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

NCCoE NATIONAL CYBERSECURITY CENTER OF EXCELLENCE

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

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

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 necessitates heavy reliance on mobile platforms while in the field, which may be used to access sensitive information. 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 (PSCR) Division and industry stakeholders, the NCCoE aims to help PSFR personnel efficiently and securely gain access to mission data via mobile devices and applications.

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This practice guide describes a reference design for multifactor authentication (MFA) and mobile single sign-on (MSSO) for native and web applications, while improving interoperability among mobile platforms, applications, and identity providers, regardless of the application development platform used in their construction. This guide discusses major architecture design considerations, explains security characteristics achieved by the reference design, and maps the security characteristics to applicable standards and security control families. For parties interested in adopting all or part of the 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; relying party; single sign-on

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Avinash Umap	Nok Nok Labs

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

Technology Partner/Collaborator	Build Involvement
Ping Identity	Federation Server
Motorola Solutions	Mobile Applications
Yubico	External Authenticators

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Technology Partner/Collaborator	Build Involvement
Nok Nok Labs	Fast Identity Online (FIDO) Universal Authentication Frame-work (UAF) Server
StrongKey	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. This guide demonstrates multifactor authentication (MFA) and mobile single sign-on (MSSO) solutions for native and web applications 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 re-create 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.

Since May 2018, when this project build was initially completed at the NCCoE laboratory, some of the products used in the build have migrated to new platforms. In addition, new specifications and standards used by the products have been published and revised. While the general integration concepts demonstrated in this guide still apply, implementers using newer or different products will have to tailor their implementation to meet the specific requirements of those products and specifications. Thus, the implementation details will be different.

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 part.

This guide contains three volumes:

- NIST Special Publication (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

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applications, hardware and software-based authenticators to demonstrate the Fast Identity Online (FIDO) standards for MFA, and 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 [1]) 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 StrongKey, 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) applications and custom-built Apple iPhone operating system (iOS) demo applications 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 Universal Second Factor (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 mobile applications 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.

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1.2.2 Architectural Overview

Figure 1-1 shows the lab build architecture.

Figure 1-1 Lab Build Architecture

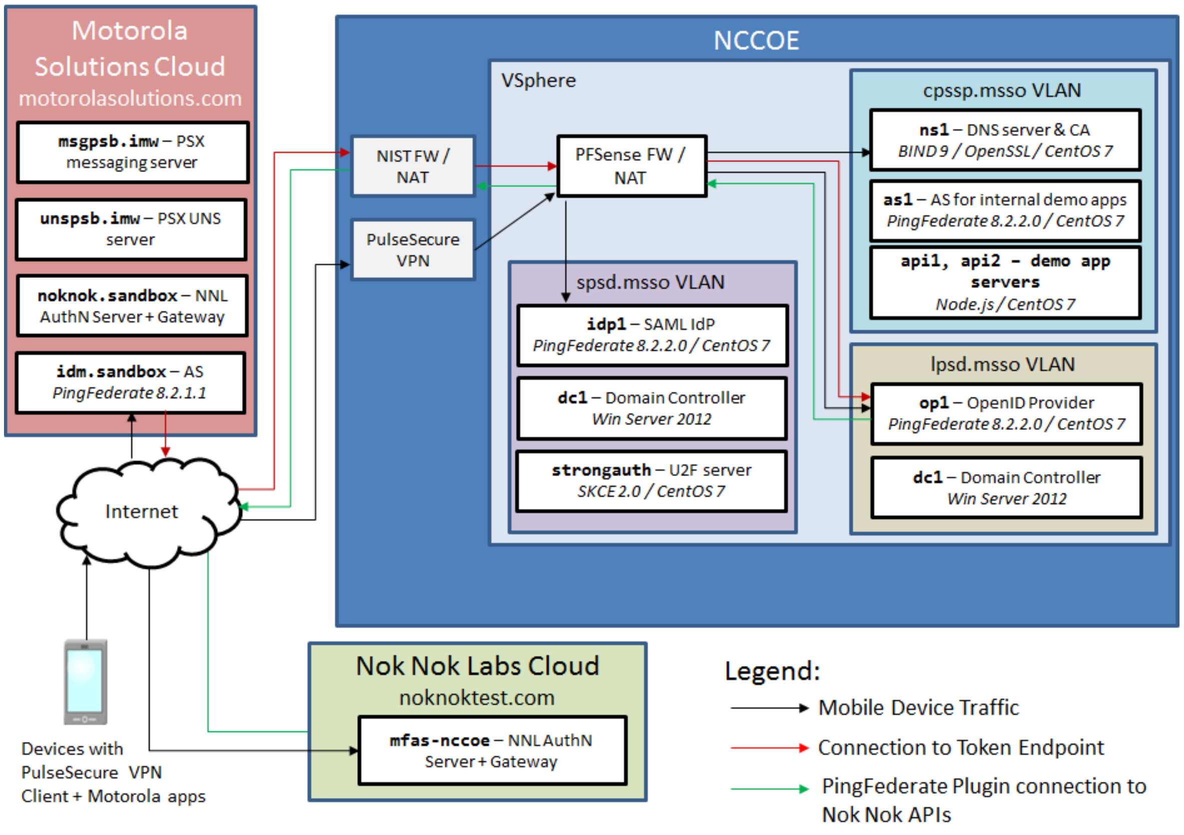
Motorola Solutions Cloud
motorolasolutions.com
msgpsb.imw – PSX messaging server
unspsb.imw – PSX UNS server
noknok.sandbox – NNL AuthN Server + Gateway
idm.sandbox – AS PingFederate 8.2.1.1
Internet
Devices with PulseSecure VPN Client + Motorola apps
NCCOE
VSphere
NIST FW / NAT
PulseSecure VPN
PFSense FW / NAT
cpssp.msso VLAN
ns1 – DNS server & CA BIND 9 / OpenSSL / CentOS 7
as1 – AS for internal demo apps PingFederate 8.2.2.0 / CentOS 7
api1, api2 – demo app servers Node.js / CentOS 7
spsd.msso VLAN
idp1 – SAML IdP PingFederate 8.2.2.0 / CentOS 7
dc1 – Domain Controller Win Server 2012
strongauth – U2F server SKCE 2.0 / CentOS 7
lpsd.msso VLAN
op1 – OpenID Provider PingFederate 8.2.2.0 / CentOS 7
dc1 – Domain Controller Win Server 2012
Nok Nok Labs Cloud
noknoktest.com
mfas-nccoe – NNL AuthN Server + Gateway
Legend:
Mobile Device Traffic
Connection to Token Endpoint
PingFederate Plugin connection to Nok Nok APIs

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

- Motorola Solutions cloud—a cloud-hosted environment providing the back-end application servers for the Motorola Solutions PSX Mapping and Messaging applications, as well as an OAuth AS that the application 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 application back ends are also hosted in the NCCoE lab for internal testing.

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- mobile devices connected to public cellular networks with the required client software to authenticate to, and access, Motorola Solutions back-end applications 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 applications hosted in the CPSSP VLAN were used to initially test and validate the federation setups in the user organization and were later expanded to support the iOS demonstration build.

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 applications on the device connect to the publicly routable PSX application 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 host names under the *.msso* top-level domain, which is not actually registered in a public DNS. To support UAF authentication at the lab-hosted OIDC IdP, the Nok Nok Passport application 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 plug-in 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.

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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 its 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 host name used in application 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 to fail, for example. 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	file names and path names, references to documents that are not hyperlinks, new terms, and placeholders	For detailed definitions of terms, see the *NCCoE Glossary.*

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Typeface/ Symbol	Meaning	Example
Bold	names of menus, options, command buttons, and fields	Choose **File > Edit.**
`Monospace`	command-line input, on-screen computer output, sample code examples, and status codes	`mkdir`
`Monospace Bold`	command-line user input contrasted with computer output	**`service sshd start`**
blue text	link to other parts of the document, a web URL, or an email address	All publications from NIST's NCCoE are available at https://www.nccoe.nist.gov.

2 How to Install and Configure 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 iOS. The NCCoE reference architecture incorporates both iOS and Android devices and applications.

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.

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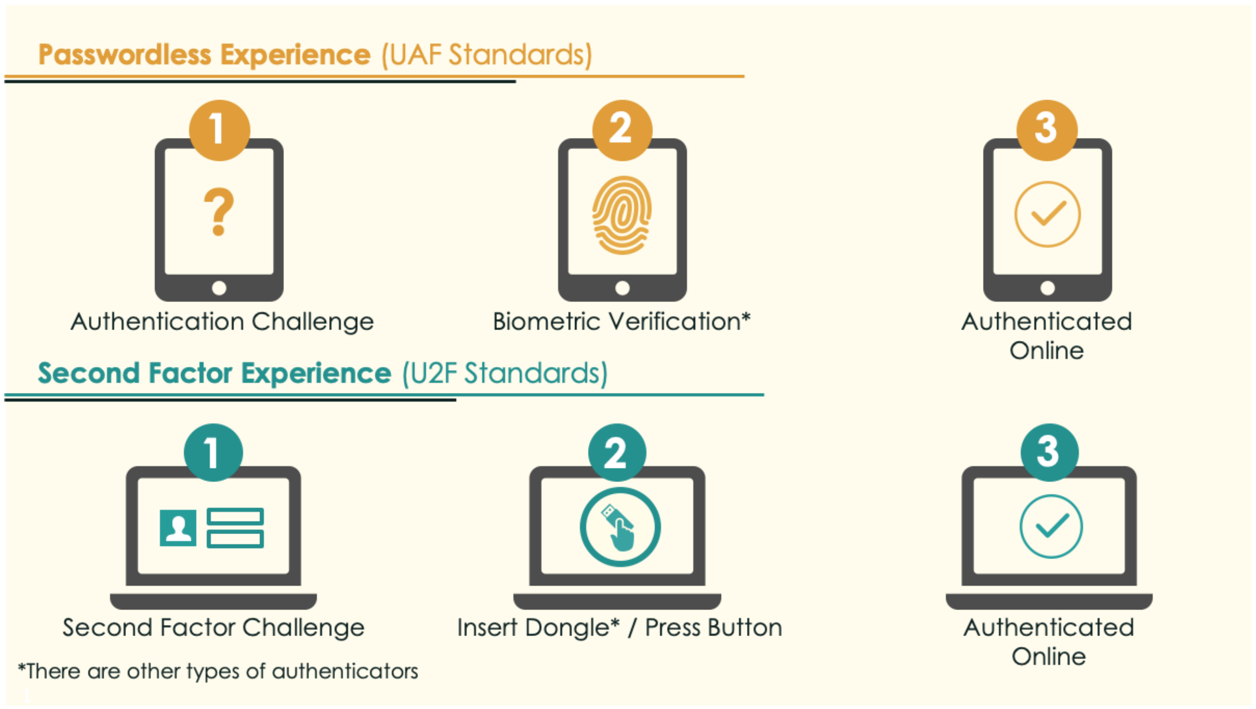
Figure 2-1 Comparison of UAF and U2F Standards


Passwordless Experience (UAF Standards)
1
Authentication Challenge
2
Biometric Verification*
3
Authenticated Online
Second Factor Experience (U2F Standards)
1
Second Factor Challenge
2
Insert Dongle* / Press Button
3
Authenticated Online
*There are other types of authenticators

The following subsections address mobile device requirements to support SSO and FIDO authentication.

2.1.1 Supporting SSO on Android Devices

While it is not strictly required, the BCP recommends that the device provide an external user-agent that supports “in-application 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 its 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

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Chrome Custom Tabs [4] states that it can be used on Android Jelly Bean (4.1), which was released in 2012, and up.

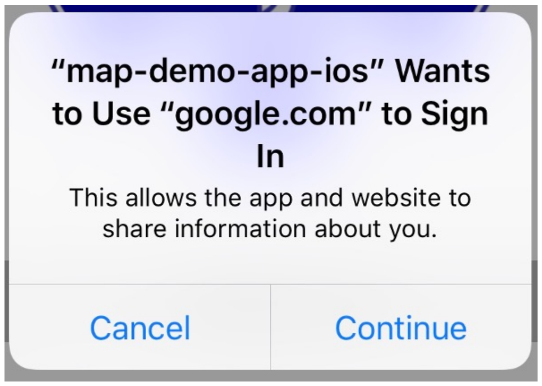
To demonstrate SSO, the NCCoE reference architecture utilized the Motorola Solutions PSX App Suite, which requires Android Lollipop (5.0) or newer.

2.1.2 Supporting SSO on iOS Devices

Apple's Safari browser is the default external user-agent provided on iOS devices, and iOS has also supported in-application browser tabs with the SFSafariViewController API [5] since iOS 9. Like Chrome Custom Tabs, SFSafariViewController provides the functionality of the OS browser without exiting from the mobile application.

Apple made changes to its in-application browser tab implementation in iOS 11 [6] that impacted SSO functionality. SFSafariViewController instances created by different applications are now effectively sandboxed from each other, with no shared cookie store between them. As described in Section 4.4 of Volume B of this practice guide, the AppAuth pattern depends on shared cookie storage to provide SSO between applications. Apple introduced a new API called SFAuthenticationSession to provide an in-application browser tab implementation specifically for authentication with SSO capabilities with access to the shared Safari cookie store. iOS also prompts for the user's consent when SFAuthenticationSession is used. An example of the consent prompt is shown in Figure 2-2.

Figure 2-2 SFAuthenticationSession Consent Prompt



"map-demo-app-ios" Wants to Use "google.com" to Sign In

This allows the app and website to share information about you.

In iOS 12, Apple replaced the SFAuthenticationSession API with ASWebAuthenticationSession [7], which performs the same functions as SFAuthenticationSession and presents an identical consent prompt. In lab testing, the build team frequently encountered issues with SFAuthenticationSession where cookies created in an SFAuthenticationSession spawned by one application were not available in an SFAuthenticationSession spawned by another application. When this issue occurred, users would be prompted to authenticate in each application that was launched and SSO did not function properly. The team has not encountered these issues with ASWebAuthenticationSession, and the SSO capabilities of in-application browser tabs are much improved in iOS 12.

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By default, the AppAuth library for iOS [8] automatically selects an appropriate user-agent based on the version of iOS installed on the mobile device as shown in Table 2-1.

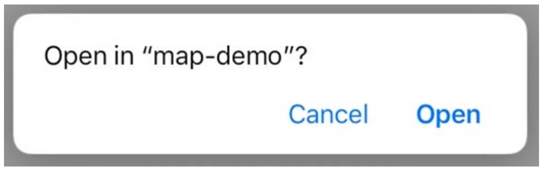
Table 2-1 AppAuth User-Agent by iOS Version

iOS Version	User-Agent
12 and higher	ASWebAuthenticationSession
11	SFAuthenticationSession
9 or 10	SFSafariViewController
8 and lower	Safari

The build team encountered issues with the FIDO UAF login flow demonstrated in this practice guide and the iOS in-application browser tab APIs (SFAuthenticationSession and ASWebAuthenticationSession). In the demo scenario, the login flow begins in the browser, which then launches the Passport application for user verification and FIDO authentication, and then control is returned to the browser to complete the authentication flow and return the user to the application. With ASWebAuthenticationSession, the authentication flow begins successfully in an in-application browser tab, and the user is redirected to the Passport application to authenticate, but control is not properly returned to the in-application browser tab when the Passport application closes. See Section 4.3.2 of Volume B of this practice guide for additional details about this issue. The build team speculates that this issue would generally apply to any login flow that entails launching an external application and then returning control to an in-application browser tab.

This issue was resolved by overriding the default user-agent selection in the AppAuth library. AppAuth provides the OIDExternalUserAgentIOSCustomBrowser interface to enable an application to specify the user-agent that should be used for the login flow. The iOS demo applications were configured to use the Safari browser instead of an in-application browser tab, which enabled the UAF login flow to succeed. The user experience with Safari is very similar to that with ASWebAuthenticationSession. The animation shown when transitioning to the web session is slightly different, and the consent dialogue shown in Figure 2-2 is not shown. After authentication is completed, however, a different dialogue is displayed, prompting the user to open the mobile application as shown in Figure 2-3.

Figure 2-3 Safari Transition Prompt


Open in “map-demo”?

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2.1.3 Supporting FIDO U2F on Android Devices

The device will need the following components for FIDO U2F:

- a web browser compatible with FIDO U2F
- a FIDO U2F client application capable of handling the challenge
- Near Field Communication (NFC) hardware support

Chrome for Android [9] is a U2F-compatible browser. Google has added U2F functionality to the Google Play Services component of Android [10], so devices running Android 5 and later can natively support U2F authentication over NFC, Universal Serial Bus (USB), and Bluetooth Low Energy (BLE) with an over-the-air update to Play Services. To support U2F in the browser, the Google Authenticator application [11] (available on Android Gingerbread [2.3.3] and up) must also be installed.

2.1.4 Supporting FIDO U2F on iOS Devices

At the time of writing, the U2F login flow demonstrated in this practice guide could not be implemented on iOS devices. Apple's Core NFC APIs do not expose required functionality to implement U2F over NFC. Yubico has published an API enabling the YubiKey Neo to be used for authentication over NFC with an iOS device, but this implementation uses the one-time password authentication mechanism of the YubiKey, not the U2F protocol [12]. BLE U2F authenticators can be paired and used with iOS devices, but their use has been limited. The Google Smart Lock application, which protects Google accounts with U2F authentication on iOS devices, is the only notable U2F implementation on iOS of which the build team is aware.

Yubico has announced development of an authenticator with a Lightning adapter, specifically targeting iOS and Mac devices; and a corresponding mobile software development kit (SDK) for iOS that could enable U2F authentication in native iOS applications [13]. To enable the AppAuth login flow used in this practice guide, a U2F-capable browser is also needed. If Apple adds W3C Web Authentication support to the Safari browser, it may support U2F authentication over Lightning and BLE in the future. Apple has already added experimental support to the Safari Technology Preview release for Mac OS [14].

2.1.5 Supporting FIDO UAF

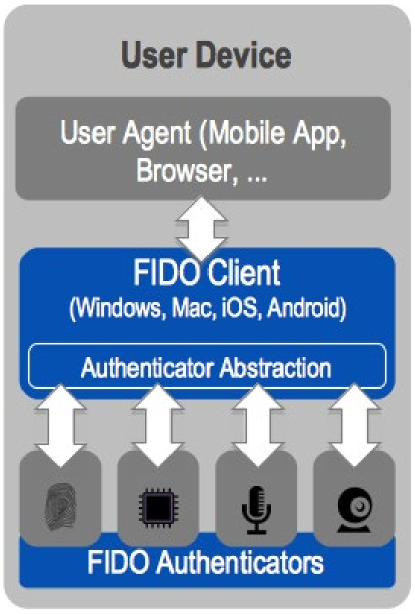
Supporting FIDO UAF is fairly similar on Android and iOS devices. The device will need the following components for FIDO UAF:

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

These components are pictured in Figure 2-4, which is from the *FIDO UAF Architectural Overview* [15].

This publication is available free of charge from: https://doi.org/10.6028/NIST.SP.1800-13.

Figure 2-4 FIDO UAF Architectural Overview


User Device
User Agent (Mobile App, Browser, ...
FIDO Client
(Windows, Mac, iOS, Android)
Authenticator Abstraction
FIDO Authenticators

While the overview refers to the last two components (client and authenticator) as separate components, these components can—and often do—come packaged in a single application. The NCCoE reference architecture utilizes the Nok Nok Passport application for Android [16] and iOS [17] to provide these two components. In addition to the applications, the device will need to provide some hardware component to support the FIDO UAF authenticator. For example, for biometric-based FIDO UAF authenticators, a camera would be needed to support face or iris scanning, a microphone would be needed to support voice prints, and a fingerprint sensor would be needed to support fingerprint biometrics. Of course, if a personal identification number (PIN) authenticator is used, a specific hardware sensor is not required. Beyond the actual input method of the FIDO UAF factor, additional (optional) hardware considerations for a UAF authenticator include secure key storage for registered FIDO key pairs, storage of biometric templates, and execution of matching functions (e.g., within dedicated hardware or on processor trusted execution environments).

2.2 How to Install and Configure the Mobile Applications

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

2.2.1 How to Install and Configure SSO-Enabled Applications

For SSO-enabled applications, there is no universal set of installation and configuration procedures; these will vary depending on the design choices of the application manufacturer. For the Android demo, the NCCoE reference architecture uses the *Motorola Solutions PSX App Suite* Version 5.4 [18].

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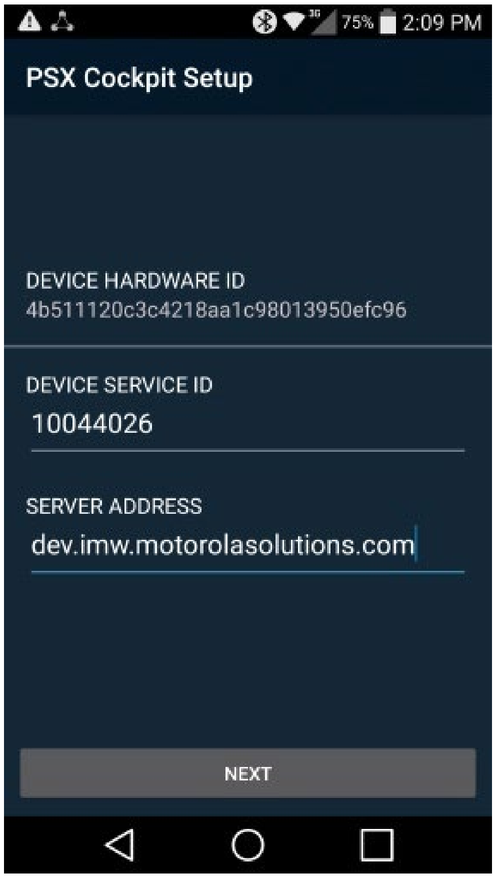
This PSX platform included several applications for the public safety community. Our setup consisted of three applications: *PSX Messenger* for text, photo, and video communication; *PSX Mapping* for shared location awareness; and *PSX Cockpit* to centralize authentication and identity information across the other applications. These applications 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 application store.

For the iOS demo, the team built two iOS demonstration applications—a mapping application called *map-demo* and a chat application called *chat-demo*. These applications were built by using Apple's XCode integrated development environment and installed on lab devices using developer certificates.

2.2.1.1 Configuring the PSX Cockpit Application

1. Open the Cockpit application. Your screen should look like Figure 2-5.

Figure 2-5 PSX Cockpit Setup



75% 2:09 PM

PSX Cockpit Setup

DEVICE HARDWARE ID
4b511120c3c4218aa1c98013950efc96

DEVICE SERVICE ID
10044026

SERVER ADDRESS
dev.imw.motorolasolutions.com

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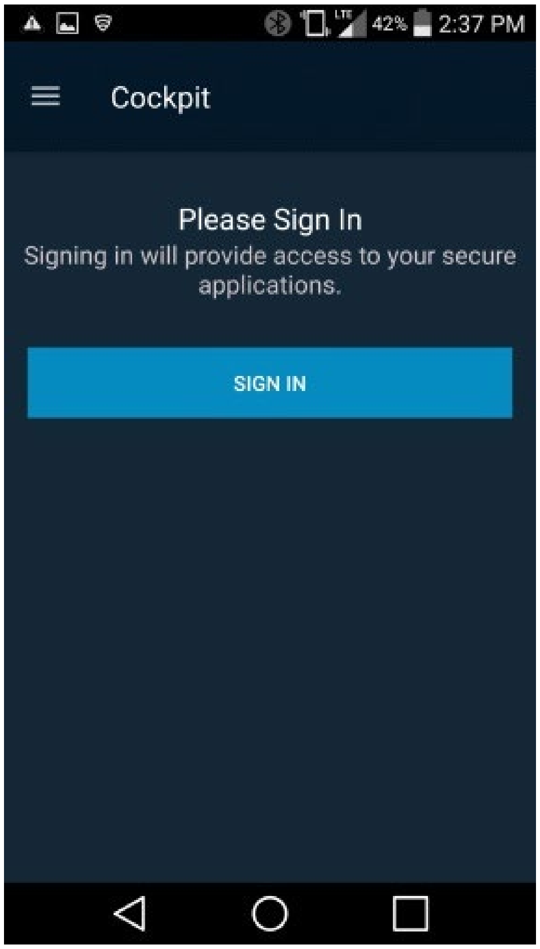
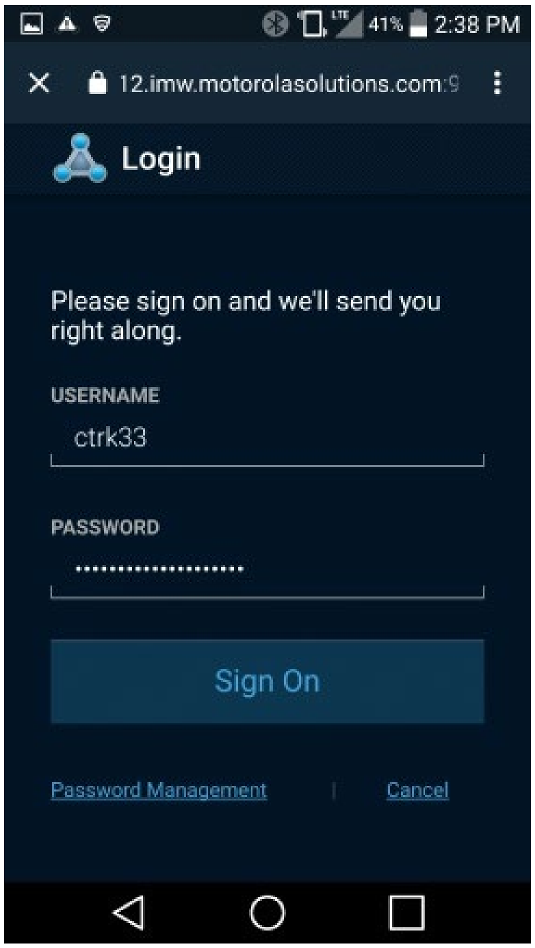
2. For **DEVICE SERVICE ID,** select a Device Service ID in the range given to you by your administrator. Note that these details will be provided by Motorola Solutions if you are using their service offering, or by your administrator if you are hosting the PSX application servers in your own environment. 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 2-6.

Figure 2-6 PSX Cockpit Setup, Continued



Please Sign In
Signing in will provide access to your secure applications.



Please sign on and we'll send you right along.

USERNAME
ctrk33

PASSWORD
••••••••••••••••••••

6. Tap **SIGN IN.**

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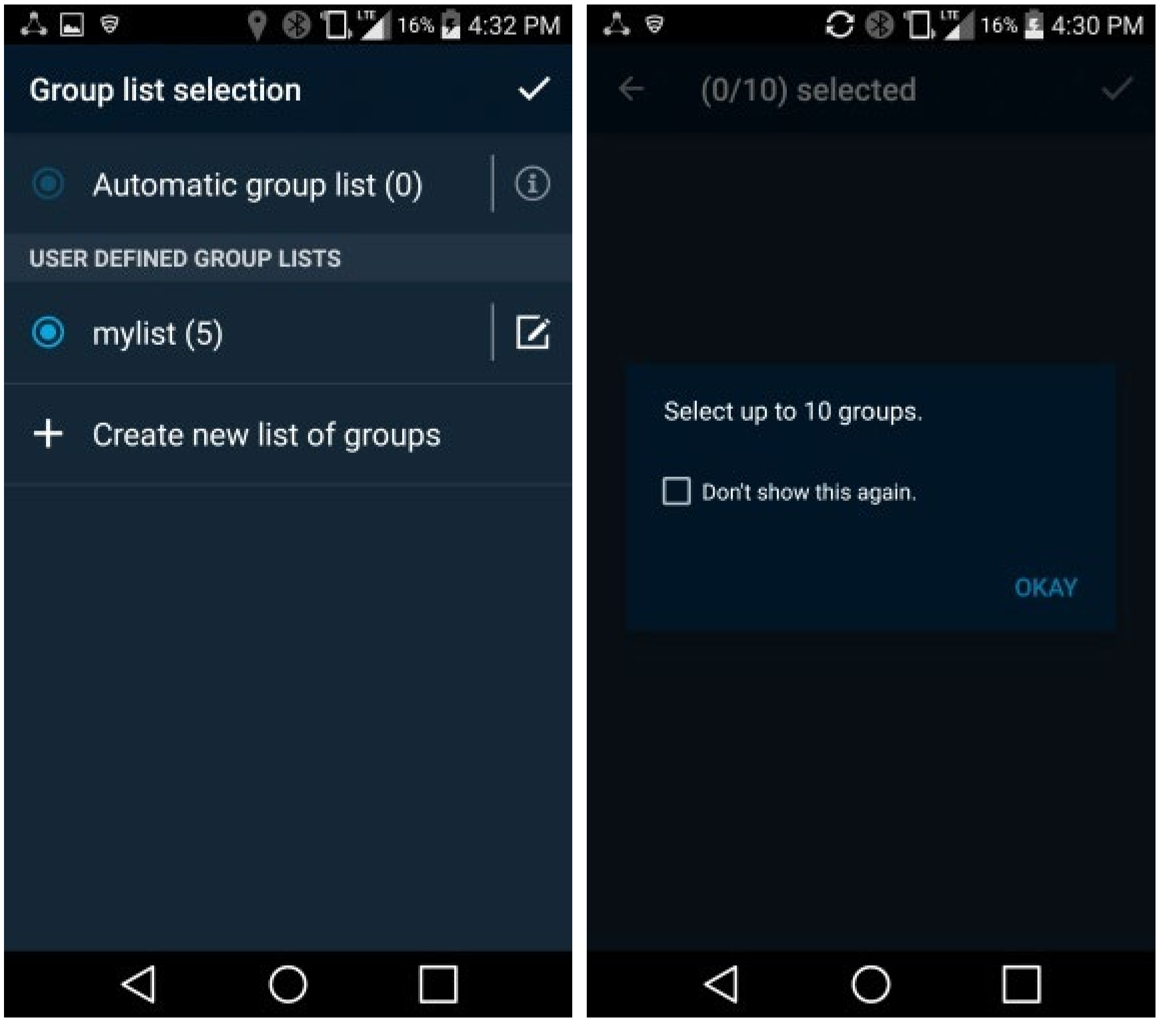
7. Log in with the authentication procedure determined by the AS and IdP policies. Note that if UAF is used, a FIDO UAF authenticator must be enrolled before this step can be completed. See Section 2.2.3 for details on FIDO UAF enrollment. After you log in, your screen should look like Figure 2-7.

Figure 2-7 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 applications.

