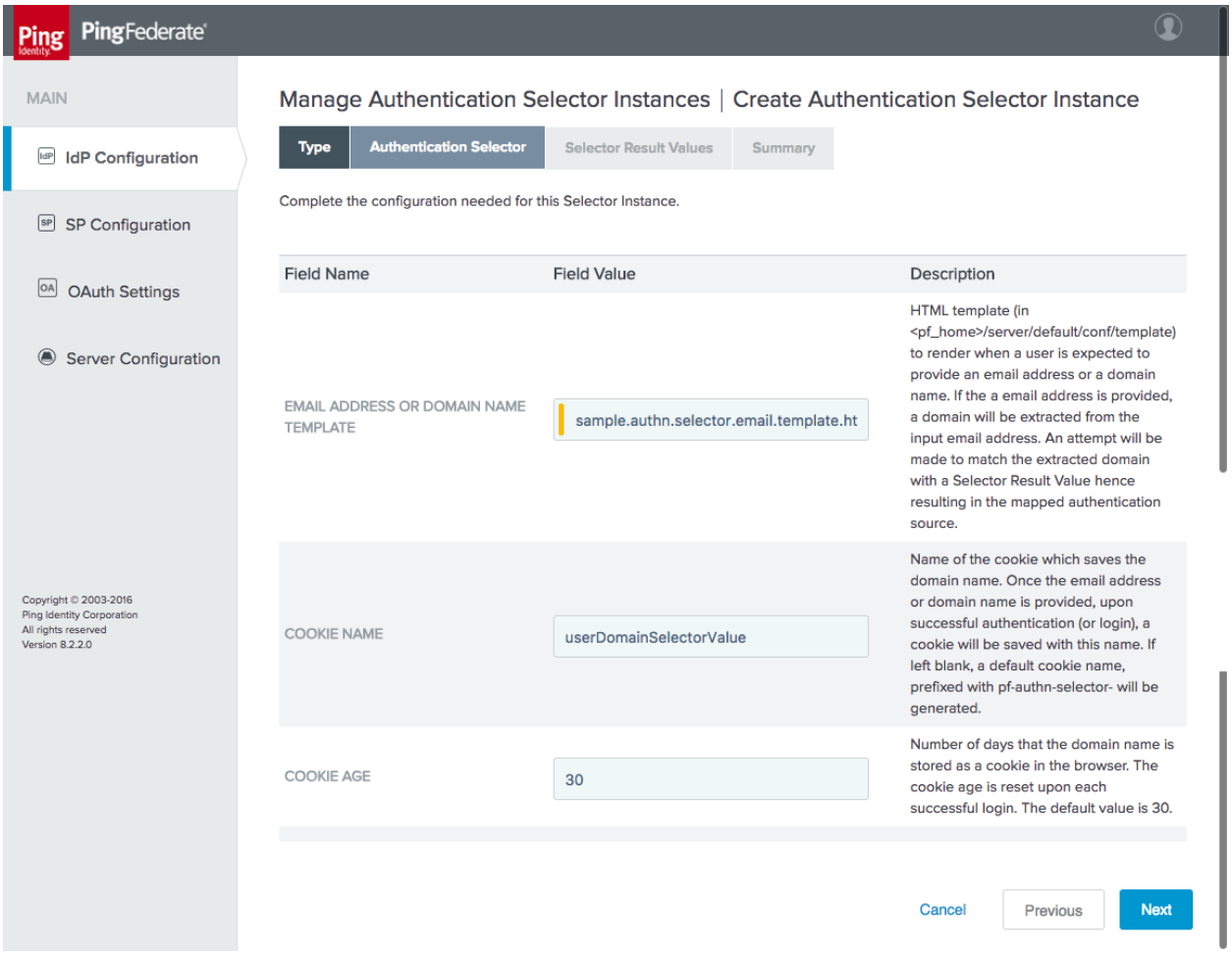
    a. On the **Type** tab, provide a meaningful name and ID for the selector instance (Figure 3-37). For the **TYPE**, select **Domain Authentication Selector**.

Figure 3-37 Authentication Selector Instance



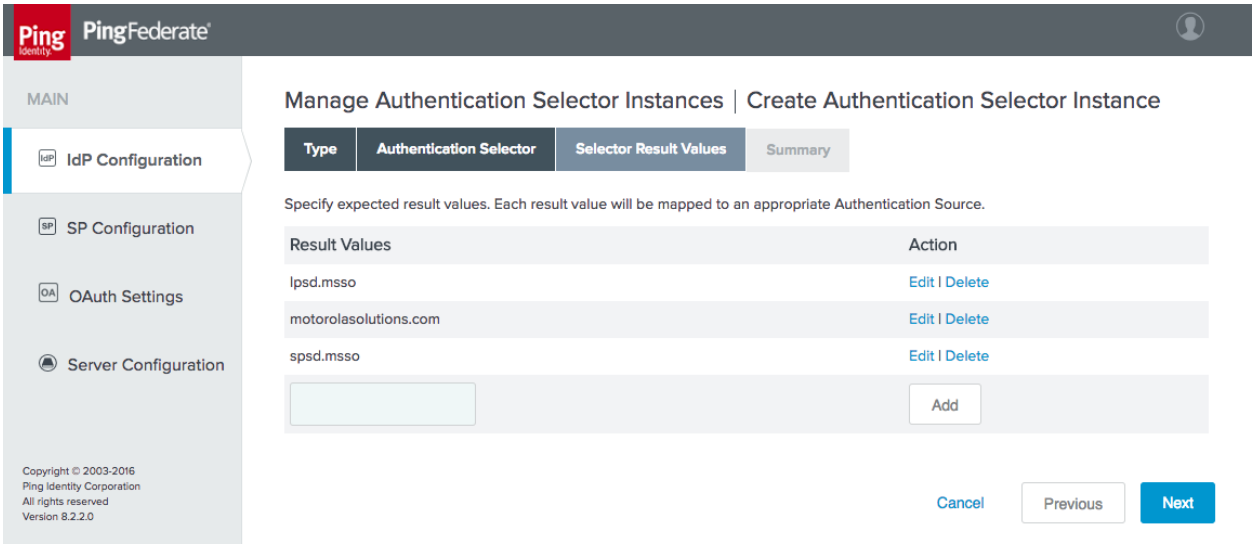
b. The next tab, **Authentication Selector**, prompts for the HyperText Markup Language (HTML) template for the page that will prompt the user to enter the domain or email address (Figure 3-38). The default value will use the template delivered with the adapter; if desired, a custom template can be used instead to modify the appearance of the page. Provide a cookie name, which will be used to persist the domain selection. Finally, the age of the cookie can be modified. By default, users will be prompted again to enter their domain after 30 days.

Figure 3-38 Authentication Selector Details



c. On the **Selector Result Values** tab, specify the expected domain values (Figure 3-39). When the domain selector is used in an access policy, different policy branches will be created for each of these values. In this case, if the domain is *motorolasolutions.com*, the user will be authenticated locally; if it is *lpsd.msso* or *spsd.msso*, the user will be redirected to the corresponding IdP to authenticate.

1436 **Figure 3-39 Selector Result Values**



1437

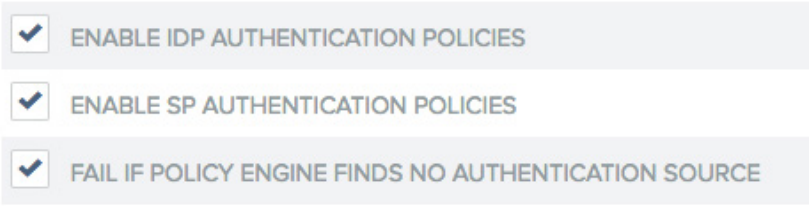
1438 d. Click **Done**, and then click **Save** to complete the selector configuration.

1439 ### *3.4.4.2 Define the Authentication Policy*

1440 1. On the IdP Configuration page, click **Policies** under **Authentication Policies**.

1441 a. Select the three checkboxes at the top of the **Manage Authentication Policies** page,
1442 which are shown in Figure 3-40.

1443 **Figure 3-40 Policy Settings**

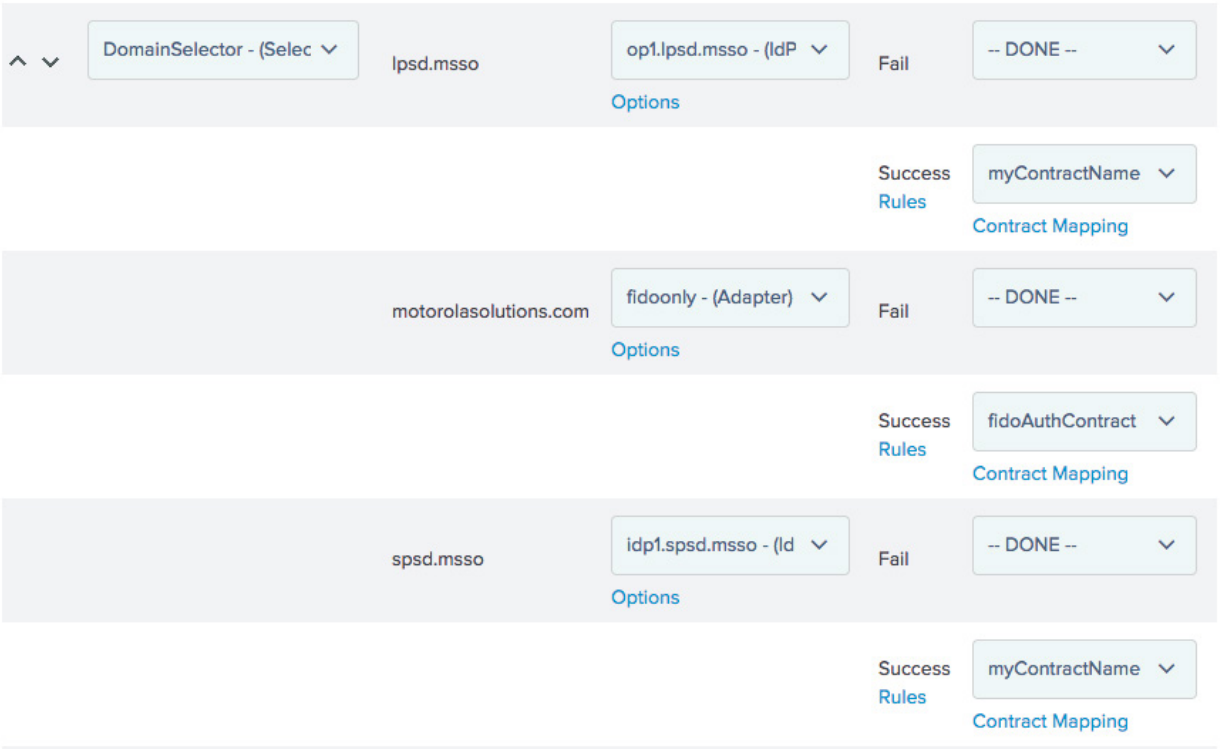


1444

1445 b. Select the **Domain Selector** as the first element in the policy (Figure 3-41). This will cre-
1446 ate policy branches for the three values defined for the policy selector.

1447 i. Select the corresponding authentication mechanism for each domain. The ex-
1448 ample shown in Figure 3-41 uses the IdP connections for the **lpsd.msso** and
1449 **spsd.msso**, as well as the “fidoonly” adapter for local authentication of users in
1450 the **motorolasolutions.com** domain.

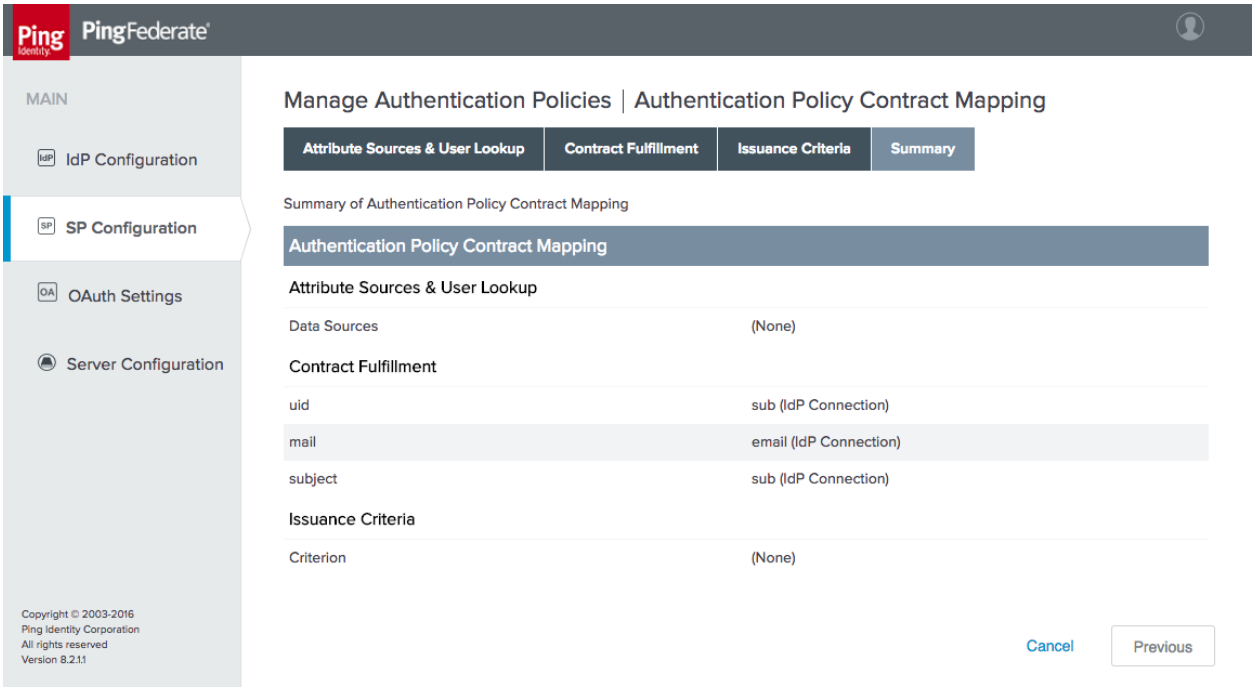
1451 **Figure 3-41 Authentication Policy**



1452

1453 ii. There is no need to specify **Options** or **Success Rules**. For the two IdP connec-
1454 tions, apply the **myContractName** policy contract upon success, with the con-
1455 tract mapping configured as shown in Figure 3-42.

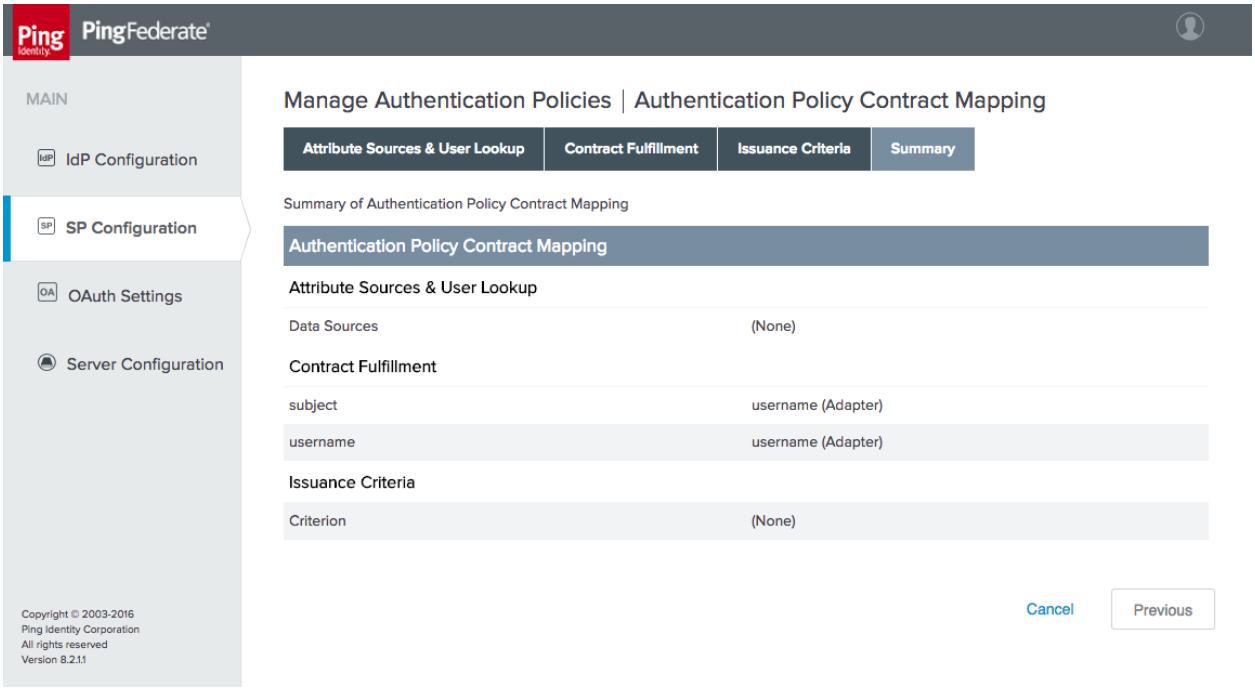
1456 **Figure 3-42 Policy Contract Mapping for IdP Connections**



1457

1458 c. For the “fidoonly” adapter, apply the **fidoAuthContract** with the contract mapping
1459 shown in Figure 3-43.

1460 **Figure 3-43 Policy Contract Mapping for Local Authentication**



1461

1462 This completes the configuration of the AS.

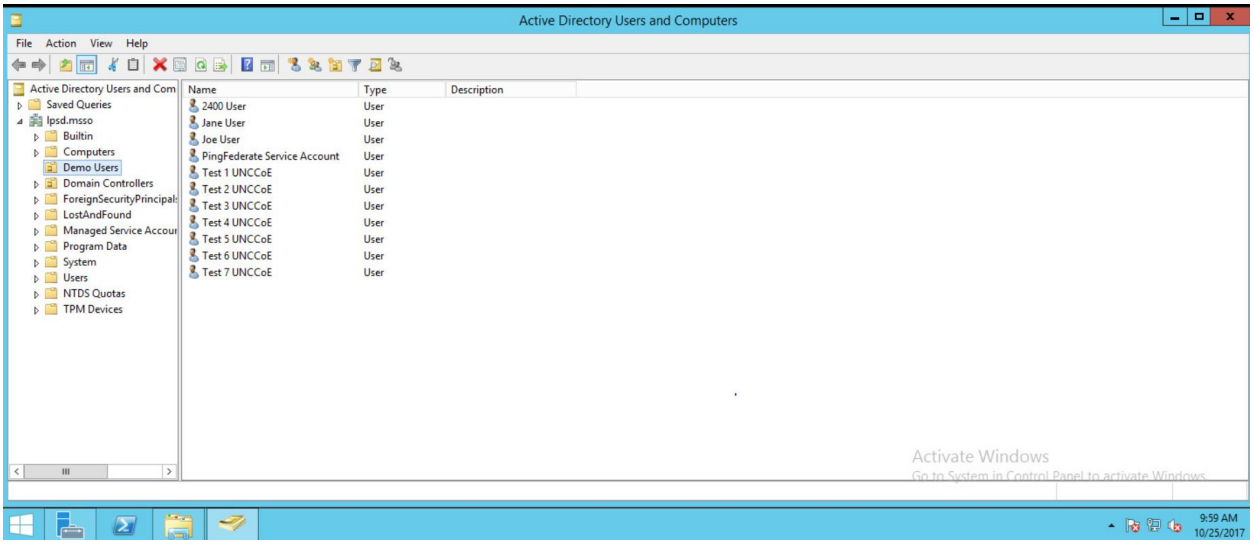
1463 4 How to Install and Configure the Identity Providers

1464 PingFederate 8.3.2.0 was used for the SAML and OIDC IdP installs. The system requirements and
1465 installation process for PingFederate are identical to the OAuth AS installation documentation in
1466 Section 3.1 and Section 3.2. The IdP configuration sections pick up the installation process after the
1467 software has been installed, at the selection of roles and protocols.

1468 4.1 How to Configure the User Store

1469 Each IdP uses its own AD forest as a user store. AD was chosen due to its widespread use across many
1470 organizations. For the purposes of this project, any LDAP directory could have served the same purpose,
1471 but in a typical organization, AD would be used for other functions, such as workstation login and
1472 authorization to apps, shared drives, printers, and other services. The **Active Directory Users and**
1473 **Computers** console (Figure 4-1) was used to create user accounts and set attributes.

1474 **Figure 4-1 Active Directory Users and Computers**



1475

1476 In addition to the user accounts that log into the lab apps, a service account must be created to enable
1477 the IdP to access and query the AD. This user's LDAP Distinguished Name (DN) and password (in the
1478 example shown in Figure 4-1) are used in the PingFederate directory integration described below.

1479 The procedure for connecting a PingFederate IdP to an LDAP directory is the same for a SAML or OIDC
1480 IdP. Documentation is provided at
1481 https://documentation.pingidentity.com/pingfederate/pf82/index.shtml#concept_configuringLdapConn
1482 ection.html#concept_configuringLdapConnection.

1483 1. To start the process, click the **Server Configuration** section tab on the left side of the
1484 PingFederate administrative console. The screen shown in Figure 4-2 will appear.

1485 **Figure 4-2 Server Configuration**

1486

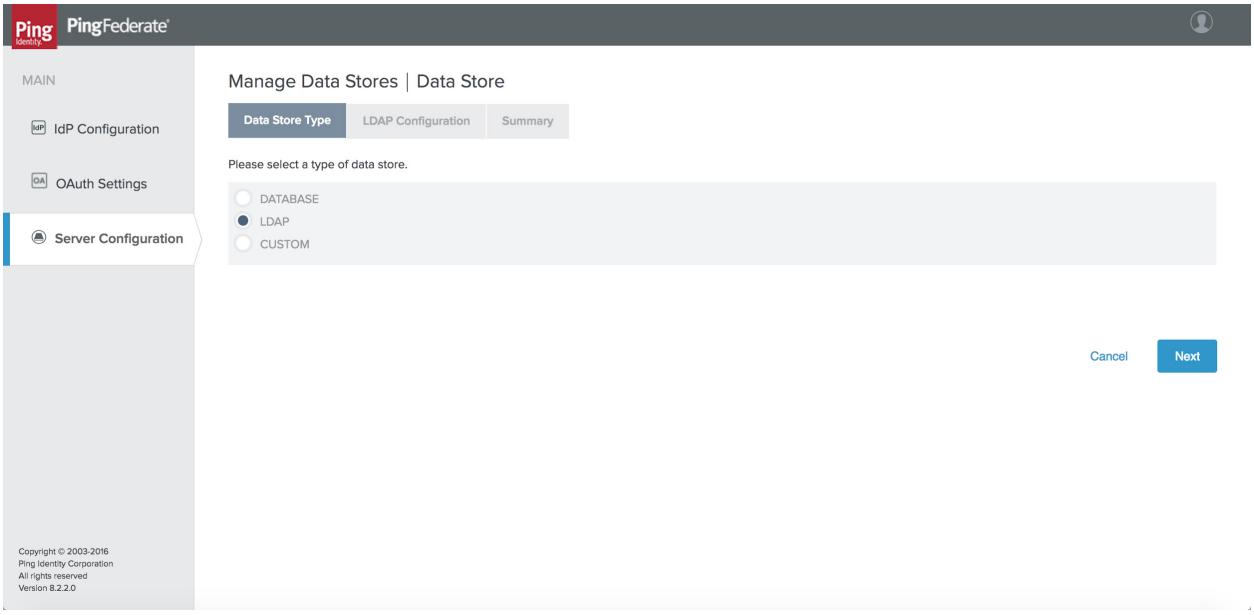
1487 2. Click **Data Stores** under **SYSTEM SETTINGS**.

1488 3. On the next screen, click **Add New Data Store**.

1489 a. The screen shown in Figure 4-3 will appear. On the **Data Store Type** tab, select **LDAP** for
1490 the data store type.

1491 i. Click **Next**.

1492 **Figure 4-3 Data Store Type**

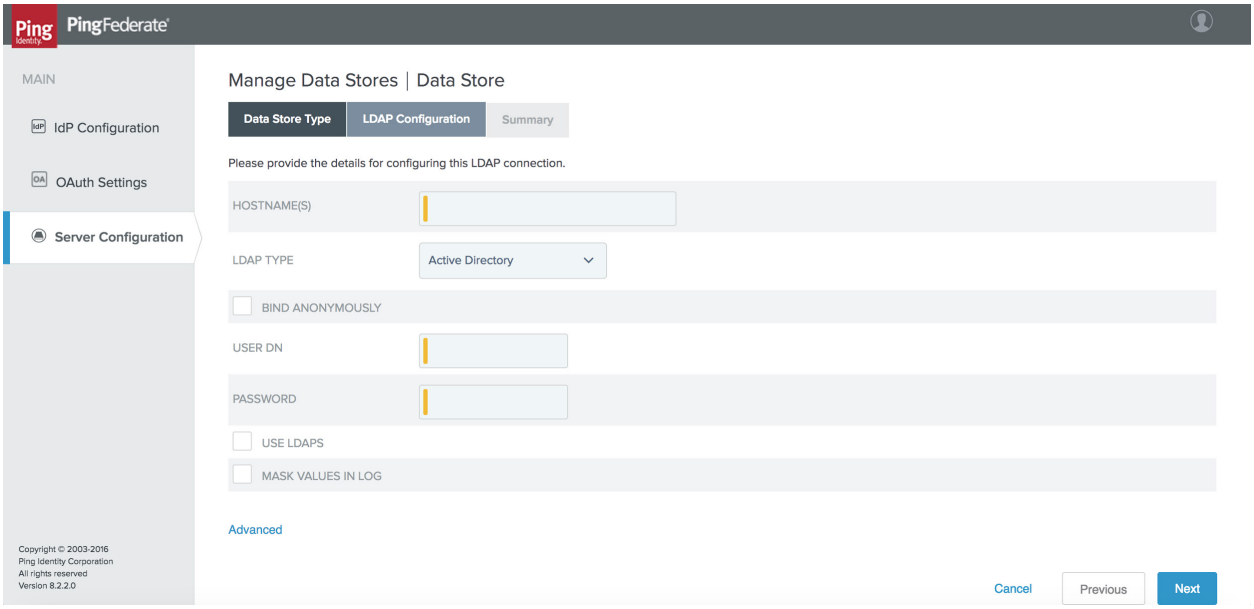


1493

1494 b. On the **LDAP Configuration** tab, enter the connection parameters for your AD or LDAP
1495 environment (Figure 4-4). Some notes on the fields on this tab are provided below. Click
1496 **Save** to exit the LDAP configuration screen once the required settings have been en-
1497 tered.