9. Tap **OKAY.** Your screen should look like Figure 2-8.

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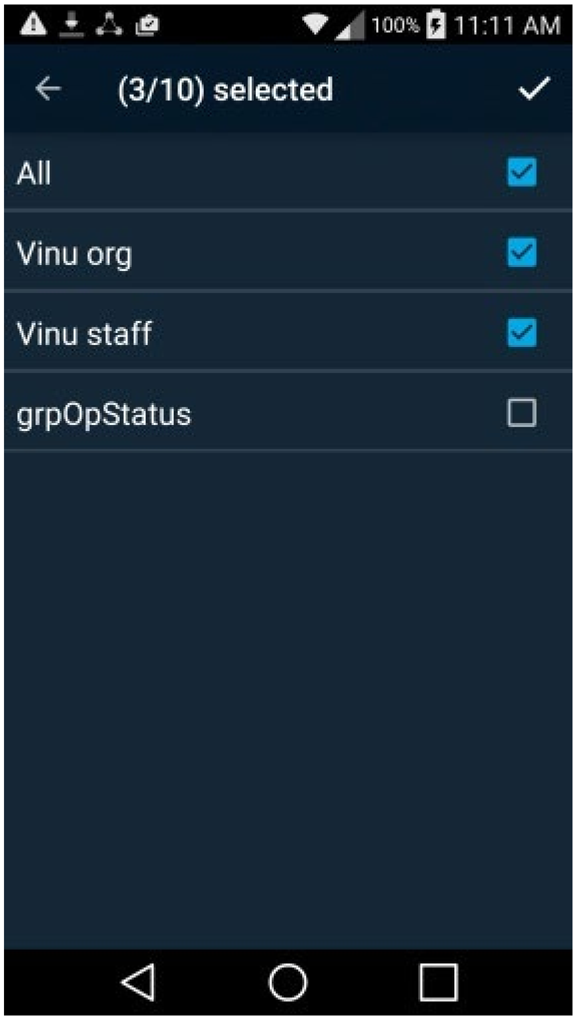
Figure 2-8 PSX Cockpit Groups



10. Check the checkboxes for the groups that you wish to use. Note that it may take a short time for the groups to appear.
11. Tap on the upper-right check mark. Your screen should look like Figure 2-9.

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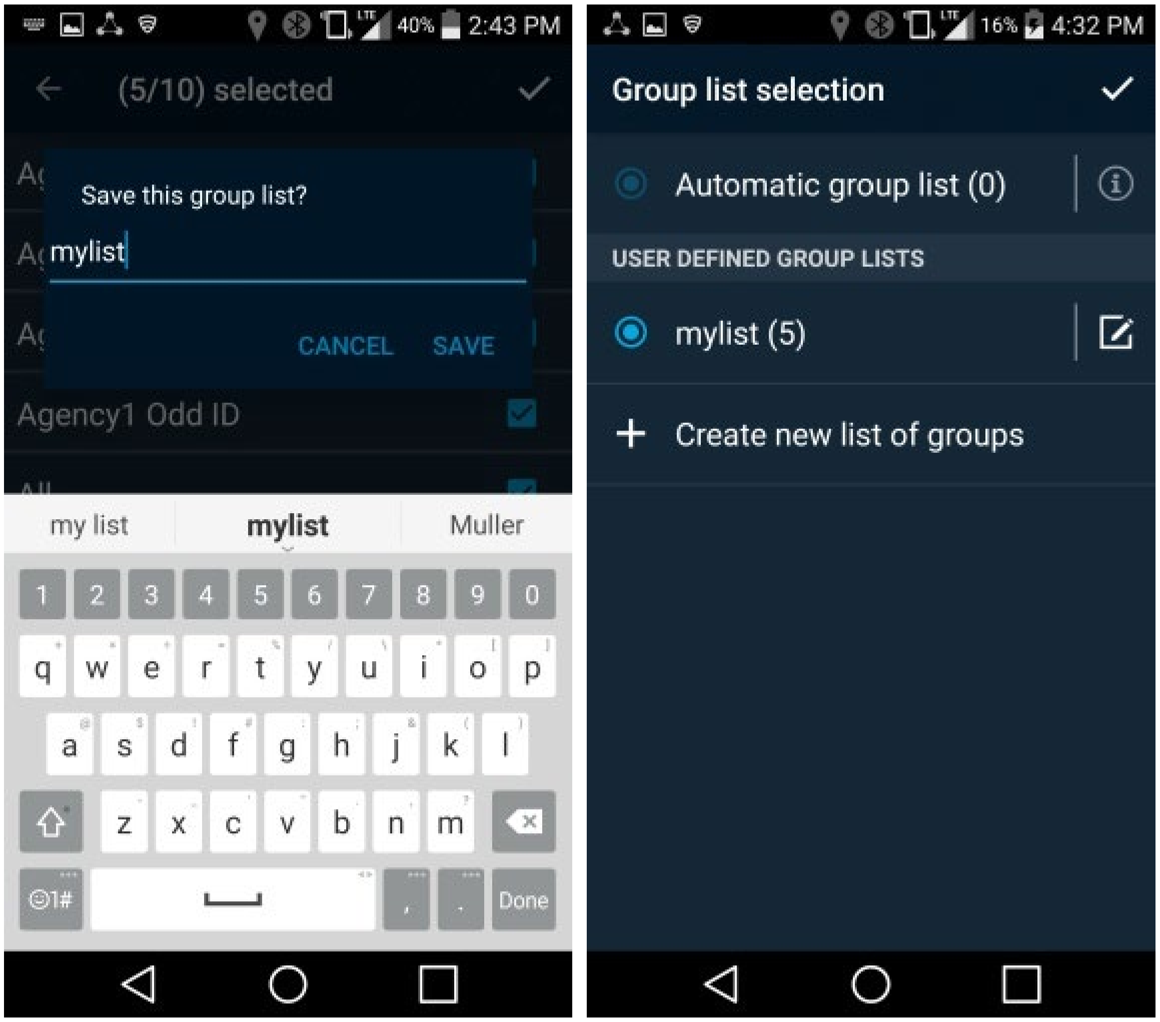
Figure 2-9 PSX Cockpit Group List Setup Complete



12. Enter a group list name (e.g., “mylist”), and tap **SAVE.**
13. Tap the upper-right check mark to select the list. Your screen should look like Figure 2-10.

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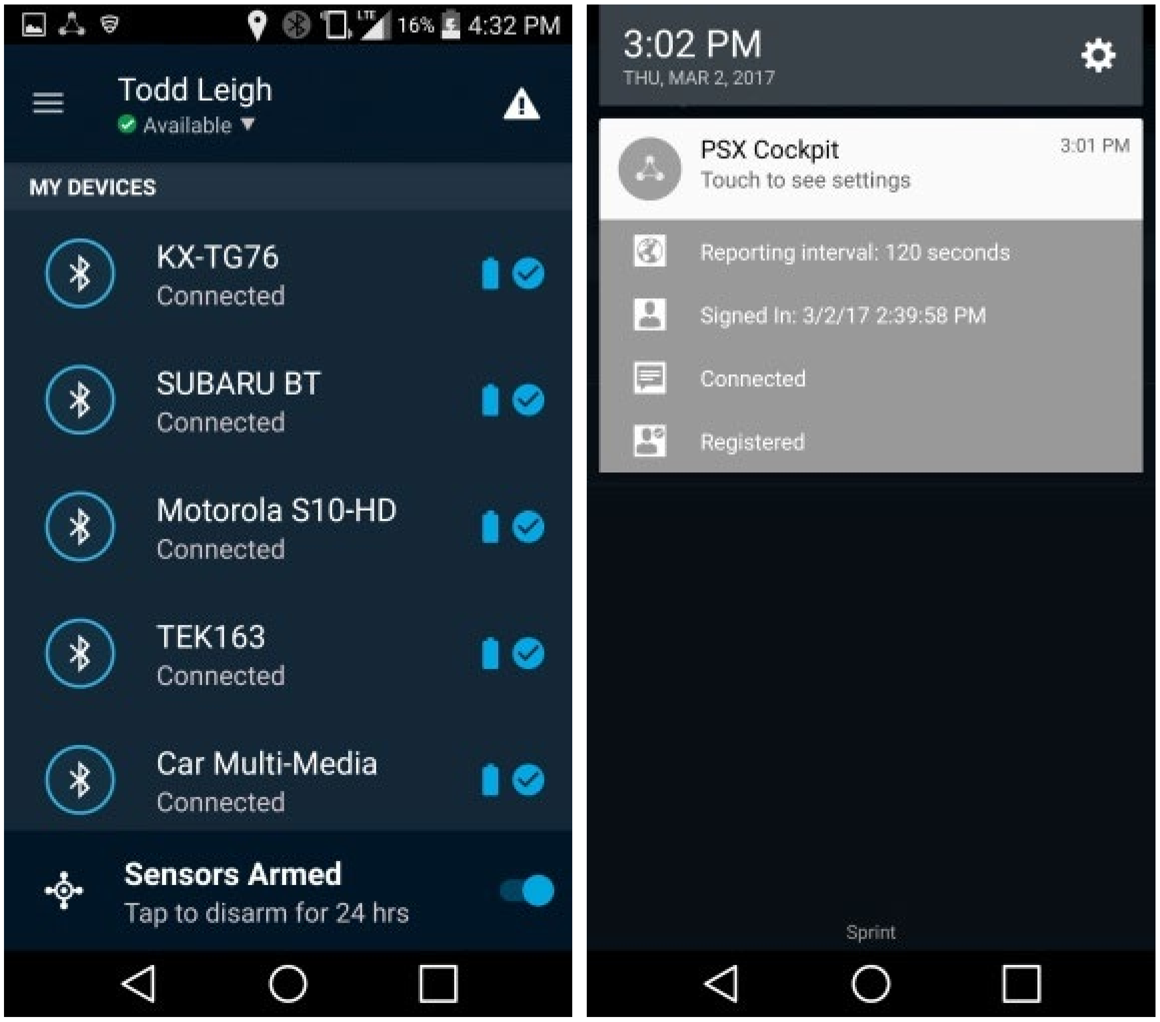
Figure 2-10 PSX Cockpit User Interface



16% 4:32 PM

Todd Leigh

Available

MY DEVICES

KX-TG76 Connected

SUBARU BT Connected

Motorola S10-HD Connected

TEK163 Connected

Car Multi-Media Connected

Sensors Armed

Tap to disarm for 24 hrs

3:02 PM

THU, MAR 2, 2017

PSX Cockpit 3:01 PM

Touch to see settings

Reporting interval: 120 seconds

Signed In: 3/2/17 2:39:58 PM

Connected

Registered

Sprint

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

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

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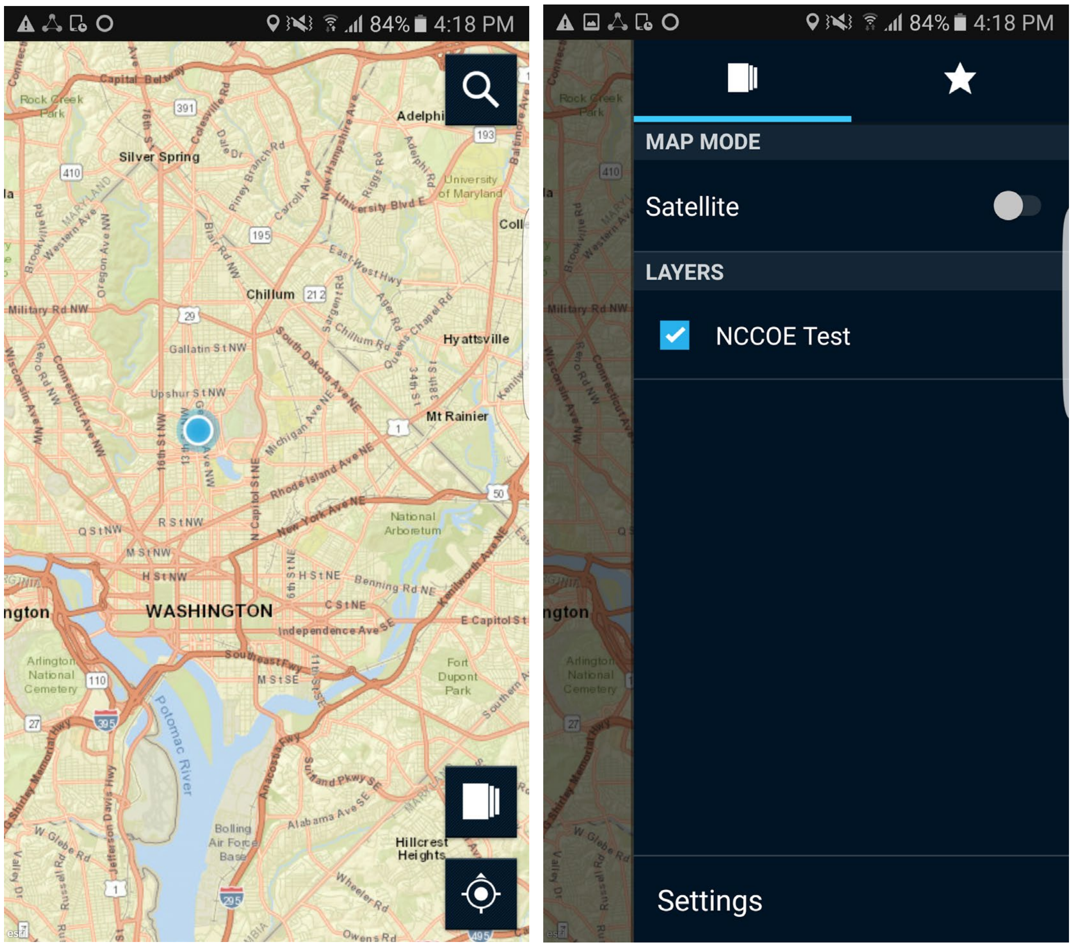
2.2.1.2 Configuring the PSX Mapping Application

1. Open the Mapping application. You should see the screen shown in Figure 2-11.

Figure 2-11 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 2-12.

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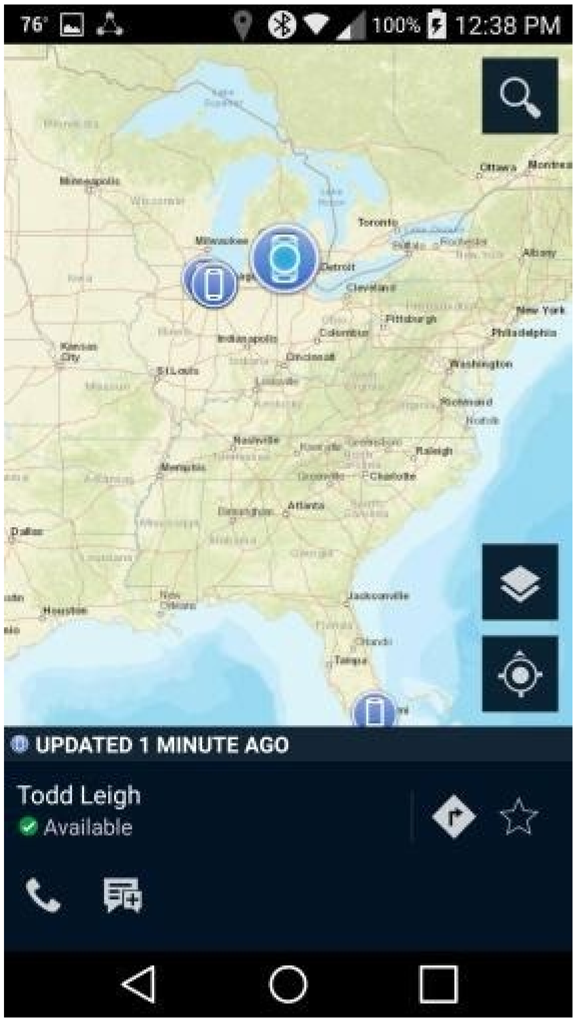
Figure 2-12 PSX Mapping Group Member Information



4. The locations of the devices that are members of that group should appear as dots on the map.
5. Select a device. A pop-up will show the user of the device and icons for phoning and messaging that user.
6. Selecting the Messenger icon for the selected user will take you to the Messenger application, where you can send a message to the user.

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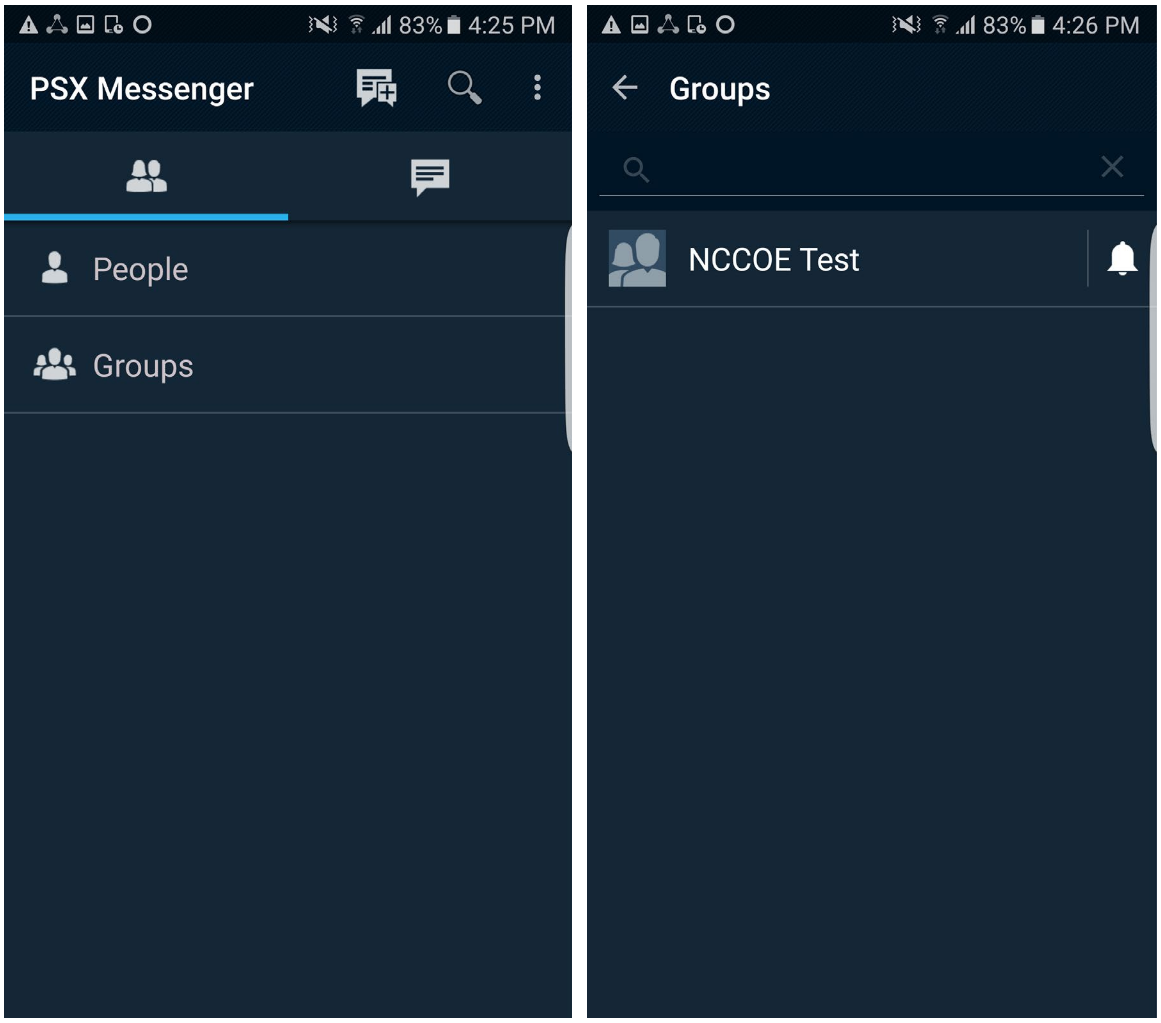
2.2.1.3 Configuring the PSX Messenger Application

1. Open the Messenger application. Your screen should look like Figure 2-13.

Figure 2-13 PSX Messenger User Interface



2. Your screen should show **People** and **Groups.** Select one of them.
3. A list of people or groups to which you can send a message should appear. Select one of them. Your screen should look like Figure 2-14.

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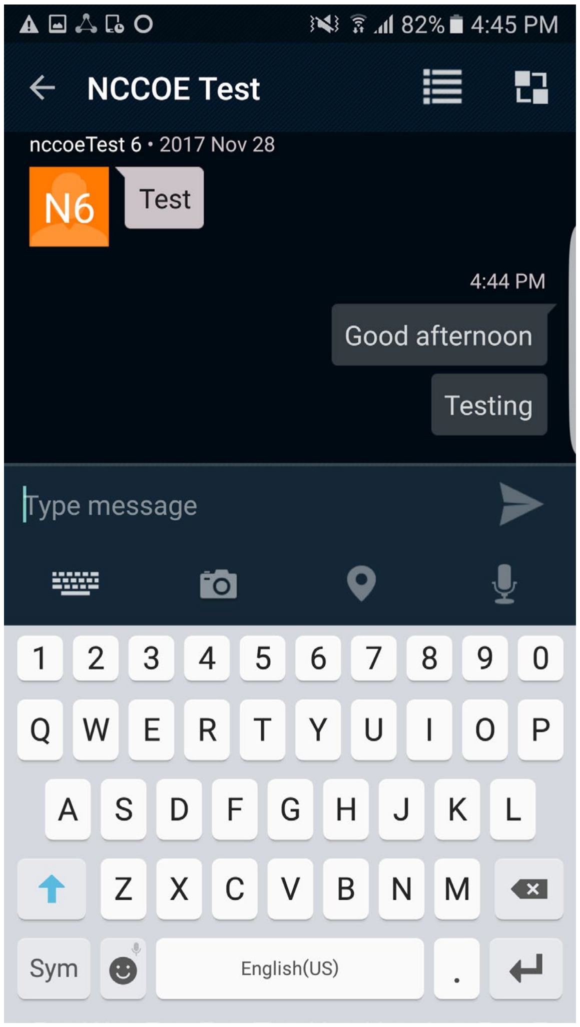
Figure 2-14 PSX Messenger Messages



Test

Good afternoon

Testing

4. You are now viewing the messaging window. You can type text for a message and attach a picture, video, voice recording, or map.
5. Tap the Send icon. The message should appear on your screen.
6. Tap the Pivot icon in the upper-right corner of the message window. Select Locate, and you will be taken to the Mapping application with the location of the people or group you selected.

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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 an Android mobile device. As explained in Section 2.1.4, the U2F login flow is not supported on iOS devices. The NCCoE reference architecture utilizes the Google Authenticator application on the mobile device and a Yubico YubiKey NEO as a hardware token. The application provides an interface between the Chrome browser and the U2F capabilities built into Play Services and is available on Google's Play Store [11].

2.2.2.1 Installing Google Authenticator

1. On your Android device, open the Play Store application.
2. Search for Google Authenticator, and install the application. There is no configuration needed until you are ready to register a FIDO U2F token with a StrongKey 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 application they are using. For instance, when using the PSX Cockpit application, 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 2-15.

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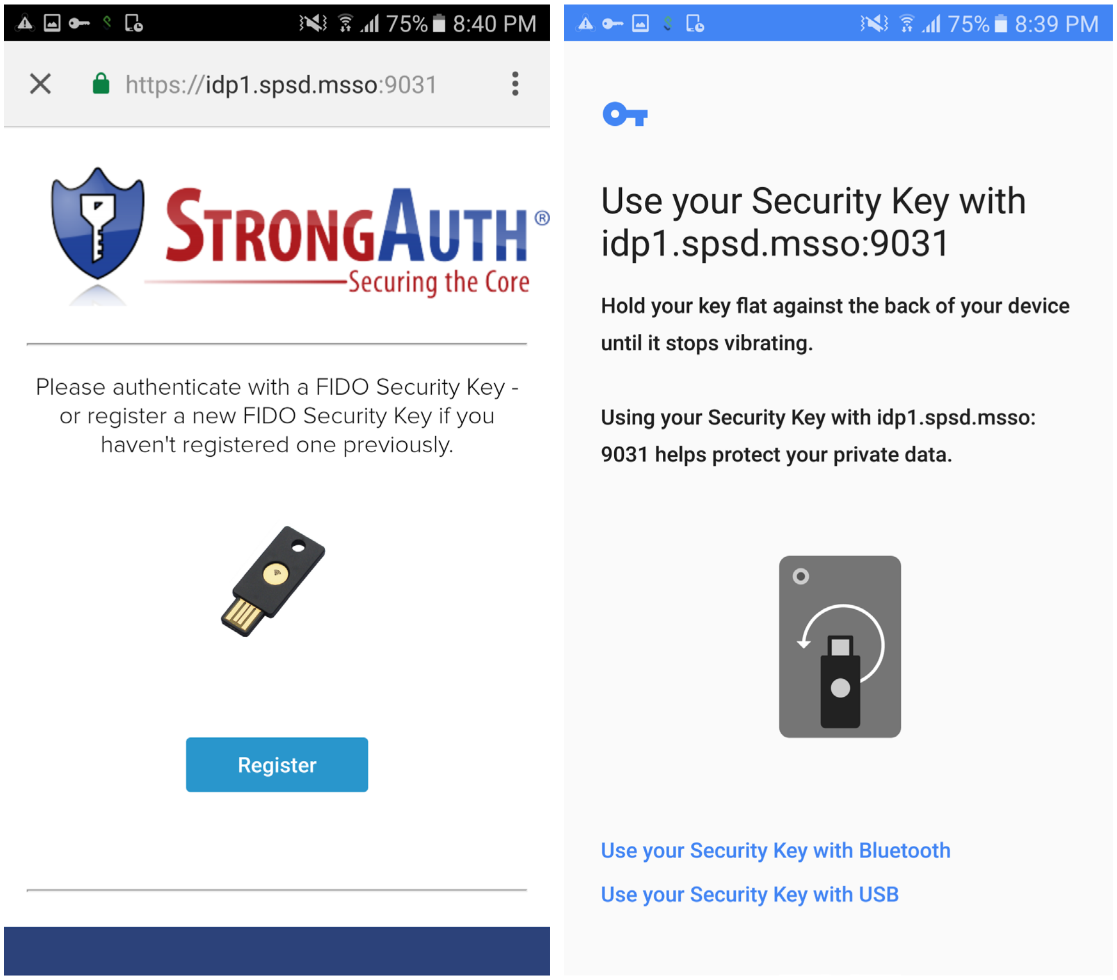
Figure 2-15 FIDO U2F Registration


75% 8:40 PM
https://idp1.spsd.msso:9031
StrongAuth®
Securing the Core
Register
75% 8:39 PM
Use your Security Key with Bluetooth
Use your Security Key with USB

Please authenticate with a FIDO Security Key - or register a new FIDO Security Key if you haven't registered one previously.

Use your Security Key with idp1.spsd.msso:9031

Hold your key flat against the back of your device until it stops vibrating.

Using your Security Key with idp1.spsd.msso:9031 helps protect your private data.

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

1. Click **Register,** and the web page will activate the Google Authenticator application, which asks you to use a U2F token to continue (Figure 2-15 above).
2. Hold the U2F token to your device, and the token will be registered to your account and you will be redirected to the U2F login screen again.

2.2.2.3 Authenticating with the Token

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

1. Click **Authenticate** (Figure 2-16), and the Google Authenticator application will be activated once more.

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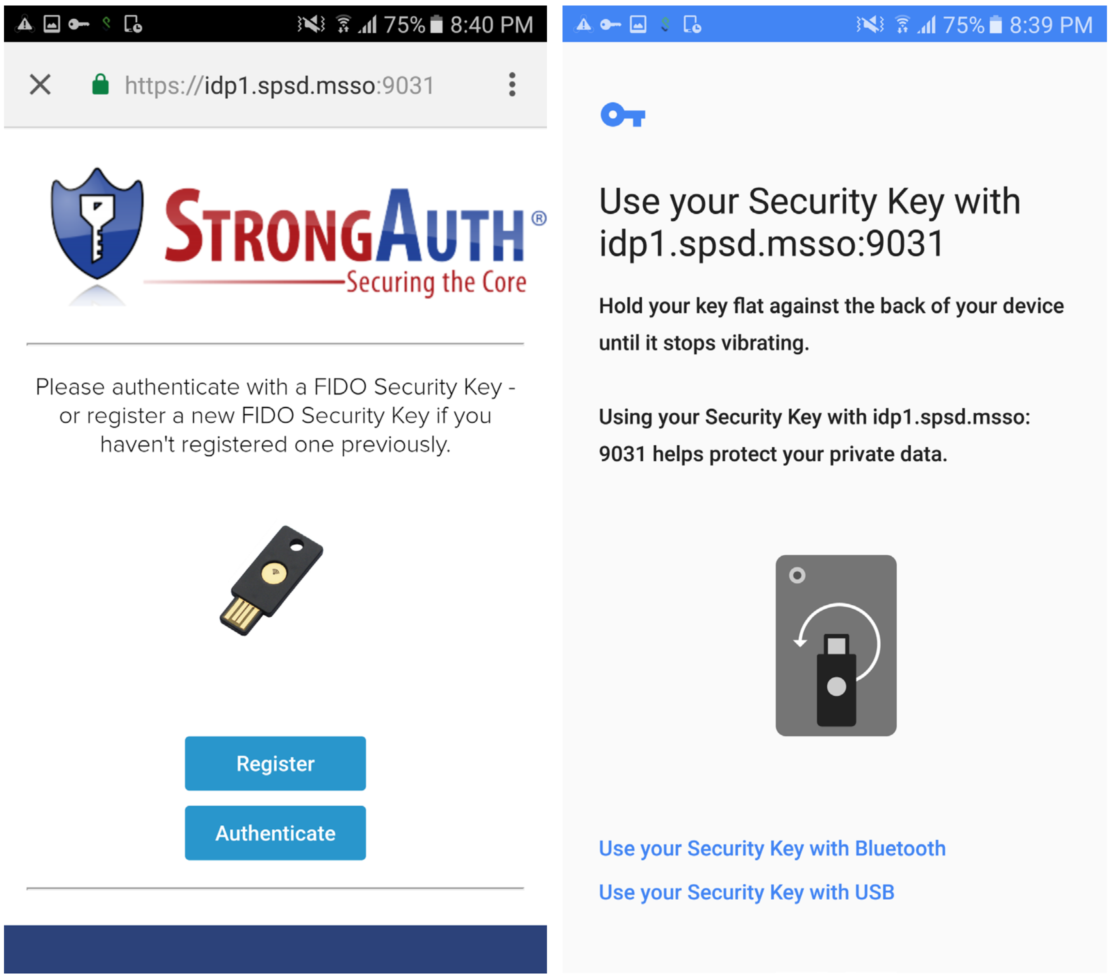
2. Hold the U2F token to your device, and then the authentication will be successful and the SSO flow will continue.

Figure 2-16 FIDO U2F Authentication


75% 8:40 PM
https://idp1.spsd.msso:9031
STRONGAUTH
Securing the Core
Register
Authenticate
75% 8:39 PM
Use your Security Key with Bluetooth
Use your Security Key with USB

Please authenticate with a FIDO Security Key - or register a new FIDO Security Key if you haven't registered one previously.

Use your Security Key with idp1.spsd.msso:9031

Hold your key flat against the back of your device until it stops vibrating.

Using your Security Key with idp1.spsd.msso:9031 helps protect your private data.

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 application (hereafter referred to as "Passport"). The Passport application functions as the client-side UAF application and is available on Google's Play Store [16] and Apple's App Store [17]. 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).*

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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 used a Quick Response (QR) code to enroll the device onto Nok Nok Labs' test server.

2.2.3.1 Installing Passport on Android

1. On your Android device, open the Play Store application.
2. Search for Nok Nok Passport, and install the application. 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 application during authentication; it will automatically be invoked by the SSO-enabled application (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 Installing Passport on iOS

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

As with the Android application, the Passport application for iOS is invoked automatically during login with a UAF-enabled server.

2.2.3.3 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" application provided with the NNAS. This sample implementation does not meet the FIDO requirement of authentication prior

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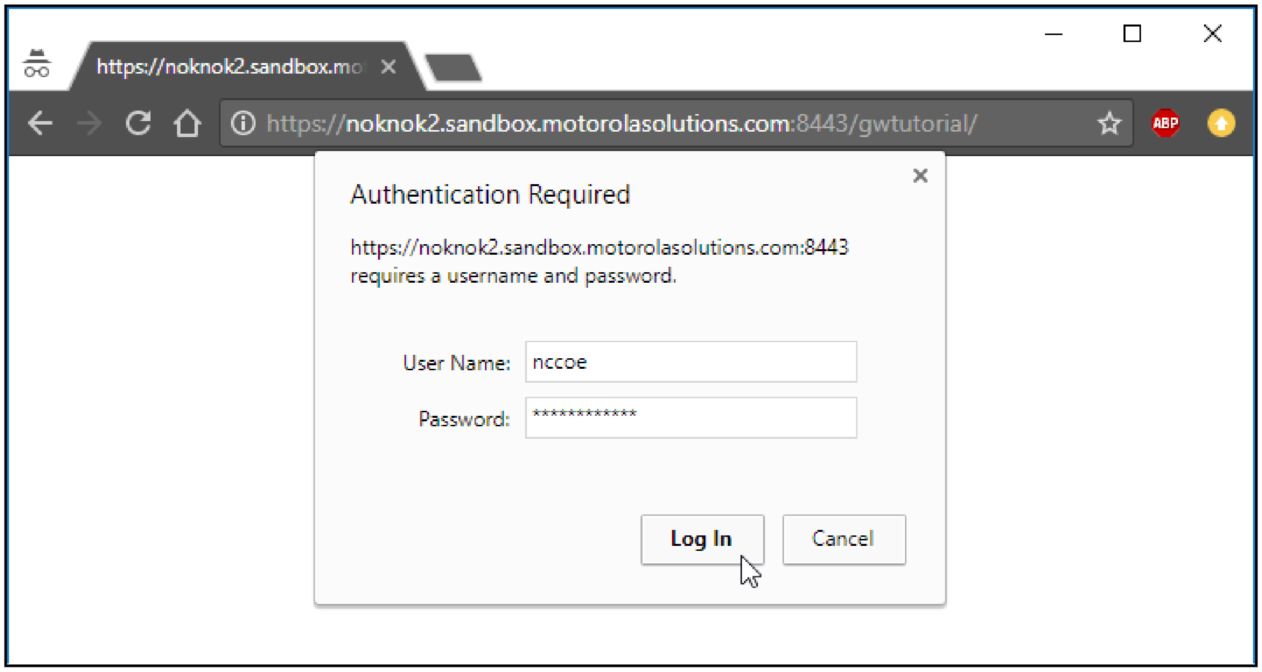
to registration. The production version of the NNAS may require additional steps and may have a different interface.

Screenshots that demonstrate the enrollment process are shown in Figure 2-17 through Figure 2-24.

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 2-17).

Figure 2-17 Nok Nok Labs Tutorial Application Authentication



https://noknok2.sandbox.motorolasolutions.com:8443/gwtutorial/

Authentication Required

https://noknok2.sandbox.motorolasolutions.com:8443 requires a username and password.

User Name: nccoe

Password: *************

2. Once you have logged in to the NNAS as an administrator, you need to identify which user you want to manage. Enter the username and click **Login** (Figure 2-18).

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

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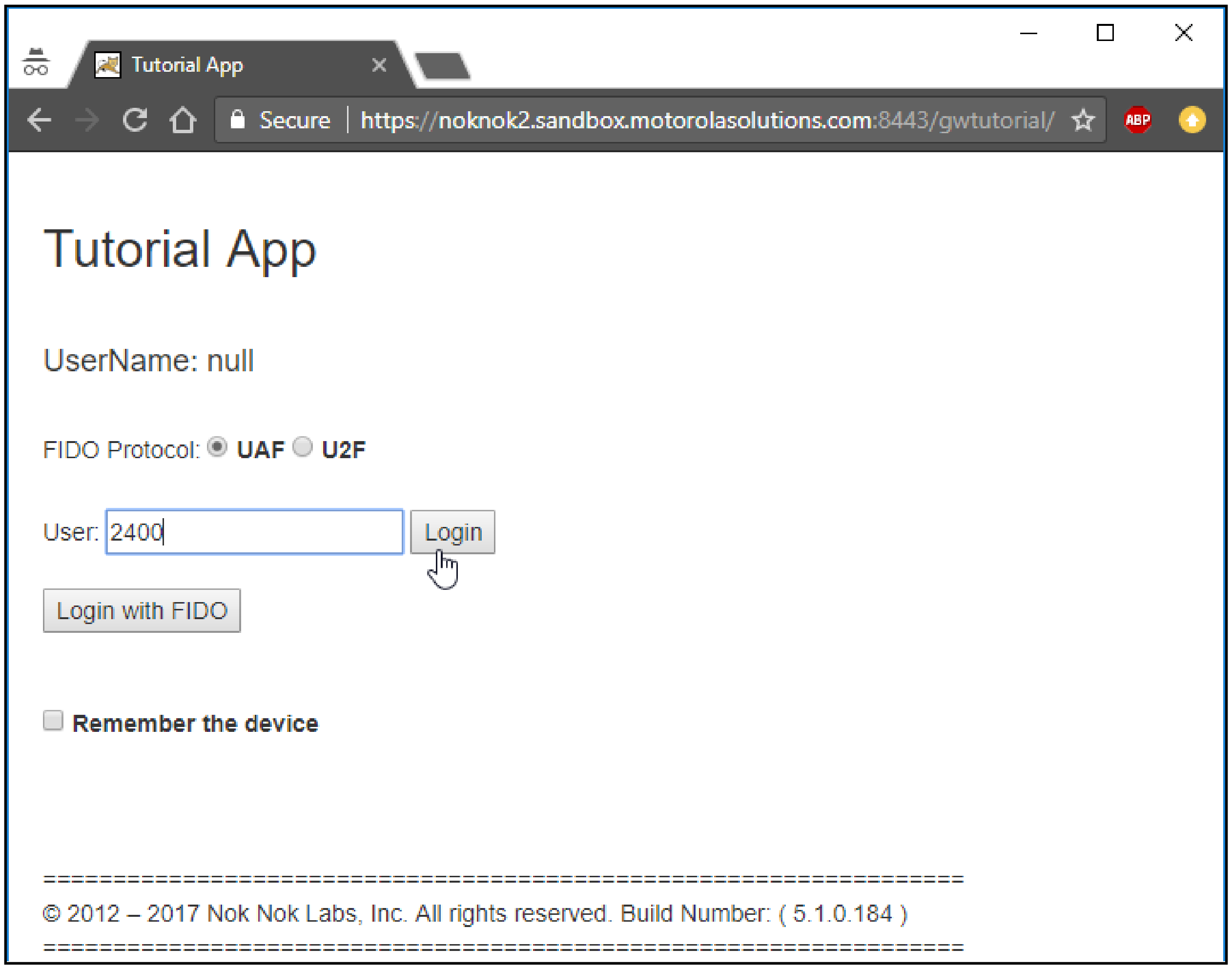
Figure 2-18 Nok Nok Labs Tutorial Application Login



Tutorial App

https://noknok2.sandbox.motorolasolutions.com:8443/gwtutorial/

Tutorial App

UserName: null

FIDO Protocol: [✓ UAF] U2F

User: 2400

===

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===

3. Once you have selected the user, you will need to start the FIDO UAF registration process. To begin, click **Register** (Figure 2-19).

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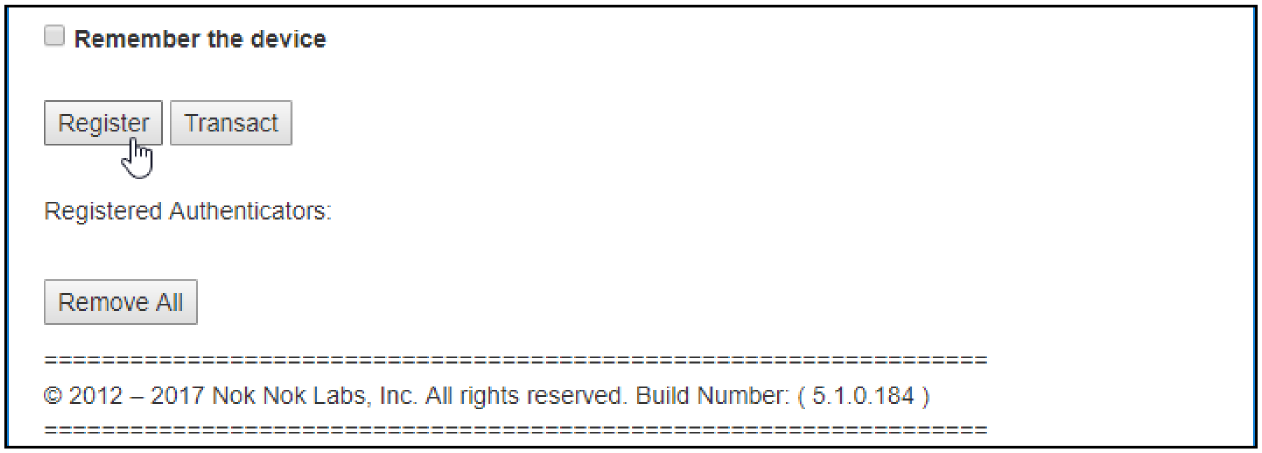
Figure 2-19 FIDO UAF Registration Interface



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

4. You will see a window with a QR code and a countdown (Figure 2-20). You have three minutes to finish the registration process with your device.

    a. Once the QR image appears, launch the Passport application on the phone. The Passport application activates the device camera to enable capturing the QR code by centering the code in the square frame in the middle of the screen (Figure 2-21).

    b. Once the QR code is scanned, the application prompts the user to select the type of verification (fingerprint, PIN, etc.) to use (Figure 2-21). The selections may vary based on the authenticator modules installed on the device. Figure 2-21 shows the Passport application on an Android device. Figure 2-22 shows the same flow on an iOS device. On iOS devices that support Face ID, such as the iPhone X, Face ID is available as a user verification option.

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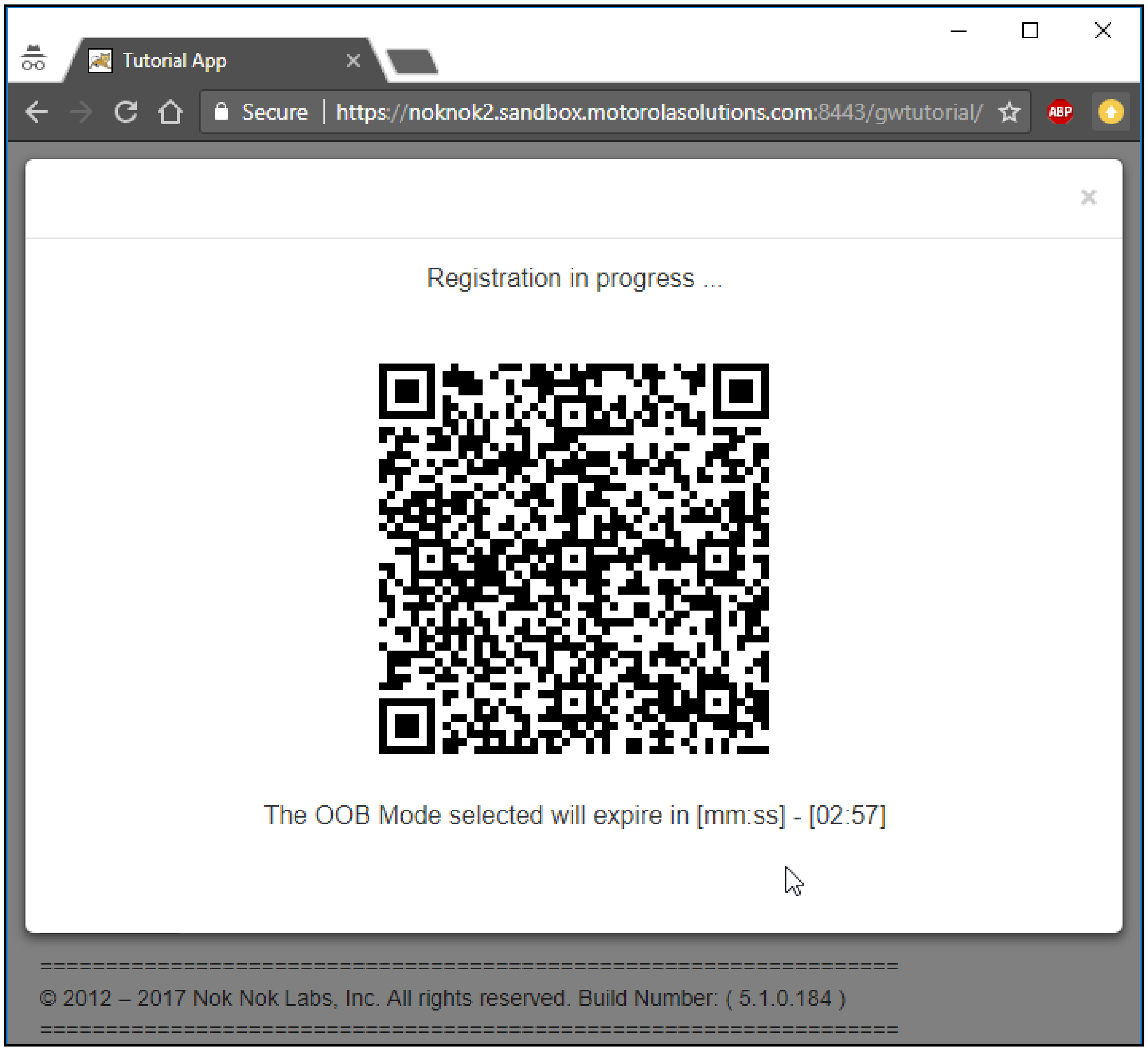
Figure 2-20 FIDO UAF Registration QR Code


Tutorial App
Secure
https://noknok2.sandbox.motorolasolutions.com:8443/gwtutorial/

Registration in progress ...

The OOB Mode selected will expire in [mm:ss] - [02:57]

==

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==

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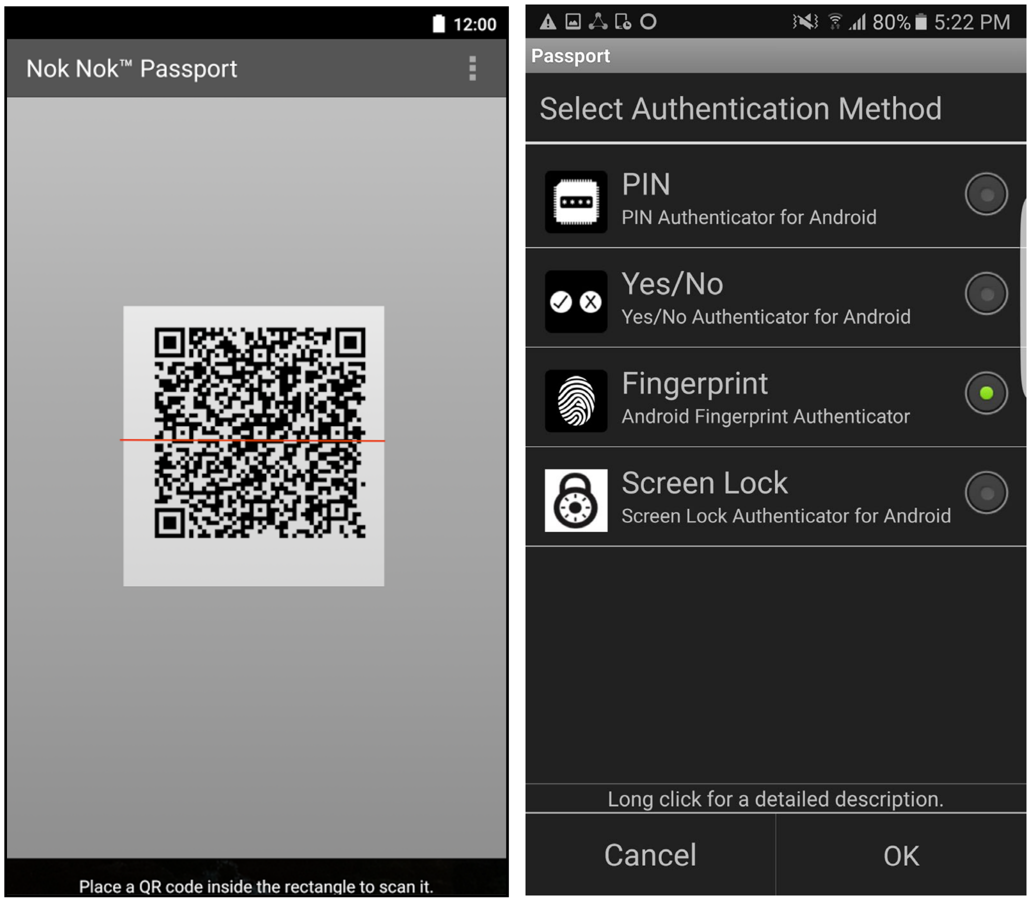
Figure 2-21 FIDO UAF Registration Device Flow, Android Device



Place a QR code inside the rectangle to scan it.

Select Authentication Method

- PIN — PIN Authenticator for Android ○
- Yes/No — Yes/No Authenticator for Android ○
- Fingerprint — Android Fingerprint Authenticator ●
- Screen Lock — Screen Lock Authenticator for Android ○

Long click for a detailed description.

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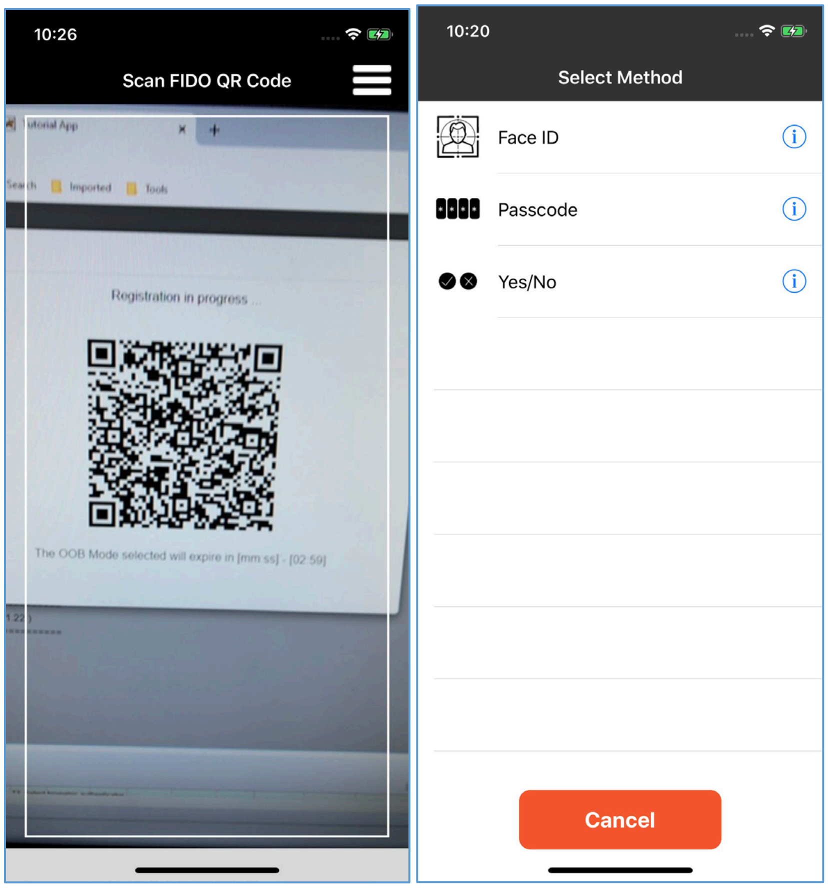
Figure 2-22 FIDO UAF Registration Device Flow, iPhone X


10:26
Scan FIDO QR Code
Registration in progress ...
The OOB Mode selected will expire in [mm:ss] - [02:59]
10:20
Select Method
Face ID
Passcode
Yes/No
Cancel

5. The user is then prompted to perform user verification with the selected method. In the example shown in Figure 2-23, a fingerprint authenticator is registered. The user is prompted for a fingerprint scan to complete registration. The fingerprint authenticator uses a fingerprint previously registered in the Android screen-lock settings. If a PIN authenticator were registered, the user would be prompted to set a PIN instead.

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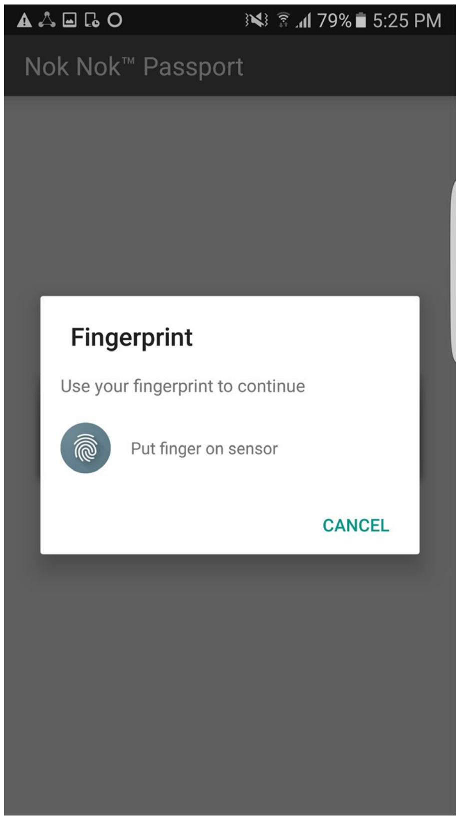
Figure 2-23 FIDO UAF Fingerprint Authenticator, Android Device



6. If user verification is successful, then a new UAF key pair is generated, the public key is sent to the server, and registration is completed (Figure 2-24).

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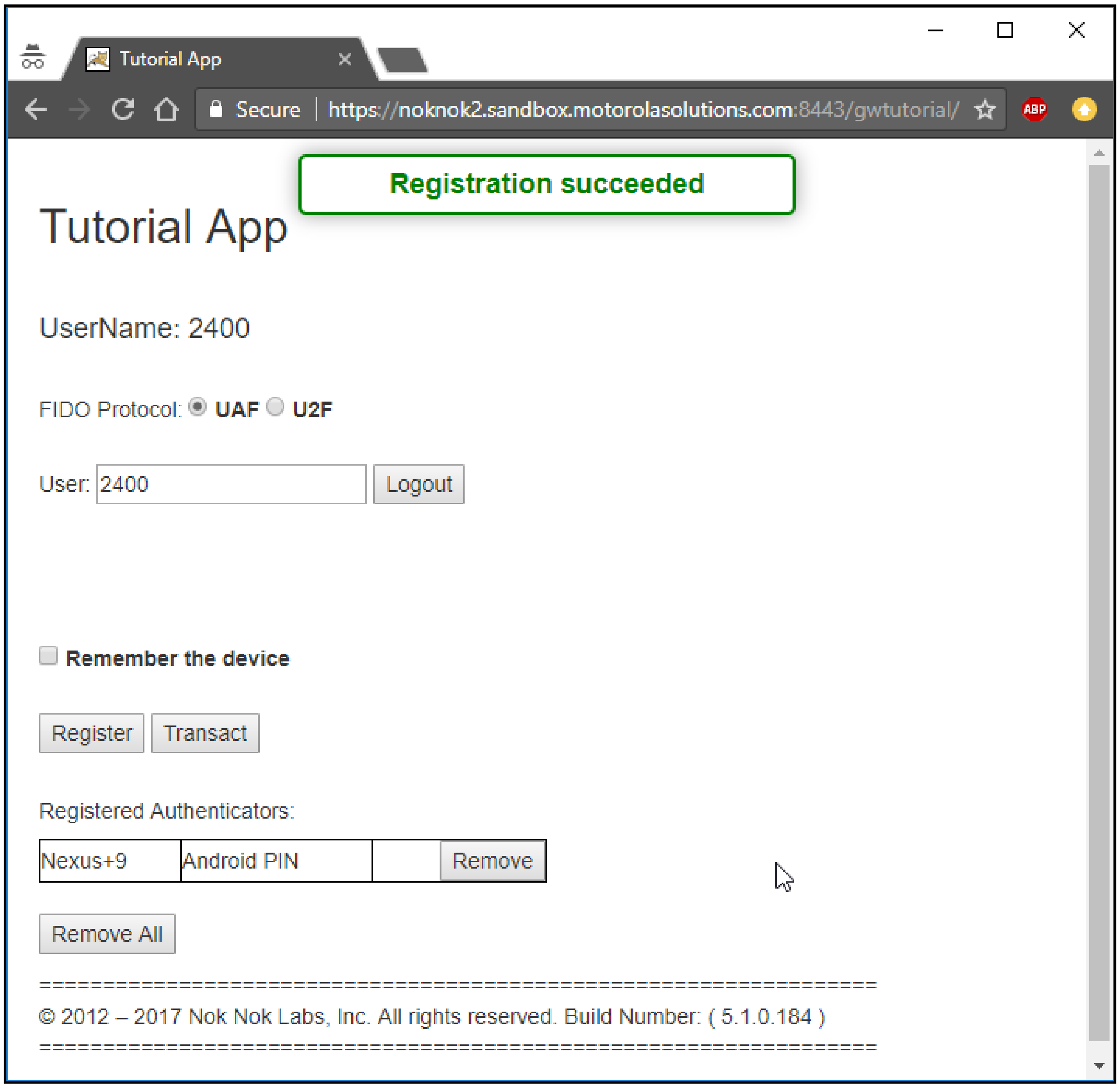
Figure 2-24 FIDO UAF Registration Success


Tutorial App
Secure
https://noknok2.sandbox.motorolasolutions.com:8443/gwtutorial/

Registration succeeded

Tutorial App

UserName: 2400

FIDO Protocol: [✓ UAF] U2F

User: 2400 Logout

Remember the device

Register Transact

Registered Authenticators:

Nexus+9	Android PIN		Remove

Remove All

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

2.3 How Application Developers Must Integrate AppAuth for SSO

Application developers can easily integrate AppAuth to add SSO capabilities to their applications. The first step to doing this is reading through the documentation on GitHub for AppAuth for Android [19] or iOS [8]. After doing so, an application developer can begin the integration of AppAuth. The degree of this integration can vary—for instance, you may choose to utilize user attributes to personalize the

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user's application experience. The following sections describe AppAuth integration for Android and iOS applications.

For either platform, the mobile application must be registered with the OAuth AS and given a client ID as described in Section 3.3. The client ID will be needed when building the mobile application.

2.3.1 AppAuth Integration for Android

In this example, we use Android Studio 3.0, Android Software Development Kit 25, and Gradle 2.14.1.

2.3.1.1 Adding the Library Dependency

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

```
===============================================================================
dependencies {
...
   compile 'net.openid:appauth:0.7.0'
}
===============================================================================
```

2.3.1.2 Adding Activities to the Manifest

1. First, you need to identify your AS's host name, OAuth redirect path, and what scheme was set when you registered your application. The scheme here is contrived, but it is common practice to use reverse DNS style names; you should choose whatever aligns with your organization's common practices. Another alternative to custom schemes is to use App Links.
2. Edit your *AndroidManifest.xml* file, and add these lines:

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

<manifest xmlns:android="http://schemas.android.com/apk/res/android"
   xmlns:tools="http://schemas.android.com/tools"
   package="com.example.app">
...
      <activity
         android:name="net.openid.appauth.RedirectUriReceiverActivity"
         tools:node="replace">
         <intent-filter>
            <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>
```

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```
        </activity>
        <activity android:name=".activity.AuthResultHandlerActivity" />
        <activity android:name=".activity.AuthCanceledHandlerActivity" />
    </application>
</manifest>

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

2.3.1.3 Creating 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 {
```

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```
                return AuthState.jsonDeserialize(jsonString);
            } catch (JSONException jsonException) {
                // handle this appropriately
            }
        }
        return null;
    }
}

================================================================================

public class AuthResultHandlerActivity extends Activity {

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

    private AuthState mAuthState;
    private AuthorizationService mAuthService;

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

        AuthorizationResponse res =
AuthorizationResponse.fromIntent(getIntent());
        AuthorizationException ex =
AuthorizationException.fromIntent(getIntent());
        mAuthState = new AuthState(res, ex);
        mAuthService = Utility.getAuthorizationService(this);

        if (res != null) {
            Log.d(TAG, "Received AuthorizationResponse");
            performTokenRequest(res.createTokenExchangeRequest());
        } else {
            Log.d(TAG, "Authorization failed: " + ex);
        }
    }

    @Override

    protected void onDestroy() {

        super.onDestroy();

        mAuthService.dispose();

    }

    private void performTokenRequest(TokenRequest request) {
        TokenResponseCallback callback = new TokenResponseCallback() {
            @Override
            public void onTokenRequestCompleted(
                    TokenResponse tokenResponse,
                    AuthorizationException authException) {
                receivedTokenResponse(tokenResponse, authException);
```

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```
            }
        };
        mAuthService.performTokenRequest(request, callback);
    }

    private void receivedTokenResponse(TokenResponse tokenResponse,
                                       AuthorizationException authException) {
        Log.d(TAG, "Token request complete");
        if (tokenResponse != null) {
            mAuthState.update(tokenResponse, authException);

            // persist auth state to SharedPreferences
            PreferenceManager.getDefaultSharedPreferences(this)
                    .edit()
                    .putString("AUTHSTATE", mAuthState.jsonSerializeString())
                    .commit();

            String accessToken = mAuthState.getAccessToken();
            if (accessToken != null) {
                // 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();
    }
}

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

2.3.1.4 Executing the OAuth 2 Authorization Flow

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

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

// 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,
```

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```
        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
    }
}

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

2.3.1.5 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
```

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```
        } 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();
    }
});


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

2.3.2 AppAuth Integration for iOS

The iOS demo applications were built with XCode 10.1 for iOS deployment target 11.0. using the Swift programming language.

2.3.2.1 Adding the Library Dependency

The AppAuth library can be added to an XCode project by using either the CocoaPods or Carthage dependency manager. The CocoaPods method automatically uses the official released version of the library. To use a particular code branch or to get recent updates not available in the release version, Carthage must be used. The official release should be suitable for the majority of applications.

To add the AppAuth library by using CocoaPods:

1. Create a Podfile in the root directory of the project. The following is a sample Podfile from the maps-demo application that adds AppAuth and two other libraries.