1498 - **HOSTNAME(S)**: Enter the Fully Qualified Domain Name (FQDN) or the complete
1499 Internet Protocol (IP) address of an AD domain controller. A port number can be
1500 specified if AD is running on non-standard ports.
1501 - **LDAP TYPE**: This is the LDAP server in use—AD in this case.
1502 - **BIND ANONYMOUSLY**: For AD environments, allowing anonymous BIND
1503 (Berkeley Internet Name Domain) is not recommended.
1504 - **USER DN**: This is the Distinguished Name of the PingFederate user account
1505 created in AD; in this build architecture, this account is used only for querying
1506 AD, so it does not require any special privileges.
1507 - **PASSWORD**: This is the password for the PingFederate AD user.
1508 - **USE LDAPS**: This can be enabled if AD is configured to serve LDAP over TLS.
1509 - **MASK VALUES IN LOG**: This prevents attributes returned from this data source
1510 from being exposed in server logs.

1511 **Figure 4-4 LDAP Data Store Configuration**



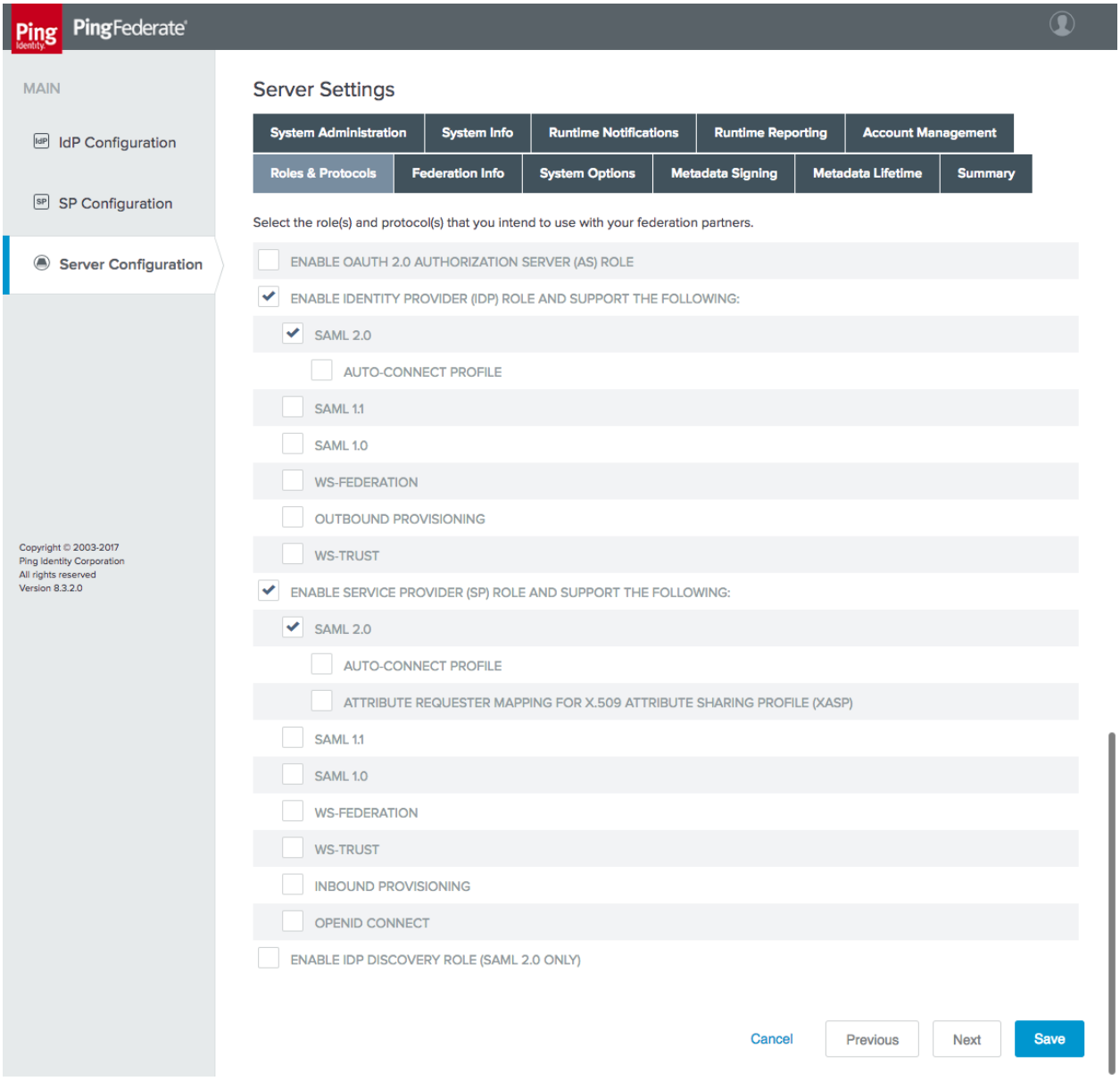
1512

1513 4.2 How to Install and Configure the SAML Identity Provider

1514 1. On the **Server Configuration** screen, click **Server Settings**.

1515 a. On the **Roles & Protocols** tab, enable roles and protocols to configure the server as a
1516 SAML IdP (Figure 4-5).

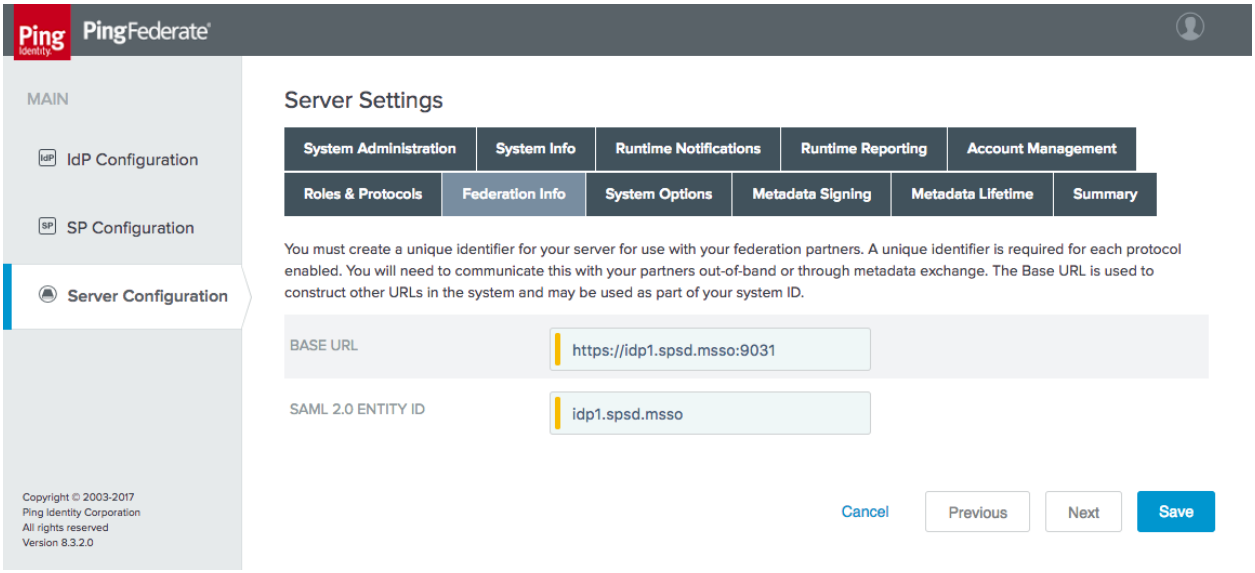
1517 **Figure 4-5 Server Roles for SAML IdP**



1518

1519 b. On the **Federation Info** tab, specify the **BASE URL** and **SAML 2.0 ENTITY ID** of the IdP
1520 (Figure 4-6). The **BASE URL** should be a URL resolvable by your mobile clients. The **EN-**
1521 **TITY ID** should be a meaningful name that is unique among federation partners; in this
1522 case, the FQDN of the server is used.

1523 **Figure 4-6 SAML IdP Federation Info**



1524

1525 4.2.1 Configuring Authentication to the IdP

1526 This example configures an authentication policy that requires the user to authenticate with username
1527 and password and then with a FIDO U2F token.

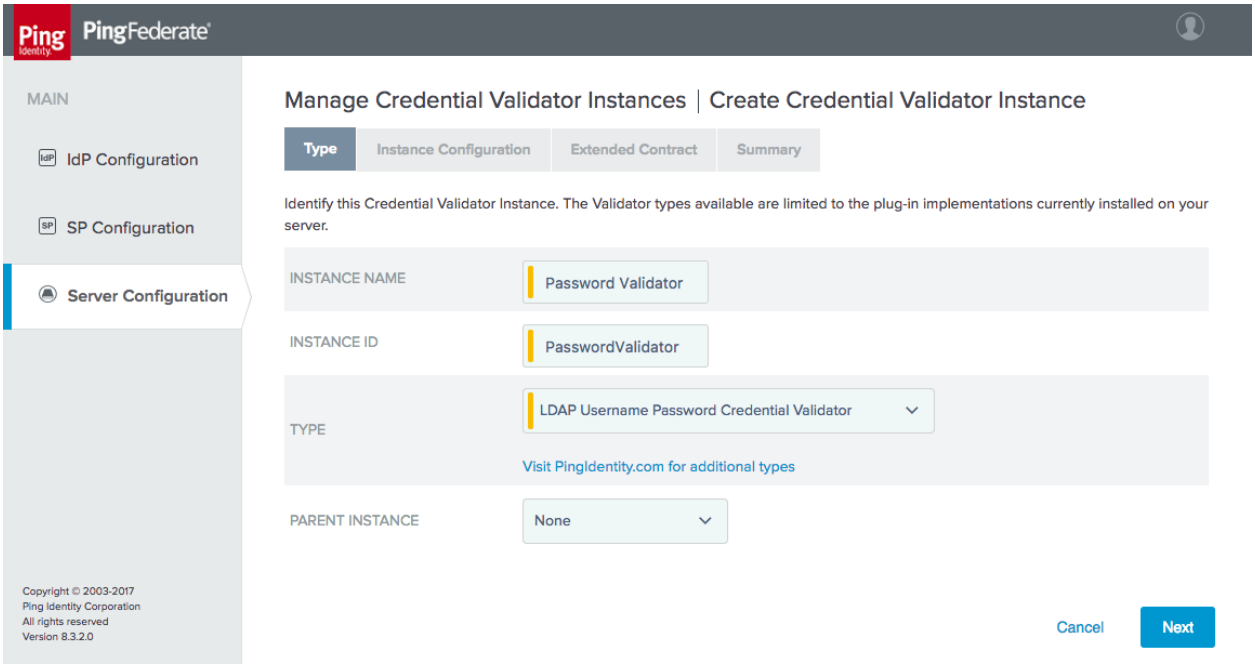
1528 *4.2.1.1 Configure the Password Validator*

1529 1. On the **Server Configuration** section tab, click **Password Credential Validators** under
1530 **Authentication**.

1531 2. Click **Create New Instance**.

1532 a. On the **Type** tab, for the **TYPE**, choose **LDAP Username Password Credential Validator**
1533 (Figure 4-7). This example will authenticate AD usernames and passwords by using the
1534 AD data store defined in Section 4.1.

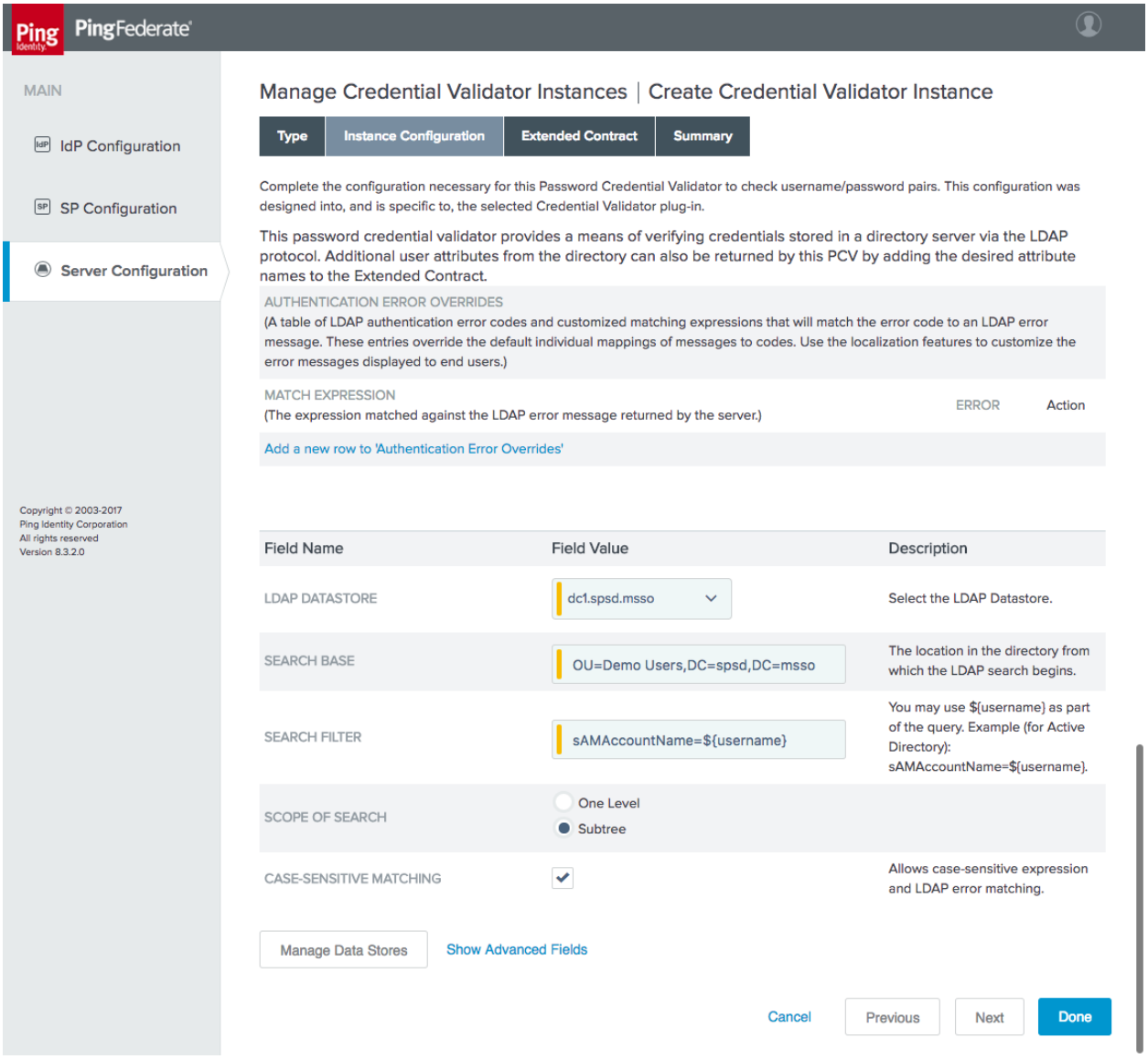
1535 **Figure 4-7 Create Password Credential Validator**



1536

1537 b. On the **Instance Configuration** tab, specify the parameters for searching the LDAP direc-
1538 tory for user accounts (Figure 4-8). Select the data store created in Section 4.1, and en-
1539 ter the appropriate search base and filter. This example will search for a *sAMAccount-*
1540 *Name* matching the username entered on the login form.

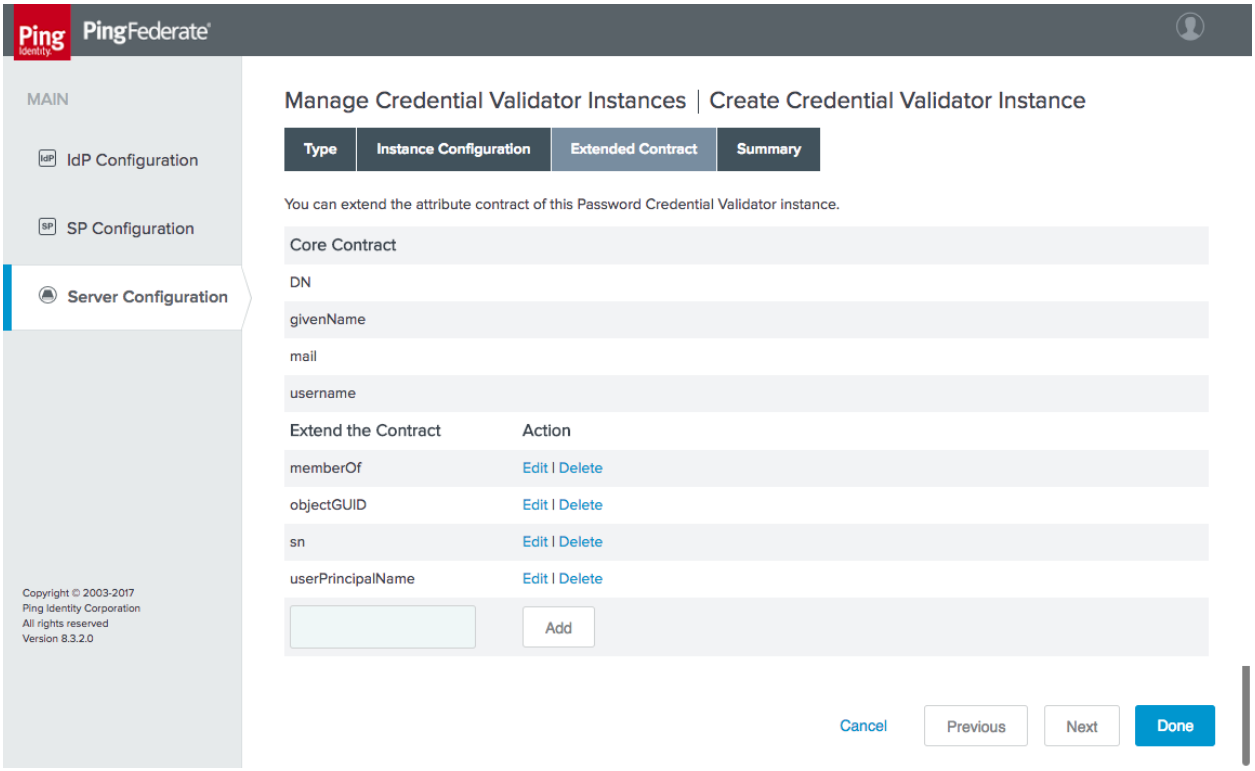
1541 **Figure 4-8 Credential Validator Configuration**



1542

1543 c. The **Extended Contract** tab enables the retrieval of additional attributes from the LDAP
1544 server, which can be used in assertions to RPs (Figure 4-9). The example shown in
1545 Figure 4-9 adds several AD attributes to the contract.

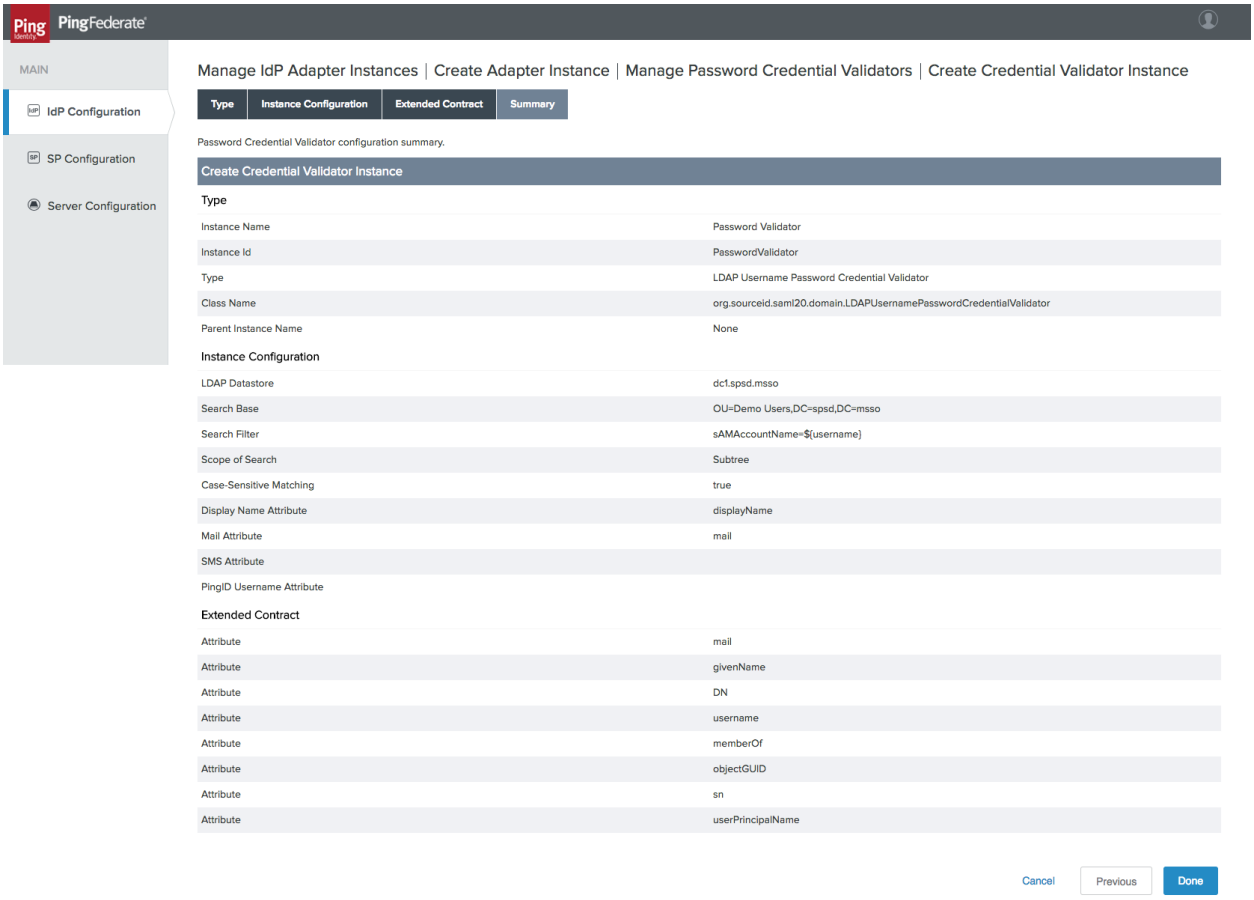
1546 **Figure 4-9 Password Credential Validator Extended Contract**



1547

1548 d. Finally, the **Summary** tab shows all of the values for the configured validator
1549 (Figure 4-10).

1550 **Figure 4-10 Password Validator Summary**



1551

1552 e. Click **Done**, and then click **Save** to complete the setup of the password validator.

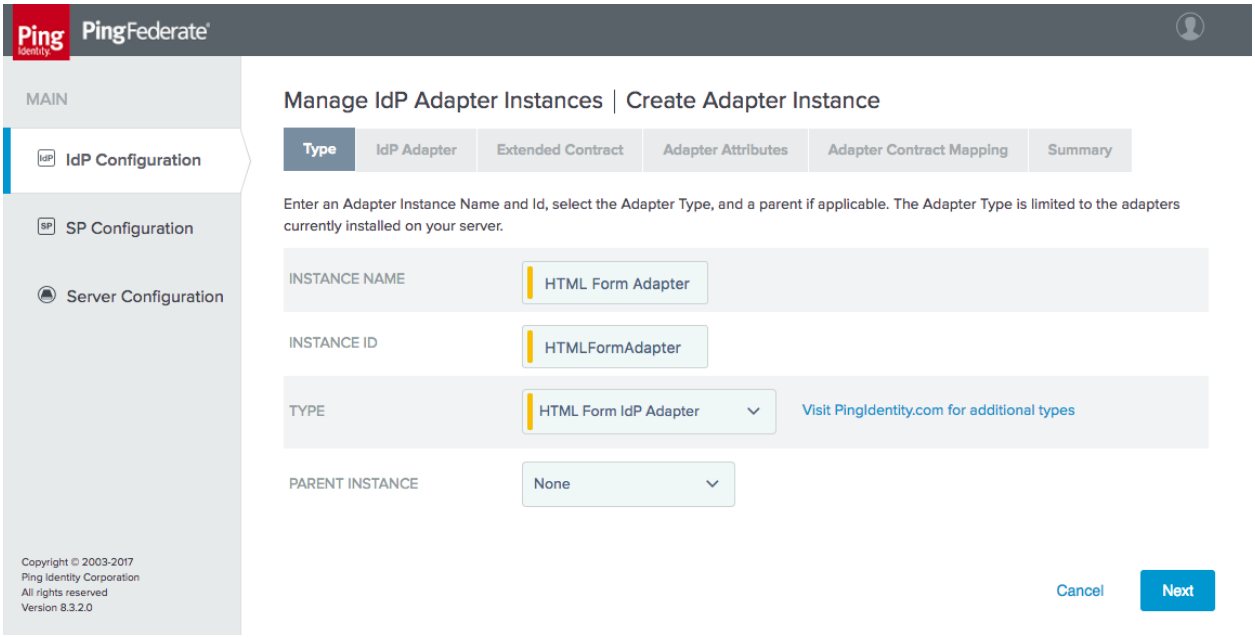
1553 ### *4.2.1.2 Configure the HTML Form Adapter*

1554 1. On the **IdP Configuration** section tab, click **Adapters**.

1555 2. Click **Create New Instance**.

1556 a. On the **Type** tab, create the name and ID of the adapter, and select the **HTML Form IdP**
1557 **Adapter** for the **TYPE** (Figure 4-11).