```
================================================================================
source 'https://github.com/CocoaPods/Specs.git'
target 'map-demo-app-ios' do
    pod 'GoogleMaps'
    pod 'GooglePlaces'
    pod 'AppAuth'
end
================================================================================
```

2. Open a terminal, navigate to the root directory of the project, and run the command:

```
pod install
```

3. In XCode, close any open projects. Click **File-Open**, navigate to the root of the project, and open the file <project-name>.xcworkspace.

To add the AppAuth library by using Carthage:

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1. Create a Cartfile with the following contents in the root directory of the project:

```
================================================================================
github "openid/AppAuth-iOS" "master"
================================================================================
```

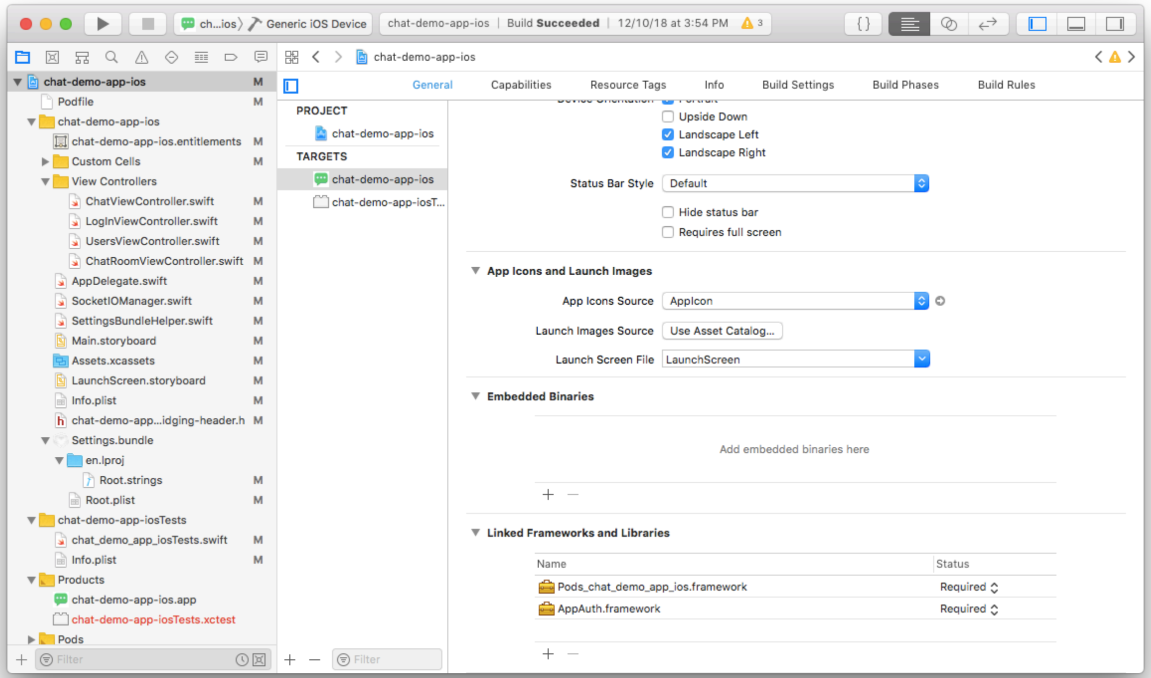
2. Open a terminal, navigate to the root directory of the project, and run the command:

   ```
   carthage bootstrap
   ```

3. In XCode, click on the project in the project navigator and select the **General** tab. Under **Linked Frameworks and Libraries**, click the plus icon to add a framework.

4. Click **Add Other…**. A file selection dialogue should open and display the root folder of the project. Navigate to the Carthage/Build/iOS subfolder, select **AppAuth.framework**, and click **Open**. The Frameworks and Libraries interface is shown in Figure 2-25.

Figure 2-25 Linked Frameworks and Libraries



- [ ] Upside Down
- [x] Landscape Left
- [x] Landscape Right

Status Bar Style: Default

- [ ] Hide status bar
- [ ] Requires full screen

App Icons and Launch Images

App Icons Source: AppIcon

Launch Images Source: Use Asset Catalog...

Launch Screen File: LaunchScreen

Embedded Binaries

Add embedded binaries here

Linked Frameworks and Libraries

Name	Status
Pods_chat_demo_app_ios.framework	Required
AppAuth.framework	Required

5. On the **Build Phases** tab, click the plus icon in the top left corner of the editor and select **New Run Script Phase** as shown in Figure 2-26.

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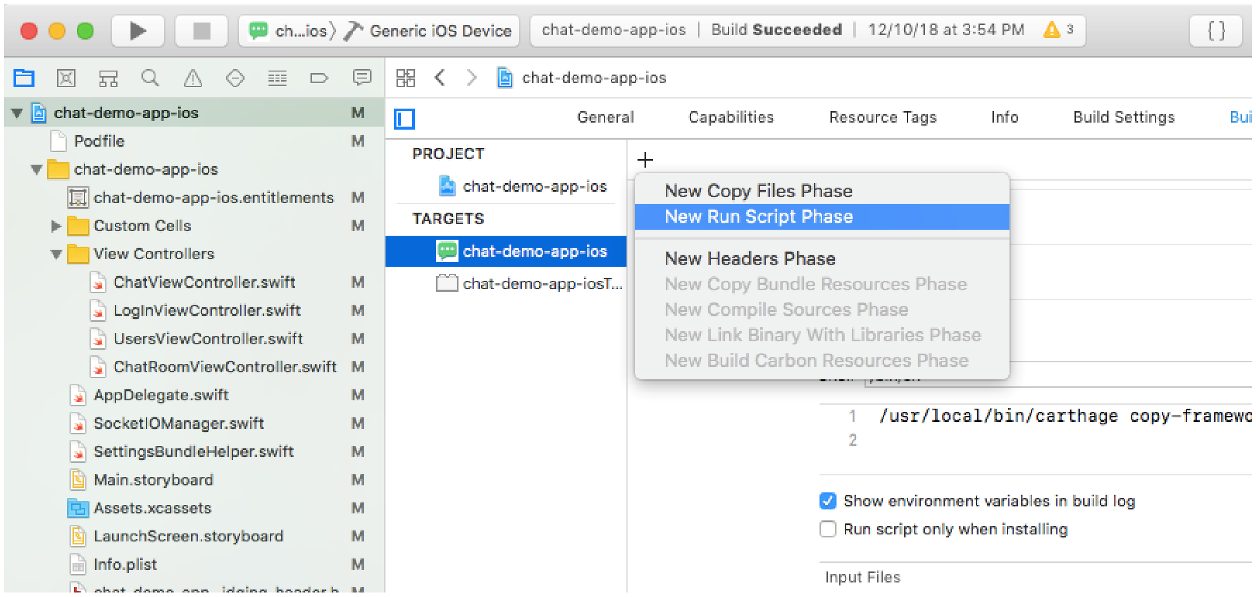
Figure 2-26 Creating a New Run Script Phase



6. Add the following command to the Run Script:

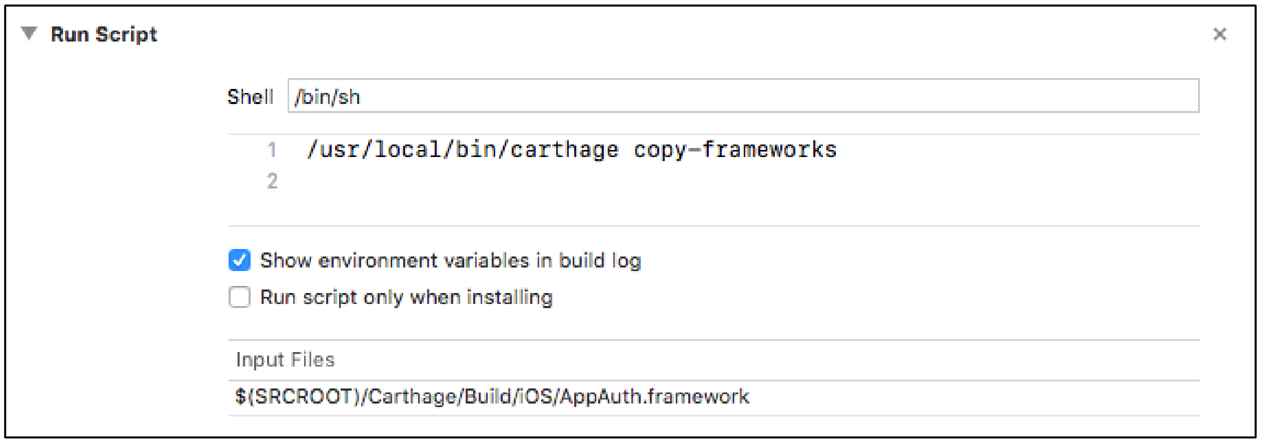
   `/usr/local/bin/carthage copy-frameworks`

7. Click the plus icon under **Input Files** and add the following entry:

   `$(SRCROOT)/Carthage/Build/iOS/AppAuth.framework`

   Figure 2-27 shows a completed Run Script.

Figure 2-27 Carthage Run Script


Run Script

Shell /bin/sh

```
/usr/local/bin/carthage copy-frameworks
```

☑ Show environment variables in build log

☐ Run script only when installing

Input Files

$(SRCROOT)/Carthage/Build/iOS/AppAuth.framework

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Once either of the above procedures is completed, you should be able to import AppAuth into your project without compiler errors.

2.3.2.2 Registering a Custom URL Scheme

To enable the AS to send a redirect through the browser back to your mobile application, you must either register a custom URL scheme or use Universal Links. This example shows the use of a custom URL scheme. This scheme must be included in the redirect_uri registered with the AS; see Section 3.3 for details on OAuth client registration. To configure the custom URL scheme:

1. In the XCode Project Navigator, select the **Info.plist** file.
2. Select **URL Types** and click the Plus icon to add a type.
3. Under the created item, click on the selector icon and choose **URL Schemes**.
4. Edit the item value to match the URL scheme. Figure 2-28 shows a custom URL scheme of "org.mitre.chatdemo."

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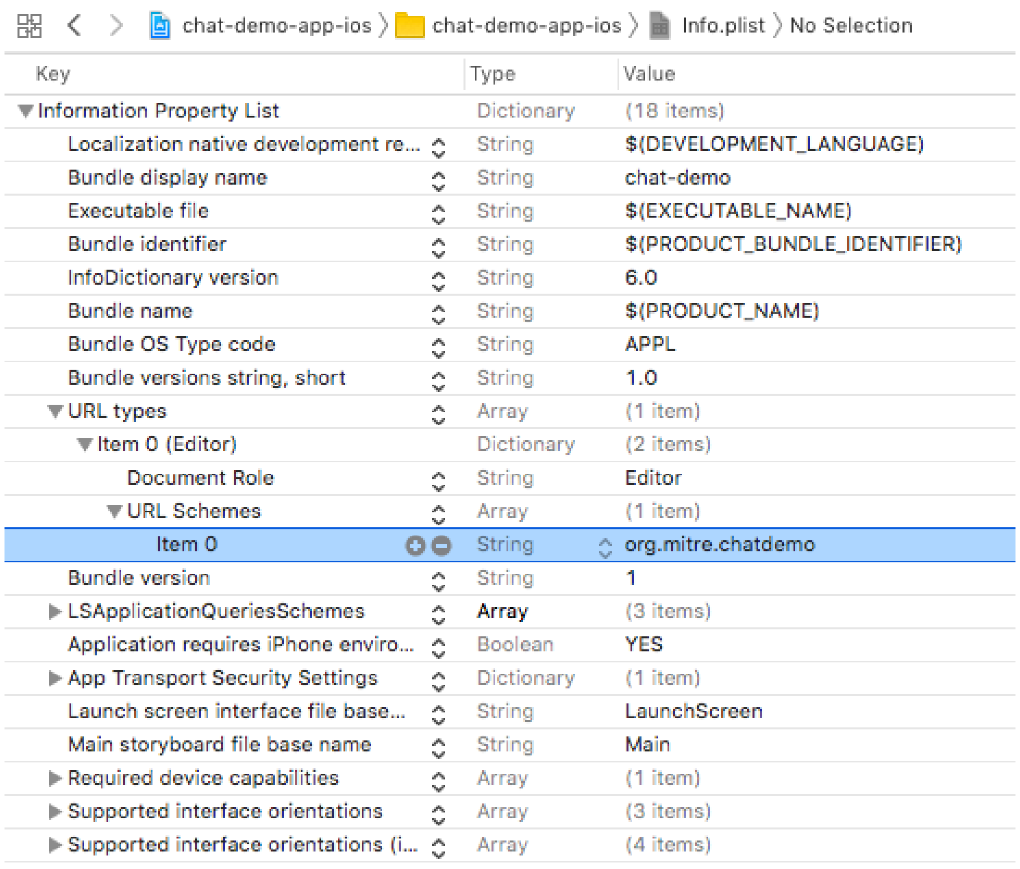
Figure 2-28 Custom URL Scheme



chat-demo-app-ios 〉 chat-demo-app-ios 〉 Info.plist 〉 No Selection

Key	Type	Value
▼Information Property List	Dictionary	(18 items)
Localization native development re...	String	$(DEVELOPMENT_LANGUAGE)
Bundle display name	String	chat-demo
Executable file	String	$(EXECUTABLE_NAME)
Bundle identifier	String	$(PRODUCT_BUNDLE_IDENTIFIER)
InfoDictionary version	String	6.0
Bundle name	String	$(PRODUCT_NAME)
Bundle OS Type code	String	APPL
Bundle versions string, short	String	1.0
▼URL types	Array	(1 item)
▼Item 0 (Editor)	Dictionary	(2 items)
Document Role	String	Editor
▼URL Schemes	Array	(1 item)
Item 0	String	org.mitre.chatdemo
Bundle version	String	1
▶LSApplicationQueriesSchemes	Array	(3 items)
Application requires iPhone enviro...	Boolean	YES
▶App Transport Security Settings	Dictionary	(1 item)
Launch screen interface file base...	String	LaunchScreen
Main storyboard file base name	String	Main
▶Required device capabilities	Array	(1 item)
▶Supported interface orientations	Array	(3 items)
▶Supported interface orientations (i...	Array	(4 items)

2.3.2.3 Handling Authorization Responses

Add the following lines to AppDelegate.swift to handle authorization responses submitted to your application's redirect_uri:

```
===============================================================================
var currentAuthorizationFlow:OIDAuthorizationFlowSession?
func application(_ app: UIApplication, open url: URL, options:
[UIApplicationOpenURLOptionsKey : Any] = [:]) -> Bool {
        if let authorizationFlow = self.currentAuthorizationFlow,
        authorizationFlow.resumeAuthorizationFlow(with: url) {
                self.currentAuthorizationFlow = nil
                return true
        }
        return false
}
===============================================================================
```

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2.3.2.4 Executing the OAuth 2 Authorization Flow

In the View Controller that handles authentication events, add the necessary code to use AppAuth to submit authorization requests to the AS. The configuration parameters for the AS, such as the URLs for the authorization and token endpoints, can be automatically discovered if the AS supports OpenID Connect Discovery; otherwise, these parameters must be provided either in settings or in the code. In this example, they are specified in the code. This example also demonstrates how to specify the user-agent for the authorization flow; in this case, Safari will be used.

```
===============================================================================
class LogInViewController: UIViewController, OIDAuthStateChangeDelegate,
OIDAuthStateErrorDelegate {
   let kAppAuthExampleAuthStateKey = authState";

   ...

   func authenticateUsingLab() {
      var configuration: OIDServiceConfiguration =
OIDServiceConfiguration(authorizationEndpoint: URL(string:
"https://as1.cpssp.msso:9031/as/authorization.oauth2")!, tokenEndpoint: URL(string:
"https://as1.cpssp.msso:9031/as/token.oauth2")!)

      guard let redirectURI = URL(string:
"org.mitre.chatdemo:/msso.nccoe.nist/oauth2redirect") else {
         print("Error creating URL for :
org.mitre.chatdemo:/msso.nccoe.nist/oauth2redirect")
         return
      }

      guard let appDelegate = UIApplication.shared.delegate as? AppDelegate else {
         print("Error accessing AppDelegate")
         return
      }

      // builds authentication request
      let request = OIDAuthorizationRequest(configuration: configuration,
                                    clientId: "chatdemo",
                                    clientSecret: nil,
                                    scopes: ["testScope"],
                                    redirectURL: redirectURI,
                                    responseType: OIDResponseTypeCode,
                                    additionalParameters: nil)

      print("Initiating authorization request with scope: \(request.scope ??
"DEFAULT_SCOPE")")

      doAuthWithAutoCodeExchange(configuration: configuration, request: request,
appDelegate: appDelegate)
   }
```

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```
    func doAuthWithAutoCodeExchange(configuration: OIDServiceConfiguration, request:
OIDAuthorizationRequest, appDelegate: AppDelegate) {

        let coordinator: OIDAuthorizationUICoordinatorCustomBrowser =
OIDAuthorizationUICoordinatorCustomBrowser.customBrowserSafari()

        appDelegate.currentAuthorizationFlow = OIDAuthState.authState(byPresenting:
request, uiCoordinator: coordinator) { authState, error in
            if let authState = authState {
                self.assignAuthState(authState: authState)
                self.segueToChat()
            } else {
                print("Authorization error: \(error?.localizedDescription ??
"DEFAULT_ERROR")")
                self.assignAuthState(authState: nil)
            }
        }
    func saveState(){
        // for production usage consider using the OS Keychain instead
        if authState != nil{
            let archivedAuthState = NSKeyedArchiver.archivedData(withRootObject:
authState!)
            UserDefaults.standard.set(archivedAuthState, forKey:
kAppAuthExampleAuthStateKey)
        }
        else{
            UserDefaults.standard.set(nil, forKey: kAppAuthExampleAuthStateKey)
        }
        UserDefaults.standard.synchronize()
    }

    func loadState(){
        // loads OIDAuthState from NSUSerDefaults
        guard let archivedAuthState = UserDefaults.standard.object(forKey:
kAppAuthExampleAuthStateKey) as? NSData else{
            return
        }
        guard let authState = NSKeyedUnarchiver.unarchiveObject(with: archivedAuthState
as Data) as? OIDAuthState else{
            return
        }
        assignAuthState(authState: authState)
    }

    func assignAuthState(authState:OIDAuthState?){
        if (self.authState == authState) {
            return;
        }
        self.authState = authState
        self.authState?.stateChangeDelegate = self
        self.saveState()
    }
```

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```
    func didChange(_ state: OIDAuthState) {
        authState = state
        authState?.stateChangeDelegate = self
        self.saveState()
    }

    func authState(_ state: OIDAuthState, didEncounterAuthorizationError error: Error)
{
        print("Received authorization error: \(error)")
    }
}
================================================================================
```

2.3.2.5 Fetching and Using the Access Token

The access token can be retrieved from the authState object. If the access token has expired, the application may need to use a refresh token to obtain a new access token or initiate a new authorization request if it does not have an active refresh token. Access tokens are typically used in accordance with RFC 6750 [20], most commonly in the Authorization header of a Hypertext Transfer Protocol (HTTP) request to an API server. The following example shows a simple usage of an access token to call an API:

```
================================================================================
public func requestChatRooms() {
    let urlString = "\(protocolIdentifier)://\(ipAddress):\(port)/getChatRooms"
    print("URLString \(urlString)")
    guard let url = URL(string: urlString) else { return }
    let token: String? = self.authState?.lastTokenResponse?.accessToken
    var request = URLRequest(url: url)
    request.httpMethod = "GET"
    request.setValue("Bearer \(token)", forHTTPHeaderField: "Authorization")
    URLSession.shared.dataTask(with: request) { (data, response, error) in
        if error != nil {
            print(error!.localizedDescription)
        }
        else {
            guard let data = data else { return }
            let json = try? JSONSerialization.jsonObject(with: data, options: [])

            if let array = json as? [Any] {
                if let firstObject = array.first {
                    if let dictionary = firstObject as? [String: String] {
                        self.chatRooms = dictionary
                        self.loadRooms()
                    }
                }
            }
        }
    }.resume()
}
================================================================================
```

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AppAuth also provides a convenience function, performActionWithFreshTokens, which will automatically handle token refresh if the current access token has expired.

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 as specified in RFC 6749, The OAuth Authorization Framework [21].

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
- 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

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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: 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.

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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: https://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 three programs that 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 systemwide.
2. To make Java available to all users, the JAVA_HOME environment variable is 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 https://www.oracle.com/technetwork/java/javase/downloads/jce8-download-2133166.html.

This publication is available free of charge from: https://doi.org/10.6028/NIST.SP.1800-13.

4. Decompress 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
```

8. 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://documentation.pingidentity.com/pingfederate/pf82/index.shtml - gettingStartedGuide/pf_t_installPingFederateRedHatEnterpriseLinux.html.

This publication is available free of charge from: https://doi.org/10.6028/NIST.SP.1800-13.

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://documentation.pingidentity.com/pingfederate/pf82/index.shtml - gettingStartedGuide/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.

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.

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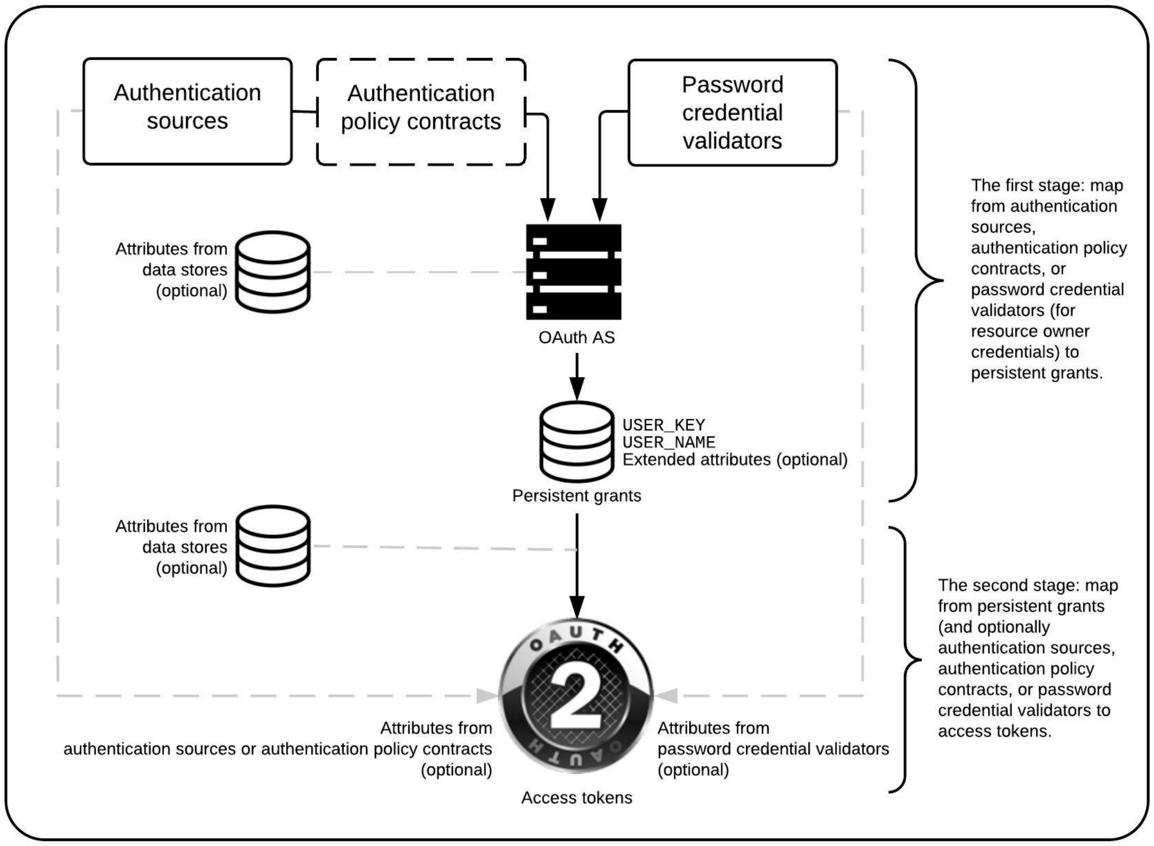
An understanding of the PingFederate OAuth implementation helps provide context for the configurations documented in this guide. PingFederate supports several different authentication flows and mechanisms, but there is a common framework for how user attributes are mapped into OAuth tokens. This framework 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.

Figure 3-1 Access Token Attribute Mapping Framework


Authentication sources
Authentication policy contracts
Password credential validators
Attributes from data stores (optional)
OAuth AS
USER_KEY
USER_NAME
Extended attributes (optional)
Persistent grants
Attributes from data stores (optional)
Attributes from authentication sources or authentication policy contracts (optional)
Attributes from password credential validators (optional)
Access tokens
The first stage: map from authentication sources, authentication policy contracts, or password credential validators (for resource owner credentials) to persistent grants.
The second stage: map from persistent grants (and optionally authentication sources, authentication policy contracts, or password credential validators to access tokens.

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), is used to build a persistent grant context. The two mandatory attributes in the persistent grant context are:

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- **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 applications 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.

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.

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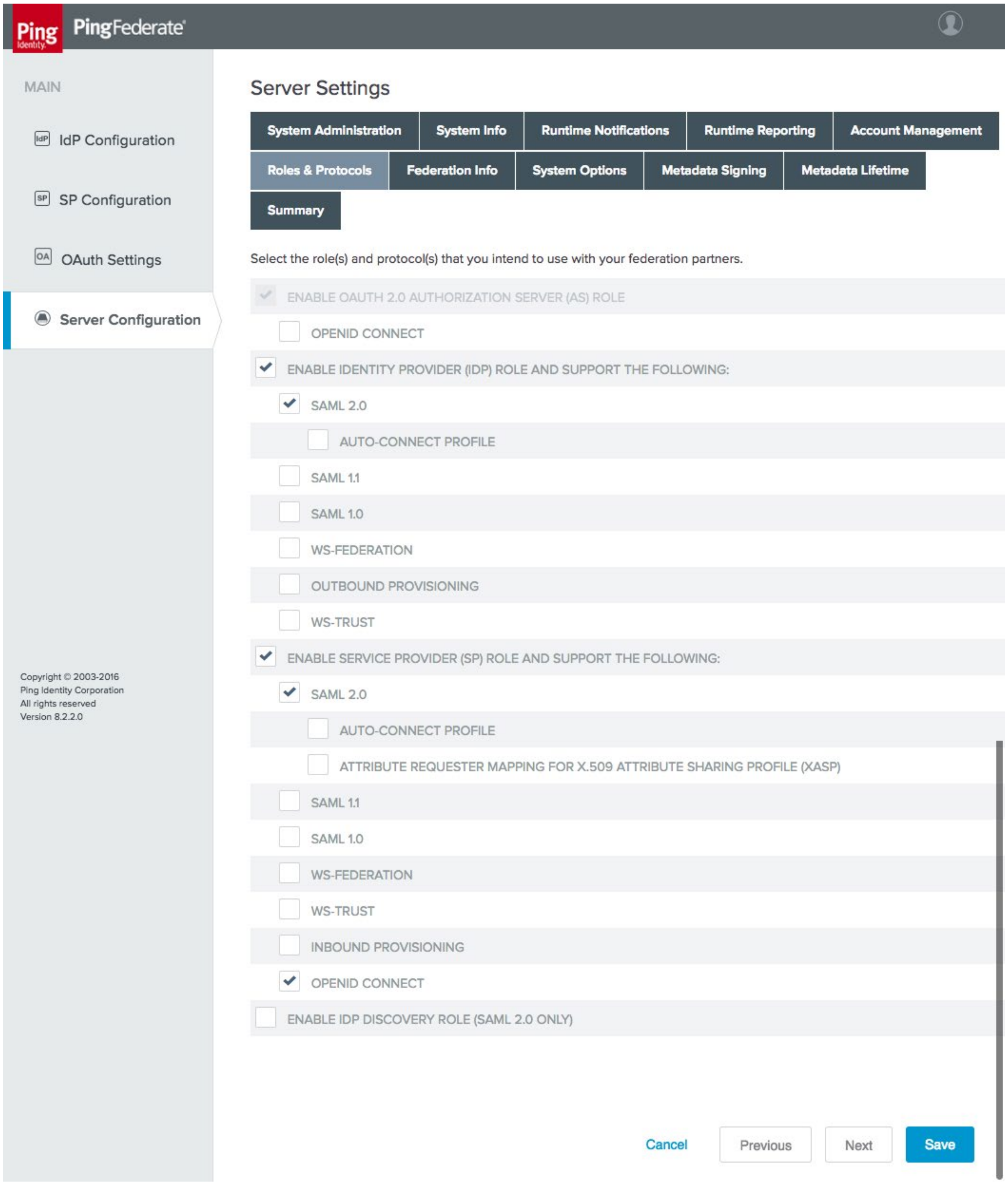
Figure 3-2 Server Roles for AS



Server Settings

Select the role(s) and protocol(s) that you intend to use with your federation partners.

- [✓] ENABLE OAUTH 2.0 AUTHORIZATION SERVER (AS) ROLE
  - [ ] OPENID CONNECT
- [✓] ENABLE IDENTITY PROVIDER (IDP) ROLE AND SUPPORT THE FOLLOWING:
  - [✓] SAML 2.0
    - [ ] AUTO-CONNECT PROFILE
  - [ ] SAML 1.1
  - [ ] SAML 1.0
  - [ ] WS-FEDERATION
  - [ ] OUTBOUND PROVISIONING
  - [ ] WS-TRUST
- [✓] ENABLE SERVICE PROVIDER (SP) ROLE AND SUPPORT THE FOLLOWING:
  - [✓] SAML 2.0
    - [ ] AUTO-CONNECT PROFILE
    - [ ] ATTRIBUTE REQUESTER MAPPING FOR X.509 ATTRIBUTE SHARING PROFILE (XASP)
  - [ ] SAML 1.1
  - [ ] SAML 1.0
  - [ ] WS-FEDERATION
  - [ ] WS-TRUST
  - [ ] INBOUND PROVISIONING
  - [✓] OPENID CONNECT
- [ ] ENABLE IDP DISCOVERY ROLE (SAML 2.0 ONLY)

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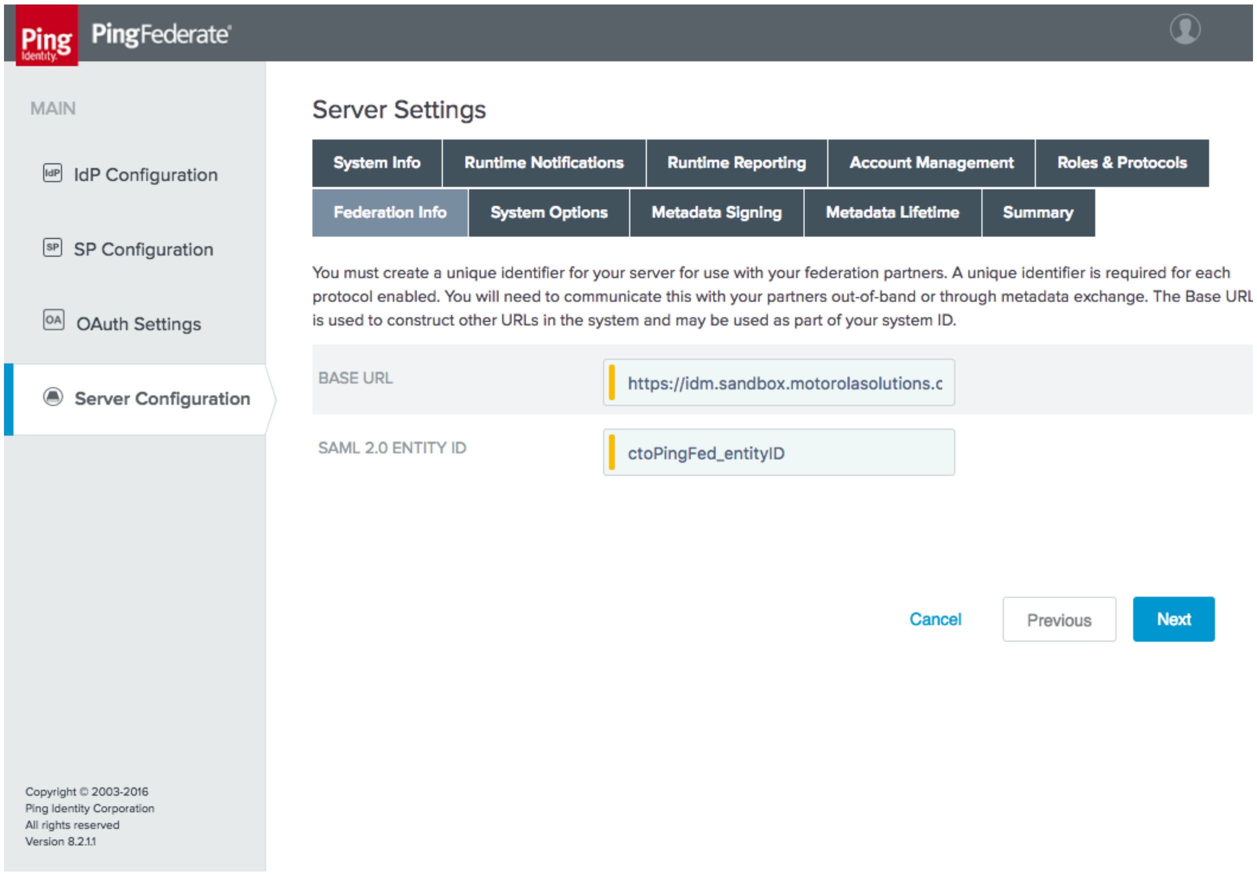
   c. Also under **Server Settings**, on the **Federation Info** tab, enter the **BASE URL** and **SAML 2.0 ENTITY ID** (Figure 3-3). The **BASE URL** should use a public DNS name that is resolvable by any federation partners. The **SAML 2.0 ENTITY ID** is simply an identifier string that must be unique among federation partners; it is recommended to be a Uniform Resource Identifier (URI), per the SAML 2.0 Core specification [22].

Figure 3-3 Federation Info



You must create a unique identifier for your server for use with your federation partners. A unique identifier is required for each protocol enabled. You will need to communicate this with your partners out-of-band or through metadata exchange. The Base URL is used to construct other URLs in the system and may be used as part of your system ID.

BASE URL	https://idm.sandbox.motorolasolutions.c
SAML 2.0 ENTITY ID	ctoPingFed_entityID

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).

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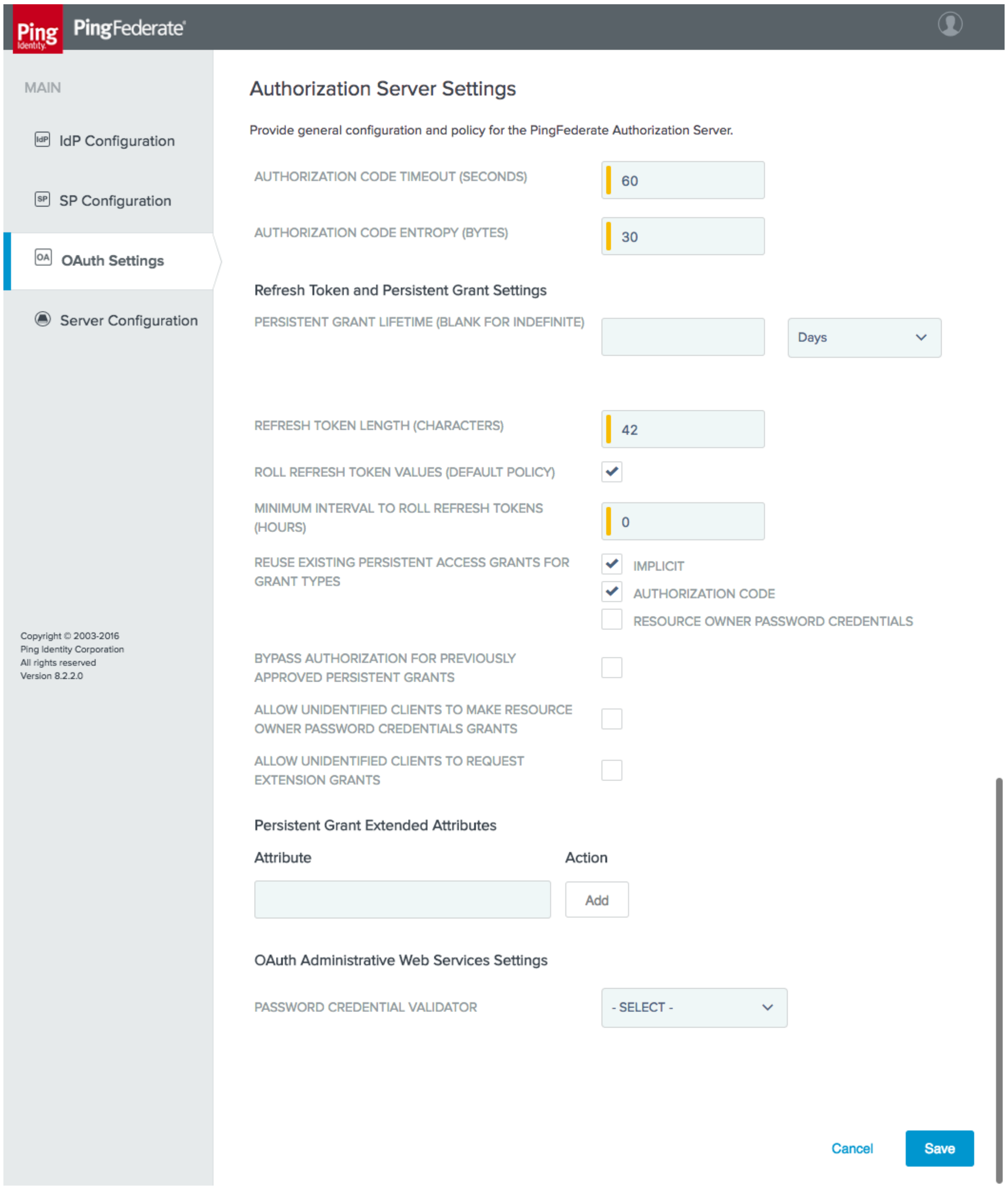
Figure 3-4 AS Settings



Authorization Server Settings

Provide general configuration and policy for the PingFederate Authorization Server.

AUTHORIZATION CODE TIMEOUT (SECONDS)	60
AUTHORIZATION CODE ENTROPY (BYTES)	30

Refresh Token and Persistent Grant Settings

PERSISTENT GRANT LIFETIME (BLANK FOR INDEFINITE)	Days
REFRESH TOKEN LENGTH (CHARACTERS)	42
ROLL REFRESH TOKEN VALUES (DEFAULT POLICY)	✓
MINIMUM INTERVAL TO ROLL REFRESH TOKENS (HOURS)	0
REUSE EXISTING PERSISTENT ACCESS GRANTS FOR GRANT TYPES	✓ IMPLICIT ✓ AUTHORIZATION CODE ☐ RESOURCE OWNER PASSWORD CREDENTIALS
BYPASS AUTHORIZATION FOR PREVIOUSLY APPROVED PERSISTENT GRANTS	☐
ALLOW UNIDENTIFIED CLIENTS TO MAKE RESOURCE OWNER PASSWORD CREDENTIALS GRANTS	☐
ALLOW UNIDENTIFIED CLIENTS TO REQUEST EXTENSION GRANTS	☐

Persistent Grant Extended Attributes

Attribute	Action
	Add

OAuth Administrative Web Services Settings

PASSWORD CREDENTIAL VALIDATOR	- SELECT -

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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)* [23], 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 HTTP Basic authentication if the OAuth Representational State Transfer Web Service is used for managing client applications; this functionality was not used for this build.

3. Next, configure scopes, as required, for the application. Click the **OAuth Settings** section tab, and then click **Scope Management**. The specific scope values will be determined by the client application 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 applications suite.

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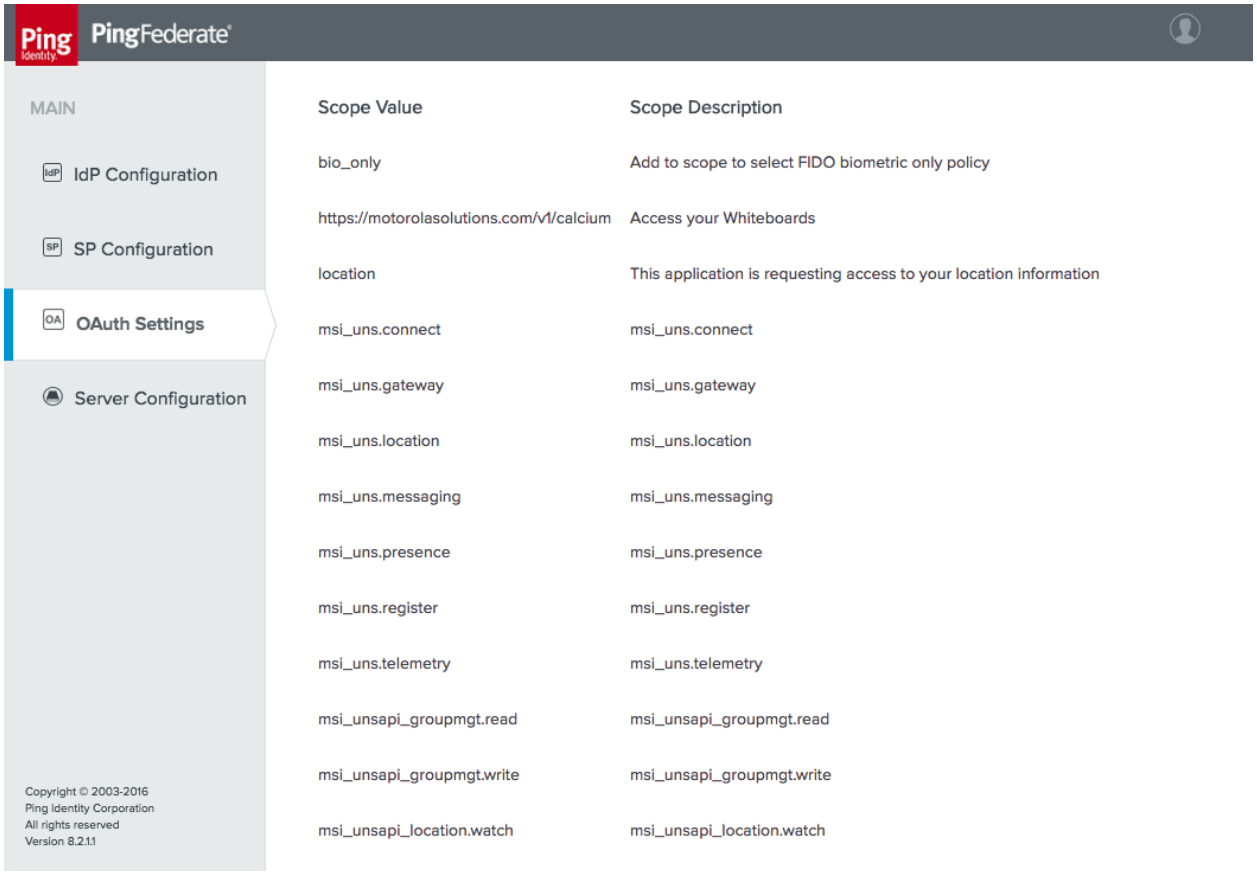
Figure 3-5 Scopes



Scope Value	Scope Description
bio_only	Add to scope to select FIDO biometric only policy
https://motorolasolutions.com/v1/calcium	Access your Whiteboards
location	This application is requesting access to your location information
msi_uns.connect	msi_uns.connect
msi_uns.gateway	msi_uns.gateway
msi_uns.location	msi_uns.location
msi_uns.messaging	msi_uns.messaging
msi_uns.presence	msi_uns.presence
msi_uns.register	msi_uns.register
msi_uns.telemetry	msi_uns.telemetry
msi_unsapi_groupmgt.read	msi_unsapi_groupmgt.read
msi_unsapi_groupmgt.write	msi_unsapi_groupmgt.write
msi_unsapi_location.watch	msi_unsapi_location.watch

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

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

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

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

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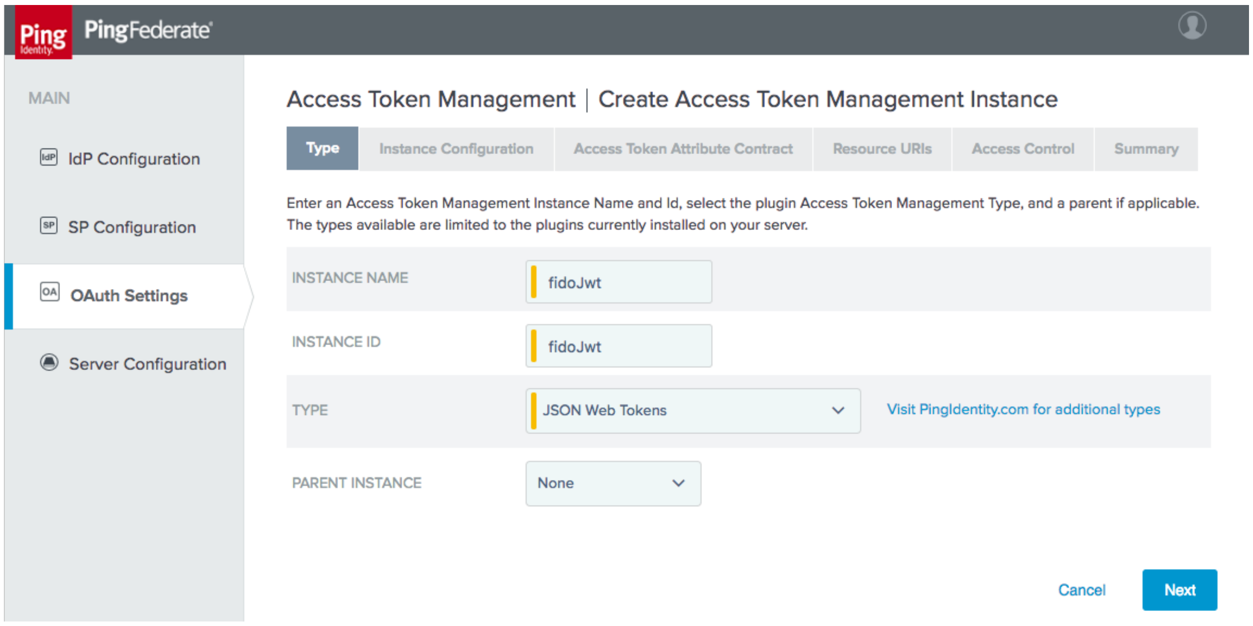
Figure 3-6 Access Token Management Instance



Access Token Management | Create Access Token Management Instance

Enter an Access Token Management Instance Name and Id, select the plugin Access Token Management Type, and a parent if applicable. The types available are limited to the plugins currently installed on your server.

INSTANCE NAME	fidoJwt
INSTANCE ID	fidoJwt
TYPE	JSON Web Tokens
PARENT INSTANCE	None

5. On the next tab, **Instance Configuration**, select a symmetric key or certificate to use for JWT signing (Figure 3-7). In this instance, a signing certificate was created as described in Section 3.2.4. Tokens can also optionally be encrypted using JSON Web Encryption (JWE) [24]; in this case, the client developer would provide a certificate in order to receive encrypted messages. JWE was not used in the lab build.

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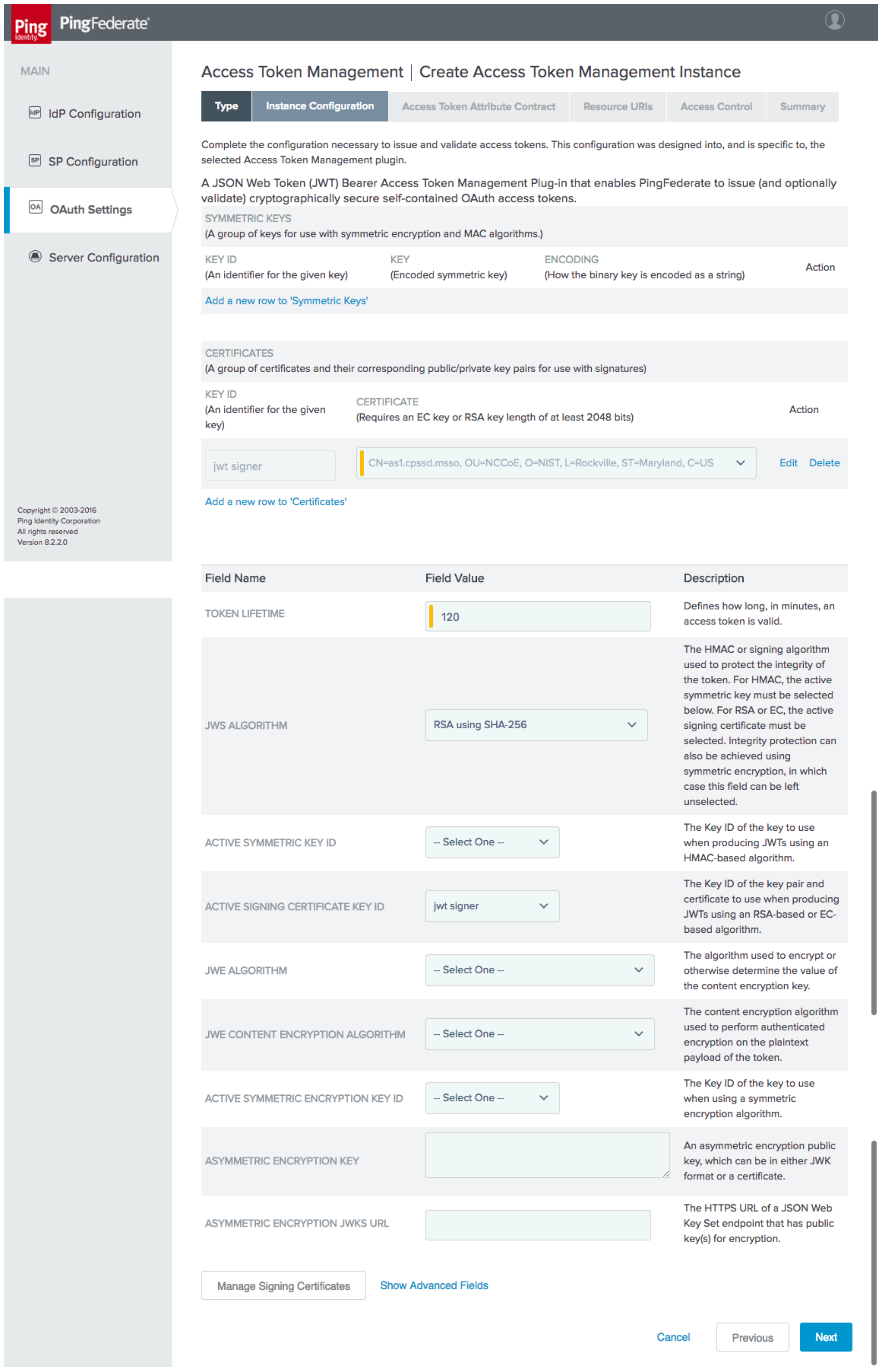
Figure 3-7 Access Token Manager Instance Configuration



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Access Token Management | Create Access Token Management Instance

Complete the configuration necessary to issue and validate access tokens. This configuration was designed into, and is specific to, the selected Access Token Management plugin.

A JSON Web Token (JWT) Bearer Access Token Management Plug-in that enables PingFederate to issue (and optionally validate) cryptographically secure self-contained OAuth access tokens.

SYMMETRIC KEYS
(A group of keys for use with symmetric encryption and MAC algorithms.)

KEY ID (An identifier for the given key)	KEY (Encoded symmetric key)	ENCODING (How the binary key is encoded as a string)	Action

Add a new row to 'Symmetric Keys'

CERTIFICATES
(A group of certificates and their corresponding public/private key pairs for use with signatures)

KEY ID (An identifier for the given key)	CERTIFICATE (Requires an EC key or RSA key length of at least 2048 bits)	Action
jwt signer	CN=as1.cpssd.msso, OU=NCCoE, O=NIST, L=Rockville, ST=Maryland, C=US	Edit Delete

Add a new row to 'Certificates'

Field Name	Field Value	Description
TOKEN LIFETIME	120	Defines how long, in minutes, an access token is valid.
JWS ALGORITHM	RSA using SHA-256	The HMAC or signing algorithm used to protect the integrity of the token. For HMAC, the active symmetric key must be selected below. For RSA or EC, the active signing certificate must be selected. Integrity protection can also be achieved using symmetric encryption, in which case this field can be left unselected.
ACTIVE SYMMETRIC KEY ID	-- Select One --	The Key ID of the key to use when producing JWTs using an HMAC-based algorithm.
ACTIVE SIGNING CERTIFICATE KEY ID	jwt signer	The Key ID of the key pair and certificate to use when producing JWTs using an RSA-based or EC-based algorithm.
JWE ALGORITHM	-- Select One --	The algorithm used to encrypt or otherwise determine the value of the content encryption key.
JWE CONTENT ENCRYPTION ALGORITHM	-- Select One --	The content encryption algorithm used to perform authenticated encryption on the plaintext payload of the token.
ACTIVE SYMMETRIC ENCRYPTION KEY ID	-- Select One --	The Key ID of the key to use when using a symmetric encryption algorithm.
ASYMMETRIC ENCRYPTION KEY		An asymmetric encryption public key, which can be in either JWK format or a certificate.
ASYMMETRIC ENCRYPTION JWKS URL		The HTTPS URL of a JSON Web Key Set endpoint that has public key(s) for encryption.

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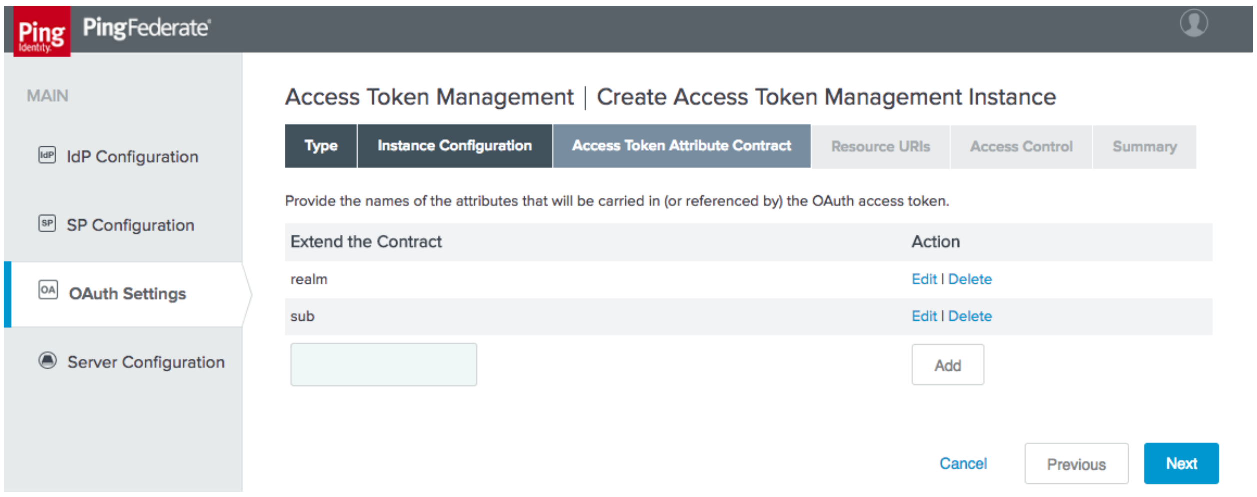
6. On the **Access Token Attribute Contract** tab, add the two values **realm** and **sub** to the attribute contract (Figure 3-8).

Figure 3-8 Access Token Manager Attribute Contract



Access Token Management | Create Access Token Management Instance

Provide the names of the attributes that will be carried in (or referenced by) the OAuth access token.

Extend the Contract	Action
realm	Edit I Delete
sub	Edit I Delete
	Add

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 application 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.

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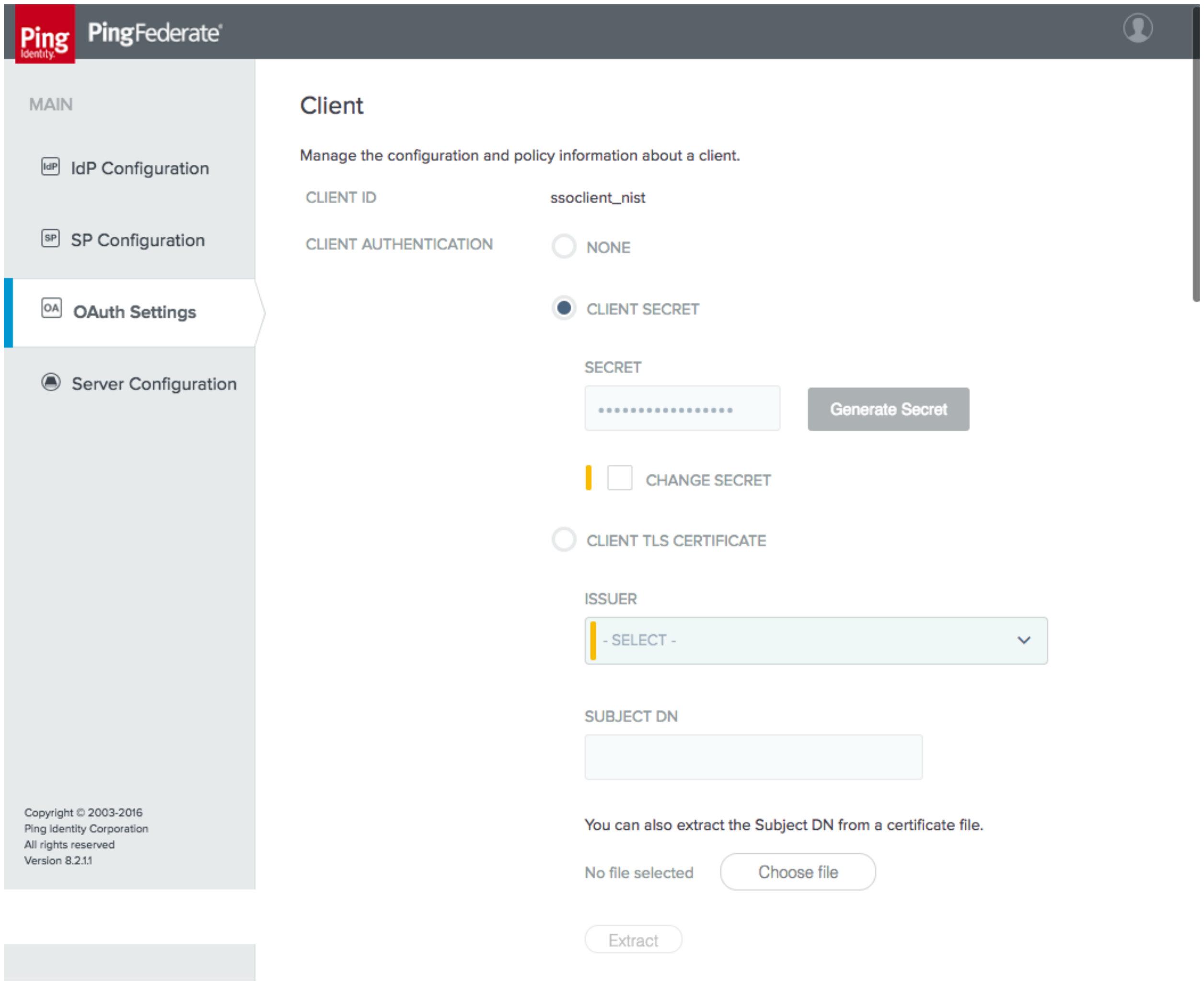
Figure 3-9 OAuth Client Registration, Part 1



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Client

Manage the configuration and policy information about a client.

CLIENT ID ssoclient_nist

CLIENT AUTHENTICATION ○ NONE [✓ ● CLIENT SECRET] ○ CLIENT TLS CERTIFICATE

SECRET ••••••••••••••••

☐ CHANGE SECRET

ISSUER - SELECT -

SUBJECT DN

You can also extract the Subject DN from a certificate file.

No file selected

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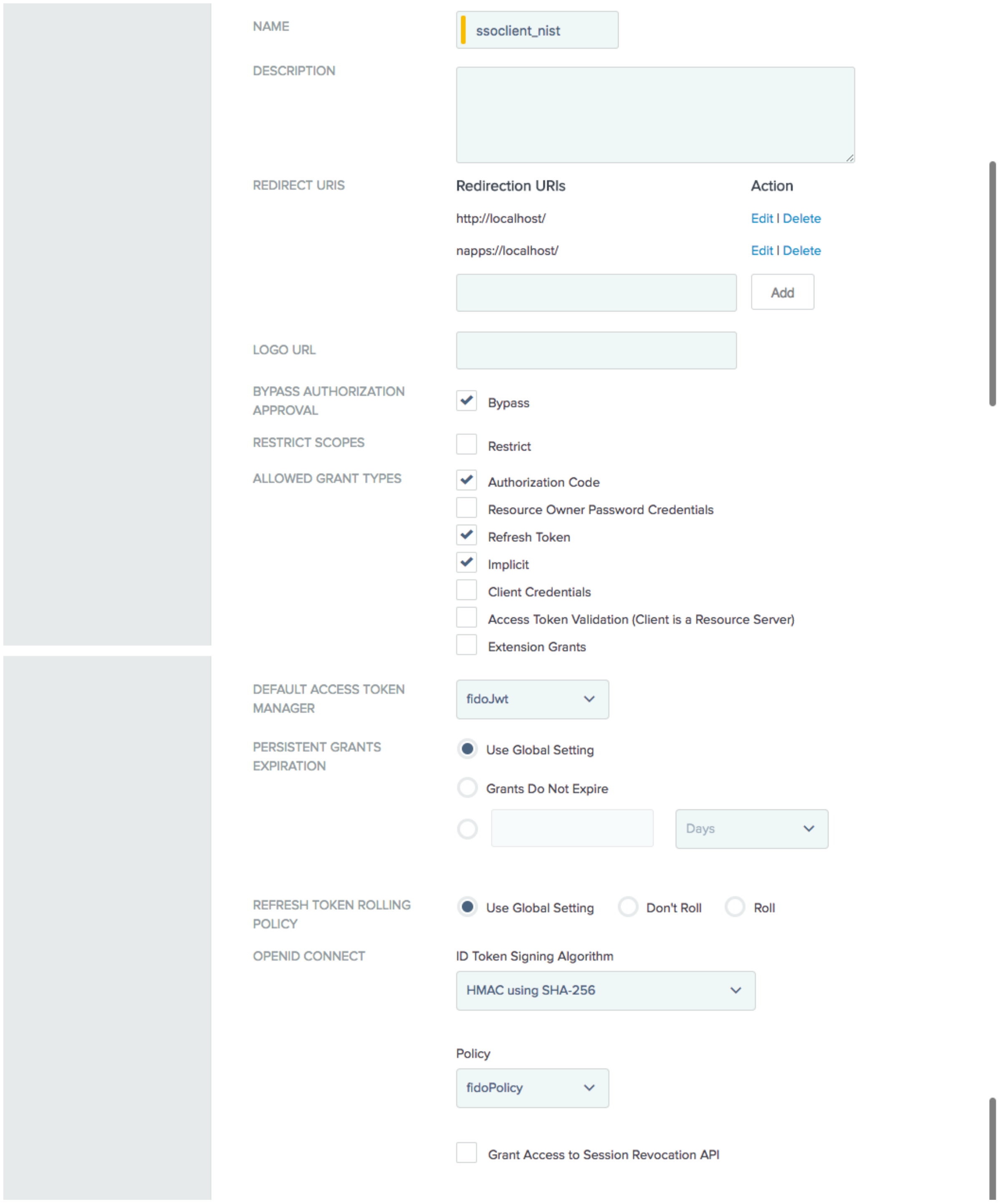
Figure 3-10 OAuth Client Registration, Part 2



NAME	ssoclient_nist
DESCRIPTION	
REDIRECT URIS	Redirection URIs / Action: http://localhost/ — Edit | Delete; napps://localhost/ — Edit | Delete
LOGO URL	
BYPASS AUTHORIZATION APPROVAL	[✓ Bypass]
RESTRICT SCOPES	Restrict
ALLOWED GRANT TYPES	[✓ Authorization Code], Resource Owner Password Credentials, [✓ Refresh Token], [✓ Implicit], Client Credentials, Access Token Validation (Client is a Resource Server), Extension Grants
DEFAULT ACCESS TOKEN MANAGER	fidoJwt
PERSISTENT GRANTS EXPIRATION	[✓ Use Global Setting], Grants Do Not Expire, Days
REFRESH TOKEN ROLLING POLICY	[✓ Use Global Setting], Don't Roll, Roll
OPENID CONNECT	ID Token Signing Algorithm: HMAC using SHA-256; Policy: fidoPolicy; Grant Access to Session Revocation API

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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 applications on the test devices.
- **CLIENT AUTHENTICATION**: This may be set to **NONE**, **CLIENT SECRET** (for HTTP basic authentication), or **CLIENT TLS CERTIFICATE**. For native mobile application clients, there is no way to protect a client secret or private key and provide it to all instances of the application with any guarantee of confidentiality, as a user might be able to reverse-engineer the application to obtain any secrets delivered with it, or to debug the application to capture any secrets delivered at runtime. Therefore, a value of **NONE** is acceptable for native mobile applications, 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**: Redirect 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 application 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.