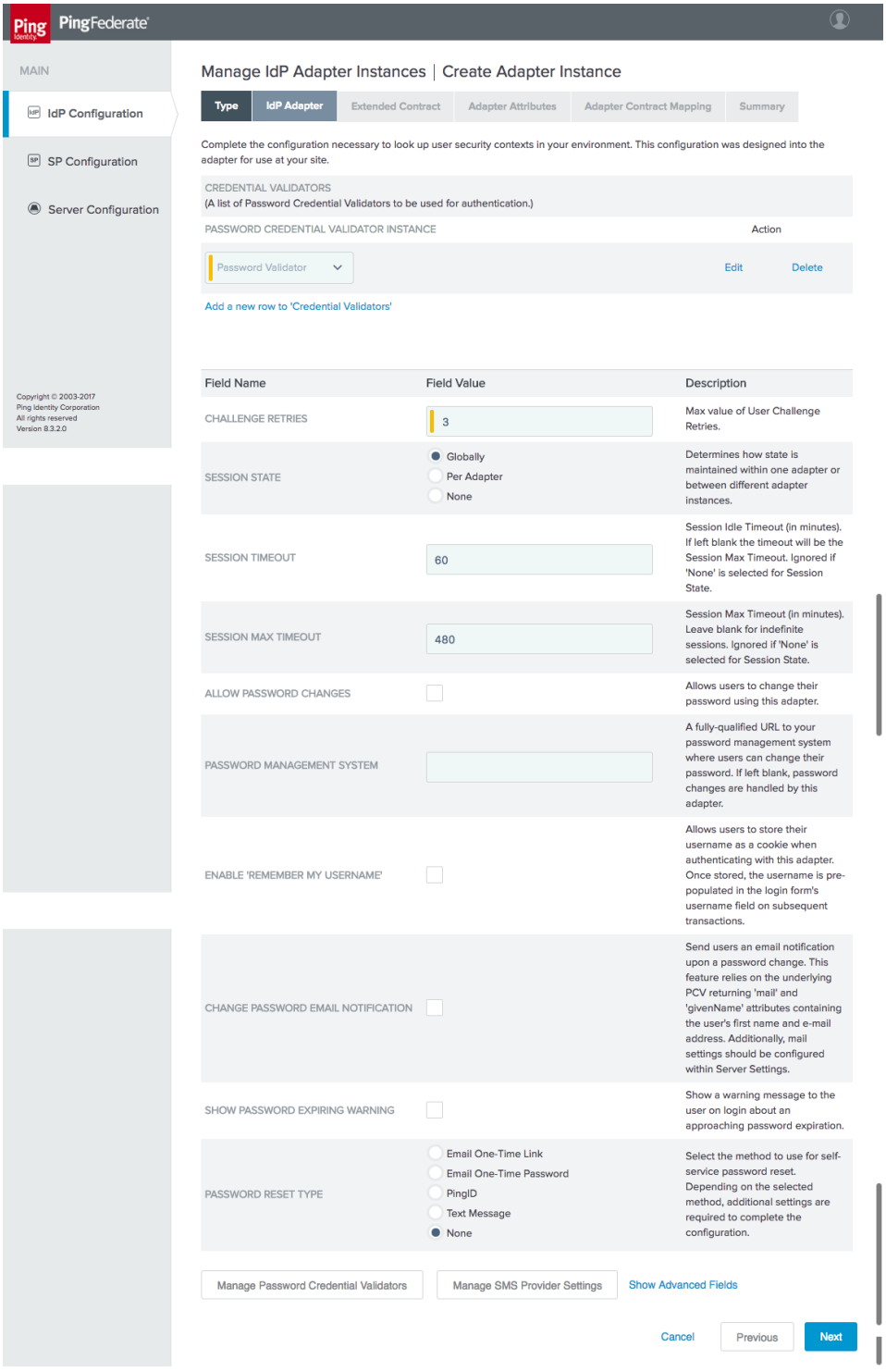
1558 **Figure 4-11 HTML Form Adapter Instance**



1559

1560 b. On the **IdP Adapter** tab, add the **Password Validator** instance created in the previous
1561 section (Figure 4-12). This tab provides several options for customizing the login page
1562 and supporting password resets and password recovery that would be relevant to a Pro-
1563 duction deployment. In the lab, password resets were not supported, and these fields
1564 were left at their default values.

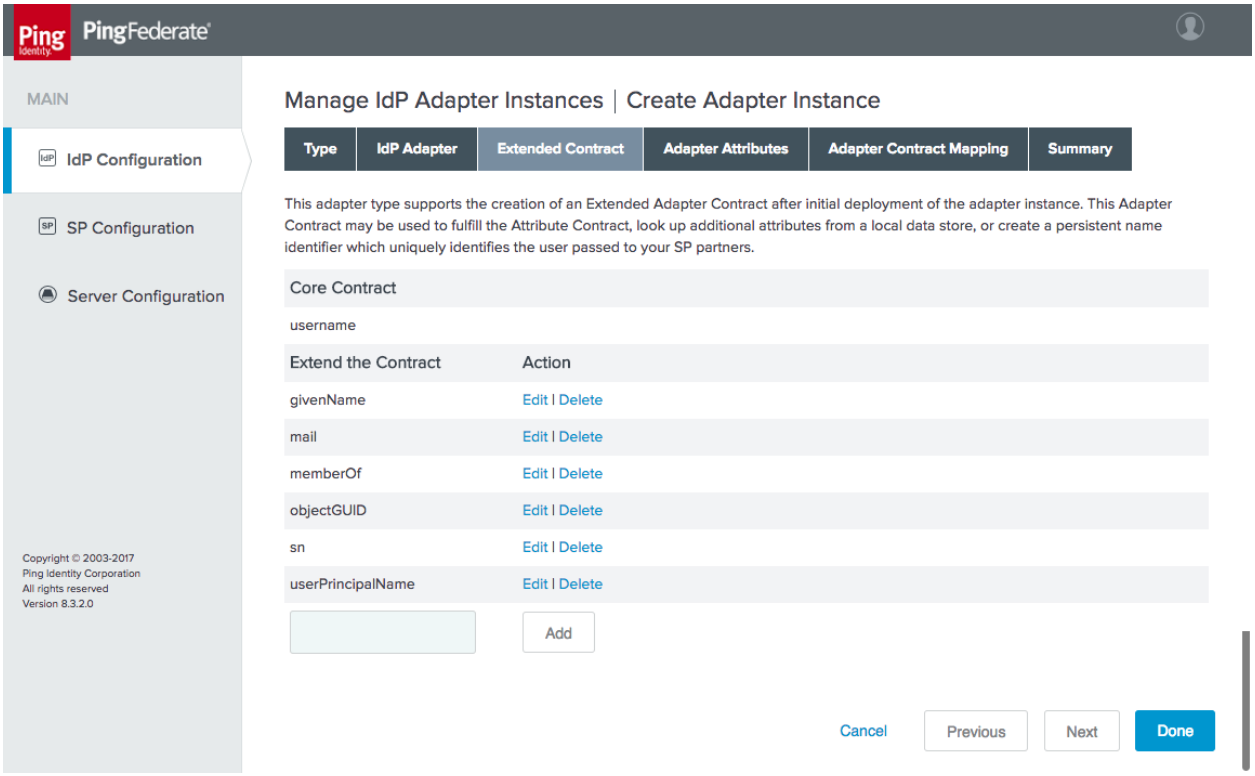
1565 **Figure 4-12 Form Adapter Settings**



1566

c. On the **Extended Contract** tab, the same attributes returned from AD by the Password Validator are added to the adapter contract, to make them available for further use by the IdP (Figure 4-13).

Figure 4-13 Form Adapter Extended Contract



d. On the **Adapter Attributes** tab, select the **Pseudonym** checkbox for the **username** attribute.

e. There is no need to configure anything on the **Adapter Contract Mapping** tab, as all attributes are provided by the adapter. Click **Done**, and then click **Save** to complete the Form Adapter configuration.

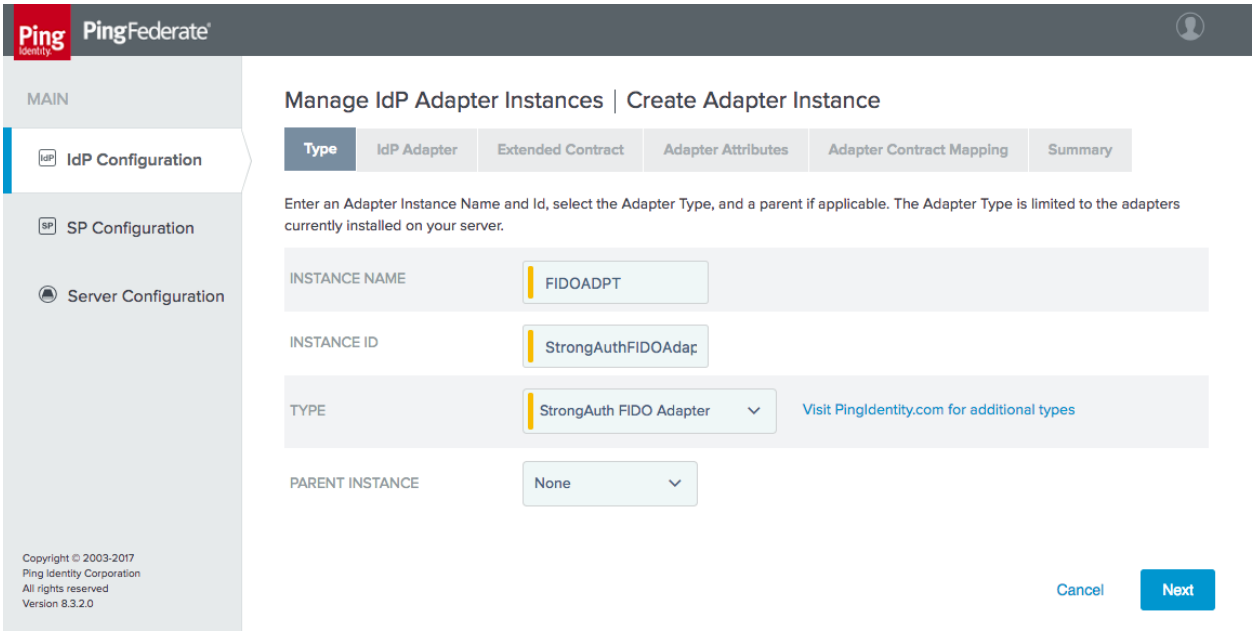
4.2.1.3 Configure the FIDO U2F Adapter

Before this step can be completed, the FIDO U2F server, StrongAuth StrongKey CryptoEngine (SKCE), must be installed and configured, and the StrongAuth U2F adapter for PingFederate must be installed on the IdP. See Section 6 for details on completing these tasks.

1. On the **IdP Configuration** section tab, click **Adapters**.
2. Click **Create New Instance**.

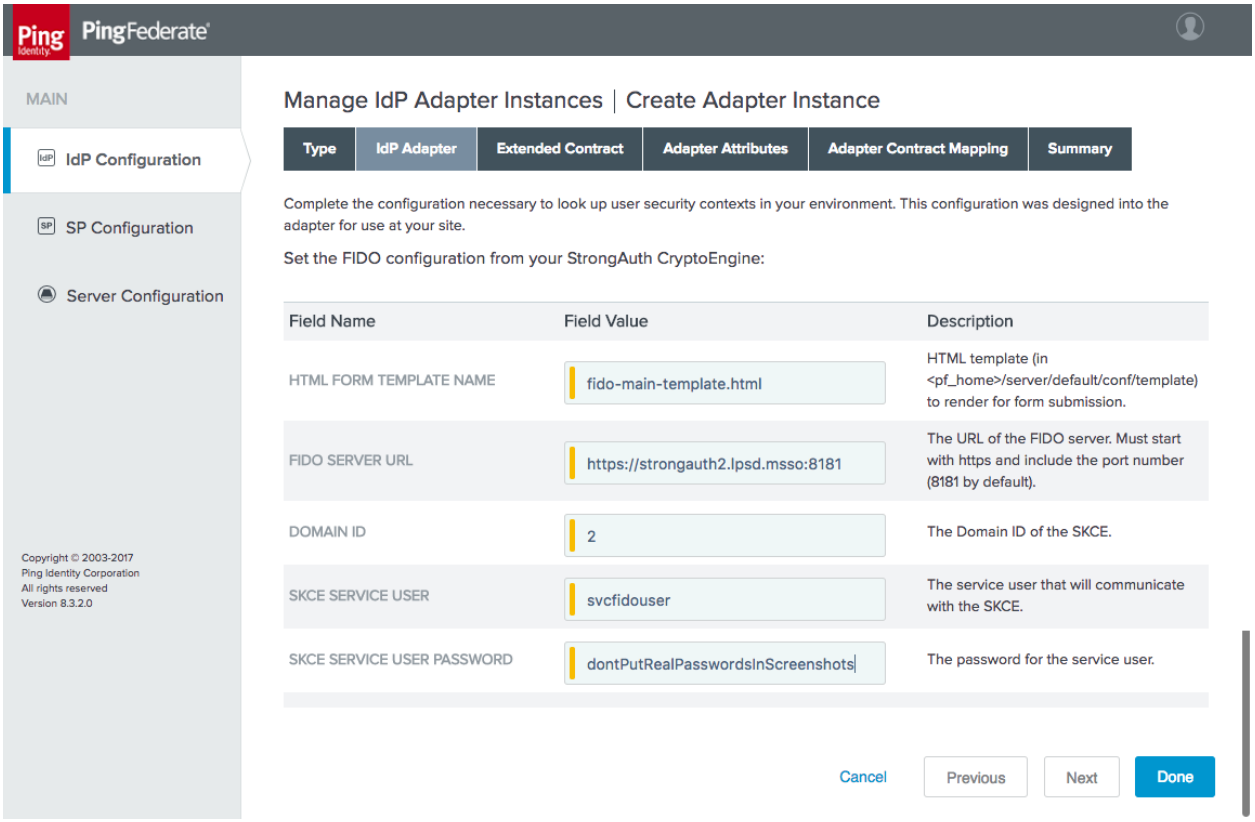
a. Enter meaningful values for **INSTANCE NAME** and **INSTANCE ID**. For the **TYPE,** select "StrongAuth FIDO Adapter." Click **Next**.

Figure 4-14 Create U2F Adapter Instance



b. On the **IdP Adapter** tab, keep the default value of the **HTML FORM TEMPLATE NAME** to use the template that is provided with the StrongAuth U2F plugin, or specify a custom template if desired to change the design of the user interface (Figure 4-15). The **FIDO SERVER URL**, **DOMAIN ID**, **SKCE SERVICE USER**, and **SKCE SERVICE USER PASSWORD** are determined in the setup of the SKCE; refer to Section 6 for details.

1592 **Figure 4-15 U2F Adapter Settings**



1593

1594 c. There is no need to extend the contract for the U2F adapter; therefore, skip the **Ex-**
1595 **tended Contract** tab.

1596 d. On the **Adapter Attributes** tab, select the **Pseudonym** checkbox for the **username** at-
1597 tribute.

1598 e. There is also no need for an **Adapter Contract Mapping**; therefore, skip the **Adapter**
1599 **Contract Mapping** tab.

1600 f. Click **Done**, and then click **Save**.

1601 ### *4.2.1.4 Configure the Authentication Policies*

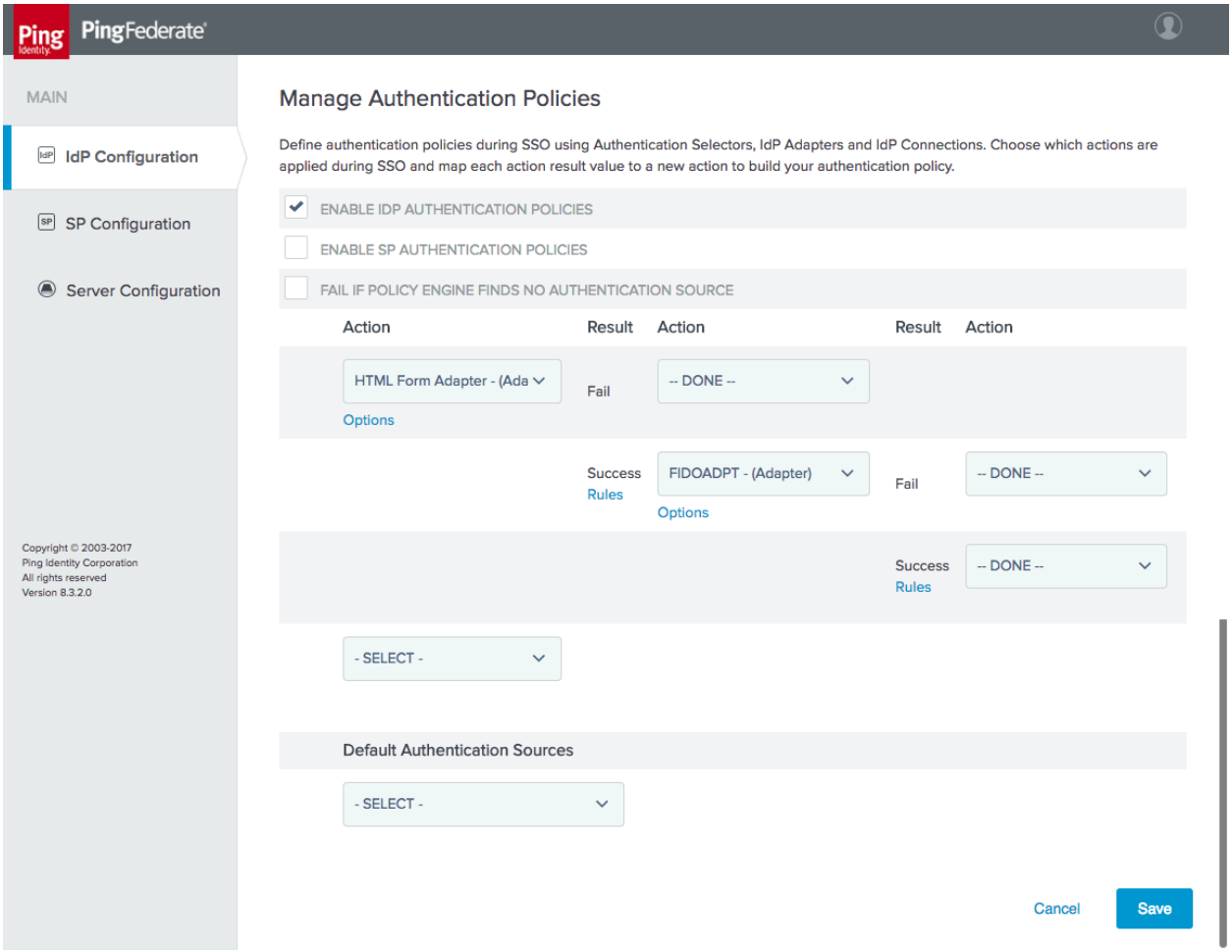
1602 1. On the **IdP Configuration** page, click **Policies**.

1603 a. Under **Manage Authentication Policies**, click the **ENABLE IDP AUTHENTICATION POLI-**
1604 **CIES** checkbox, and create a policy that starts with the **HTML Form Adapter** action
1605 (Figure 4-16).

i. On the **Success** branch, add the FIDO U2F adapter (**FIDOADPT**) for the **Action**.

ii. Click **Save**.

Figure 4-16 IdP Authentication Policy



4.2.2 Configure the SP Connection

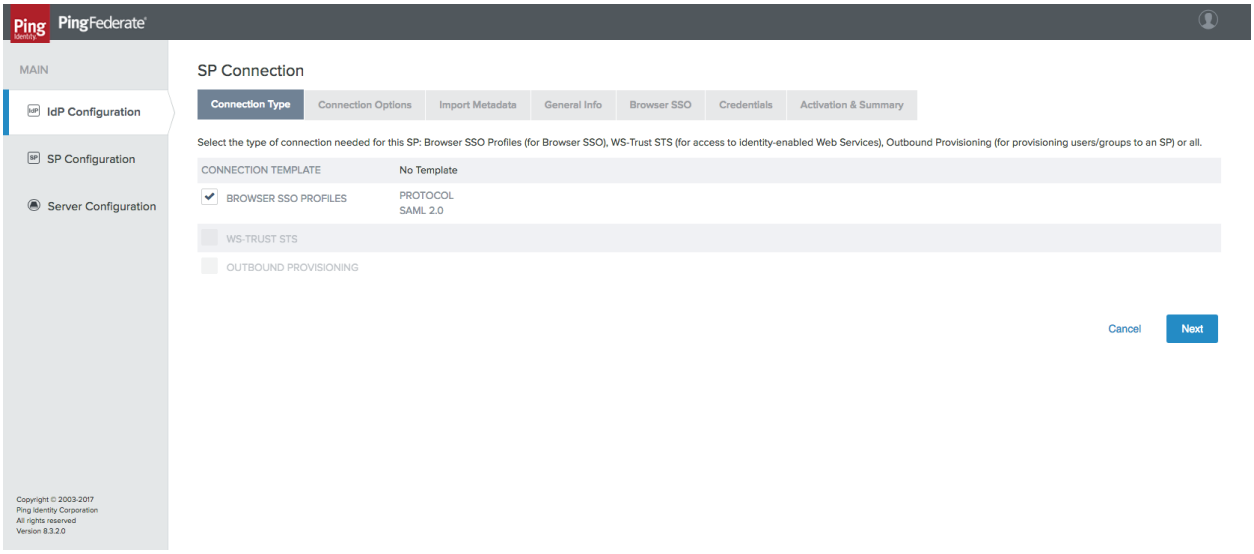
Each RP that will receive authentication assertions from the IdP must be configured as an SP connection. As explained in Section 3.4.2.1, this activity requires coordination between the administrators of the IdP and the RP to provide the necessary details to configure the connection. Exchanging metadata files can help automate some of the configuration process.

This section documents the configuration for the SP connection between the SAML IdP in the NCCoE Lab and the OAuth AS in the Motorola Solutions cloud instance.

1. To create a new SP connection, click the **IdP Configuration** section tab, and then click **Create New** under **SP Connections**.

    a. On the **Connection Type** tab, select **BROWSER SSO PROFILES**, and select the **SAML 2.0** protocol (Figure 4-17). In this case, SAML 2.0 is pre-selected because no other protocols are enabled on this IdP.

Figure 4-17 SP Connection Type

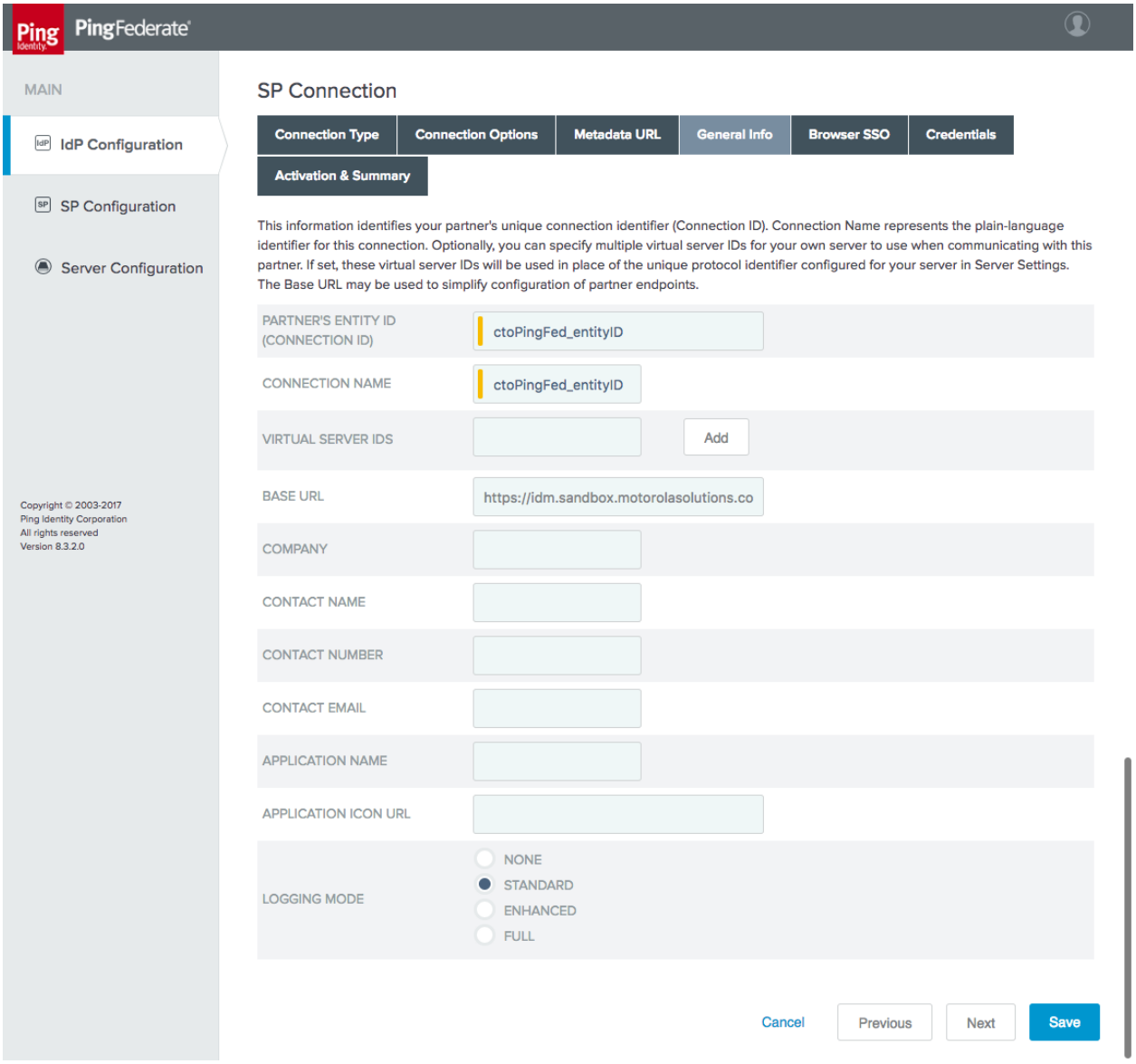


    b. On the **Connection Options** tab, only **BROWSER SSO** needs to be selected.

    c. If metadata for the SP is available, it can be imported on the **Import Metadata** tab. This metadata can be specified in the form of a file upload or URL.

    d. On the **General Info** tab, enter the **PARTNER'S ENTITY ID (CONNECTION ID)** (Figure 4-18); this must match the **ENTITY ID** configured on the **Federation Info** tab in the **Server Configuration** of the SP. The SP's **BASE URL** should also be added on this **General Info** tab.