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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.

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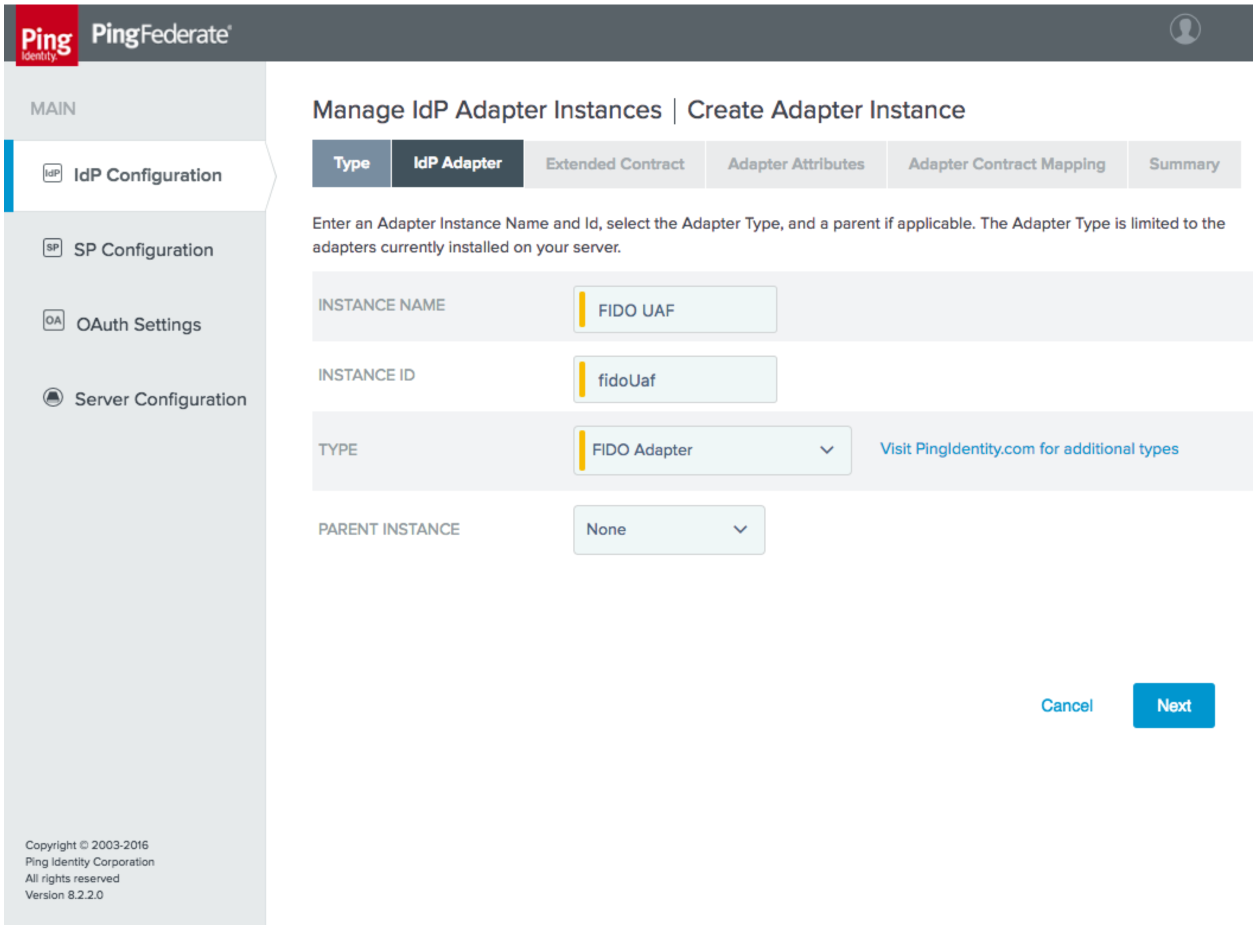
Figure 3-11 Create Adapter Instance



Manage IdP Adapter Instances | Create Adapter Instance

Enter an Adapter Instance Name and Id, select the Adapter Type, and a parent if applicable. The Adapter Type is limited to the adapters currently installed on your server.

INSTANCE NAME	FIDO UAF
INSTANCE ID	fidoUaf
TYPE	FIDO Adapter
PARENT INSTANCE	None

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

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

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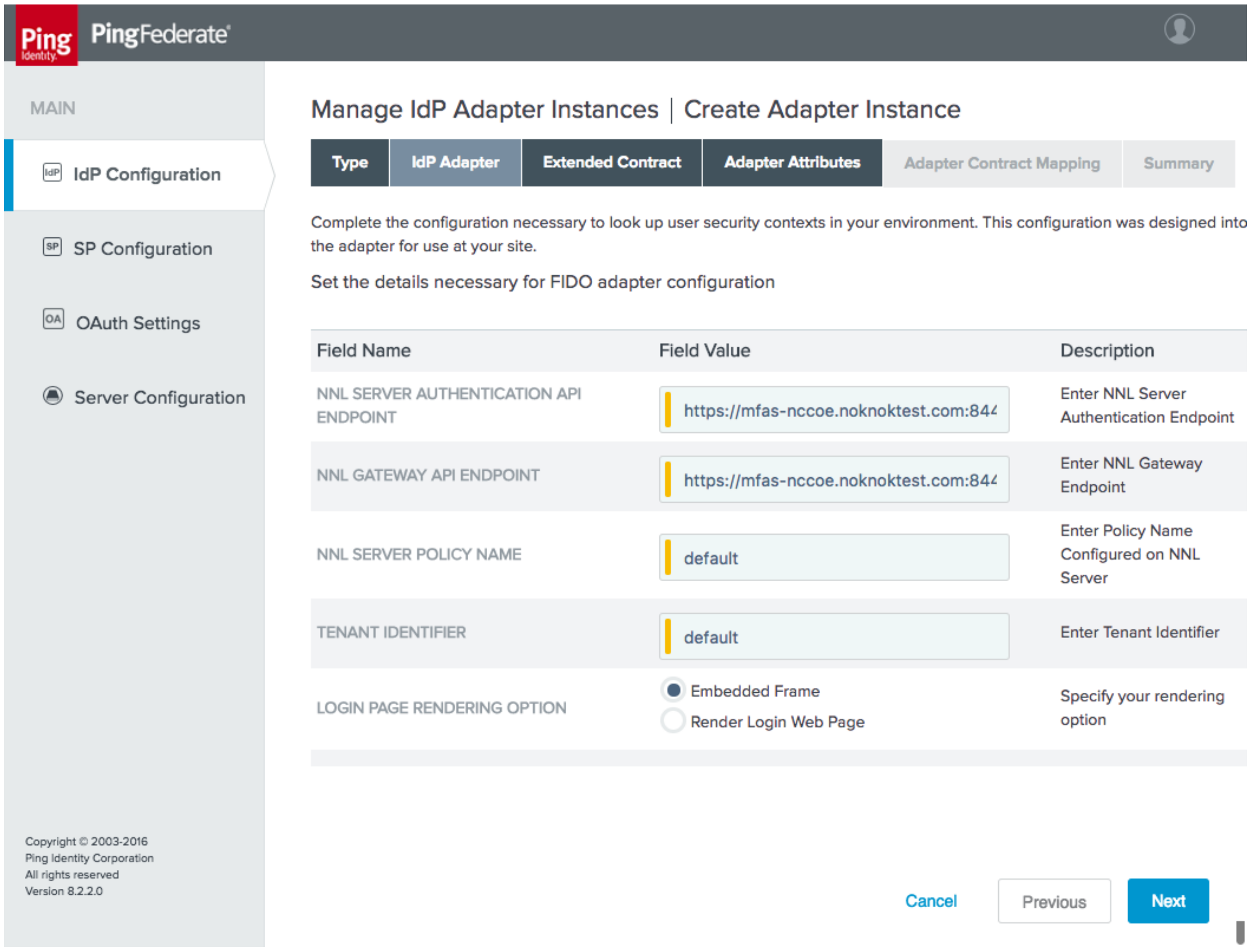
Figure 3-12 FIDO Adapter Settings



Manage IdP Adapter Instances | Create Adapter Instance

Complete the configuration necessary to look up user security contexts in your environment. This configuration was designed into the adapter for use at your site.

Set the details necessary for FIDO adapter configuration

Field Name	Field Value	Description
NNL SERVER AUTHENTICATION API ENDPOINT	https://mfas-nccoe.noknoktest.com:844	Enter NNL Server Authentication Endpoint
NNL GATEWAY API ENDPOINT	https://mfas-nccoe.noknoktest.com:844	Enter NNL Gateway Endpoint
NNL SERVER POLICY NAME	default	Enter Policy Name Configured on NNL Server
TENANT IDENTIFIER	default	Enter Tenant Identifier
LOGIN PAGE RENDERING OPTION	● Embedded Frame ○ Render Login Web Page	Specify your rendering option

c. The **Extended Contract** tab also stayed as the default for the adapter, which provides the **riskscore**, **transactionid**, **transactiontext**, and **username** values (Figure 3-13). If desired, additional attributes could be added to the contract and looked up in a user directory, based on the username returned from the adapter.

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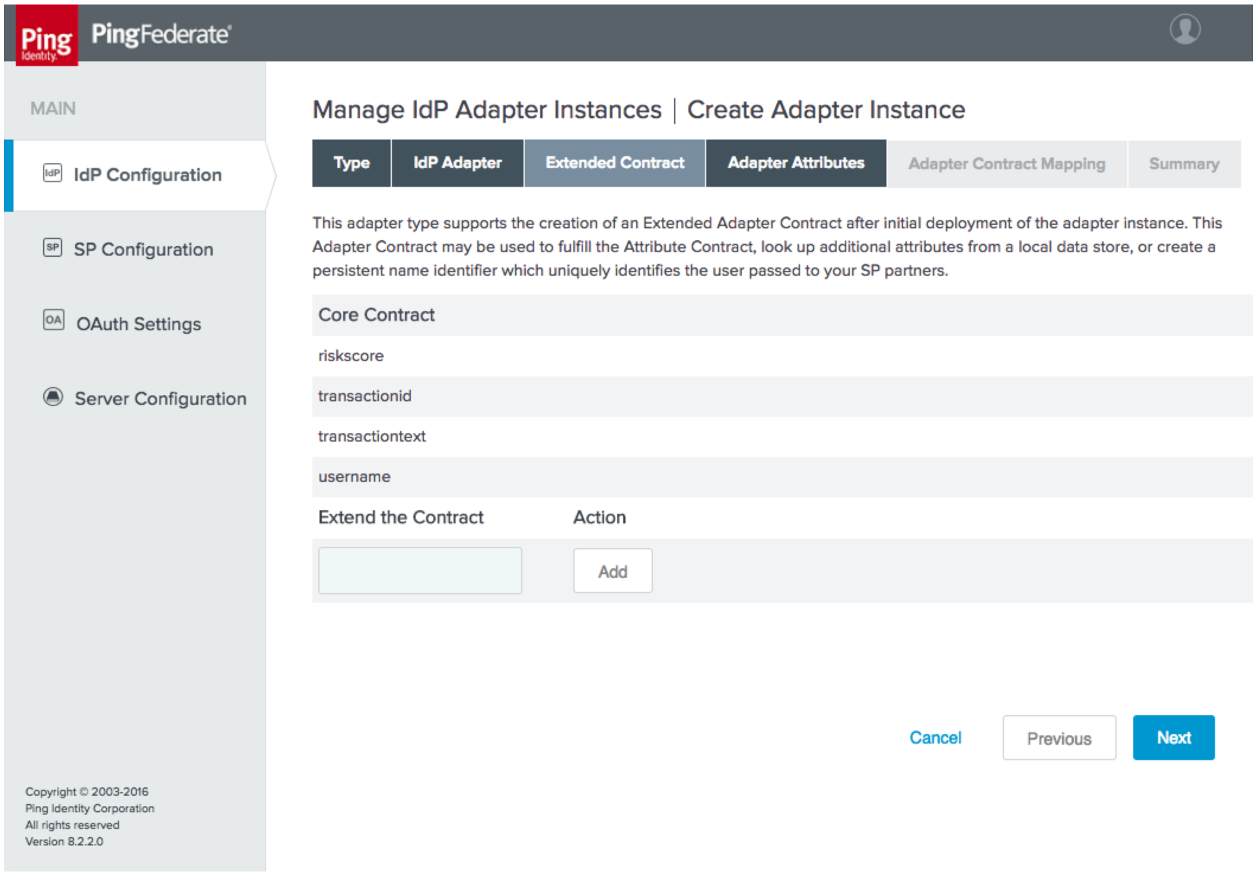
Figure 3-13 FIDO Adapter Contract



Manage IdP Adapter Instances | Create Adapter Instance

This adapter type supports the creation of an Extended Adapter Contract after initial deployment of the adapter instance. This Adapter Contract may be used to fulfill the Attribute Contract, look up additional attributes from a local data store, or create a persistent name identifier which uniquely identifies the user passed to your SP partners.

Core Contract
riskscore
transactionid
transactiontext
username

Extend the Contract	Action
	Add

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

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

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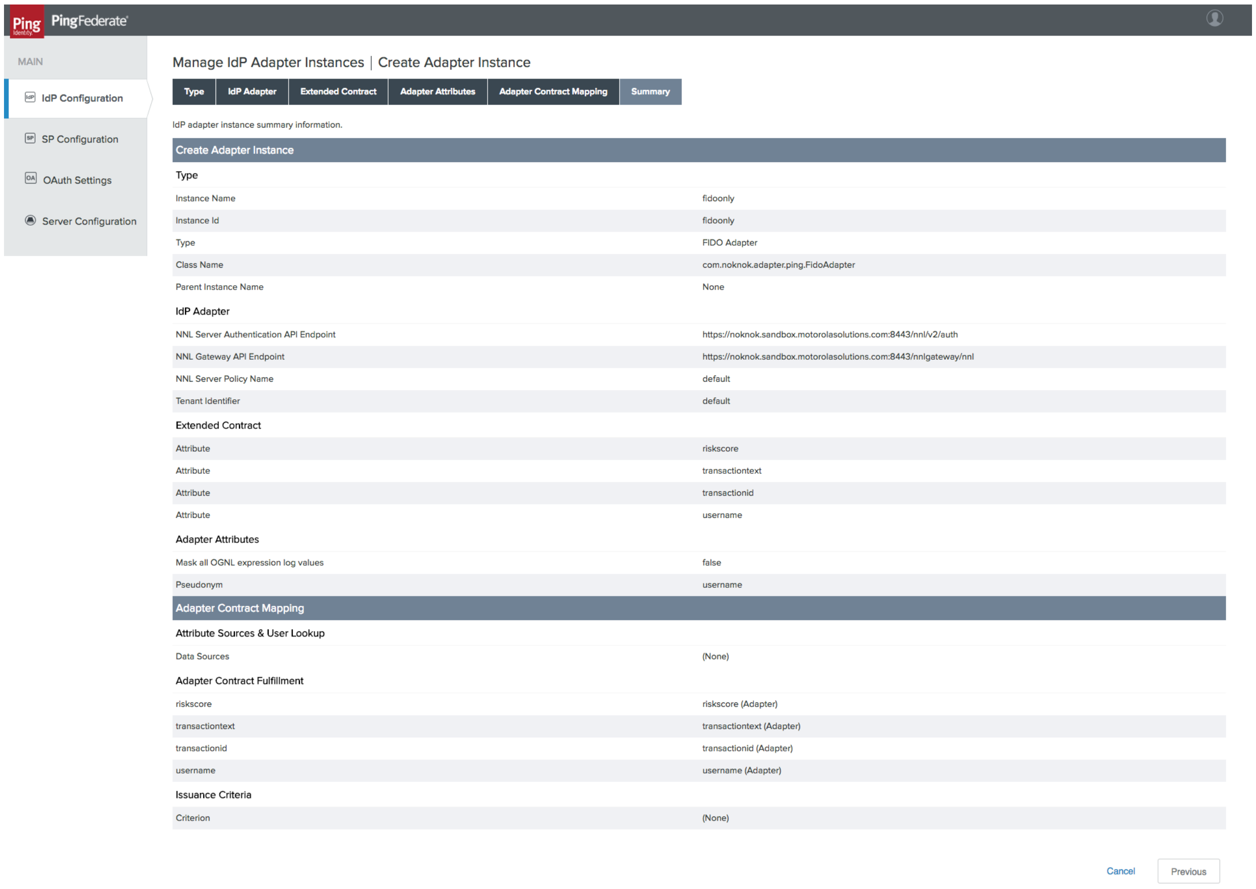
Figure 3-14 FIDO Adapter Instance Summary



Manage IdP Adapter Instances | Create Adapter Instance

IdP adapter instance summary information.

Create Adapter Instance

Type	
Instance Name	fidoonly
Instance Id	fidoonly
Type	FIDO Adapter
Class Name	com.noknok.adapter.ping.FidoAdapter
Parent Instance Name	None
IdP Adapter	
NNL Server Authentication API Endpoint	https://noknok.sandbox.motorolasolutions.com:8443/nnl/v2/auth
NNL Gateway API Endpoint	https://noknok.sandbox.motorolasolutions.com:8443/nnlgateway/nnl
NNL Server Policy Name	default
Tenant Identifier	default
Extended Contract	
Attribute	riskscore
Attribute	transactiontext
Attribute	transactionid
Attribute	username
Adapter Attributes	
Mask all OGNL expression log values	false
Pseudonym	username

Adapter Contract Mapping

Attribute Sources & User Lookup	
Data Sources	(None)
Adapter Contract Fulfillment	
riskscore	riskscore (Adapter)
transactiontext	transactiontext (Adapter)
transactionid	transactionid (Adapter)
username	username (Adapter)
Issuance Criteria	
Criterion	(None)

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

3.4.1.2 Create Policy Contract

1. To create a Policy Contract, navigate to the **IdP Configuration** section tab, and select **Policy Contracts** under **Authentication Policies**. A policy contract defines the set of attributes that will be provided by an authentication policy.
2. Click **Create New Contract**.
    a. On the **Contract Info** tab, give the contract a meaningful name (Figure 3-15).

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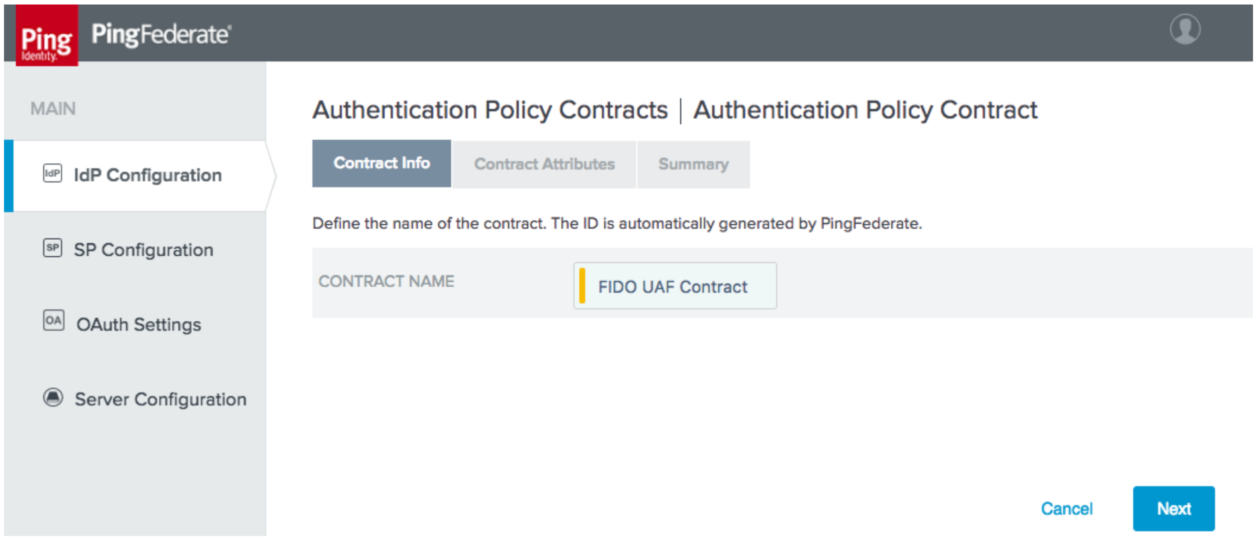
Figure 3-15 Policy Contract Information



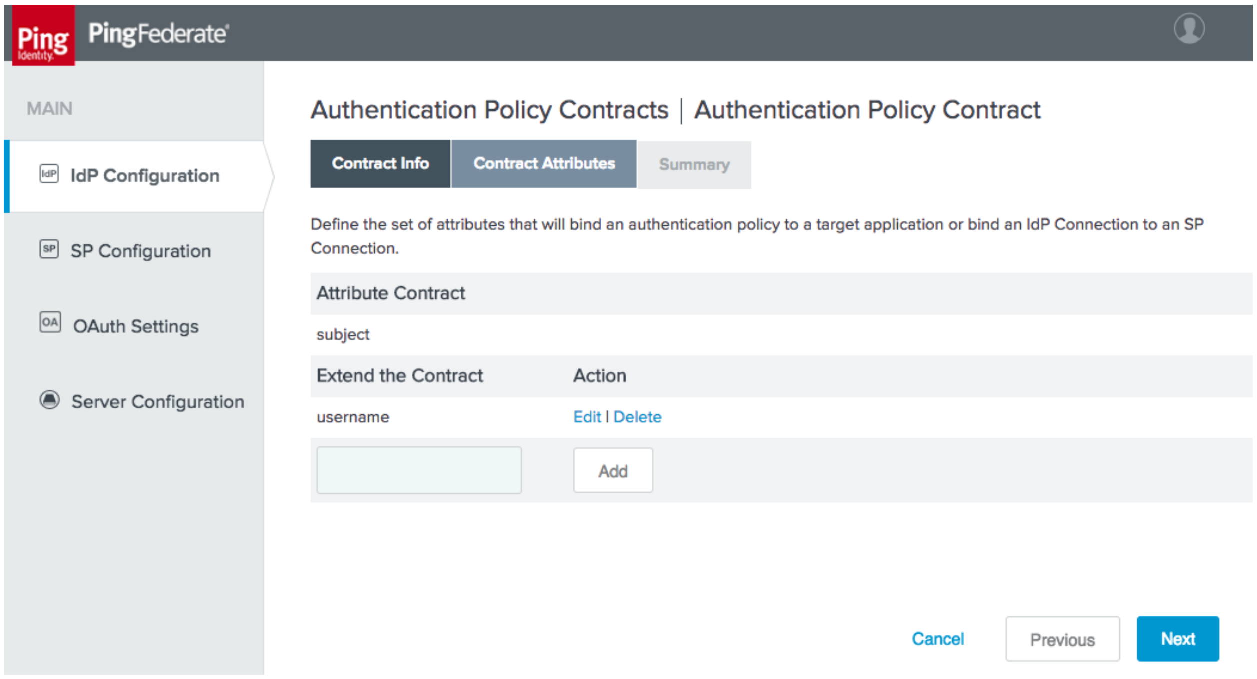
Authentication Policy Contracts | Authentication Policy Contract

Define the name of the contract. The ID is automatically generated by PingFederate.

CONTRACT NAME: FIDO UAF Contract

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

Figure 3-16 Policy Contract Attributes



Authentication Policy Contracts | Authentication Policy Contract

Define the set of attributes that will bind an authentication policy to a target application or bind an IdP Connection to an SP Connection.

Attribute Contract	
subject	

Extend the Contract	Action
username	Edit | Delete

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

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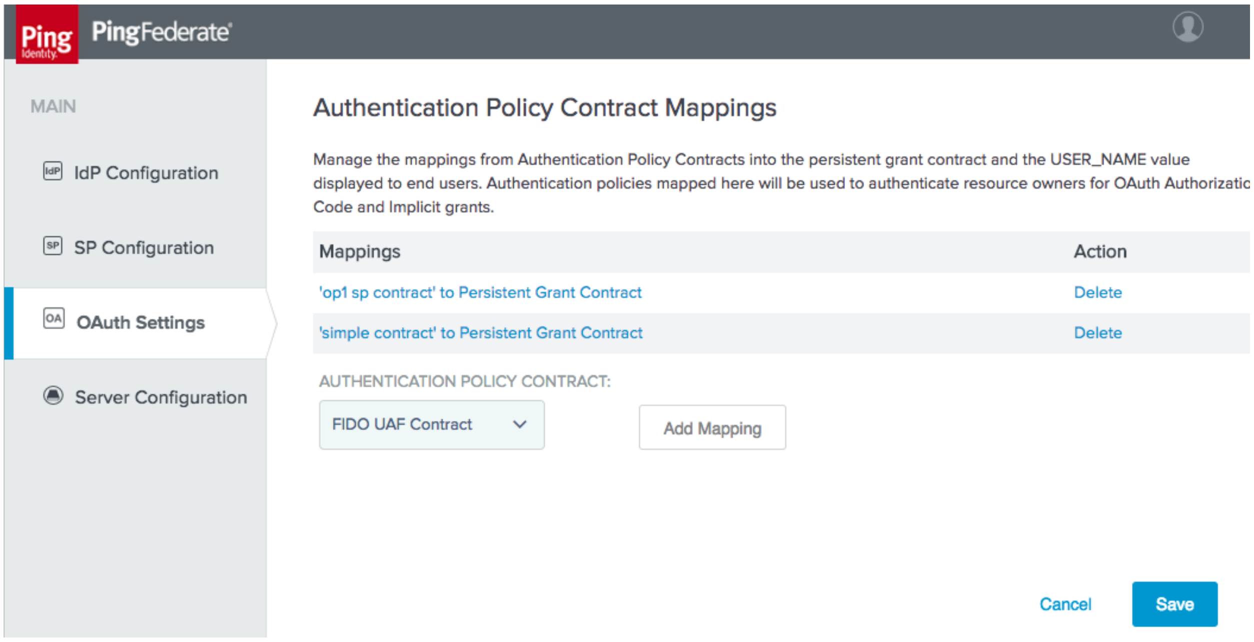
3.4.1.3 Create Policy Contract Mapping

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



Authentication Policy Contract Mappings

Manage the mappings from Authentication Policy Contracts into the persistent grant contract and the USER_NAME value displayed to end users. Authentication policies mapped here will be used to authenticate resource owners for OAuth Authorizatic Code and Implicit grants.

Mappings	Action
'op1 sp contract' to Persistent Grant Contract	Delete
'simple contract' to Persistent Grant Contract	Delete

AUTHENTICATION POLICY CONTRACT: FIDO UAF Contract

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).

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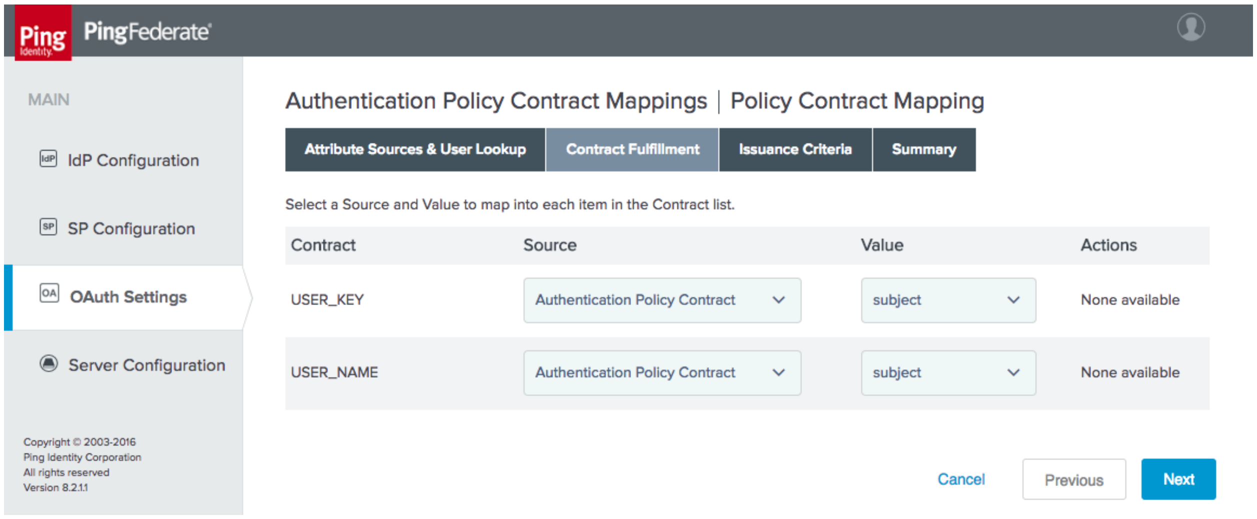
Figure 3-18 Authentication Policy Contract Fulfillment



Authentication Policy Contract Mappings | Policy Contract Mapping

Select a Source and Value to map into each item in the Contract list.

Contract	Source	Value	Actions
USER_KEY	Authentication Policy Contract	subject	None available
USER_NAME	Authentication Policy Contract	subject	None available

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

3.4.1.4 Create Access Token Mapping

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

1. On the **OAuth Settings** section tab, under **Token & Attribute Mapping**, click **Access Token Mapping**.
   a. Select **Default** for the **CONTEXT** (Figure 3-19).
   b. Select the **ACCESS TOKEN MANAGER** created previously (Figure 3-19).