1631 **Figure 4-18 SP Connection General Info**

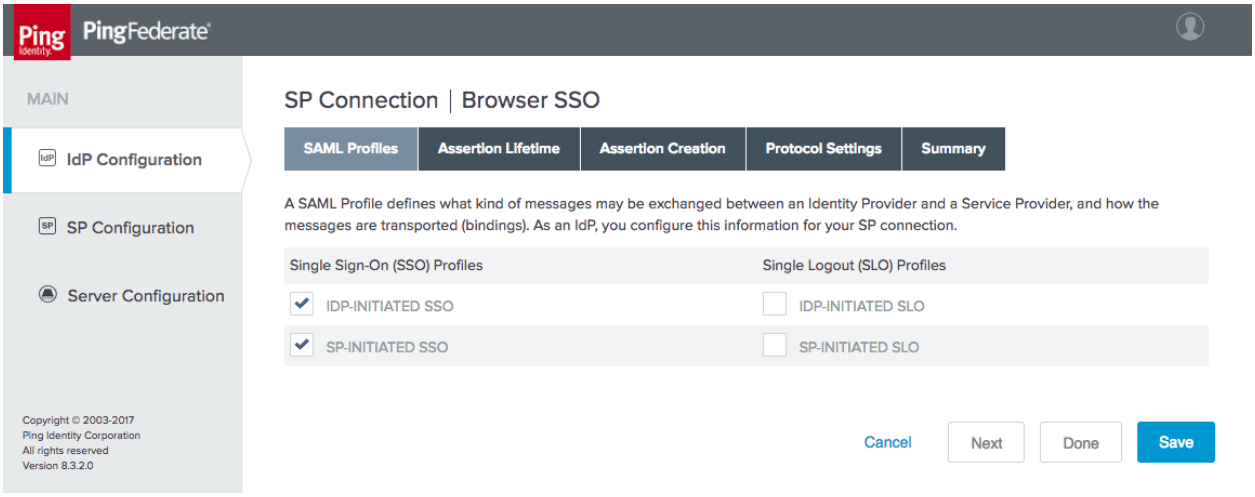


1632

1633 e. On the **Browser SSO** tab, click **Configure Browser SSO**. This opens another multi-tabbed
1634 configuration screen.

1635 i. On the **SAML Profiles** tab, different SSO and Single Log-Out (SLO) profiles can be
1636 enabled (Figure 4-19). Only **SP-INITIATED SSO** is demonstrated in this lab build.

1637 **Figure 4-19 SP Browser SSO Profiles**



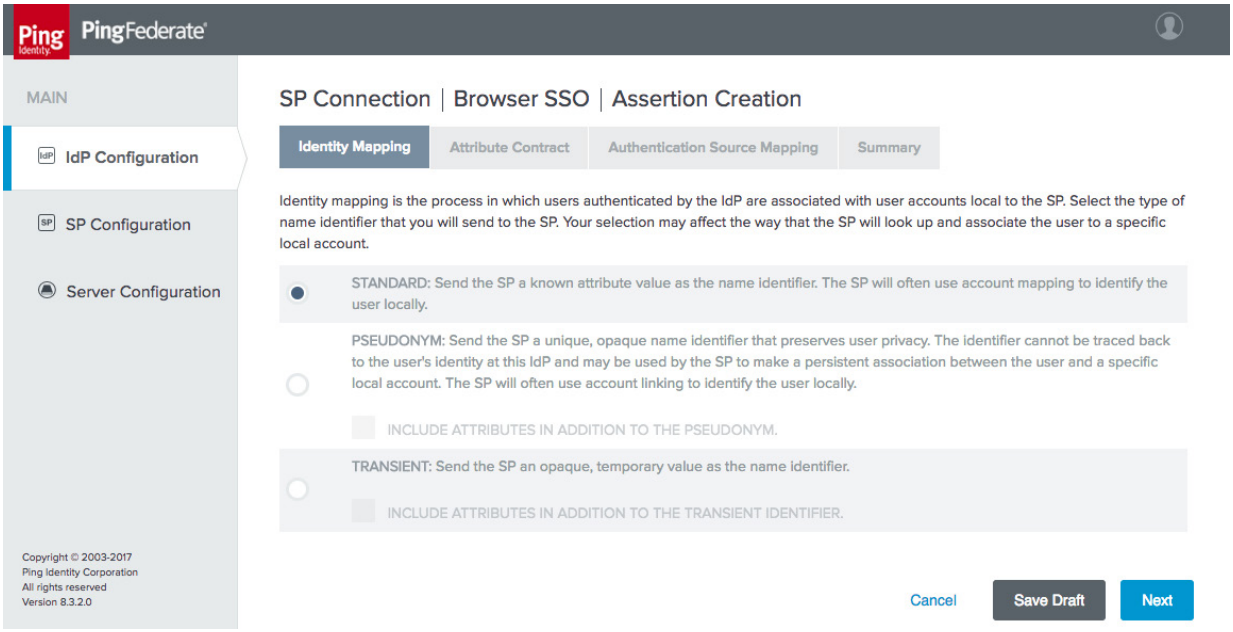
1638

1639 ii. On the **Assertion Lifetime** tab, time intervals during which SPs should consider
1640 assertions valid can be configured in minutes before and after assertion crea-
1641 tion. In the lab, these were both set to the default of five minutes.

1642 iii. On the **Assertion Creation** tab, click **Configure Assertion Creation**. This opens a
1643 new multi-tabbed configuration screen.

1644 1) On the **Identity Mapping** tab, select the **STANDARD** mapping (Figure 4-20).
1645 The other options are more suitable for situations where identifiers are
1646 sensitive or where there are privacy concerns over the tracking of users.

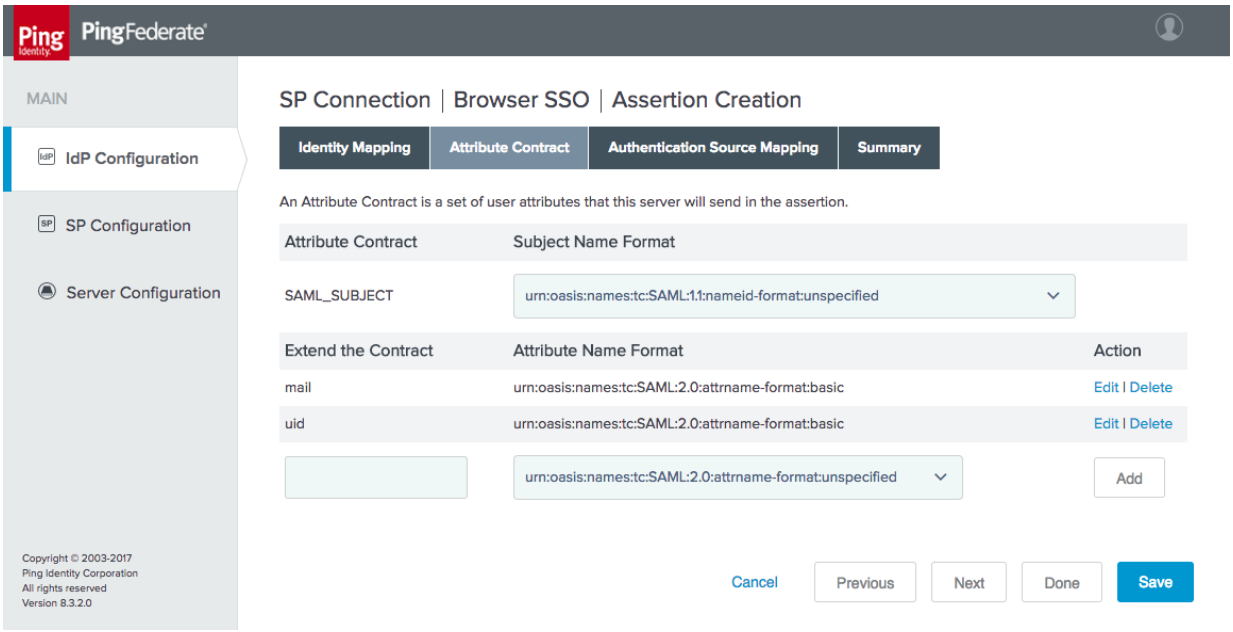
1647 **Figure 4-20 Assertion Identity Mapping**



1648

1649 2) On the **Attribute Contract** tab, extend the contract to include the **mail** and
1650 **uid** attributes with the basic name format (Figure 4-21). Other attributes
1651 can be added here as needed.

1652 **Figure 4-21 Assertion Attribute Contract**



1653

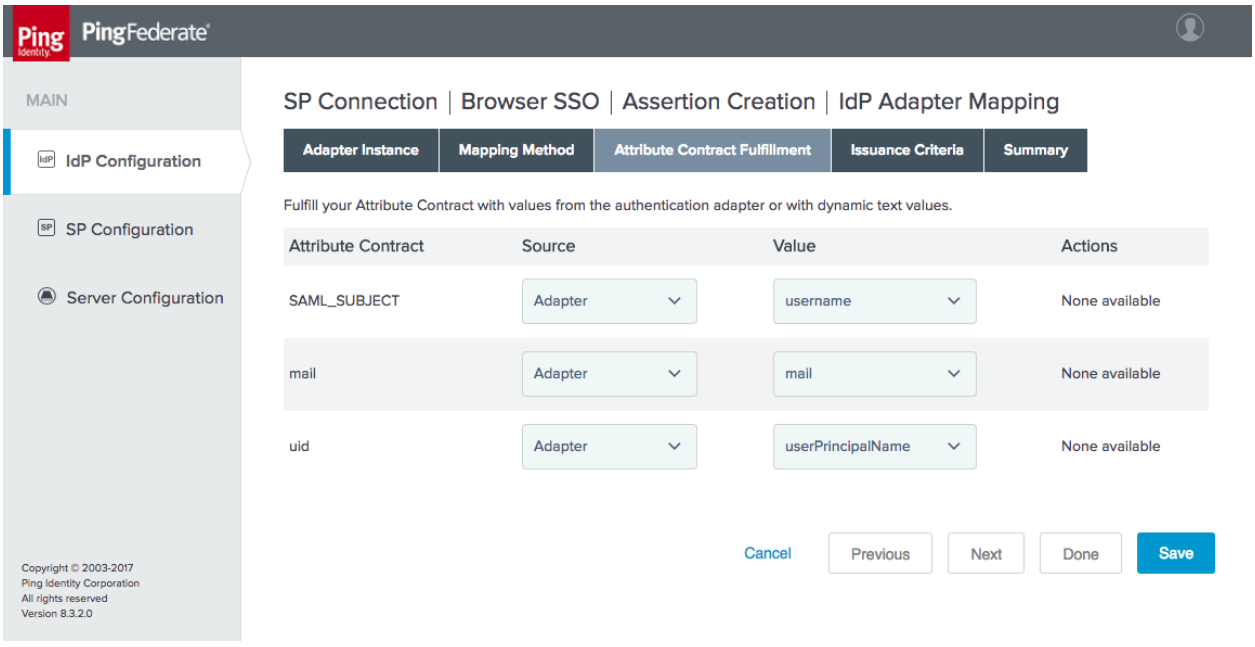
3) On the **Authentication Source Mapping** tab, attributes provided by authentication adapters and policy contracts can be mapped to the assertion attribute contract, identifying which data will be used to populate the assertions. The FIDO U2F adapter and the HTML Form Adapter should appear under **Adapter Instance Name**. Select the HTML Form Adapter, as it can provide the needed attributes from LDAP via the Password Validator and the AD data store connection. This brings up another multi-tabbed configuration screen.

   a) The **Adapter Instance** tab shows the attributes that are returned by the selected adapter. Click **Next**.

   b) The **Mapping Method** tab provides options to query additional data stores to build the assertions, but in this case, all of the required attributes are provided by the HTML Form Adapter. Select **USE ONLY THE ADAPTER CONTRACT VALUES IN THE SAML ASSERTION**.

   c) On the **Attribute Contract Fulfillment** tab, map the **SAML_SUBJECT**, **mail**, and **uid** attributes to the **username**, **mail**, and **userPrincipalName** adapter values (Figure 4-22).

Figure 4-22 Assertion Attribute Contract Fulfillment



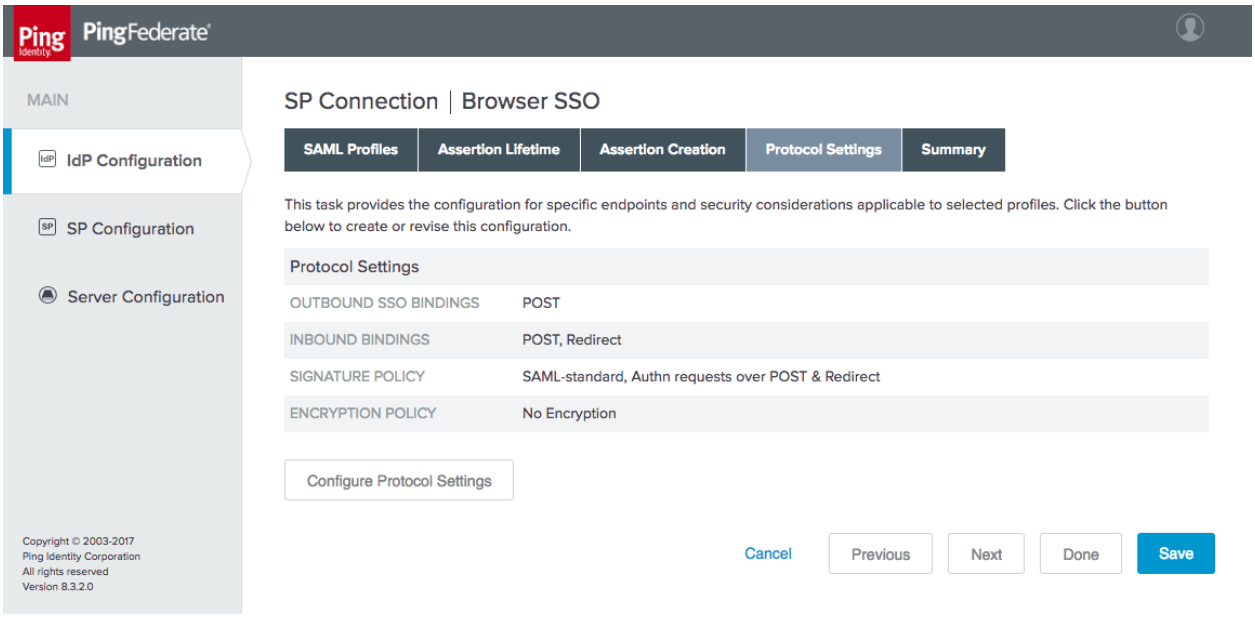
d) No **Issuance Criteria** are required; therefore, skip the **Issuance Criteria** tab.

e) Click **Done** to exit the IdP Adapter Mapping.

4) Click **Done** to exit the Assertion Creation.

iv. On the **Protocol Settings** tab, options such as additional SAML bindings, signature policy details, and assertion encryption policies can be specified (Figure 4-23). For the lab build, these values were left at their default settings.

Figure 4-23 Browser SSO Protocol Settings



v. Click **Done** to exit Browser SSO.

f. On the **Credentials** tab, the certificate to use for signing assertions can be specified. A self-signed certificate can be generated by PingFederate, or a trusted certificate can be obtained and uploaded. Click **Configure Credentials** to create or manage signing credentials.

g. On the **Activation & Summary** tab, the connection status can be set to **ACTIVE**. All configured settings for the SP connection are also displayed for verification.

h. Click **Save** to complete the SP connection configuration.

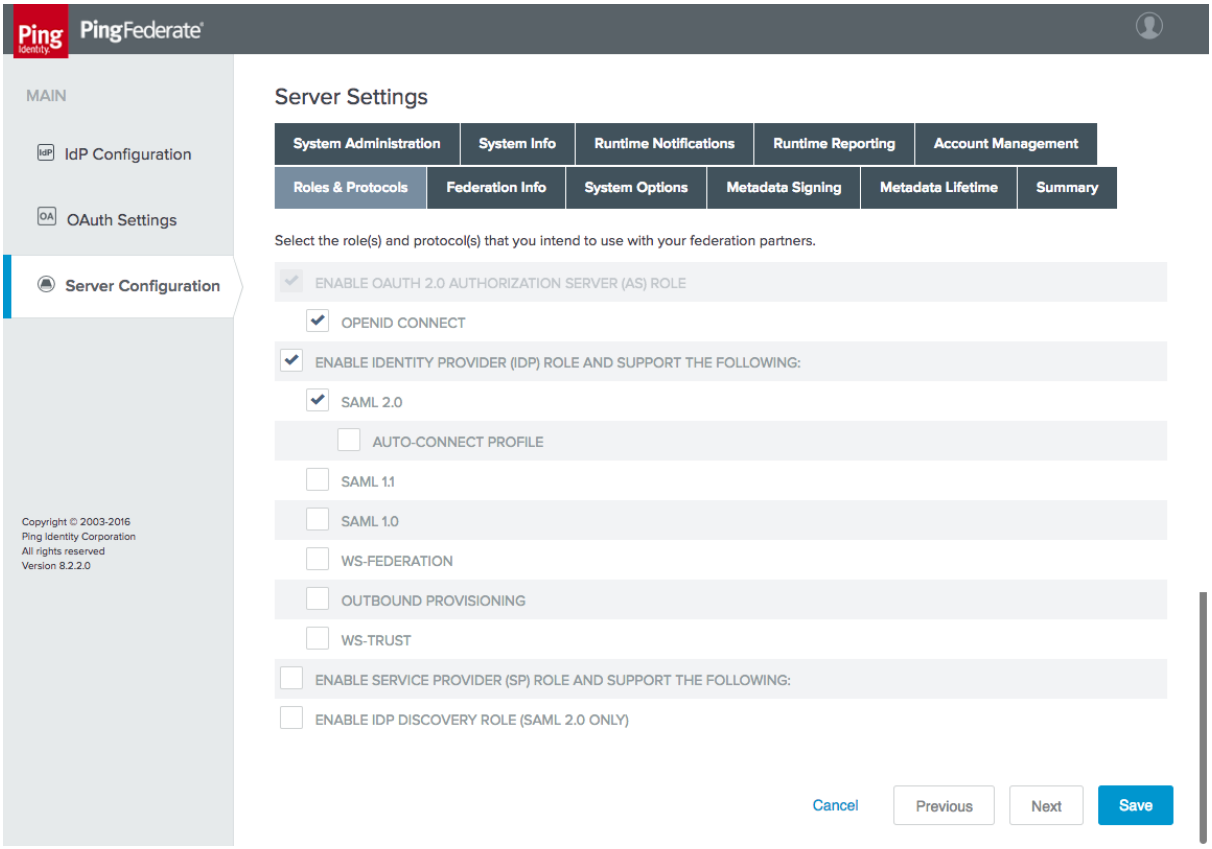
This completes the configuration of the SAML IdP.

4.3 How to Install and Configure the OIDC Identity Provider

1. On the **Server Configuration** section tab, click **Server Settings**.

    a. On the **Roles & Protocols** tab, enable the roles and protocols as shown in Figure 4-24. Although the OIDC IdP does not actually use the SAML protocol, some required configuration settings are unavailable if the IdP role is not enabled.

Figure 4-24 OIDC IdP Roles



    b. On the **Federation Info** tab, specify the **BASE URL** and **SAML 2.0 ENTITY ID**. The **BASE URL** must be a URL that is exposed to clients.

2. On the **OAuth Settings** section tab, click **Authorization Server Settings** to configure general OAuth and OIDC parameters. The OIDC IdP's settings on this page are identical to those for the OAuth AS; refer to Section 3.3 for notes on these settings.

3. On the **OAuth Settings** section tab, click **Scope Management**.
    a. Add the scopes defined in the OpenID Connect Core specification [15]:
        - openid
        - profile
        - email
        - address
        - phone

4.3.1 Configuring Authentication to the OIDC IdP

In the lab architecture, the OIDC IdP supports FIDO UAF authentication through integration with the NNAS and the Nok Nok Labs Gateway, using the Nok Nok FIDO UAF adapter for PingFederate. Configuring UAF authentication to the OIDC IdP cannot be completed until the Nok Nok Labs servers are available and the UAF plugin has been installed on the IdP server as specified in Section 5.

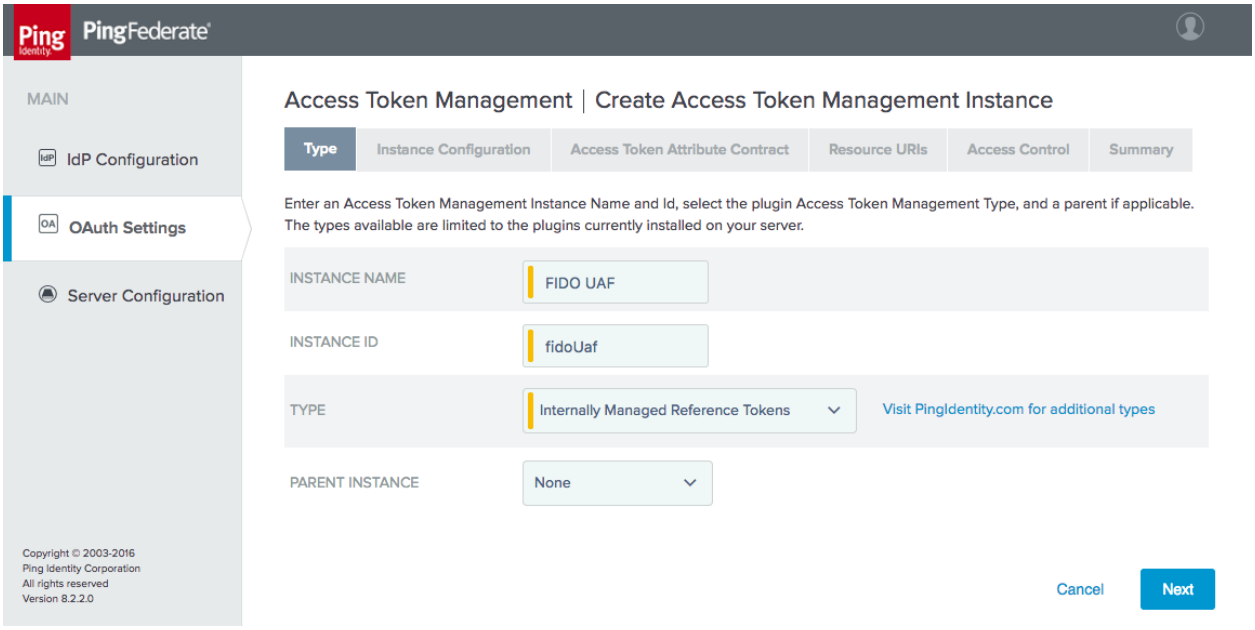
4.3.1.1 Configure the FIDO UAF Plugin

The steps to configure the FIDO UAF plugin for the OIDC IdP are identical to those documented in Section 3.4.1.1 for direct authentication using UAF at the AS. The only difference in the lab build was the URLs for the NNAS and the Nok Nok Labs Gateway, as the AS and the OIDC IdP used two different instances of the Nok Nok Labs server.

4.3.1.2 Configure an Access Token Management Instance

1. On the **OAuth Settings** section tab, click **Access Token Management**.
2. Click **Create New Instance**.
    a. On the **Type** tab, provide an **INSTANCE NAME** and **INSTANCE ID** (Figure 4-25).
        i. Select **Internally Managed Reference Tokens** for the **TYPE**.

1725 **Figure 4-25 Create Access Token Manager**

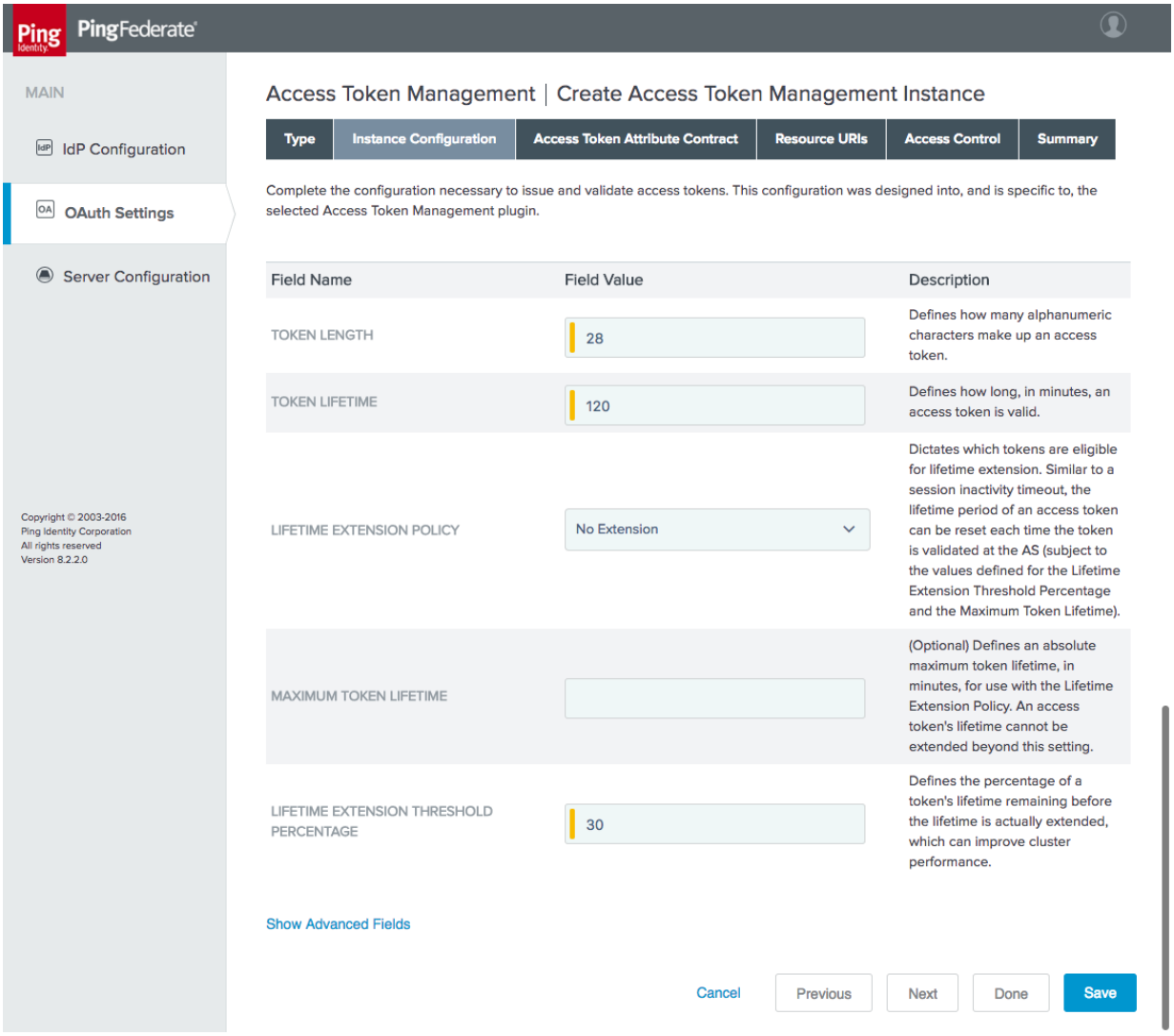


1726

1727 Although we have selected reference tokens, the ID Token is always issued in
1728 the form of a JWT. The token that is being configured here is not the ID Token,
1729 but rather the access token that will be issued to authorize the RP to call the
1730 userinfo endpoint at the IdP to request additional claims about the user.
1731 Because this access token only needs to be validated by the OIDC IdP itself,
1732 reference tokens are sufficient. In the Authorization Code flow, the RP obtains
1733 both the ID Token and the access token in exchange for the authorization code
1734 at the IdP's token endpoint.

1735 b. Click the **Instance Configuration** tab to configure some security properties of the access
1736 token, such as its length and lifetime (Figure 4-26). For the lab build, the default values
1737 were accepted.

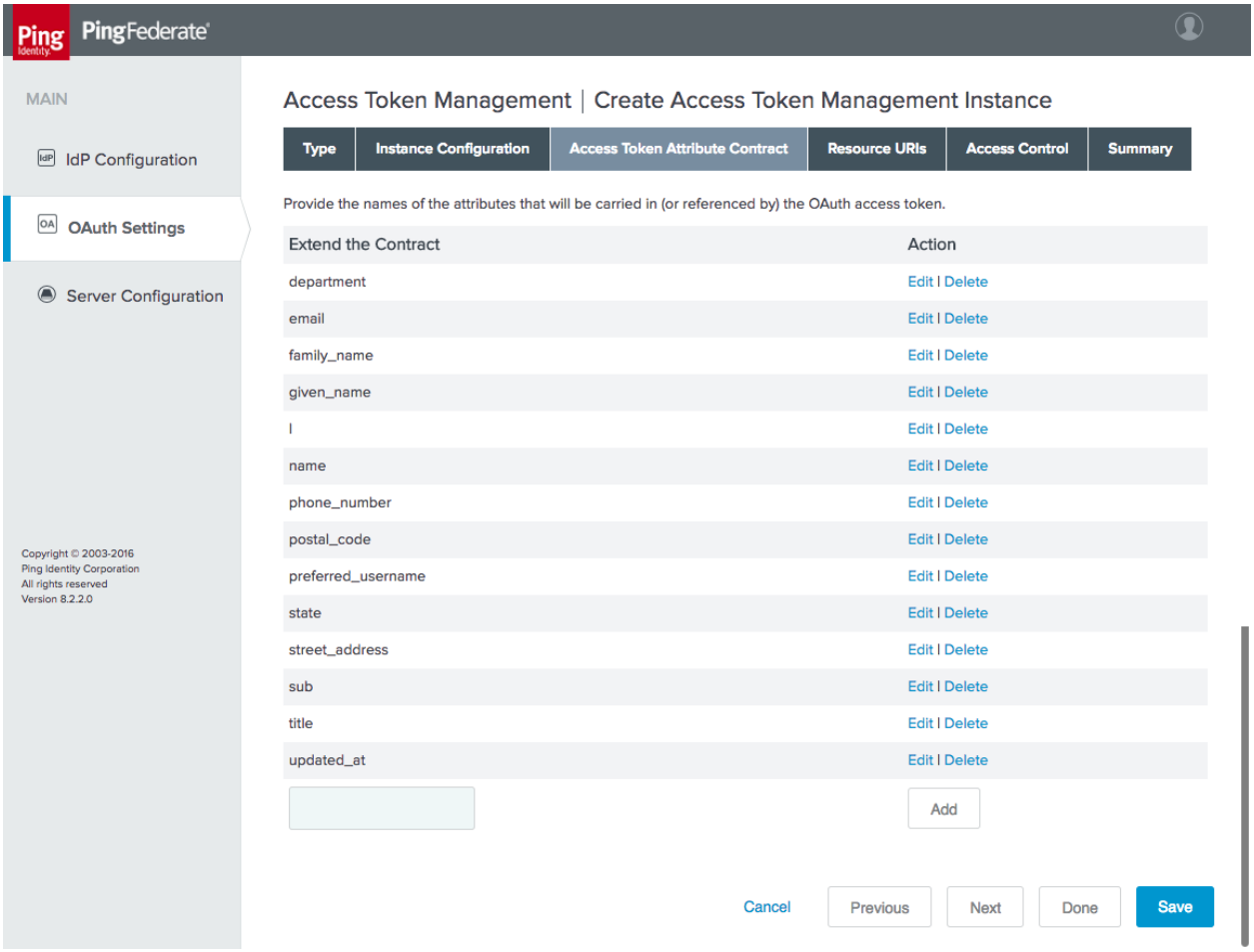
1738 **Figure 4-26 Access Token Manager Configuration**



1739

1740 c. On the **Access Token Attribute Contract** tab, extend the contract with any attributes
1741 that will be included in the ID Token (Figure 4-27). In the example shown in Figure 4-27,
1742 several attributes that will be queried from AD have been added.

1743 **Figure 4-27 Access Token Attribute Contract**



1744

1745 d. There is no need to configure the **Resource URIs** or **Access Control** tabs; these tabs can
1746 be skipped.

1747 e. Click **Done**, and then click **Save**.

1748 ### *4.3.1.3 Configure an IdP Adapter Mapping*

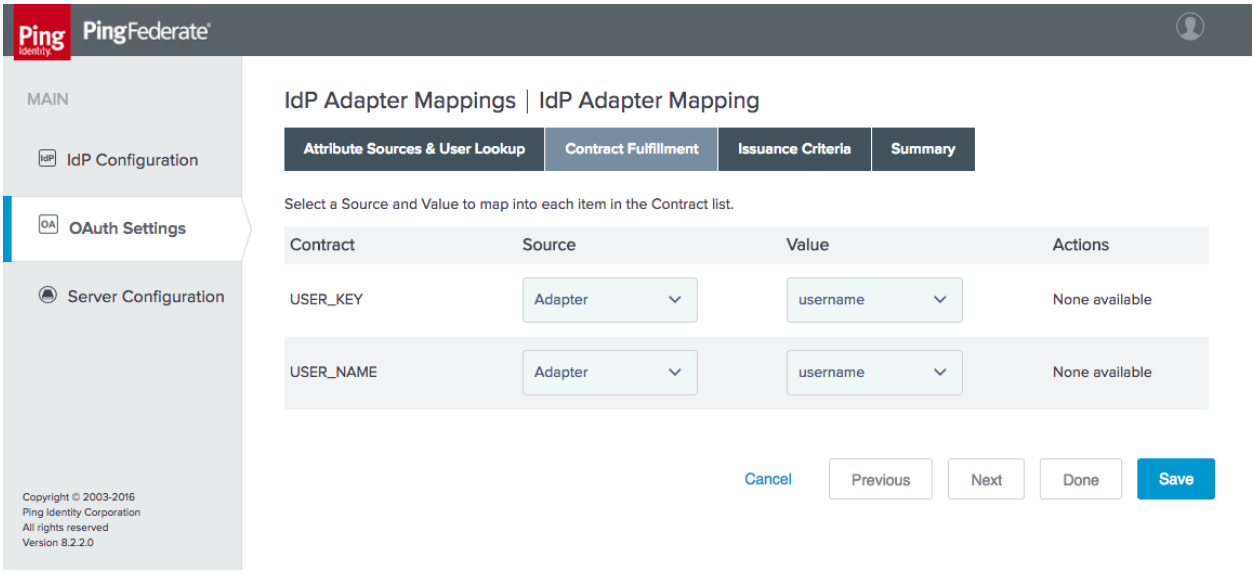
1749 The IdP Adapter Mapping determines how the persistent grant attributes are populated using
1750 information from authentication adapters.

1751 1. Click the **OAuth Settings** section tab, and then click **IdP Adapter Mapping**.

1752 2. Select the UAF adapter instance created in Section 4.3.1.1, and then click **Add Mapping**.

a. On the **Contract Fulfillment** tab, map both **USER_KEY** and **USER_NAME** to the **username** value returned from the adapter (Figure 4-28).

Figure 4-28 Access Token Contract Fulfillment

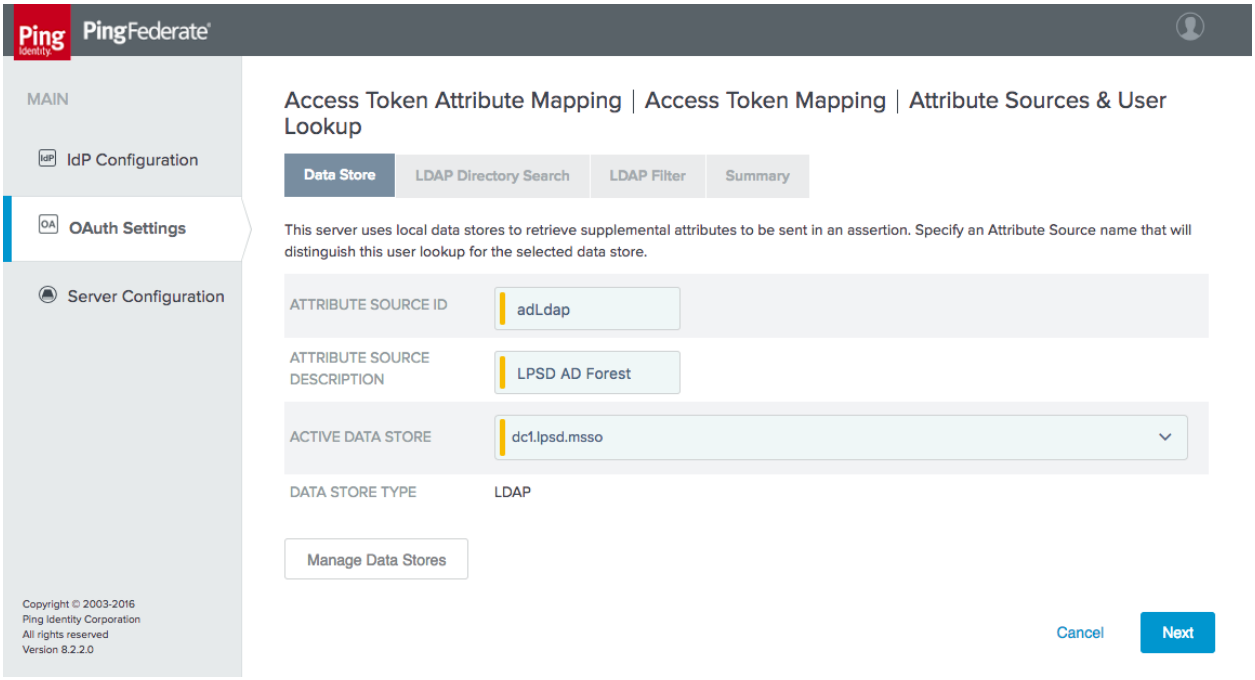


4.3.1.4 *Configure an Access Token Mapping*

The Access Token Mapping determines how the access token attribute contract is populated. In this example, the values returned from the adapter are supplemented with attributes retrieved from AD, and issuance criteria are used to require the user to be actually found in AD for a token to be issued. Depending on the credential and access life-cycle processes used in a given organization, there may be a lag in deactivating the authenticator or the AD account when a user's access is terminated. Organizations' authentication policies should account for these conditions and should allow or deny access appropriately.

1. On the **OAuth Settings** section tab, click **Access Token Mapping**.
2. Under **CONTEXT** and **ACCESS TOKEN MANAGER**, select the IdP Adapter and Access Token Manager created in the preceding steps, and click **Add Mapping**.
    a. On the **Attribute Sources & User Lookup** tab, click **Add Attribute Source**. This brings up another multi-tabbed configuration.
        i. On the **Data Store** tab, give the attribute source an ID and description (Figure 4-29). For **ACTIVE DATA STORE**, select the user store created in Section 4.1.

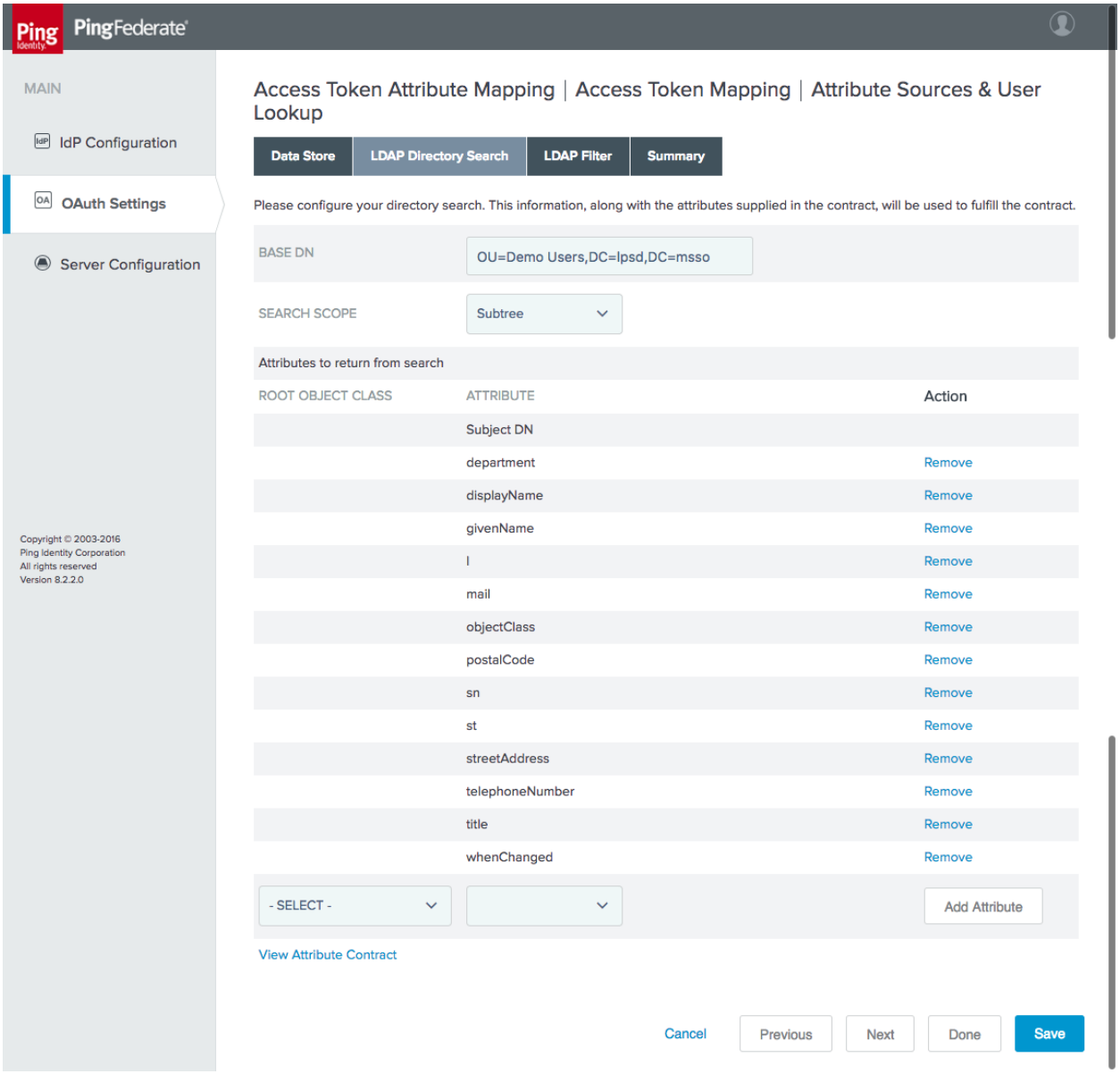
1773 **Figure 4-29 Data Store for User Lookup**



1774

1775 ii. On the **LDAP Directory Search** tab, specify the **BASE DN** and **SEARCH SCOPE**,
1776 and add the AD attributes to be retrieved (Figure 4-30). When specifying attrib-
1777 utes, it is necessary to first select the root object class that contains the attrib-
1778 ute. Common attributes associated with user accounts may be derived from the
1779 **User** or **OrganizationalPerson** class, for example. Refer to Microsoft's AD
1780 Schema documentation [16] to identify the class from which a given attribute is
1781 derived.

1782 **Figure 4-30 Attribute Directory Search**



1783

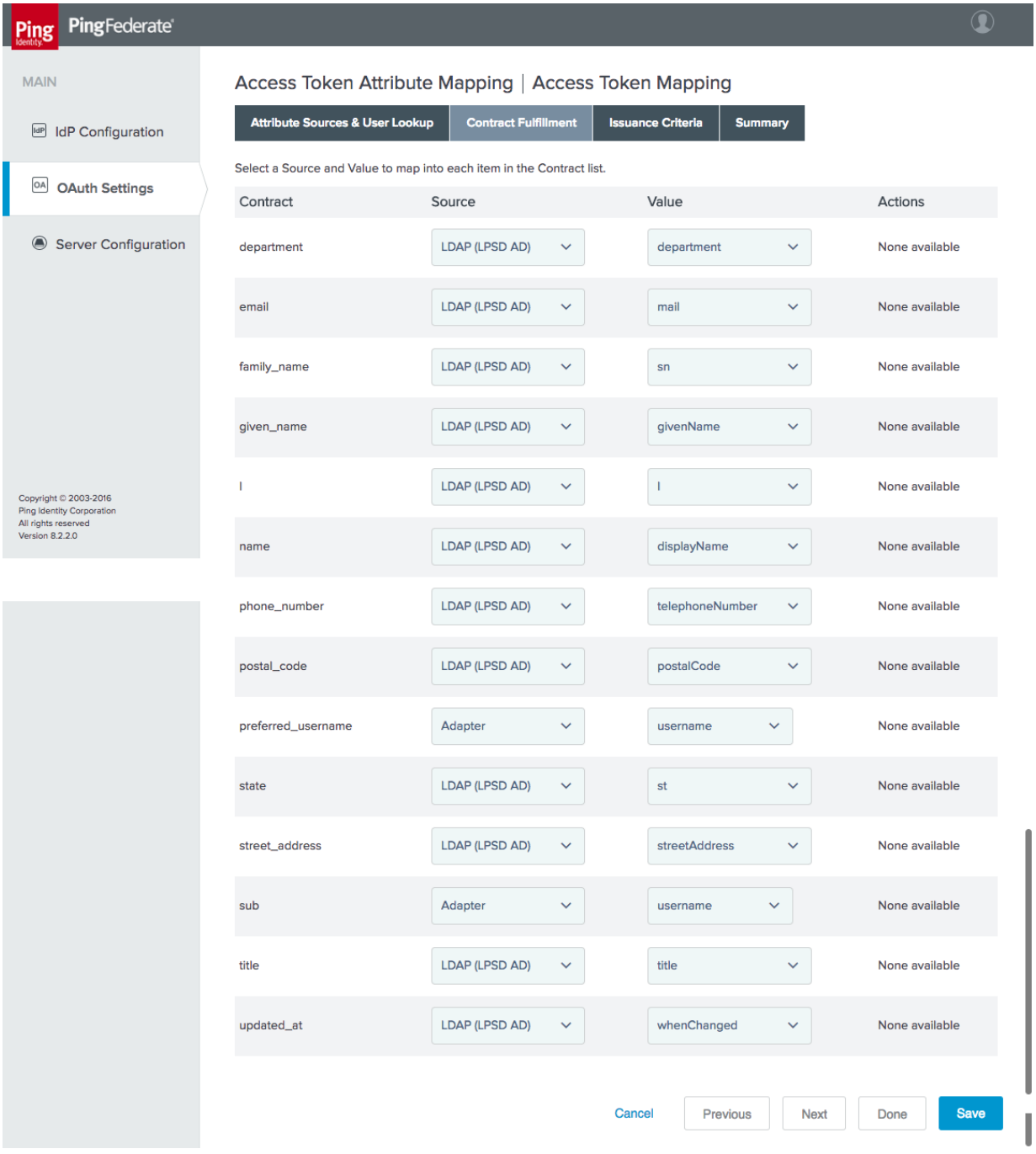
1784 iii. On the **LDAP Filter** tab, create the filter to select the relevant user account. In
1785 this example, the username from the adapter is matched against the AD SAM
1786 account name:

1787 `sAMAccountName=${adapter.username}`

1788 iv. Click **Done** to exit the attribute source configuration.

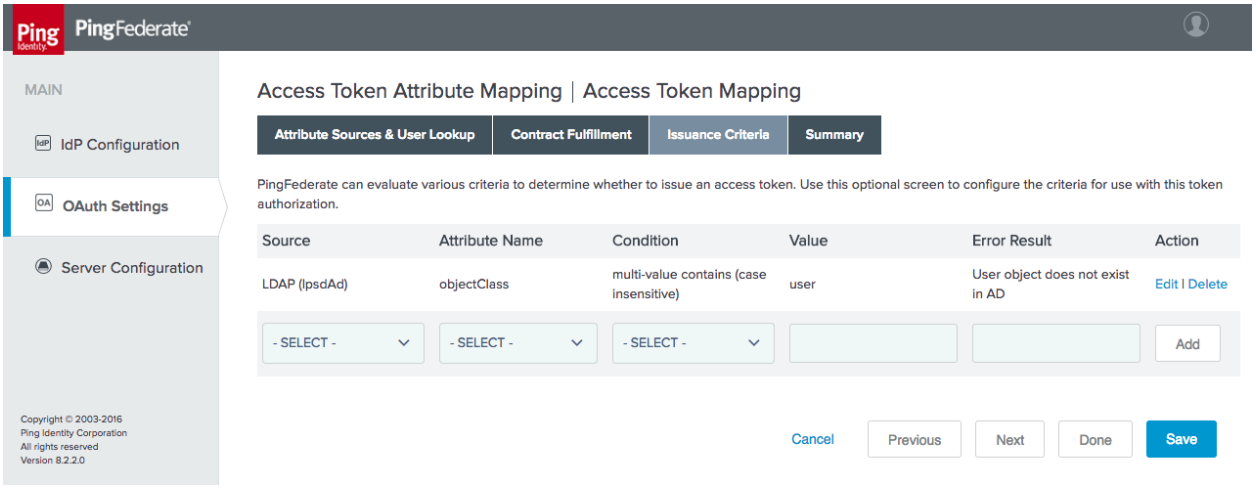
b. On the **Contract Fulfillment** tab, specify the source and value to use for each attribute in the access token attribute contract (Figure 4-31).

Figure 4-31 Access Token Contract Fulfillment



c. On the **Issuance Criteria** tab, define a rule that will prevent token issuance if the user account doesn't exist in AD (Figure 4-32). In this case, the **objectClass** attribute, which all AD objects have, is checked for the **Value** called **user**. If no user account is found in AD, this attribute will have no **Value**, the **Condition** will be false, and the specified **Error Result** will appear in the PingFederate server log.

Figure 4-32 Access Token Issuance Criteria



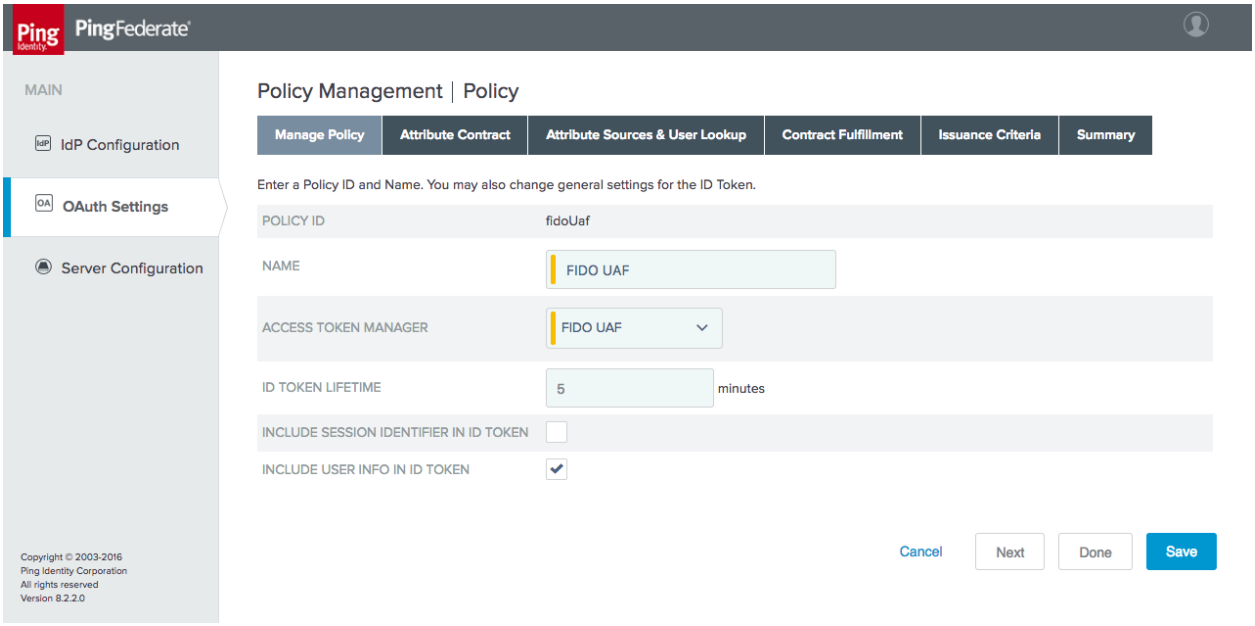
d. Click **Done**, and then click **Save** to finish the Access Token Attribute Mapping configuration.