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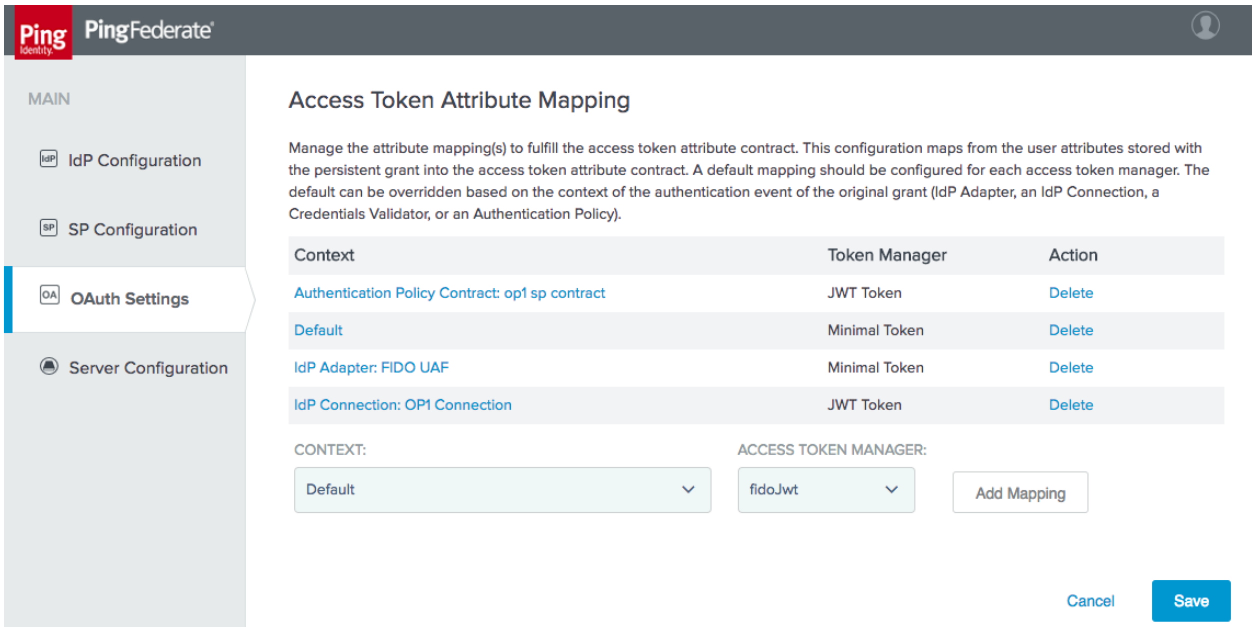
Figure 3-19 Create Access Token Attribute Mapping



Access Token Attribute Mapping

Manage the attribute mapping(s) to fulfill the access token attribute contract. This configuration maps from the user attributes stored with the persistent grant into the access token attribute contract. A default mapping should be configured for each access token manager. The default can be overridden based on the context of the authentication event of the original grant (IdP Adapter, an IdP Connection, a Credentials Validator, or an Authentication Policy).

Context	Token Manager	Action
Authentication Policy Contract: op1 sp contract	JWT Token	Delete
Default	Minimal Token	Delete
IdP Adapter: FIDO UAF	Minimal Token	Delete
IdP Connection: OP1 Connection	JWT Token	Delete

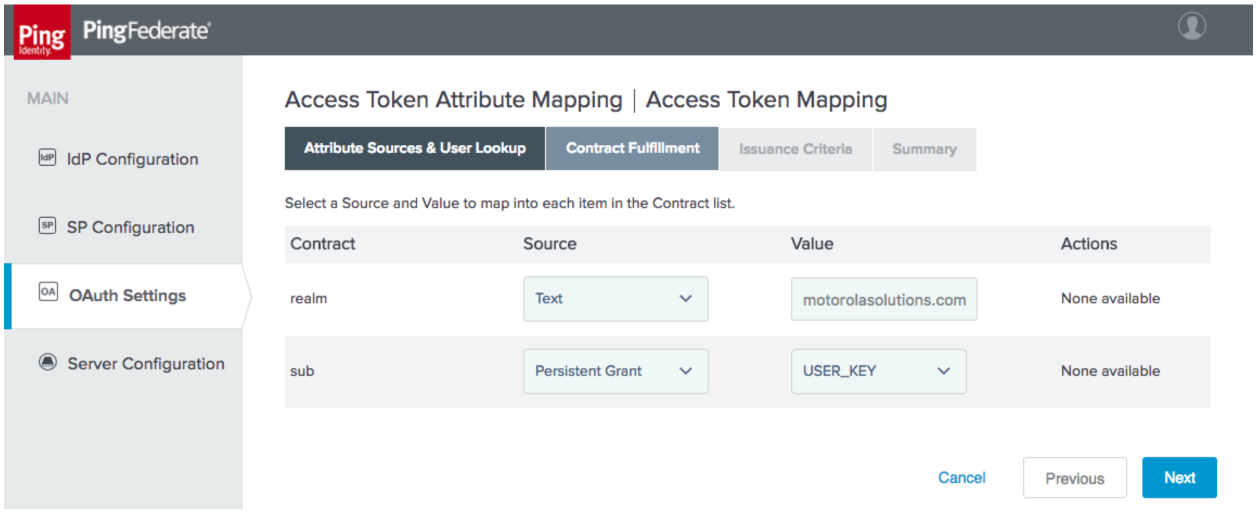
CONTEXT: Default
ACCESS TOKEN MANAGER: fidoJwt

c. Click **Add Mapping**.

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

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

Figure 3-20 Access Token Mapping Contract Fulfillment



Access Token Attribute Mapping | Access Token Mapping

Select a Source and Value to map into each item in the Contract list.

Contract	Source	Value	Actions
realm	Text	motorolasolutions.com	None available
sub	Persistent Grant	USER_KEY	None available

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   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**.

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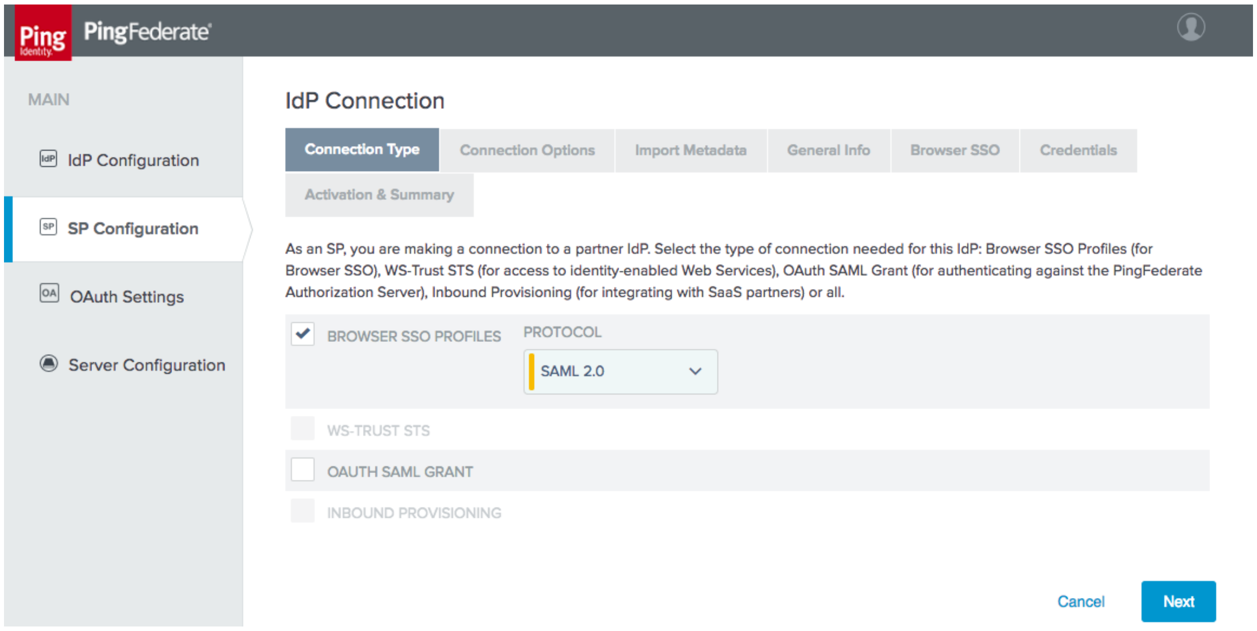
Figure 3-21 Create IdP Connection

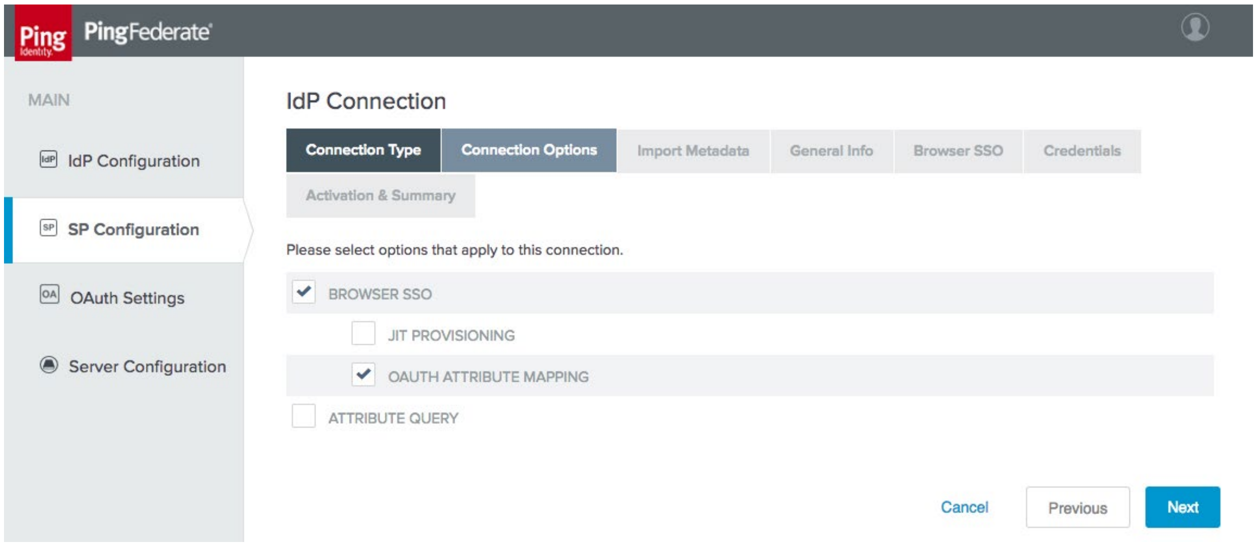


As an SP, you are making a connection to a partner IdP. Select the type of connection needed for this IdP: Browser SSO Profiles (for Browser SSO), WS-Trust STS (for access to identity-enabled Web Services), OAuth SAML Grant (for authenticating against the PingFederate Authorization Server), Inbound Provisioning (for integrating with SaaS partners) or all.

- [✓] BROWSER SSO PROFILES — PROTOCOL: SAML 2.0
- [ ] WS-TRUST STS
- [ ] OAUTH SAML GRANT
- [ ] INBOUND PROVISIONING

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

Figure 3-22 IdP Connection Options



Please select options that apply to this connection.

- [✓] BROWSER SSO
  - [ ] JIT PROVISIONING
  - [✓] OAUTH ATTRIBUTE MAPPING
- [ ] ATTRIBUTE QUERY

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

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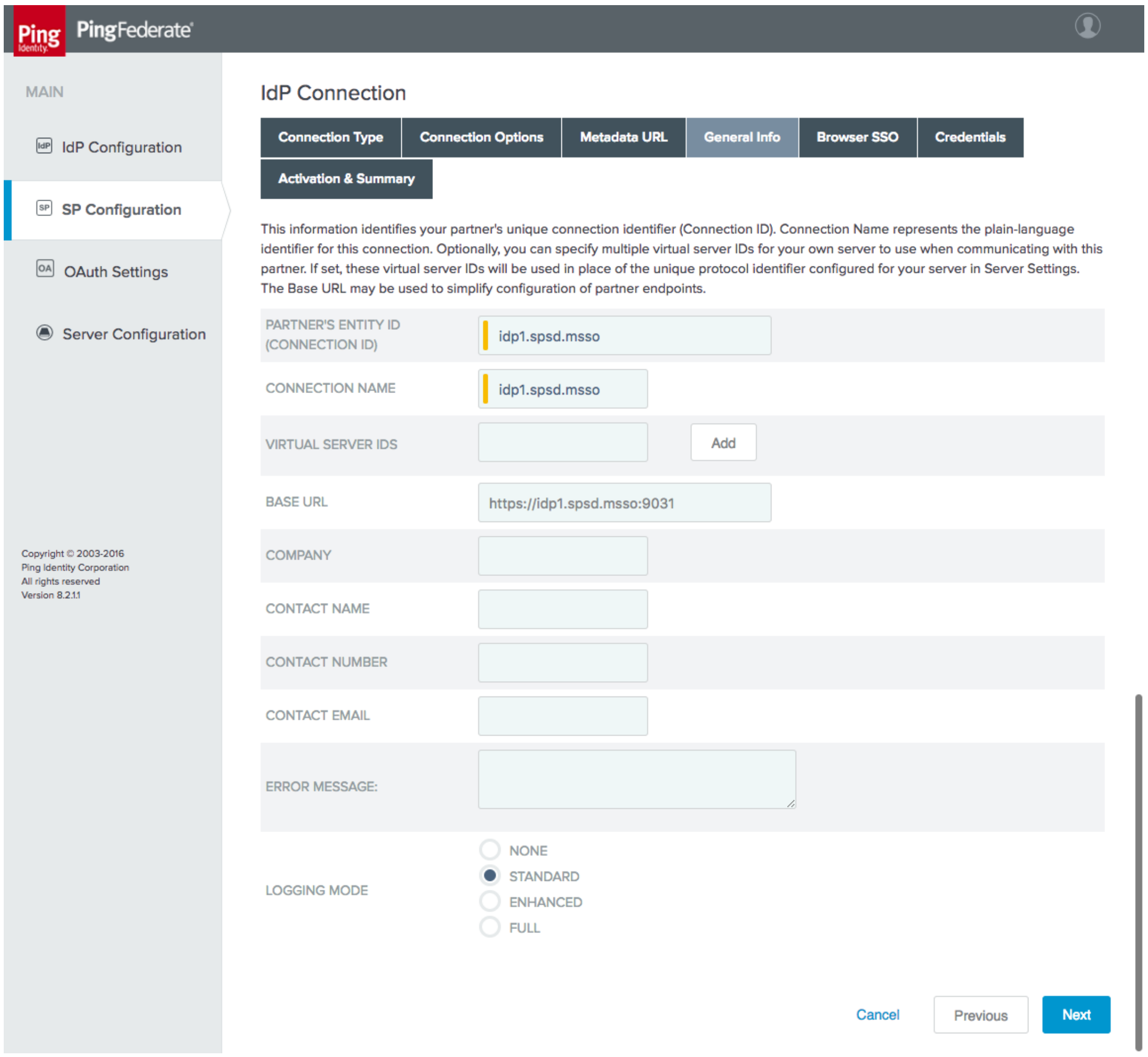
d. On the **General Info** tab, enter the **PARTNER'S ENTITY ID (CONNECTION ID)** and **BASE URL** of the IdP, and provide a **CONNECTION NAME** (Figure 3-23).

Figure 3-23 IdP Connection General Info



This information identifies your partner's unique connection identifier (Connection ID). Connection Name represents the plain-language identifier for this connection. Optionally, you can specify multiple virtual server IDs for your own server to use when communicating with this partner. If set, these virtual server IDs will be used in place of the unique protocol identifier configured for your server in Server Settings. The Base URL may be used to simplify configuration of partner endpoints.

PARTNER'S ENTITY ID (CONNECTION ID)	idp1.spsd.msso
CONNECTION NAME	idp1.spsd.msso
VIRTUAL SERVER IDS	
BASE URL	https://idp1.spsd.msso:9031
COMPANY	
CONTACT NAME	
CONTACT NUMBER	
CONTACT EMAIL	
ERROR MESSAGE:	
LOGGING MODE	NONE [✓ STANDARD] ENHANCED FULL

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).

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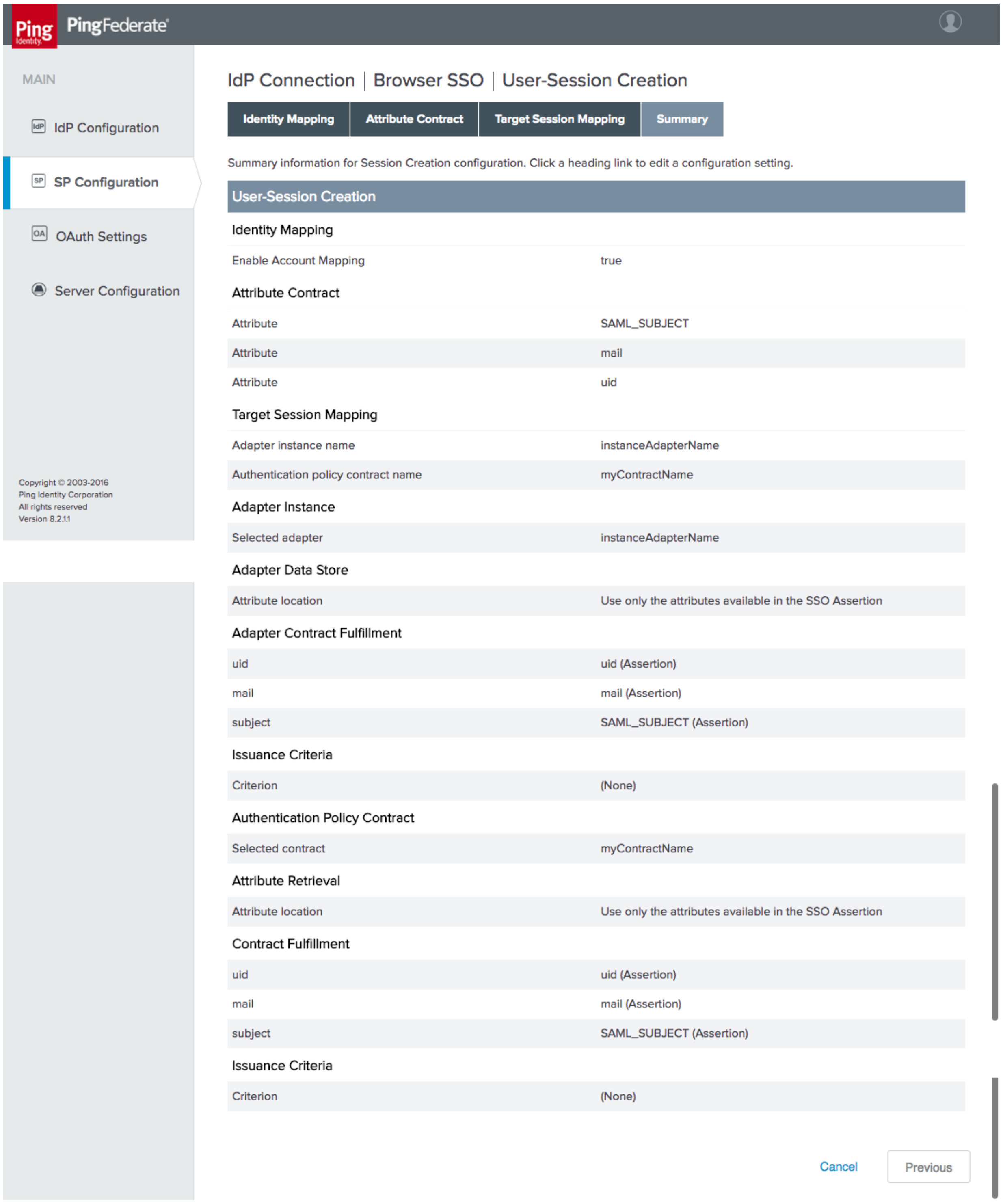
Figure 3-24 IdP Connection–User-Session Creation



IdP Connection | Browser SSO | User-Session Creation

Summary information for Session Creation configuration. Click a heading link to edit a configuration setting.

User-Session Creation

Identity Mapping	
Enable Account Mapping	true
Attribute Contract	
Attribute	SAML_SUBJECT
Attribute	mail
Attribute	uid
Target Session Mapping	
Adapter instance name	instanceAdapterName
Authentication policy contract name	myContractName
Adapter Instance	
Selected adapter	instanceAdapterName
Adapter Data Store	
Attribute location	Use only the attributes available in the SSO Assertion
Adapter Contract Fulfillment	
uid	uid (Assertion)
mail	mail (Assertion)
subject	SAML_SUBJECT (Assertion)
Issuance Criteria	
Criterion	(None)
Authentication Policy Contract	
Selected contract	myContractName
Attribute Retrieval	
Attribute location	Use only the attributes available in the SSO Assertion
Contract Fulfillment	
uid	uid (Assertion)
mail	mail (Assertion)
subject	SAML_SUBJECT (Assertion)
Issuance Criteria	
Criterion	(None)

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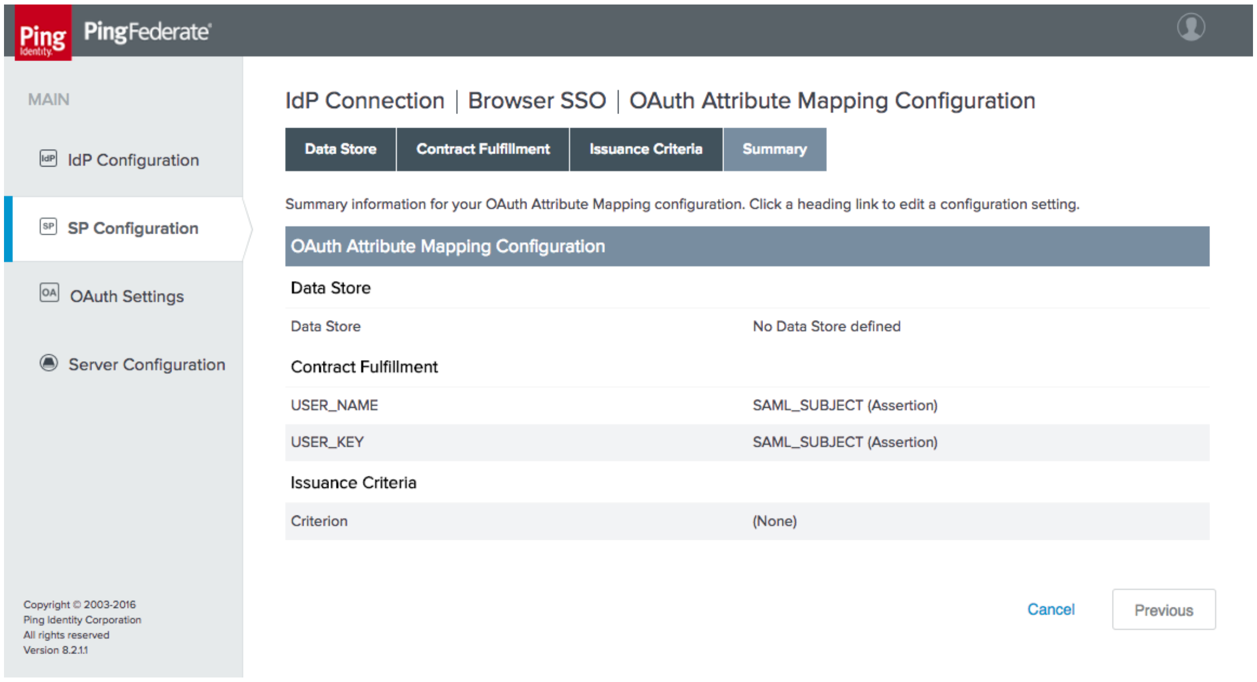
ii. On the **OAuth Attribute Mapping Configuration** tab, select **MAP DIRECTLY INTO PERSISTENT GRANT**. Configure the OAuth attribute mapping as shown in Figure 3-25. This maps both required values in the persistent grant context to the SAML subject. Click **Next**, then **Next** again to skip the **Issuance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

Figure 3-25 IdP Connection OAuth Attribute Mapping



Summary information for your OAuth Attribute Mapping configuration. Click a heading link to edit a configuration setting.

OAuth Attribute Mapping Configuration

Data Store

Data Store	No Data Store defined

Contract Fulfillment

USER_NAME	SAML_SUBJECT (Assertion)
USER_KEY	SAML_SUBJECT (Assertion)

Issuance Criteria

Criterion	(None)

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.

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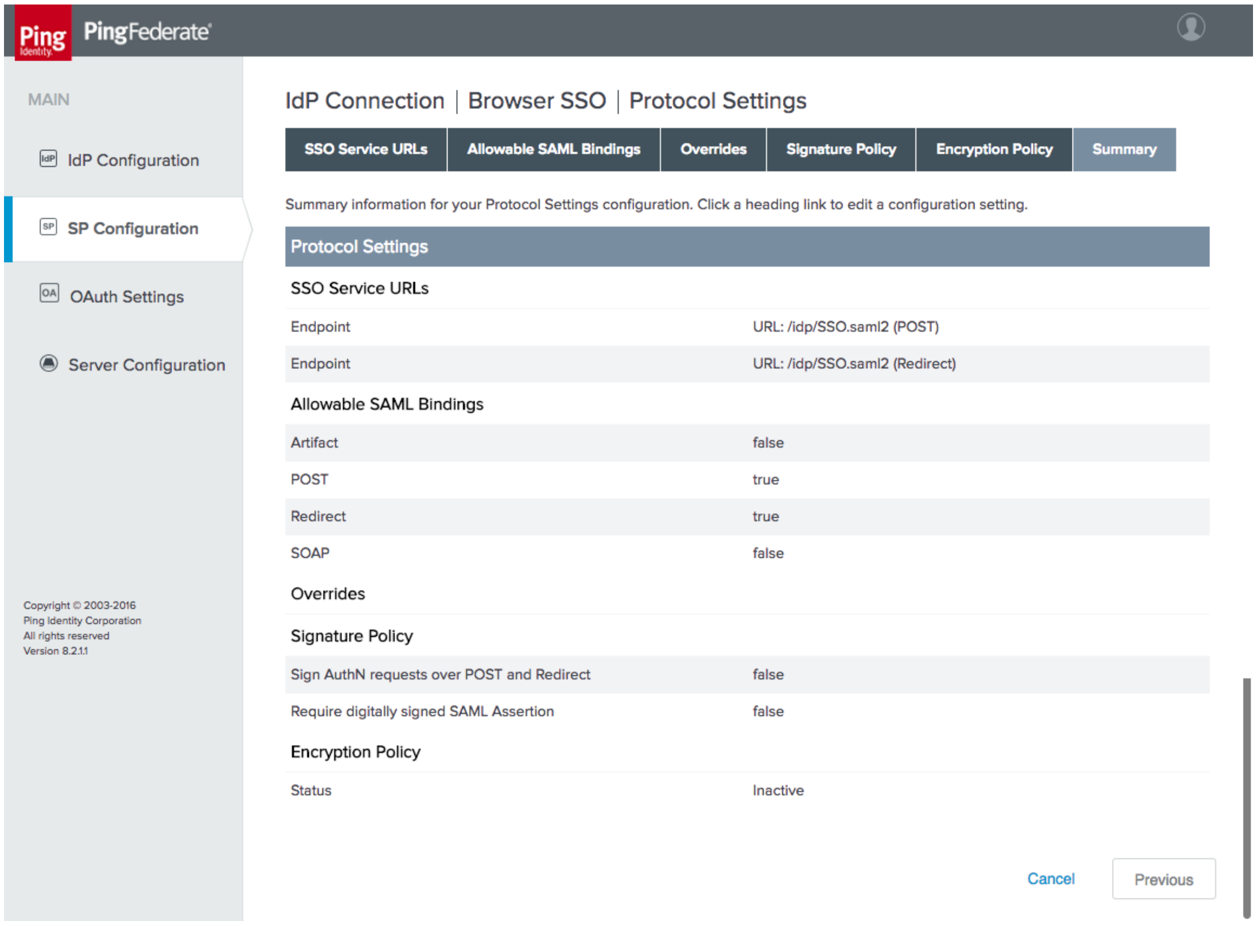
Figure 3-26 IdP Connection—Protocol Settings



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IdP Connection | Browser SSO | Protocol Settings

Summary information for your Protocol Settings configuration. Click a heading link to edit a configuration setting.

Protocol Settings

SSO Service URLs

Endpoint	URL: /idp/SSO.saml2 (POST)
Endpoint	URL: /idp/SSO.saml2 (Redirect)

Allowable SAML Bindings

Artifact	false
POST	true
Redirect	true
SOAP	false

Overrides

Signature Policy

Sign AuthN requests over POST and Redirect	false
Require digitally signed SAML Assertion	false

Encryption Policy

Status	Inactive

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

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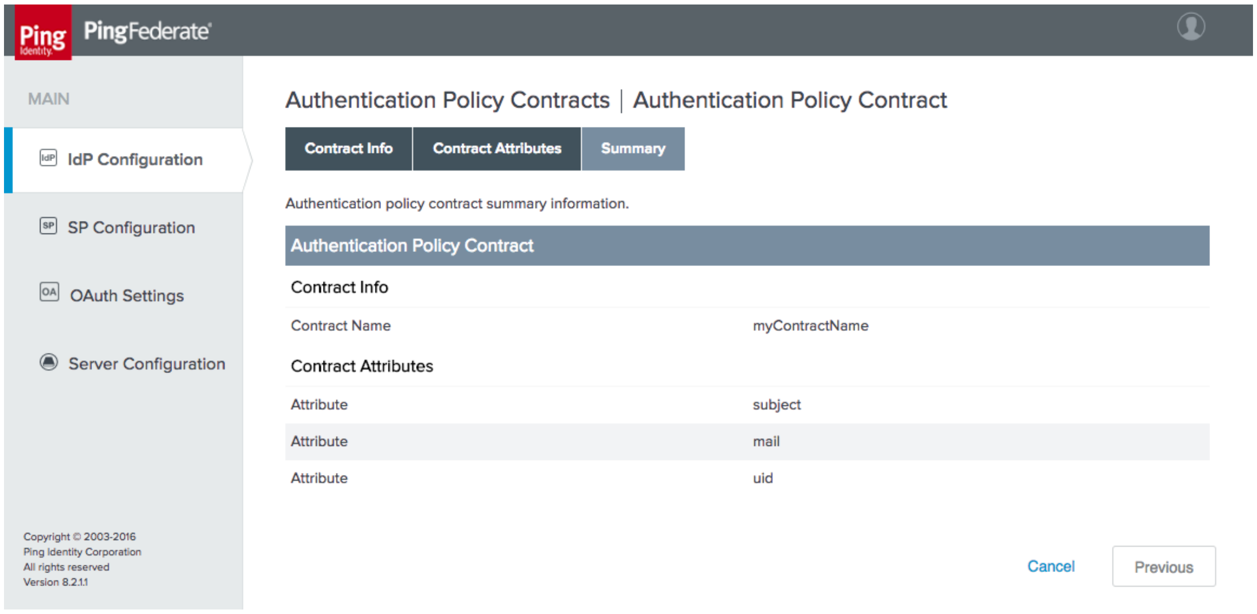
3.4.2.2 Create Policy Contract

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



Authentication Policy Contracts | Authentication Policy Contract

Authentication policy contract summary information.

Authentication Policy Contract

Contract Info	
Contract Name	myContractName
Contract Attributes	
Attribute	subject
Attribute	mail
Attribute	uid

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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).