4.3.1.5 Configure an OIDC Policy

1. On the **OAuth Settings** tab, click **OpenID Connect Policy Management**.
2. Click **Add Policy**.

    a. On the **Manage Policy** tab, create a **POLICY ID** and **NAME**, and select the **INCLUDE USER INFO IN ID TOKEN** checkbox (Figure 4-33). This selection means that the user's attributes will be included as claims in the ID Token JWT. The advantage of this approach is that the RP can directly obtain user attributes from the ID Token without making additional requests to the IdP. The alternative is to include only a subject claim in the ID Token, and to have the RP call the IdP's userinfo endpoint to obtain additional user attributes.

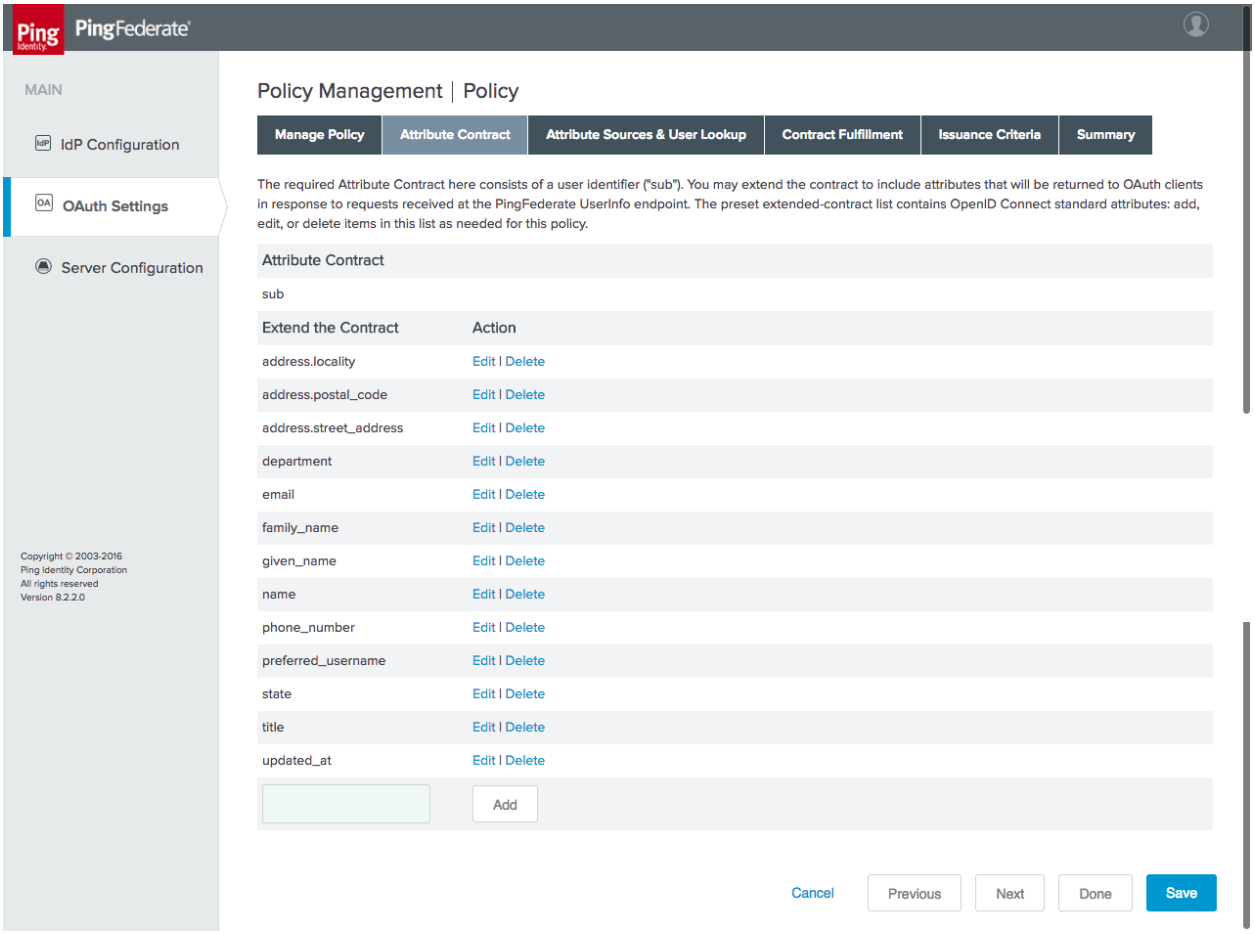
1812 **Figure 4-33 OIDC Policy Creation**



1813

1814 b. On the **Attribute Contract** tab, the set of attributes in the contract can be edited
1815 (Figure 4-34). The contract is automatically populated with the standard claims defined
1816 in the OIDC Core specification. In the example shown in Figure 4-34, some claims have
1817 been removed and others have been added to accommodate the attribute available
1818 from AD.

1819 **Figure 4-34 OIDC Policy Attribute Contract**

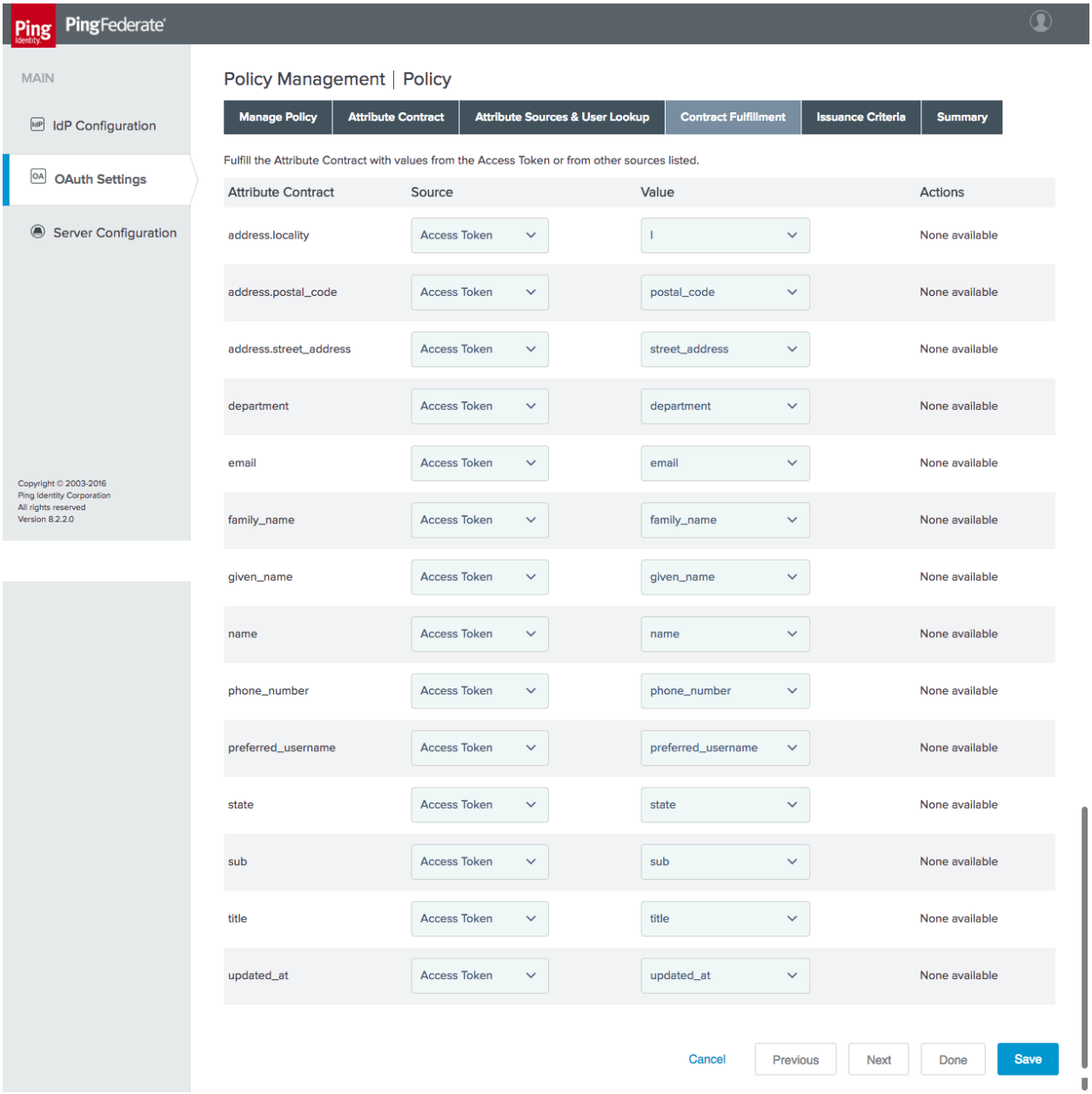


1820

1821 c. Skip the **Attribute Sources & User Lookup** tab; there is no need to retrieve additional
1822 attributes.

1823 d. On the **Contract Fulfillment** tab, populate the OIDC attributes with the corresponding
1824 values from the Access Token context (Figure 4-35).

1825 **Figure 4-35 OIDC Policy Contract Fulfillment**



1826

1827 e. There is no need for additional issuance criteria; therefore, skip the **Issuance Criteria**
1828 tab.

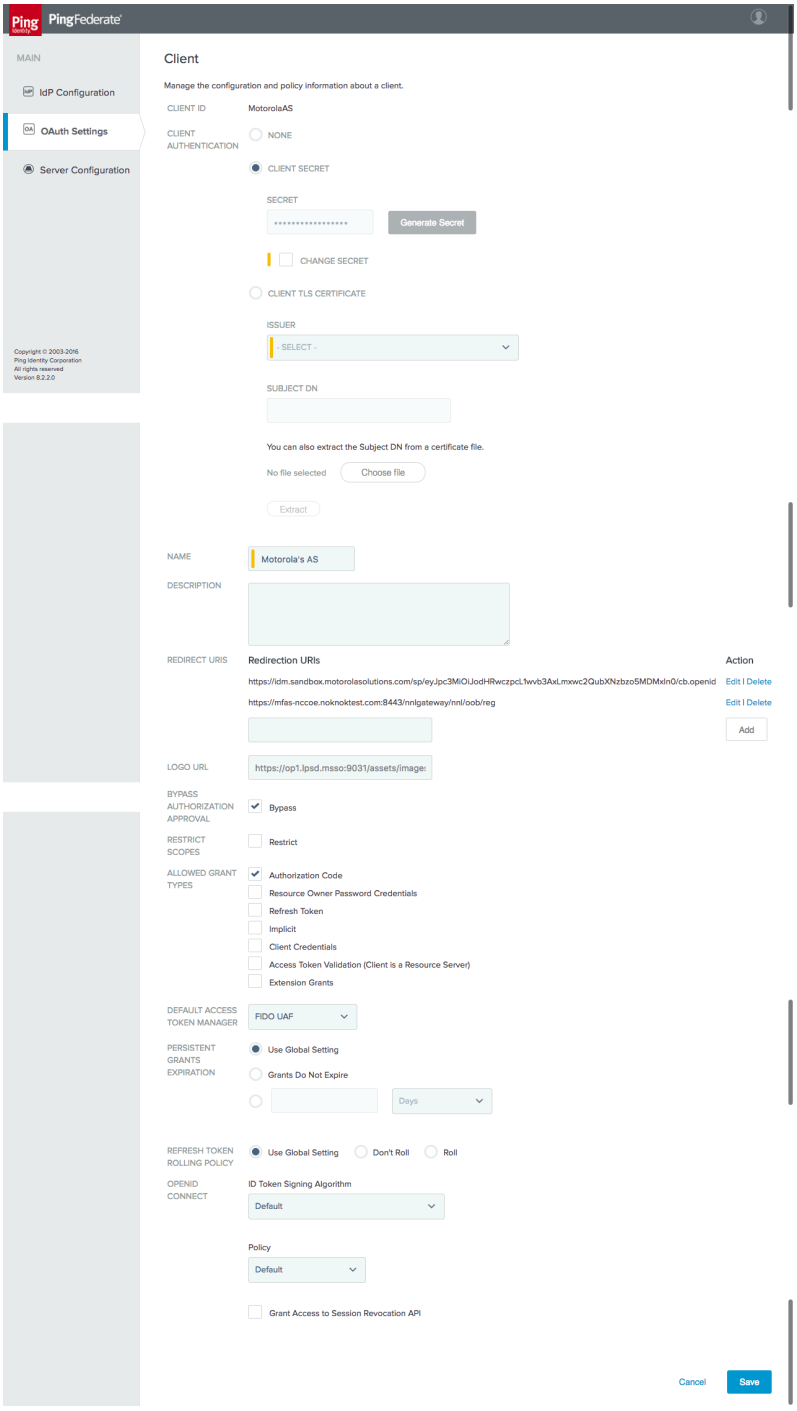
1829 f. Click **Save** to complete the OIDC Policy configuration.

4.3.2 Configuring the OIDC Client Connection

Registering a client at an OIDC IdP is analogous to creating an SP connection at a SAML IdP. Some coordination is required between the administrators of the two systems. The client ID and client secret must be provided to the RP, and the RP must provide the redirect URI to the IdP.

1. To add a client, click the **OAuth Settings** section tab, and then click **Create New** under **Clients**.
    a. Create a **CLIENT ID** and **CLIENT SECRET** (Figure 4-36). If mutual TLS authentication is being used instead, the RP must provide its certificate, which can be uploaded to the client creation page. Only the **Authorization Code** grant type is needed for this integration. In the example shown in Figure 4-36, user prompts to authorize the sharing of the user's attributes with the RP have been disabled in favor of streamlining access to apps.

1840 **Figure 4-36 OIDC Client Configuration**



1841

1842 This completes configuration of the OIDC IdP.

5 How to Install and Configure the FIDO UAF Authentication Server

For the lab build environment, the Nok Nok Labs S3 Authentication Suite provides FIDO UAF integration. The S3 Authentication Suite can support a variety of different deployments and architectures, as described in the Solution Guide [17]. This section briefly describes the overall deployment architecture used for this build.

The Nok Nok Labs SDKs can be directly integrated into mobile apps, providing UAF client functionality directly within the app. This deployment would be more suitable to use cases that do not involve federation, where the requirement is to authenticate users directly at the app back-end. Nok Nok Labs also provides "Out-of-Band" (OOB) integration. OOB can support workflows where a mobile device is used for true OOB authentication of logins or transactions initiated on another device, such as a laptop or workstation. OOB also can be used for authentication flows in a mobile web browser, including OAuth authorization flows or IdP authentication, as implemented in this build by using the AppAuth pattern.

When OOB is used in a cross-device scenario, the user must first register the mobile device by scanning a QR code displayed in the browser. Subsequent authentication requests can be sent by push notification to the registered device. When the OOB flow is initiated in a mobile browser, however, the authentication request can be sent directly to the app running the Nok Nok Labs SDK by using mobile platform technologies to open links directly in mobile apps (*App Links* for Android, or *Universal Links* for iOS). The FIDO client that processes the OOB authentication request can be either a custom app incorporating the Nok Nok Labs SDK, or the Nok Nok Labs Passport app, which provides a ready-made implementation.

The components of the Nok Nok Labs deployment for this build architecture are as follows:

- Nok Nok Labs Passport – provides UAF client functionality as well as Authenticator-Specific Modules (ASMs) and authenticators on the mobile device
- Nok Nok Labs PingFederate UAF Adapter – a PingFederate plugin providing integration between a PingFederate AS or IdP and the NNAS, enabling UAF authentication or transaction verification to be integrated into PingFederate authentication policies
- NNAS – provides core UAF server functionality, including the generation and verification of challenges, as well as APIs for interactions with UAF clients and the PingFederate Adapter
- Nok Nok Labs Gateway – provides a simplified interface to request FIDO operations from the Authentication Server, as well as integration with the existing app session management infrastructure
- Nok Nok Labs Gateway Tutorial App – a demonstration web app implementation that provides simple U2F and UAF authentication and registration workflows

In a typical production implementation, the gateway functions for authenticator management (registration and de-registration) would typically require strong authentication, implemented through the Gateway's session management integration. Nok Nok Labs' documentation for the PingFederate plugin provides examples for defining a "reg" OAuth scope to request authenticator registration. An OAuth Scope Authentication Selector could be used in a PingFederate authentication policy to trigger the required strong authentication process.

5.1 Platform and System Requirements

The following subsections list the hardware, software, and network requirements for the various Nok Nok Labs components.

5.1.1 Hardware Requirements

Nok Nok Labs specifies the following minimum hardware requirements for the NNAS and Nok Nok Labs Gateway components. The requirements for acceptable performance will depend on the anticipated user population and server load. See the *Enabling Scalability & Availability* section of the *Solution Guide* for architecture guidance on deploying the NNAS in a clustered configuration.

- Processor: 1 CPU
- Memory: 4 GB RAM
- Hard disk drive size: 10 GB

5.1.2 Software Requirements

Complete software requirements for the NNAS are provided in the *Nok Nok Labs Authentication Server Administration Guide* [18]. The major requirements are summarized below:

- OS: Red Hat Enterprise Linux 7 or CentOS 7
- Relational database system: MySQL 5.7.10 or later versions, Oracle Database 12c, or PostgreSQL 9.2 or 9.4
- Application server: Apache Tomcat 8.0.x or 8.5.x
- Java: Oracle JDK Version 8
- Build tool: Apache Ant 1.7 or later versions
- For clustered deployments: Redis 2.8 or later versions
- Google Cloud Messenger (GCM) or Apple Push Notification System (APNS), if using push messages

The Nok Nok Labs PingFederate Adapter is compatible with PingFederate 8.1.3 or later versions.

The Nok Nok Labs Gateway is also deployed in Tomcat.

5.2 How to Install and Configure the FIDO UAF Authentication Server

The installation process for the Authentication Server is documented in the *Administration Guide*. A high-level summary is provided below, with notes relevant to the lab build:

- Install the OS and dependent software, including Java and Tomcat. The database can be installed on the same host as Tomcat, or remotely. Provision a TLS certificate for the server, and configure Tomcat to use TLS.
- The configuration for push notifications to support OOB authentication is not required for this build; push notifications would be used when the mobile device is used to authenticate logins or transactions initiated on a separate device.
- Follow the instructions to generate an encryption key, and encrypt database credentials in the installation script. Encrypting the push notification credentials is not required, unless that functionality will be used.
- For this lab build, the standalone installation was used. The standalone option uses the PostgreSQL database on the same host as the Authentication Server, and also installs the Tutorial app.
- After running the installation script, delete the encryption key (`NNL_ENCRYPTION_KEY_BASE64`) from *nnl-install-conf.sh*.
- For this lab build, the default policies and authenticators were used. In a production deployment, policies could be defined to control the authenticator types that could be registered and used to authenticate.
- Provisioning a Facet ID is not necessary for the OOB integration with Nok Nok Labs Passport, as used in the lab. If the Nok Nok Labs SDK were integrated with a custom mobile app, then the Facet ID would need to be configured, and the *facets.uaf* file would need to be published at a URL where it is accessible to clients.
- App link/universal link integration (optional) – In the lab, the default setting using an app link under https://app.noknok.com was used. This is acceptable for testing, but in a production deployment, an app link pointing to the IdP's actual domain name would typically be used. It should be noted that the FQDN for the app link must be different from the authentication endpoint (i.e., the IdP's URL) at least by sub-domain.
- Configure tenant-specific and global parameters. For the lab build, a single tenant was used. Many parameters can be left at the default settings. Some notes on specific parameters are provided below:
  - `uaf.application.id` – This should be a URL that is accessible to clients. In a production deployment, the AS may not be accessible, so this may need to be hosted on a different server.

- `uaf.facet.id` – There is no need to modify the Facet ID setting to enable the use of the Passport app for OOB authentication; however, if other custom apps were directly integrating the Nok Nok Labs SDK, they would need to be added here.

- For a production deployment, client certificate authentication to the Authentication Server should be enabled. This is done by configuring the Tomcat HTTP connector to require client certificates. This requires provisioning a client certificate for the gateway (and any other servers that need to call the Nok Nok Labs APIs). See the notes in Section 5.3 of the *Administration Guide* about configuring the Gateway to use client certificate authentication. A general reference on configuring TLS in Tomcat 8 can be found at https://tomcat.apache.org/tomcat-8.0-doc/ssl-howto.html.

5.3 How to Install and Configure the FIDO UAF Gateway Server

The Nok Nok Labs Gateway app is delivered as a Web Archive (WAR) file that can be deployed to a Tomcat server. For the lab build, it was deployed on the same server as the NNAS.

Configure the required settings in the `nnlgateway.properties` file, including the settings listed below:

- `mfas_location` – NNAS URL
- `server.auth.enabled` – should be set to true; also requires configuring the trust-store settings
- `client.auth.enabled` – see notes in Section 5.2 above; should be enabled for strong client authentication in production deployments; also requires configuring the keystore settings

In addition, the Gateway Tutorial app was installed by deploying the `gwtutorial.war` file and configuring the required URLs in `gwtutorial.properties`.

5.4 How to Install and Configure the FIDO UAF Adapter for the OAuth 2 AS

Nok Nok Labs provided a tar file containing a set of software tools for integration and testing with PingFederate. Version 5.1.0.501 of the Ping Integration library was used for the lab build. The installation process is summarized below; refer to the *Nok Nok PingFederate Adapter Integration Guide* [19] for full details:

1. Extract the *adapter* folder from the *nnl-ping-integration-5.1.0.501.tar* file onto the PingFederate server where the adapter will be installed.
2. Stop PingFederate if it is running, and run the installation script. The path to the PingFederate installation is passed as an argument; run the script by using an account with write access to the PingFederate installation:

   ```
   $ ./adapter-deploy.sh /usr/share/pingfederate-8.2.2/pingfederate
   ```

3. Configure the *adapter.properties* file (located in the PingFederate directory under *server/default/conf*) as required for the server and client TLS authentication settings specified

earlier in the Authentication Server configuration. If push notifications are enabled, configure the relevant settings.

4. The *Configure Session Manager* and *Deploy Nok Nok Gateway OOB* sections of the *Integration Guide* provide settings to use PingFederate to protect the Registration endpoint on the Nok Nok Labs Gateway. This could be used in conjunction with the custom "reg" scope and a PingFederate authentication policy to require strong authentication prior to UAF authenticator registration. This configuration was not tested in the lab.

The *Configure PingFederate Console* section of the *Integration Guide* walks through the complete configuration of a PingFederate OIDC provider. See Section 4.3 of this guide for the procedure to configure the OpenID Provider.

6 How to Install and Configure the FIDO U2F Authentication Server

The SKCE from StrongAuth performs the FIDO U2F server functionality in the build architecture. StrongAuth's main product is the StrongAuth Key Appliance, but the company also distributes much of its software under the *Lesser General Public License (LGPL)*, published by the Free Software Foundation. SKCE 2.0 Build 163 was downloaded from its repository on *Sourceforge* and was used for this build. For more information, documentation, and download links, visit the vendor's site at https://www.strongauth.com/products/foss.

6.1 Platform and System Requirements

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

6.1.1 Software Requirements

StrongAuth's website lists the OSs on which SKCE has been tested:

- CentOS 6.X or 7.X, 64-bit
- Windows 7 Professional, 64-bit

Since SKCE is a Java app, in theory it should be able to run on any OS that supports a compatible version of Java and the other required software. The app was built with the Oracle JDK Version 8, Update 72. For this build, SKCE was installed on a CentOS 7.4 server; therefore, these steps assume a Linux installation.

SKCE can be installed manually or with an installation script included in the download. SKCE depends on other software components, including an SQL database, an LDAP directory server, and the Glassfish Java app server. By default, the script will install MariaDB, OpenDJ, and Glassfish all on a single server. SKCE can also utilize AD for LDAP.

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

- Glassfish 4.1
- Java Cryptography Extension (JCE) Unlimited Strength Jurisdiction Policy Files 8
- JDK 8, Update 121
- OpenDJ 3.0.0
- MariaDB 10.1.22
- MariaDB Java Client

See StrongAuth's scripted installation instructions for details and download links: https://sourceforge.net/p/skce/wiki/Install%20StrongAuth%20CryptoEngine%202.0%20%28Build%20163%29%20scripted/.

To download OpenDJ, you must register for a free account for *ForgeRock BackStage*.

SKCE can also utilize an AD LDAP service. The LDAP directory contains system user accounts for managing the SKCE (generating cryptographic keys, etc.) Data pertaining to registered users and authenticators is stored in the SQL database, not in LDAP.

6.1.2 Hardware Requirements

StrongAuth recommends installing SKCE on a server with at least 10 GB of available disk space and 4 GB of RAM.

6.1.3 Network Requirements

The SKCE API is hosted on Transmission Control Protocol (TCP) Port 8181. Any apps that request U2F registration, authentication, or deregistration actions from the SKCE need to be able to connect on this port. Glassfish runs an HTTPS service on this port. Use firewall-cmd, iptables, or any other system utility for manipulating the firewall to open this port.

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

- 3306 – MariaDB listener
- 4848 – Glassfish administrative console
- 1389 – OpenDJ LDAP service

6.2 How to Install and Configure the FIDO U2F Authentication Server

StrongAuth's scripted installation process is documented at https://sourceforge.net/p/skce/wiki/Install%20StrongAuth%20CryptoEngine%202.0%20%28Build%20163%29%20scripted/.

The installation procedure consists of the following steps:

- Downloading the software dependencies to the server where SKCE will be installed
- Making any required changes to the installation script
- Running the script as root/administrator
- Performing post-installation configuration

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 install script: If different versions of any of the software dependencies were downloaded, update the file names in the install 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 install 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 install 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 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 PingFederate server hosting the IdP in the following location:

   /usr/share/pingfederate-8.3.2/pingfederate/server/default/conf/template/assets/scripts

   which enables the file to be accessed by clients at the following URL: *https://oidp1.slpsd.msso:9031/assets/scripts/app.json.*

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

6. (For CentOS 7) create firewall rule: The install script attempts to open the required port 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. Install additional libraries: Depending on how CentOS was installed, some additional libraries may be required to run the graphical key custodian setup tool. In the lab, the SKCE server did not include X11 or a graphical desktop, so the key custodian setup was run over Secure Shell (SSH) with X11 forwarding. To install additional libraries needed for this setup, run the following commands:

```
# yum install libXrender
# yum install libXtst
```

   Note that running the graphical configuration tool over SSH also requires configuring X11 forwarding in the SSH daemon (**sshd**) on the server, and using the `-X` command line option when connecting from an SSH client.

8. Run the key custodian setup tool: In production deployments, the use of a Hardware Security Module (HSM) and Universal Serial Bus (USB) drive for the security officer and key custodian credentials is strongly recommended. In the lab, the software security module was used. Also, the lab setup utilized a single SKCE server; in this case, all instructions pertaining to copying keys to a secondary appliance can be ignored.

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

```
$ sudo systemctl restart glassfishd
```

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

11. 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.

12. Complete Step 4 if you are installing secondary SKCE instances; this was not done for this build, but is recommended for a production installation.

13. Install a TLS certificate (optional): The SKCE installation script creates a self-signed certificate for the SKCE. It is possible to use the self-signed certificate, though PingFederate and any other servers that integrate with the SKCE would need to be configured to trust it. However, many organizations will have their own CAs, and will want to generate a trusted certificate for the SKCE for production use. To generate and install the certificate, follow the steps listed below:

    a. The keystore used by the SKCE Glassfish server is listed below:

    ```
    /usr/local/strongauth/glassfish4/glassfish/domains/domain1/config/keystore.jks
    ```

    b. The default password for the keystore is “changeit”.

    c. Use keytool to generate a keypair and certificate signing request. For example, the following commands generate a 2048-bit key pair with the alias “msso,” and export a Certificate Signing Request (CSR):

    ```
    $ keytool -genkeypair -keyalg RSA -keysize 2048 -alias msso -keystore keystore.jks
    ```

    ```
    $ keytool -certreq -alias msso -file strongauth.req -keystore keystore.jks
    ```

    d. Submit the CSR to your organization’s CA, and import the signed certificate along with the root and any intermediates:

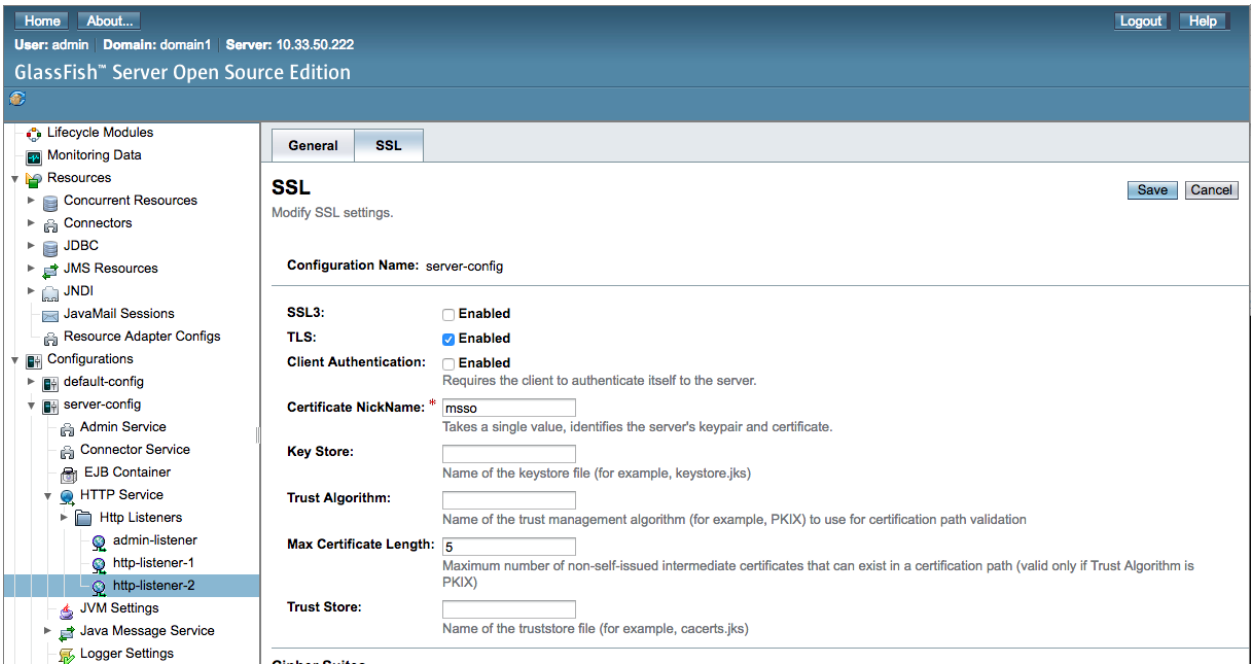
    ```
    $ keytool -import -trustcacerts -alias msso-root -file lab-certs/root.pem -keystore keystore.jks
    ```

    ```
    $ keytool -import -alias msso -file lab-certs/strongauth.lpsd.msso.cer -keystore keystore.jks
    ```

    e. To configure the SKCE to use the new certificate, log into the Glassfish administrative console on the SKCE server. The console runs on Port 4848; the username is “admin,” and the password will be whatever was configured for `GLASSFISH_PASSWORD` in the *install-skce.sh* script.

i. Navigate to *Configurations*, *server-config*, *HTTP Service*, *Http Listeners*, *http-listener-2*, as shown in Figure 6-1. On the **SSL** tab, set the **Certificate NickName** to the alias that was created with the "keytool -genkeypair" command above.

Figure 6-1 Glassfish SSL Settings



f. Click **Save**, and then restart glassfish. If logged on as the glassfish user, run the following command:

```
$ sudo service glassfishd restart
```

g. In a browser, access the SKCE web service on Port 8181, and ensure that it is using the newly created certificate.

h. For the FIDO Engine tests below to complete successfully, the main CA trust store for the JDK will need to be updated with your organization's CA certificate. This can also be done with keytool:

```
$ keytool -import -trustcacerts -file lab-certs/root.pem -keystore
$JAVA_HOME/jre/lib/security/cacerts
```

14. 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-%20Build%20163/.

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.

If the FIDO Engine tests are completed without errors, proceed to Section 6.3 to integrate the SKCE with the IdP. If any errors are encountered, the Glassfish log file (located at */usr/local/strongauth/glassfish4/glassfish/domains/domain1/logs/server.log*) should contain messages to aid in troubleshooting.

6.3 How to Install and Configure the FIDO U2F Adapter for the IdP

To incorporate FIDO U2F authentication into a login flow at the IdP, some integration is needed to enable the IdP to call the SKCE APIs. In the lab build architecture, FIDO U2F authentication was integrated into a SAML IdP. PingFederate has a plugin architecture that enables the use of custom and third-party adapters in the authentication flow. StrongAuth provides a PingFederate plugin to enable PingFederate IdPs (or AS) to support U2F authentication. This section describes the installation of the plugin on a PingFederate server. For details on how to integrate U2F authentication to a login flow, see Section 4.2.1.3.

The StrongAuth plugin for PingFederate is delivered in a zip file containing documentation and all of the required program files.

1. To begin the installation process, upload the zip file to the PingFederate server where the StrongAuth plugin will be installed, and unzip the files.
2. If Apache Ant is not already installed on the server, install it now by using the server's package manager. For CentOS, this can be done by running the following command:

   ```
   # yum install ant
   ```

3. Once Apache Ant is installed, follow the "Installation" instructions in the *StrongAuth – Ping Federate FIDO IdP Adapter Installation Guide* [20], which consist of copying the plugin files to the required directories in the PingFederate installation, and running *build.sh*. If the script runs successfully, it will build the plugin using Ant and restart PingFederate.
4. Follow the steps in "Table 2: Configure the SKCE" in the *Installation Guide*. For this build, the *app.json* file needs to be copied to a browser-accessible location on the PingFederate server where the plugin is being installed. In the lab, we placed it under the following location:

   /usr/share/pingfederate-8.3.2/pingfederate/server/default/conf/template/assets/scripts

5. This enables the *app.json* to be accessed at the URL *https://idp1.spsd.msso:9031/assets/scripts/app.json*. Note that Steps 4 and 5 in Table 2 of the *Installation Guide* are only required if the SKCE is using the default self-signed certificate; if a trusted certificate was installed as described in Section 6.2, then those steps can be skipped.

6. Download the JQuery 2.2.0 library at the URL below, and save it to the scripts folder referenced above: https://code.jquery.com/jquery-2.2.0.min.js.

7. Follow the steps in "Table 3: Configure the Ping Federate Instance" in the *Installation Guide*. Importing the SKCE self-signed certificate is not required if a trusted certificate was created. Installation of the JCE unlimited policy was described in the PingFederate installation instructions in Section 3, so that too can be skipped at this point, if it has already been done. Steps 7–9 should be completed in any case.

8. Follow the steps in "Table 4: Configuring the FIDO Adapter" in the *Installation Guide*. In Step 5, the Domain ID typically should be set to "1," unless you have defined multiple domains in the SKCE. For the username and password, use the values configured earlier in *install-skce.sh*.

9. "Table 5: Ping Federate OAuth Configuration Steps" in the *Installation Guide* provides an example of how to incorporate U2F into a login flow, along with username/password form login, by creating a composite adapter that includes the login form and U2F adapters, and using a selector to activate the composite adapter whenever an OAuth authorization request includes the scope value "ldap." Alternatively, the individual adapters can be called directly in an authentication policy. See Chapter 4 of the *Installation Guide* for additional examples of using U2F in authentication policies.

6.3.1 FIDO U2F Registration in Production

By default, the StrongAuth Ping plugin enables the registration of U2F authenticators. In production, an authorized registration process should be established to provide adequate assurance in the binding of the authenticator to a claimed identity. If the FIDO adapter is accessible after single-factor password authentication, organizations may want to disable the registration functionality. See Section B.5 in Volume B of this guide for a discussion of FIDO enrollment.

7 Functional Tests

The MSSO architecture has a number of interoperating components, which can make troubleshooting difficult. This section describes tests than can be performed to validate that individual components are working as expected. If issues are encountered with the overall SSO flow, these tests may help identify the problem area.

7.1 Testing FIDO Authenticators

The FIDO Alliance implements a Functional Certification Program, in which products are evaluated for conformance to the UAF and U2F specifications. Purchasing FIDO-certified authenticators can help avoid potential authenticator implementation issues. Information on the certification program is available at https://fidoalliance.org/certification/, and the FIDO Alliance website also lists certified products.

Some resources are available to help troubleshoot individual authenticators:

- The Yubico demonstration site provides an interface for testing registration and authentication with U2F authenticators: https://demo.yubico.com/u2f.
- The Nok Nok Labs Gateway Tutorial App supports testing of the registration, authentication, and transaction verification functions of FIDO UAF authenticators.

7.2 Testing FIDO Servers

The StrongAuth SKCE documentation includes instructions on testing U2F authenticator registration, authentication, de-registration, and other functions. See Step 14 in Section 6.2.

To test the NNAS, Nok Nok Labs provides the OnRamp mobile app in the Google Play Store and the Apple App Store to test the server APIs with UAF authenticators.

7.3 Testing IdPs

If federated authentication is failing, the issue may lie at the IdP or the AS. The PingFederate server log (located by default under *<pingfederate-directory>/log/server.log*), on both ends, should provide relevant messages.

In some cases, it may be beneficial to look at the assertions being issued by the IdP and to check for the expected attributes. This could be done by integrating a demonstration app as a federation client and debugging the data returned in the assertion. For SAML, projects like SimpleSAMLphp (https://simplesamlphp.org/) provide an implementation that is easy to deploy. It is also possible to perform this testing without installing additional tools.

One method for SAML is to use Chrome Remote Debugging for Android devices: https://developers.google.com/web/tools/chrome-devtools/remote-debugging/.

By logging the authentication flow in the Network pane of Chrome's developer tools, the SAML response can be extracted and viewed. The authentication flow with the SAML IdP configured in this practice guide consists of a series of calls to the *SSO.ping* URL at the IdP. Because the SAML POST binding is used, the final *SSO.ping* response includes an HTML form that submits the SAML response back to the AS. The SAML response can be found in an input element in the page content:

```
<input type="hidden" name="SAMLResponse"
value="PHNhbWxwOlJlc3BvbnNlIFZlcnNpb249IjIuMCIgSUQ9Iko1T2xNNlZxZW5lVnpBU2doSHlsakFLYlI
uOCIgSXNzdWVJbnN0YW50PSIyMDE3LTExLTEzVDEzOjQ5OjE3LjEwMFoiIEluUmVzcG9uc2VUbz0iS2RwMXVfZ
HFPMHlNX2Z0YWVldWJnRjlvMFBYIiBEZXN0aW5hdGlvbj0iaHR0cHM6Ly9pZG0uc2FuZGJveC5tb3Rvcm9sYXN
vbHV0aW9ucy5jb20vc3AvQUNTLnNhbWwyIiB4bWxuczpzYW1scD0idXJuOm9hc2lzOm5hbWVzOnRjOlNBTUw6M
i4wOnByb3RvY29sIj48c2FtbDpJc3N1ZXIgeG1sbnM6c2FtbD0idXJuOm9hc2lzOm5hbWVzOnRjOlNBTUw6Mi4
wOmFzc2VydGlvbiI+aWRwMS5zcHNkLm1zc288L3NhbWw6SXNzdWVyPjxkczpTaWduYXR1cmUgeG1sbnM6ZHM9I
mh0dHA6Ly93d3cudzMub3JnLzIwMDAvMDkveG1sZHNpZyMiPgo8ZHM6U2lnbmVkSW5mbz4KPGRzOkNhbm9uaWN
hbGl6YXRpb25NZXRob2QgQWxnb3JpdGhtPSJodHRwOi8vd3d3LnczLm9yZy8yMDAxLzEwL3htbC1leGMtYzE0b
```

```
iMiLz4KPGRzOlNpZ25hdHVyZU1ldGhvZCBBbGdvcml0aG09Imh0dHA6Ly93d3cudzMub3JnLzIwMDEvMDQveG1
sZHNpZy1tb3JlI3JzYS1zaGEyNTYiLz4KPGRzOlJlZmVyZW5jZSBVUkk9IiNKNU9sTTZWcWVuZVZ6QVNnaEh5b
GpBS2JSLjgiPgo8ZHM6VHJhbnNmb3Jtcz4KPGRzOlRyYW5zZm9ybSBBbGdvcml0aG09Imh0dHA6Ly93d3cudzM
ub3JnLzIwMDAvMDkveG1sZHNpZyNlbnZlbG9wZWQtc2lnbmF0dXJlIi8+CjxkczpUcmFuc2Zvcm0gQWxnb3Jpd
GhtPSJodHRwOi8vd3d3LnczLm9yZy8yMDAxLzEwL3htbC1leGMtYzE0biMiLz4KPC9kczpUcmFuc2Zvcm1zPgo
8ZHM6RGlnZXN0TWV0aG9kIEFsZ29yaXRobT0iaHR0cDovL3d3dy53My5vcmcvMjAwMS8wNC94bWxlbmMjc2hhM
jU2Ii8+CjxkczpEaWdlc3RWYWx1ZT4xdlFpcUNVNmlZYTMzdlFtKzcxbEVsVm1pUUh6T2U5cytBTTdQYTk4Vlp
BPTwvZHM6RGlnZXN0VmFsdWU+CjwvZHM6UmVmZXJlbmNlPgo8L2RzOlNpZ25lZEluZm8+CjxkczpTaWduYXR1c
mVWYWx1ZT4KTHpSbUJhclk2bndGS3ZydjdTL29WYWNJSWRJRUY4eUloV0JXT0NHZ3pyMWtONGVzVi9CU3lLQ1N
XYjhKU1h3QzhWRHNNUnRXOENMNQpVRFV0NTV1OXRCa05Wanh2NWR0NStOYXQ5eWtmdnhXbU9kcGVJVTBzMXNuM
UJHdytkOTRoZUlCYVdJWE1ZOVlRaDlnV3Q2Sll0OVFhCmRGdDZrRUY1S1NDS1FBQVNlbTEyT2xLV29GK2JSbG1
HNGVsbTVMTTh1N0E3Wi9hRnZ1cDNDNmV5ZEpwK1IxaStaK0F6NHlXdmMvNmEKYnlLMTBPZ05pLzBibnprazd3L
0psdHk0ZlVEcVd6bXJyRFpwSEJ4ZkFMVW5UV2RPVDVJeko3bmpMQWtBYVN0NDYwWjUyblpBOGFBYgpVbzA4T0t
EYnZVaS9UZ2xTcUZjcDJSYStCaE9DbUR3OWJvTG9udz09CjwvZHM6U2lnbmF0dXJlVmFsdWU+CjwvZHM6U2lnb
mF0dXJlPjxzYW1scDpTdGF0dXM+PHNhbWxwOlN0YXR1c0NvZGUgVmFsdWU9InVybjpvYXNpczpuYW1lczp0Yzp
TQU1MOjIuMDpzdGF0dXM6U3VjY2VzcyIvPjwvc2FtbHA6U3RhdHVzPjxzYW1sOkFzc2VydGlvbiBJRD0iSF9tL
ldIR29VUVBELjNjVlA0MVhDVVh4YkdLIiBJc3N1ZUluc3RhbnQ9IjIwMTctMTEtMTNUMTM6NDk6MTcuMTU1WiI
gVmVyc2lvbj0iMi4wIiB4bWxuczpzYW1sPSJ1cm46b2FzaXM6bmFtZXM6dGM6U0FNTDoyLjA6YXNzZXJ0aW9uI
j48c2FtbDpJc3N1ZXI+aWRwMS5zcHNkLm1zc288L3NhbWw6SXNzdWVyPjxzYW1sOlN1YmplY3Q+PHNhbWw6TmF
tZUlEIEZvcm1hdD0idXJuOm9hc2lzOm5hbWVzOnRjOlNBTUw6MS4xOm5hbWVpZC1mb3JtYXQ6dW5zcGVjaWZpZ
WQiPnVuY2NvZXRlc3Q0PC9zYW1sOk5hbWVJRD48c2FtbDpTdWJqZWN0Q29uZmlybWF0aW9uIE1ldGhvZD0idXJ
uOm9hc2lzOm5hbWVzOnRjOlNBTUw6Mi4wOmNtOmJlYXJlciI+PHNhbWw6U3ViamVjdENvbmZpcm1hdGlvbkRhd
GEgUmVjaXBpZW50PSJodHRwczovL2lkbS5zYW5kYm94Lm1vdG9yb2xhc29sdXRpb25zLmNvbS9zcC9BQ1Muc2F
tbDIiIE5vdE9uT3JBZnRlcj0iMjAxNy0xMS0xM1QxMzo1NDoxNy4xNTVaIiBJblJlc3BvbnNlVG89IktkcDF1X
2RxTzB5TV9mdGFlZXViZ0Y5bzBQWCIvPjwvc2FtbDpTdWJqZWN0Q29uZmlybWF0aW9uPjwvc2FtbDpTdWJqZWN
0PjxzYW1sOkNvbmRpdGlvbnMgTm90QmVmb3JlPSIyMDE3LTExLTEzVDEzOjQ0OjE3LjE1NVoiIE5vdE9uT3JBZ
nRlcj0iMjAxNy0xMS0xM1QxMzo1NDoxNy4xNTVaIj48c2FtbDpBdWRpZW5jZVJlc3RyaWN0aW9uPjwvc2FtbDpTdWJqZWN
1ZGllbmNlPmN0b1BpbmdGZWRfZW50aXR5SUQ8L3NhbWw6QXVkaWVuY2U+PC9zYW1sOkF1ZGllbmNlUmVzdHJpY
3Rpb24+PC9zYW1sOkNvbmRpdGlvbnM+PHNhbWw6QXV0aG5TdGF0ZW1lbnQgU2Vzc2lvbkluZGV4PSJIX20h
Hb1VRUEQuM2NWUDQxWENVWHhiR0siIEF1dGhuSW5zdGFudD0iMjAxNy0xMS0xM1QxMzo0OToxNy4xNTNaIj48c
2FtbDpBdXRobkNvbnRleHQ+PHNhbWw6QXV0aG5Db250ZXh0Q2xhc3NSZWY+dXJuOm9hc2lzOm5hbWVzOnRjOlN
BTUw6Mi4wOmFjOmNsYXNzZXM6dW5zcGVjaWZpZWQ8L3NhbWw6QXV0aG5Db250ZXh0Q2xhc3NSZWY+PC9zYW1sO
kF1dGhuQ29udGV4dD48L3NhbWw6QXV0aG5TdGF0ZW1lbnQ+PHNhbWw6QXR0cmlidXRlU3RhdGVtZW50PjxzYW1
sOkF0dHJpYnV0ZSBOYW1lPSJaWQiIE5hbWVGb3JtYXQ9InVybjpvYXNpczpuYW1lczp0Yzp
TQU1MOjIuMDphd
HRybmFtZS1mb3JtYXQ6YmFzaWMiPjxzYW1sOkF0dHJpYnV0ZVZhbHVlIHhzaTp0eXBlPSJ4czpzdHJpbmciIHh
tbG5zOnhzPSJodHRwOi8vd3d3LnczLm9yZy8yMDAxL1hNTFNjaGVtYSIgeG1sbnM6eHNpPSJodHRwOi8vd3d3L
nczLm9yZy8yMDAxL1hNTFNjaGVtYS1pbnN0YW5jZSI+dW5jY29ldGVzdDQ8L3NhbWw6QXR0cmlidXRlVmFsdWU
+PC9zYW1sOkF0dHJpYnV0ZT48c2FtbDpBdHRyaWJ1dGUgTmFtZT0ibWFpbCIgTmFtZUZvcm1hdD0idXJuOm9hc
2lzOm5hbWVzOnRjOlNBTUw6Mi4wOmF0dHJuYW1lLWZvcm1hdDpiYXNpYyI+PHNhbWw6QXR0cmlidXRlVmFsdWU
geHNpOnR5cGU9InhzOnN0cmluZyIgeG1sbnM6eHM9Imh0dHA6Ly93d3cudzMub3JnLzIwMDEvWE1MU2NoZW1hI
iB4bWxuczp4c2k9Imh0dHA6Ly93d3cudzMub3JnLzIwMDEvWE1MU2NoZW1hLWluc3RhbmNlIj51bmNjb2V0ZXN
0NDwvc2FtbDpBdHRyaWJ1dGVWYWx1ZT48L3NhbWw6QXR0cmlidXRlPjwvc2FtbDpBdHRyaWJ1dGVTdGF0ZW1lb
nQ+PC9zYW1sOkFzc2VydGlvbj48L3NhbWxwOlJlc3BvbnNlPg==
```


The “value” string is the base64-encoded SAML response. A few lines of Python can get the SAML response into a readable format. In this example, the value above has been saved to a file called *samlresp.txt*:

```
$ python
Python 2.7.10 (default, Feb 7 2017, 00:08:15)
[GCC 4.2.1 Compatible Apple LLVM 8.0.0 (clang-800.0.34)] on darwin
```

```
Type "help", "copyright", "credits" or "license" for more information.
>>> import base64
>>> import xml.dom.minidom
>>> respFile = open("samlresp.txt", "r")
>>> respStr = base64.b64decode(respFile.read())
>>> respXml = xml.dom.minidom.parseString(respStr)
>>> print(respXml.toprettyxml())
<?xml version="1.0" ?>
<samlp:Response Destination="https://idm.sandbox.motorolasolutions.com/sp/ACS.saml2"
ID="J5OlM6VqeneVzASghHyljAKbR.8" InResponseTo="Kdp1u_dqO0yM_ftaeeubgF9o0PX"
IssueInstant="2017-11-13T13:49:17.100Z" Version="2.0"
xmlns:samlp="urn:oasis:names:tc:SAML:2.0:protocol">
      <saml:Issuer
xmlns:saml="urn:oasis:names:tc:SAML:2.0:assertion">idp1.spsd.msso</saml:Issuer>
      <ds:Signature xmlns:ds="http://www.w3.org/2000/09/xmldsig#">
            <ds:SignedInfo>
                  <ds:CanonicalizationMethod
Algorithm="http://www.w3.org/2001/10/xml-exc-c14n#"/>


                  <ds:SignatureMethod Algorithm="http://www.w3.org/2001/04/xmldsig-
more#rsa-sha256"/>
                  <ds:Reference URI="#J5OlM6VqeneVzASghHyljAKbR.8">
                        <ds:Transforms>
                              <ds:Transform
Algorithm="http://www.w3.org/2000/09/xmldsig#enveloped-signature"/>
                              <ds:Transform
Algorithm="http://www.w3.org/2001/10/xml-exc-c14n#"/>
                        </ds:Transforms>
                        <ds:DigestMethod
Algorithm="http://www.w3.org/2001/04/xmlenc#sha256"/>
<ds:DigestValue>1vQiqCU6iYa33vQm+71lElVmiQHzOe9s+AM7Pa98VZA=</ds:DigestValue>
                  </ds:Reference>
            </ds:SignedInfo>
            <ds:SignatureValue>
LzRmBarY6nwFKvrv7S/oVacIIdIEF8yIhWBWOCGgzr1kN4esV/BSyKCSWb8JSXwC8VDsMRtW8CL5
UDUt55u9tBkNVjxv5dt5+Nat9ykfvxWmOdpeIU0s1sn1BGw+d94heIBaWIXMY9YQh9gWt6JYt9Qa
dFt6kEF5KSCKQAASem12OlKWoF+bRlmG4elm5LM8u7A7Z/aFvup3C6eydJp+R1i+Z+Az4yWvc/6a
byK10OgNi/0bnzkk7w/Jlty4fUDqWzmrrDZpHBxfALUnTWdOT5IzJ7njLAkAaSt460Z52nZA8aAb
Uo08OKDbvUi/TglSqFcp2Ra+BhOCmDw9boLonw==
</ds:SignatureValue>
      </ds:Signature>
      <samlp:Status>
            <samlp:StatusCode Value="urn:oasis:names:tc:SAML:2.0:status:Success"/>
      </samlp:Status>
      <saml:Assertion ID="H_m.WHGoUQPD.3cVP41XCUXxbGK" IssueInstant="2017-11-
13T13:49:17.155Z" Version="2.0" xmlns:saml="urn:oasis:names:tc:SAML:2.0:assertion">
            <saml:Issuer>idp1.spsd.msso</saml:Issuer>
            <saml:Subject>
                  <saml:NameID Format="urn:oasis:names:tc:SAML:1.1:nameid-
format:unspecified">unccoetest4</saml:NameID>
                  <saml:SubjectConfirmation
```

```
Method="urn:oasis:names:tc:SAML:2.0:cm:bearer">
                           <saml:SubjectConfirmationData
InResponseTo="Kdp1u_dqO0yM_ftaeeubgF9o0PX" NotOnOrAfter="2017-11-13T13:54:17.155Z"
Recipient="https://idm.sandbox.motorolasolutions.com/sp/ACS.saml2"/>
                     </saml:SubjectConfirmation>
              </saml:Subject>
              <saml:Conditions NotBefore="2017-11-13T13:44:17.155Z" NotOnOrAfter="2017-
11-13T13:54:17.155Z">
                     <saml:AudienceRestriction>
<saml:Audience>ctoPingFed_entityID</saml:Audience>
                     </saml:AudienceRestriction>
              </saml:Conditions>
              <saml:AuthnStatement AuthnInstant="2017-11-13T13:49:17.153Z"
SessionIndex="H_m.WHGoUQPD.3cVP41XCUXxbGK">
                     <saml:AuthnContext>
<saml:AuthnContextClassRef>urn:oasis:names:tc:SAML:2.0:ac:classes:unspecified</saml:Au
thnContextClassRef>
                     </saml:AuthnContext>
              </saml:AuthnStatement>
              <saml:AttributeStatement>
                     <saml:Attribute Name="uid"
NameFormat="urn:oasis:names:tc:SAML:2.0:attrname-format:basic">
                           <saml:AttributeValue
xmlns:xs="http://www.w3.org/2001/XMLSchema"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:type="xs:string">unccoetest4</saml:AttributeValue>
                     </saml:Attribute>
                     <saml:Attribute Name="mail"
NameFormat="urn:oasis:names:tc:SAML:2.0:attrname-format:basic">
                           <saml:AttributeValue
xmlns:xs="http://www.w3.org/2001/XMLSchema"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:type="xs:string">unccoetest4</saml:AttributeValue>
                     </saml:Attribute>
              </saml:AttributeStatement>
       </saml:Assertion>
</samlp:Response>

>>>
```

In the above example, two attributes, `uid` and `mail`, are asserted, but the `mail` attribute does not contain a valid email address.

For OIDC, because the ID Token is retrieved over a back-channel connection between the RP and the IdP, it cannot be observed in browser traffic. As with SAML, creating a test app is one method of testing, but manual testing is also possible by using a few software tools:

1. Register an OIDC client with a client secret and a redirect URI that points to a nonexistent server. A redirect URI value like `https://127.0.0.1/test-url` will work, assuming that you do not have a web server running on your machine. In a desktop browser, submit an authentication request with a URL like the one listed below:

   https://op1.lpsd.msso:9031/as/authorization.oauth2?client_id=marktest&response_type=code&scope=openid%20address%20test%20phone%20openid%20profile%20name%20email

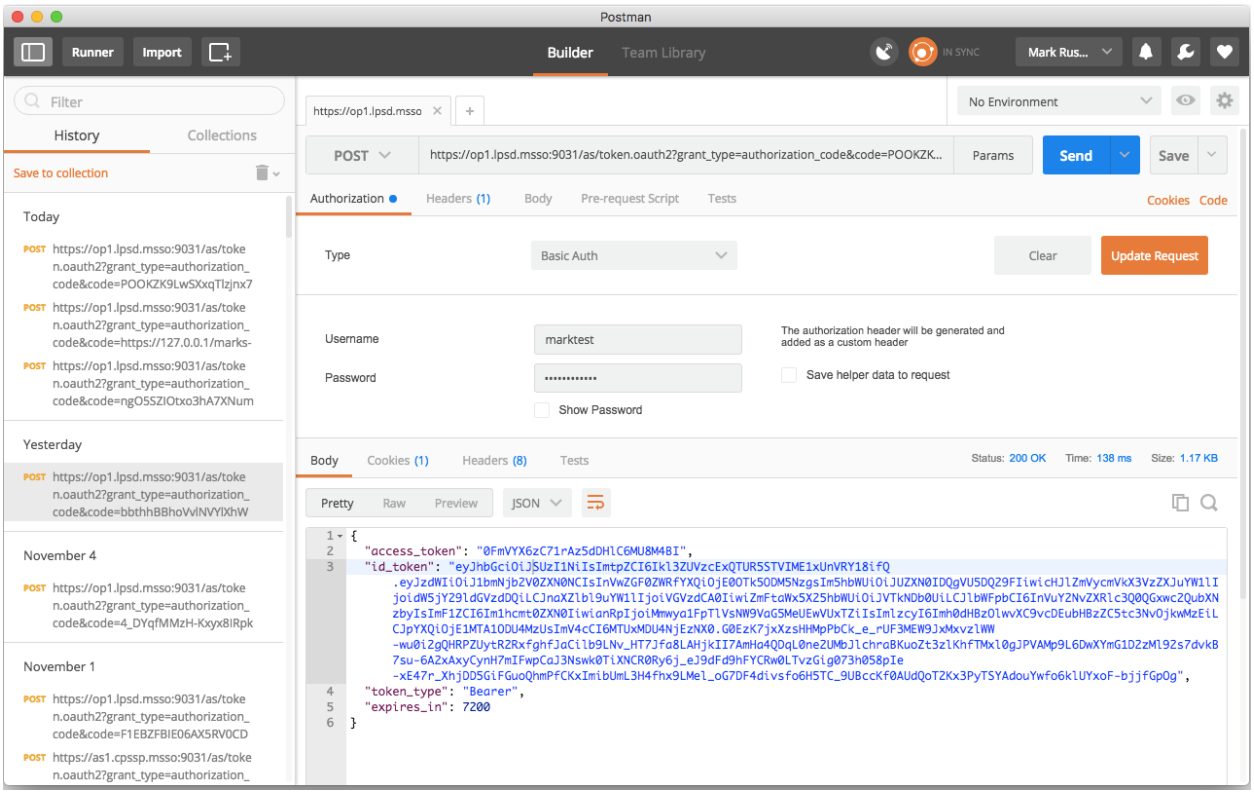
2. Replace the server name and client ID with the correct values for your environment; also make sure that the scope parameter includes `openid` and any other expected scopes. Authenticate to the IdP. In this case, because the FIDO UAF adapter is in use but is being accessed through a desktop browser, it initiates an OOB authentication, which can be completed on the mobile device. Once authentication is completed, the browser will attempt to access the redirect URL, which will result in a connection error because no web server is running on localhost. However, the authorization code can be extracted from the URL:

   https://127.0.0.1/test-url?code=Iv-pND_3o7_aJ5nFMcD-WbrVENrW7w5V75Cupx9G

The authorization code can be submitted to the IdP's token endpoint in a POST to obtain the ID Token. There are numerous ways to do this. Postman is a simple graphical-user-interface tool for testing APIs, and can be used to submit the request: https://www.getpostman.com.

Figure 7-1 shows Postman being used to retrieve an ID Token. A POST request is submitted to the OIDC IdP's token endpoint; by default, the token endpoint URL is the base URL, followed by */as/token.oauth2*. The authorization code is included as a query parameter. The client ID and client secret are used as the HTTP basic authorization username and password.

Figure 7-1 Using Postman to Obtain the ID Token



The response body is a JSON object, including the ID Token as well as an access token that can be used to access the userinfo endpoint. As with the SAML assertion, a few lines of Python can render the ID Token (which is a JWT) into a readable format:

```
$ python
Python 2.7.10 (default, Feb 7 2017, 00:08:15)
[GCC 4.2.1 Compatible Apple LLVM 8.0.0 (clang-800.0.34)] on darwin
Type "help", "copyright", "credits" or "license" for more information.
>>> import jwt
>>> import json
>>> idTokenStr =
"eyJhbGciOiJSUzI1NiIsImtpZCI6Ikl3ZUVzcExQTUR5STVIME1xUnVRY18ifQ.eyJzdWIiOiJ1bmNjb2V0ZXN0NCIsInVwZGF0ZWRfYXQiOjE0OTk5ODM5NzgsIm5hbWUiOiJUZXN0IDQgVU5DQ29FIiwicHJlZmVycmVkX3VzZXJuYW1lIjoidW5jY29ldGVzdDQiLCJnaXZlbl9uYW1lIjoiVGVzdCA0IiwiZmFtaWx5X25hbWUiOiJVTkNDb0UiLCJlbWFpbCI6InVuY2NvZXRlc3Q0QGxwc2QubXNzbyIsImF1ZCI6Im1hcmt0ZXN0IiwianRpIjoiMmwya1FpTlVsNW9VaG5MeUEwVUxTZiIsImlzcyI6Imh0dHBzOlwvXC9vcDEubHBzZC5tc3NvOjkwMzEiLCJpYXQiOjE1MTA1ODU4MzUsImV4cCI6MTUxMDU4NjEzNX0.G0EzK7jxXzsHHMpPbCk_e_rUF3MEW9JxMxvzlWW-
wu0i2gQHRPZUytR2RxfghfJaCilb9LNv_HT7Jfa8LAHjkII7AmHa4QDqL0ne2UMbJlchraBKuoZt3zlKhfTMxl0gJPVAMp9L6DwXYmG1D2zMl92s7dvkB7su-
6A2xAxyCynH7mIFwpCaJ3Nswk0TiXNCR0Ry6j_eJ9dFd9hFYCRw0LTvzGig073h058pIe-
xE47r_XhjDD5GiFGuoQhmPfCKxImibUmL3H4fhx9LMel_oG7DF4divsfo6H5TC_9UBccKf0AUdQoT2K
```

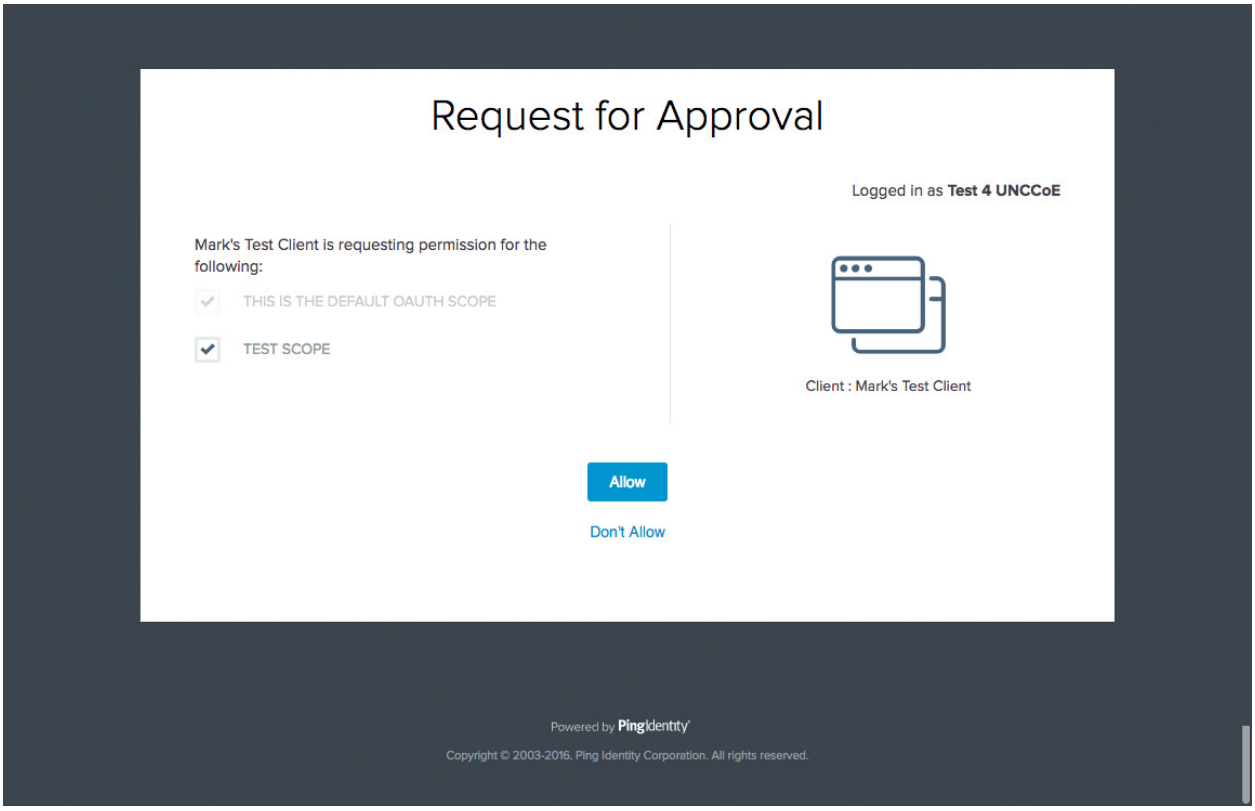
```
x3PyTSYAdouYwfo6klUYxoF-bjjfGpOg"
>>> idToken = jwt.decode(idTokenStr, verify=False)
>>> print json.dumps(idToken, indent=4)
{
    "family_name": "UNCCoE",
    "aud": "marktest",
    "sub": "unccoetest4",
    "iss": "https://op1.lpsd.msso:9031",
    "preferred_username": "unccoetest4",
    "updated_at": 1499983978,
    "jti": "2l2kQiNUl5oUhnLyA0ULSf",
    "given_name": "Test 4",
    "exp": 1510586135,
    "iat": 1510585835,
    "email": "unccoetest4@lpsd.msso",
    "name": "Test 4 UNCCoE"
}
>>>
```

This merely decodes the claims in the JWT without verifying the signature. If there is an issue with signature validation or trust in the signing key, these errors will be reported in the PingFederate server log.

7.4 Testing the AS

One simple step that can help identify problems at the AS is turning on the authorization prompts. This can be done on a per-client basis by deselecting the **BYPASS AUTHORIZATION APPROVAL** setting on the client configuration page, in the **OAuth Settings** section in the AS console. If the authorization prompt is displayed (Figure 7-2), this demonstrates that authentication has succeeded, and the list of scopes being requested by the client is displayed and can be verified.

2471 **Figure 7-2 Authorization Prompt**



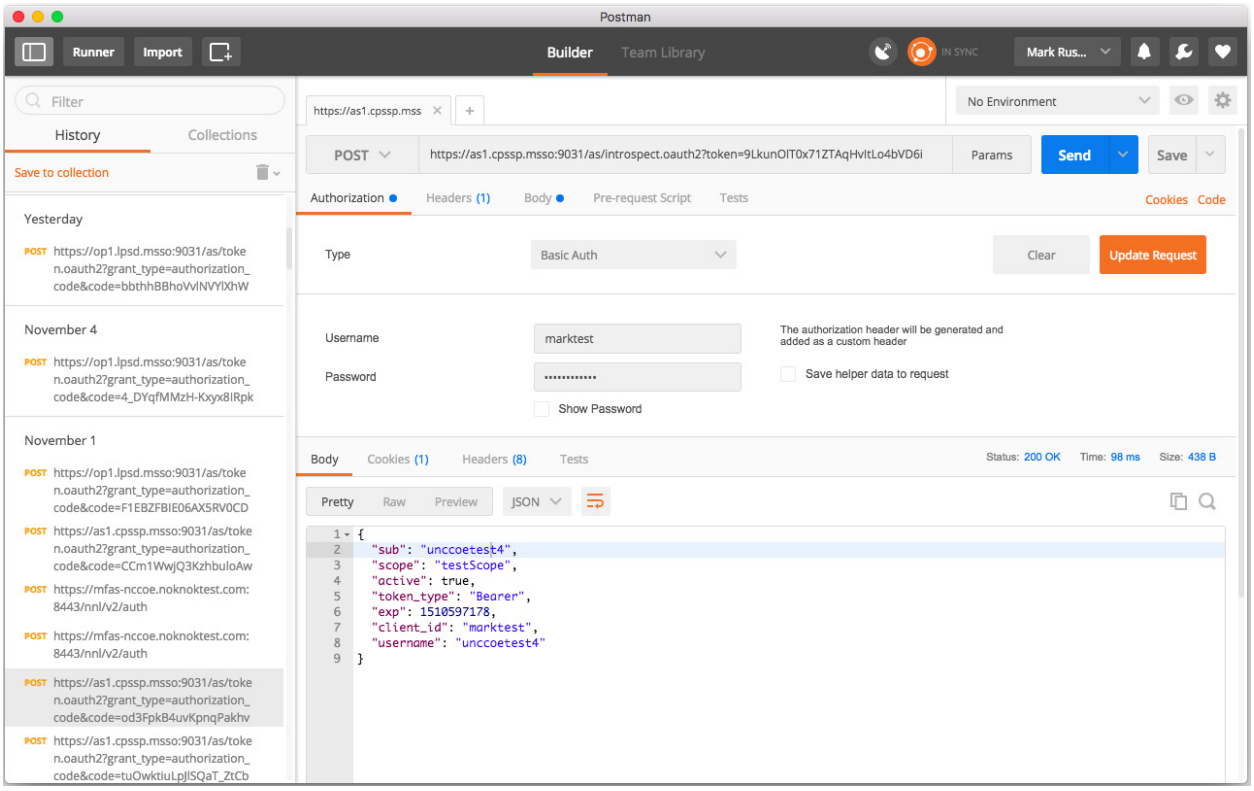
2472

2473 It is also possible to manually obtain an access token by using the same procedure that was used in the
2474 previous section to obtain an ID Token; the only difference is that an OAuth request typically would not
2475 include the `openid` scope. If the issued access token is JWT, it can be analyzed using Python as described
2476 above.

2477 If the token is not a JWT (i.e., a Reference Token management scheme is in use), the access token can be
2478 submitted to the AS's introspection endpoint as specified in RFC 7662 [21]. The default location of the
2479 introspection endpoint for PingFederate is the base URL, followed by */as/introspect.oauth2*. The request
2480 is submitted as a POST, with the access token in a query parameter called **token**. Basic authentication
2481 can be used with the client ID and secret as a username and password. The client must be authorized to
2482 call the introspection endpoint by selecting **Access Token Validation (Client is a Resource Server)** under
2483 **Allowed Grant Types** in the client configuration on the AS.

Figure 7-3 shows a token introspection request and response in Postman.

Figure 7-3 Token Introspection Request and Response



7.5 Testing the Application

One last potential problem area in this SSO architecture is the back-end app, which must accept and validate access tokens. Troubleshooting methods there will depend on the design of the app. Building robust instrumentation and error reporting into RP apps will help identify problems. If the app validates JWT access tokens, then establishing and maintaining trust in the AS's signing certificate, including maintenance when the certificate is replaced, is essential to avoid validation problems. Clock synchronization between the AS and the RP is also important; a time difference of five minutes or more can cause validation errors as well.

Appendix A Abbreviations and Acronyms

AD	Active Directory
API	Application Programming Interface
APNS	Apple Push Notification System
App	Application
App ID	Application Identification
AppAuth	Application Authentication System
AS	Authorization Server
ASM	Authenticator-Specific Module
BCP	Best Current Practice
BIND	Berkeley Internet Name Domain
CA	Certificate Authority
CPSSP	Central Public Safety Service Provider
CPU	Central Processing Unit
CRADA	Cooperative Research and Development Agreement
CSR	Certificate Signing Request
DN	Distinguished Name
DNS	Domain Name System
FIDO	Fast Identity Online
FOIA	Freedom of Information Act
FQDN	Fully Qualified Domain Name
GB	Gigabyte
GCM	Google Cloud Messenger
GHz	Gigahertz
HSM	Hardware Security Module
HTML	HyperText Markup Language
HTTP	Hypertext Transfer Protocol
HTTPS	Hypertext Transfer Protocol Secure
ID	Identification
IdP	Identity Provider
IETF	Internet Engineering Task Force
iOS	iPhone Operating System
IP	Internet Protocol
IT	Information Technology
JCE	Java Cryptography Extension
JDK	Java Development Kit
JSON	JavaScript Object Notation
JWE	JSON Web Encryption
JWT	JSON Web Token
LDAP	Lightweight Directory Access Protocol
LES	Law Enforcement Sensitive

LGPL	Lesser General Public License
LPSD	Local Public Safety Department
MDM	Mobile Device Management
MFA	Multifactor Authentication
MSSO	Mobile Single Sign-On
NAT	Network Address Translation
NCCoE	National Cybersecurity Center of Excellence
NFC	Near Field Communication
NIST	National Institute of Standards and Technology
NNAS	Nok Nok Labs Authentication Server
NTP	Network Time Protocol
OIDC	OpenID Connect
OOB	Out-of-Band
OS	Operating System
PHI	Protected Health Information
PII	Personally Identifiable Information
PIN	Personal Identification Number
PKCE	Proof Key for Code Exchange
PSCR	Public Safety Communications Research lab
PSFR	Public Safety and First Responder
PSX	Public Safety Experience
QR	Quick Response
RAM	Random Access Memory
REST	Representational State Transfer
RFC	Request for Comments
RP	Relying Party
RPM	Red Hat Package Manager
SaaS	Software as a Service
SAML	Security Assertion Markup Language
SDK	Software Development Kit
SE	Standard Edition
SKCE	StrongKey CryptoEngine
SLO	Single Log-Out
SP	Service Provider
SPSD	State Public Safety Department
SQL	Structured Query Language
SSH	Secure Shell
SSO	Single Sign-On
TCP	Transmission Control Protocol
TEE	Trusted Execution Environment
TLS	Transport Layer Security
U2F	Universal Second Factor

UAF	Universal Authentication Framework
URI	Uniform Resource Identifier
URL	Uniform Resource Locator
USB	Universal Serial Bus
USB-C	Universal Serial Bus Type-C
VLAN	Virtual Local Area Network
VPN	Virtual Private Network
WAR	Web Archive

Appendix B References

[1] W. Denniss and J. Bradley, "OAuth 2.0 for Native Apps," BCP 212, RFC 8252, DOI 10.17487/RFC8252, October 2017. [Online]. Available: https://www.rfc-editor.org/info/rfc8252. [Accessed 25 February 2018].

[2] FIDO Alliance, "FIDO Specifications Overview: UAF & U2F," 20 May 2016. [Online]. Available: https://www.slideshare.net/FIDOAlliance/fido-specifications-overview-uaf-u2f. [Accessed 25 February 2018].

[3] Google, "Chrome custom tabs smooth the transition between apps and the web," Android Developers Blog, 2 September 2015. [Online]. Available: https://android-developers.googleblog.com/2015/09/chrome-custom-tabs-smooth-transition.html. [Accessed 25 February 2018].

[4] Google, "Chrome Custom Tabs," 6 May 2016. [Online]. Available: https://developer.chrome.com/multidevice/android/customtabs. [Accessed 25 February 2018].

[5] Google, "Google Chrome: Fast & Secure," Google Play, [Online]. Available: https://play.google.com/store/apps/details?id=com.android.chrome. [Accessed 25 February 2018].

[6] Google, "Google Authenticator," Google Play, [Online]. Available: https://play.google.com/store/apps/details?id=com.google.android.apps.authenticator2. [Accessed 25 February 2018].

[7] S. Machani, R. Philpott, S. Srinivas, J. Kemp and J. Hodges, "FIDO UAF Architectural Overview, FIDO Alliance Implementation Draft," 2 February 2017. [Online]. Available: https://fidoalliance.org/specs/fido-uaf-v1.1-id-20170202/fido-uaf-overview-v1.1-id-20170202.html. [Accessed 25 February 2018].

[8] Nok Nok Labs Inc., "Nok Nok™ Passport," Google Play, [Online]. Available: https://play.google.com/store/apps/details?id=com.noknok.android.passport2. [Accessed 25 February 2018].

[9] Motorola Solutions, "PSX App Suite," [Online]. Available: https://www.motorolasolutions.com/en_us/products/psx-app-suite.html. [Accessed 25 February 2018].

[10] OpenID Foundation, "openid/AppAuth-Android," GitHub, [Online]. Available: https://github.com/openid/AppAuth-Android. [Accessed 25 February 2018].

[11] D., Hardt, Ed., "The OAuth 2.0 Authorization Framework", RFC 6749, DOI 10.17487/RFC6749," October 2012. [Online]. Available: https://www.rfc-editor.org/info/rfc6749. [Accessed 25 February 2018].

[12] S. Cantor, J. Kemp, R. Philpott and E. Maler, "Assertions and Protocols for the OASIS Security Assertion Markup Language (SAML) V2.0," 15 March 2005. [Online]. Available: http://docs.oasis-open.org/security/saml/v2.0/saml-core-2.0-os.pdf. [Accessed 25 February 2018].

[13] N. E. Sakimura, J. Bradley and N. Agarwal, "Proof Key for Code Exchange by OAuth Public Clients," RFC 7636, DOI 10.17487/RFC7636, September 2015. [Online]. Available: https://www.rfc-editor.org/info/rfc7636. [Accessed 25 February 2018].

[14] M. Jones and J. Hildebrand, "JSON Web Encryption (JWE)," RFC 7516, May 2015. [Online]. Available: https://tools.ietf.org/html/rfc7516. [Accessed 25 February 2018].

[15] N. Sakimura, J. Bradley, M. Jones, B. de Medeiros and C. Mortimore, "OpenID Connect Core 1.0 incorporating errata set 1," 8 November 2014. [Online]. Available: http://openid.net/specs/openid-connect-core-1_0.html. [Accessed 25 February 2018].

[16] Microsoft Corporation, "Active Directory Schema," [Online]. Available: https://msdn.microsoft.com/en-us/library/ms675085(v=vs.85).aspx. [Accessed 25 February 2018].

[17] Nok Nok Labs, Inc., "Nok Nok Labs S3 Authentication Suite Solution Guide," v5.1.1, 2017.

[18] Nok Nok Labs, Inc., "Nok Nok Authentication Server Administration Guide," v5.1.1, 2017.

[19] Nok Nok Labs, Inc., "Nok Nok PingFederate Adapter Integration Guide," v1.0.1, 2017.

[20] StrongAuth, Inc., "PingFederate FIDO IdP Adapter Installation Guide," Revision 2, 2017.

[21] J. Richer, Ed., "OAuth 2.0 Token Introspection," RFC 7662, October 2015. [Online]. Available: https://tools.ietf.org/html/rfc7662. [Accessed 25 February 2018].