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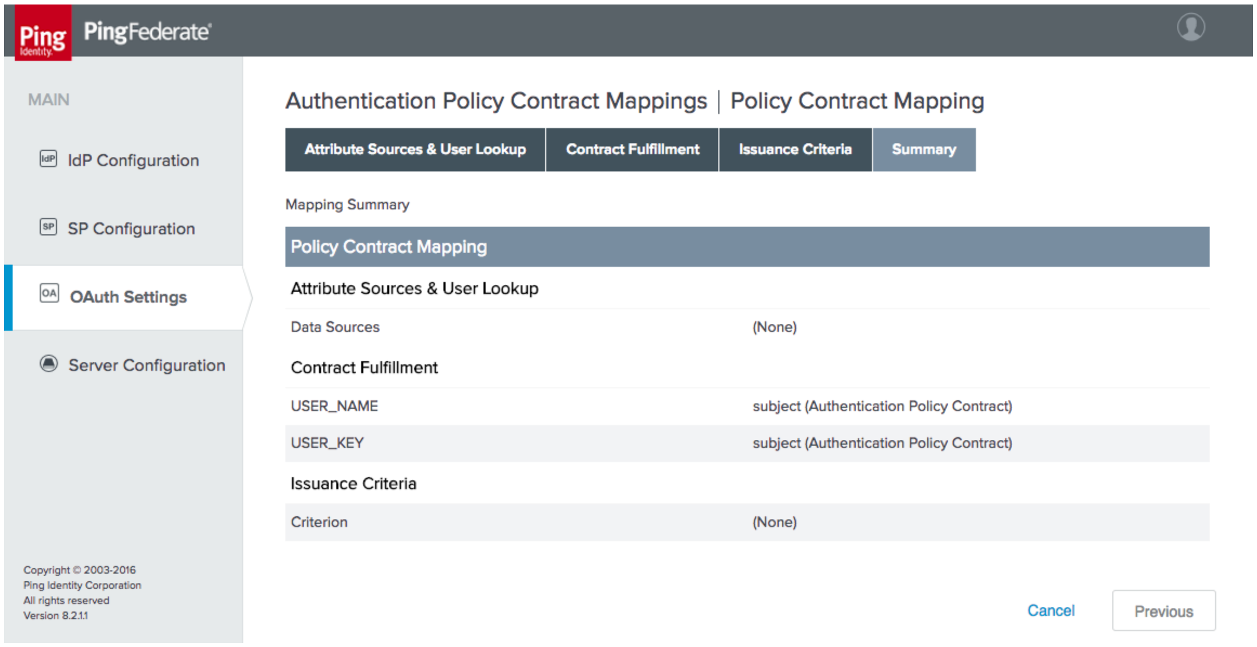
Figure 3-28 Contract Mapping for SAML RP



Authentication Policy Contract Mappings | Policy Contract Mapping

Mapping Summary

Policy Contract Mapping

Attribute Sources & User Lookup

Data Sources	(None)

Contract Fulfillment

USER_NAME	subject (Authentication Policy Contract)
USER_KEY	subject (Authentication Policy Contract)

Issuance Criteria

Criterion	(None)

2. To complete the setup for SAML authentication, kspd.msso adapter needs to be included in an authentication policy as described in Section 3.4.4.2.

3.4.3 How to Configure OIDC Authentication

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

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

3.4.3.1 Create IdP Connection

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

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

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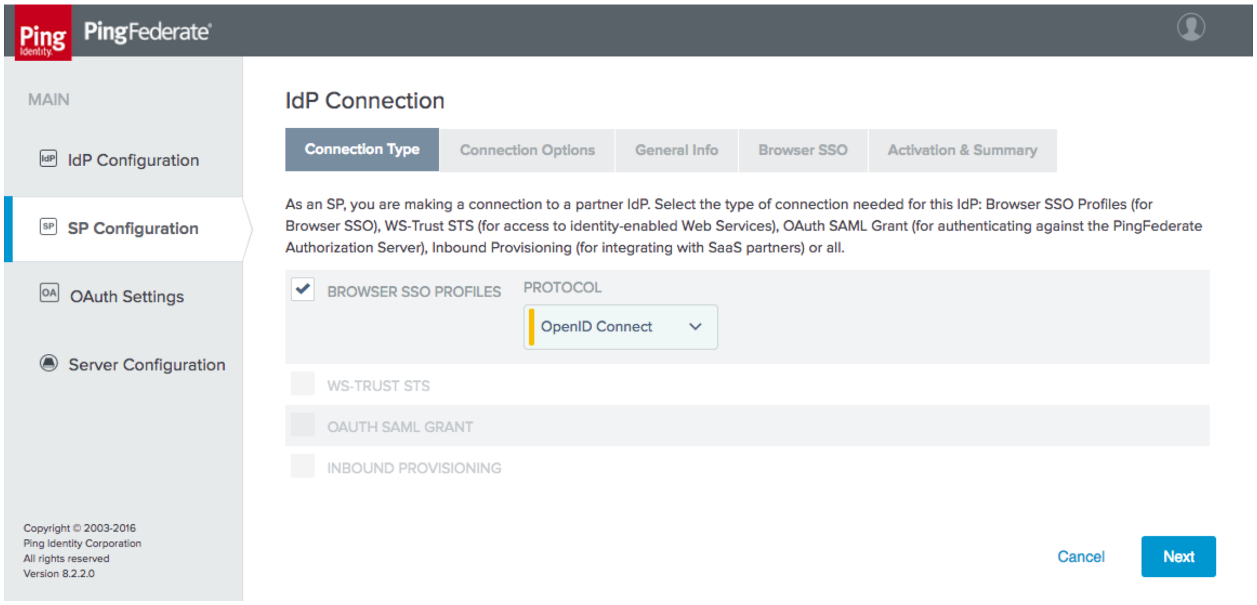
Figure 3-29 IdP Connection Type

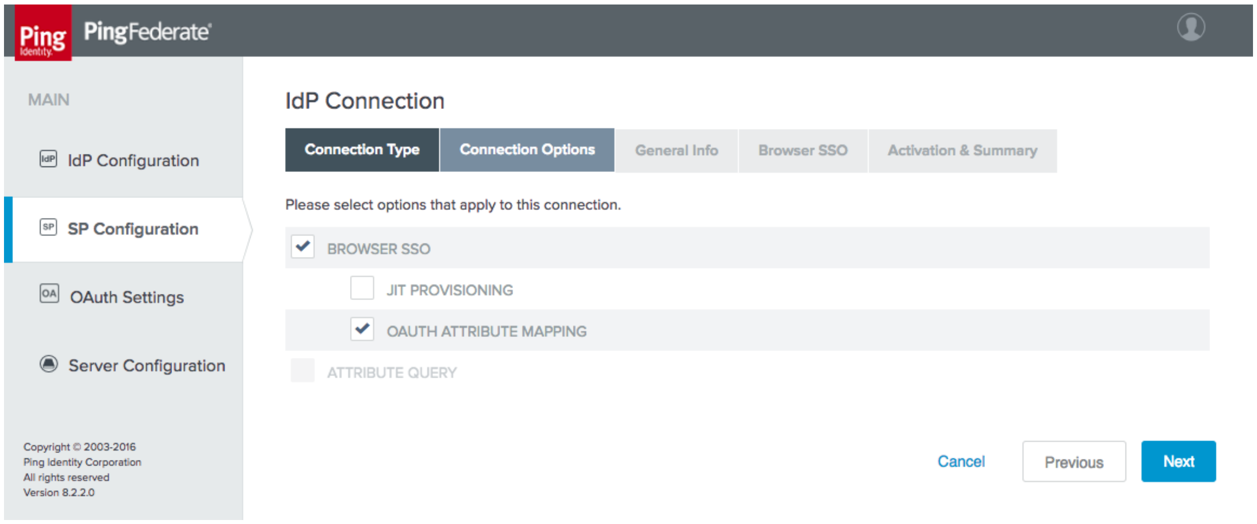


As an SP, you are making a connection to a partner IdP. Select the type of connection needed for this IdP: Browser SSO Profiles (for Browser SSO), WS-Trust STS (for access to identity-enabled Web Services), OAuth SAML Grant (for authenticating against the PingFederate Authorization Server), Inbound Provisioning (for integrating with SaaS partners) or all.

- [✓] BROWSER SSO PROFILES — PROTOCOL: OpenID Connect
- [ ] WS-TRUST STS
- [ ] OAUTH SAML GRANT
- [ ] INBOUND PROVISIONING

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

Figure 3-30 IdP Connection Options



Please select options that apply to this connection.

- [✓] BROWSER SSO
  - [ ] JIT PROVISIONING
  - [✓] OAUTH ATTRIBUTE MAPPING
- [ ] ATTRIBUTE QUERY

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

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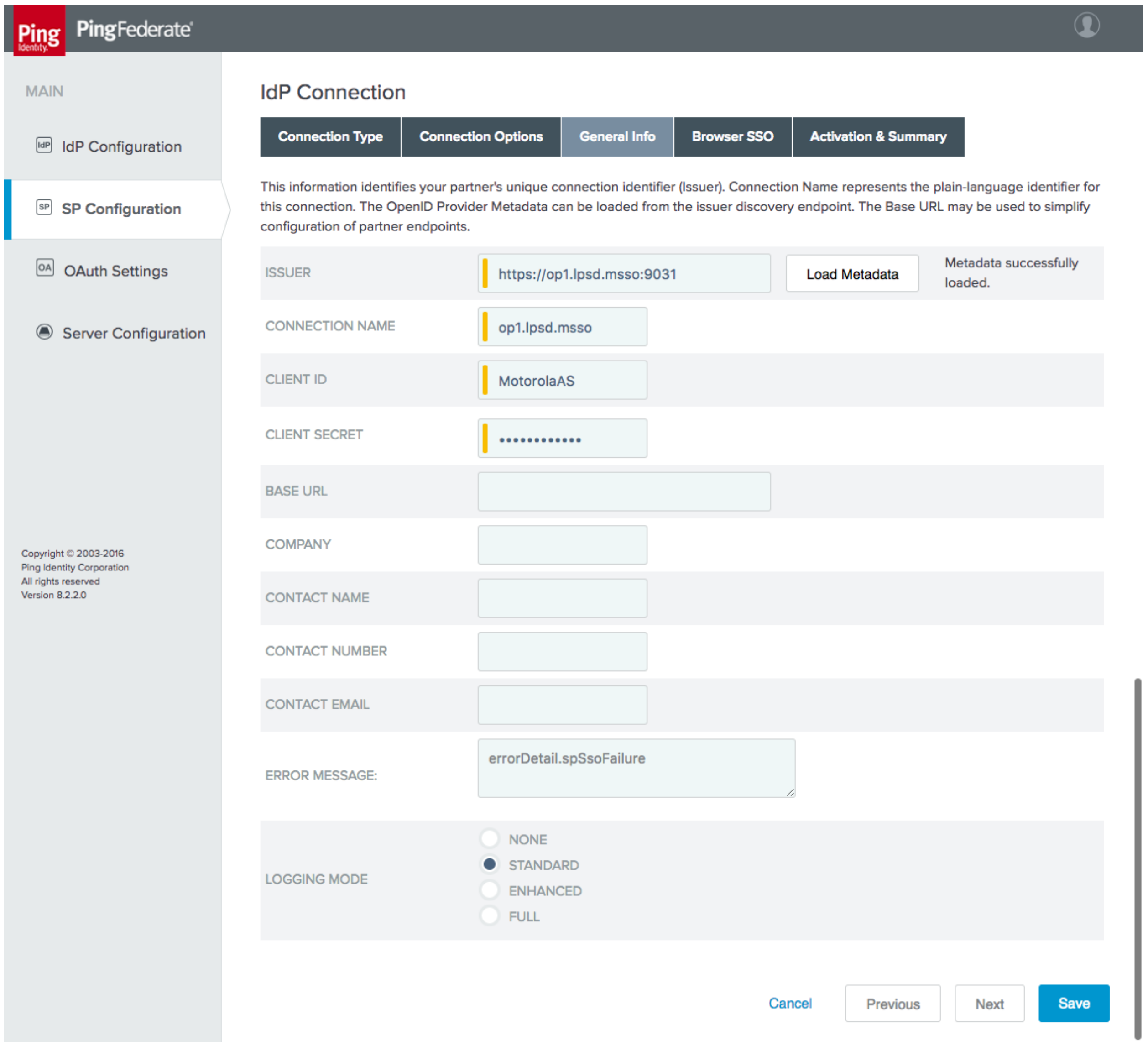
discovery endpoint. The message “Metadata successfully loaded” should appear. Provide a **CONNECTION NAME,** and enter the **CLIENT ID** and **CLIENT SECRET** provided by the IdP administrator.

Figure 3-31 IdP Connection General Info



This information identifies your partner's unique connection identifier (Issuer). Connection Name represents the plain-language identifier for this connection. The OpenID Provider Metadata can be loaded from the issuer discovery endpoint. The Base URL may be used to simplify configuration of partner endpoints.

ISSUER	https://op1.lpsd.msso:9031 — Metadata successfully loaded.
CONNECTION NAME	op1.lpsd.msso
CLIENT ID	MotorolaAS
CLIENT SECRET	••••••••••••
BASE URL	
COMPANY	
CONTACT NAME	
CONTACT NUMBER	
CONTACT EMAIL	
ERROR MESSAGE:	errorDetail.spSsoFailure
LOGGING MODE	NONE [✓ STANDARD] ENHANCED FULL

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**.

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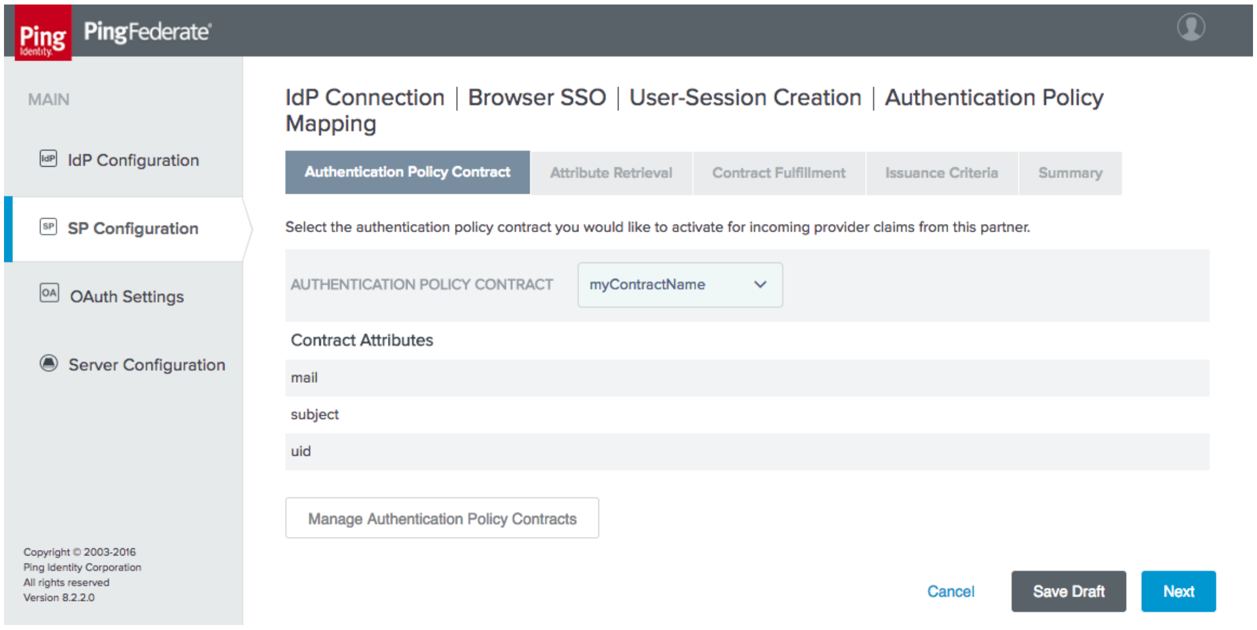
ii. On the **Authentication Policy Contract** tab, select the **AUTHENTICATION POLICY CONTRACT** created in Section 3.4.2.2 (in the example shown in Figure 3-32, it is called **myContractName**). If the policy contract has not been created, click **Manage Authentication Policy Contracts**, and create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

Figure 3-32 IdP Connection Authentication Policy Contract



IdP Connection | Browser SSO | User-Session Creation | Authentication Policy Mapping

Select the authentication policy contract you would like to activate for incoming provider claims from this partner.

AUTHENTICATION POLICY CONTRACT: myContractName

Contract Attributes

mail

subject

uid

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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).

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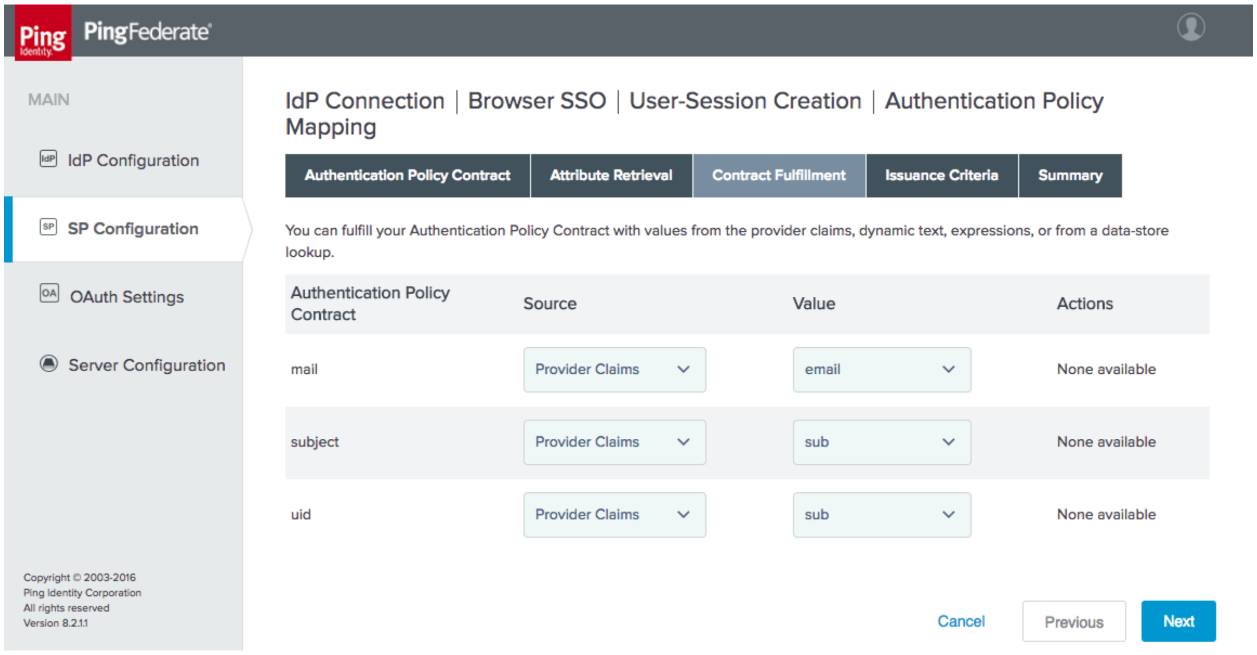
Figure 3-33 IdP Connection Policy Contract Mapping



IdP Connection | Browser SSO | User-Session Creation | Authentication Policy Mapping

You can fulfill your Authentication Policy Contract with values from the provider claims, dynamic text, expressions, or from a data-store lookup.

Authentication Policy Contract	Source	Value	Actions
mail	Provider Claims	email	None available
subject	Provider Claims	sub	None available
uid	Provider Claims	sub	None available

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

vi. Click **Next**, then **Done**, and then click **Done** again to exit the **User-Session Creation** tab.

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

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

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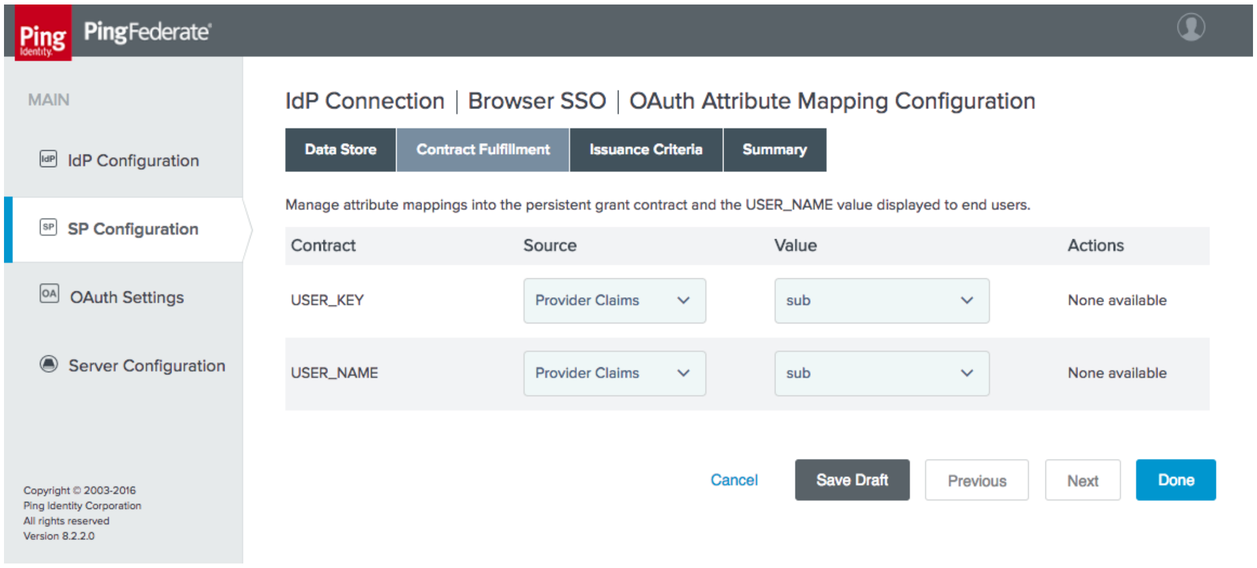
Figure 3-34 IdP Connection OAuth Attribute Mapping



IdP Connection | Browser SSO | OAuth Attribute Mapping Configuration

Manage attribute mappings into the persistent grant contract and the USER_NAME value displayed to end users.

Contract	Source	Value	Actions
USER_KEY	Provider Claims	sub	None available
USER_NAME	Provider Claims	sub	None available

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ix. Click **Done** to exit the **OAuth Attribute Mapping Configuration** setup. The **Protocol Settings** should be automatically populated through the information gathered from the discovery endpoint (Figure 3-35). If necessary, the scopes to be requested can be customized on the **Protocol Settings** tab; in the lab, these settings remained at the default.

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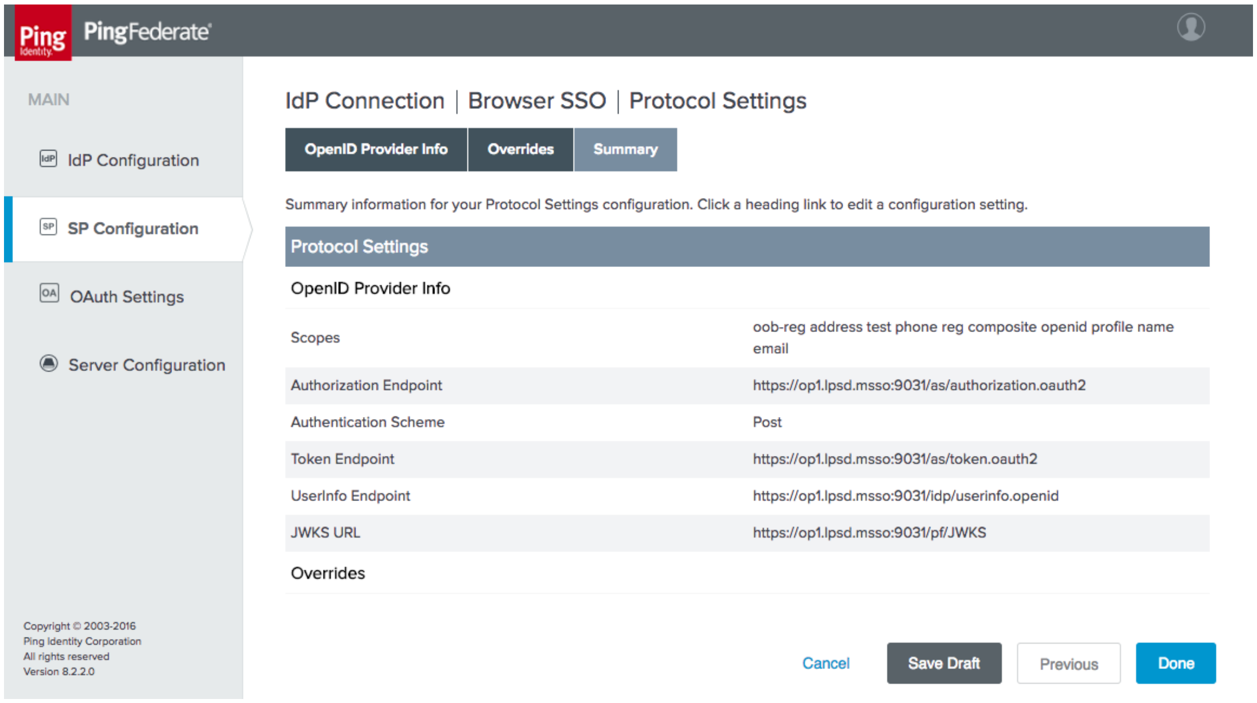
Figure 3-35 IdP Connection Protocol Settings



Summary information for your Protocol Settings configuration. Click a heading link to edit a configuration setting.

Protocol Settings	
OpenID Provider Info	
Scopes	oob-reg address test phone reg composite openid profile name email
Authorization Endpoint	https://op1.lpsd.msso:9031/as/authorization.oauth2
Authentication Scheme	Post
Token Endpoint	https://op1.lpsd.msso:9031/as/token.oauth2
UserInfo Endpoint	https://op1.lpsd.msso:9031/idp/userinfo.openid
JWKS URL	https://op1.lpsd.msso:9031/pf/JWKS
Overrides	

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

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

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

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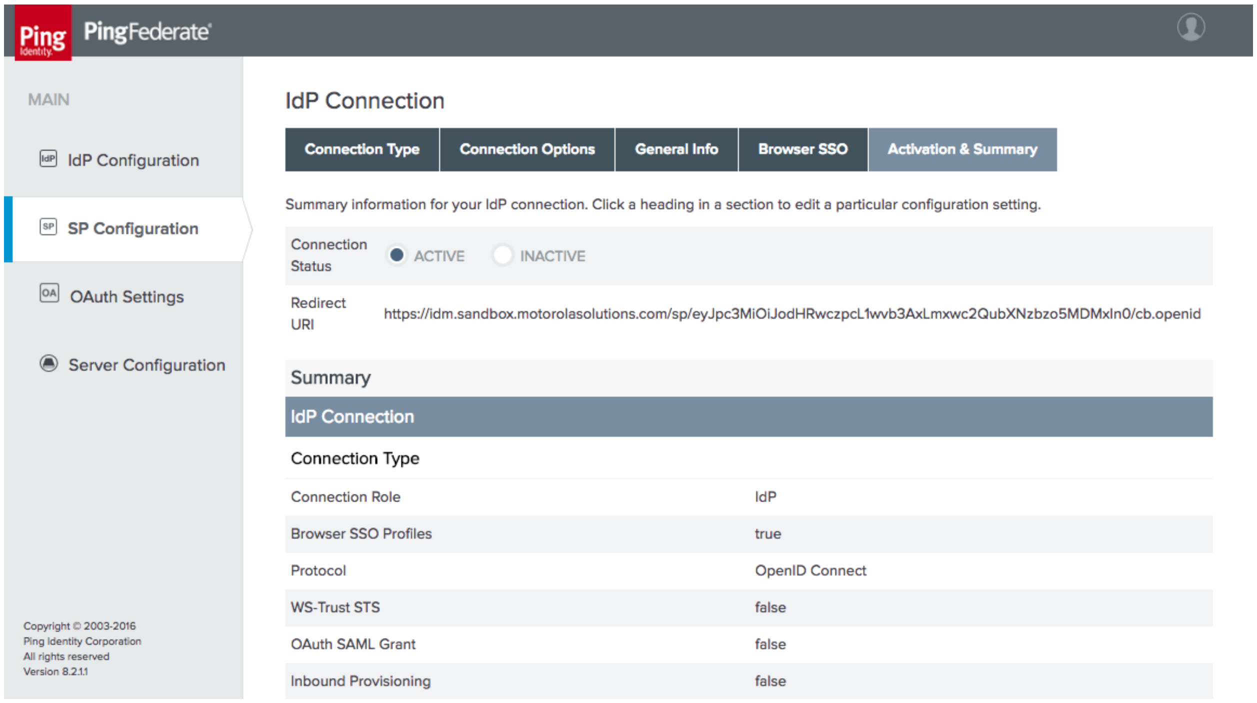
Figure 3-36 IdP Connection Activation and Summary



Summary information for your IdP connection. Click a heading in a section to edit a particular configuration setting.

Connection Status: ● ACTIVE ○ INACTIVE

Redirect URI: https://idm.sandbox.motorolasolutions.com/sp/eyJpc3MiOiJodHRwczpcL1wvb3AxLmxwc2QubXNzbzo5MDMxIn0/cb.openid

Summary

IdP Connection

Connection Type

Connection Role	IdP
Browser SSO Profiles	true
Protocol	OpenID Connect
WS-Trust STS	false
OAuth SAML Grant	false
Inbound Provisioning	false

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

3.4.3.2 Create the Policy Contract Mapping

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

3.4.4 How to Configure the Authentication Policy

3.4.4.1 Install the Domain Selector Plugin

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

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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:

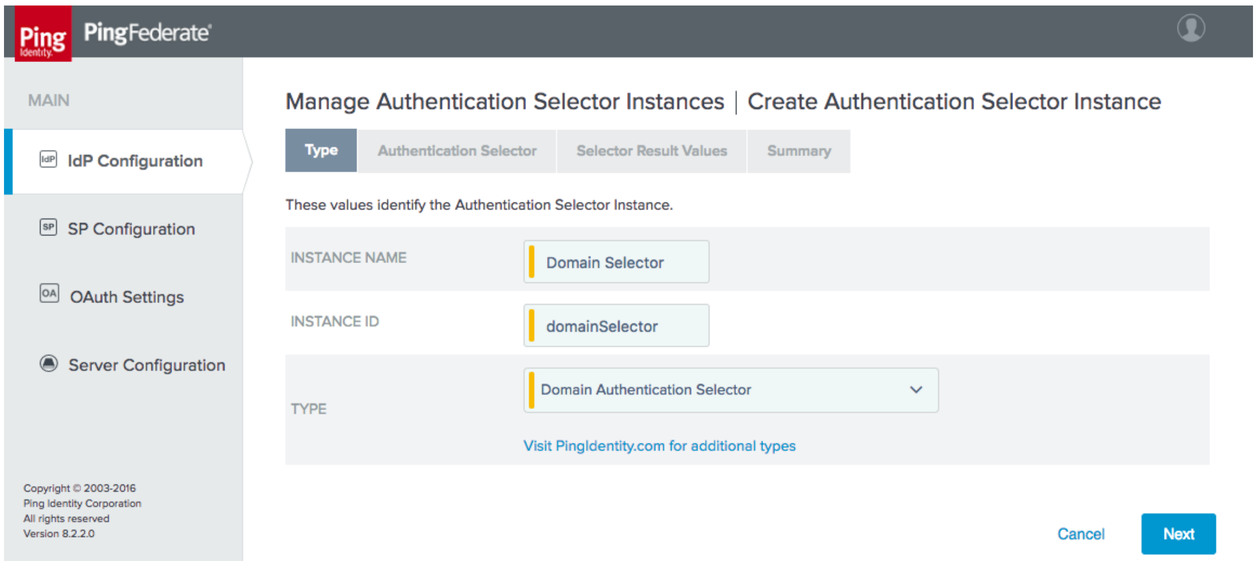
   ```
   $ ant clean-plugin

   $ 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



Manage Authentication Selector Instances | Create Authentication Selector Instance

These values identify the Authentication Selector Instance.

INSTANCE NAME: Domain Selector

INSTANCE ID: domainSelector

TYPE: Domain Authentication Selector

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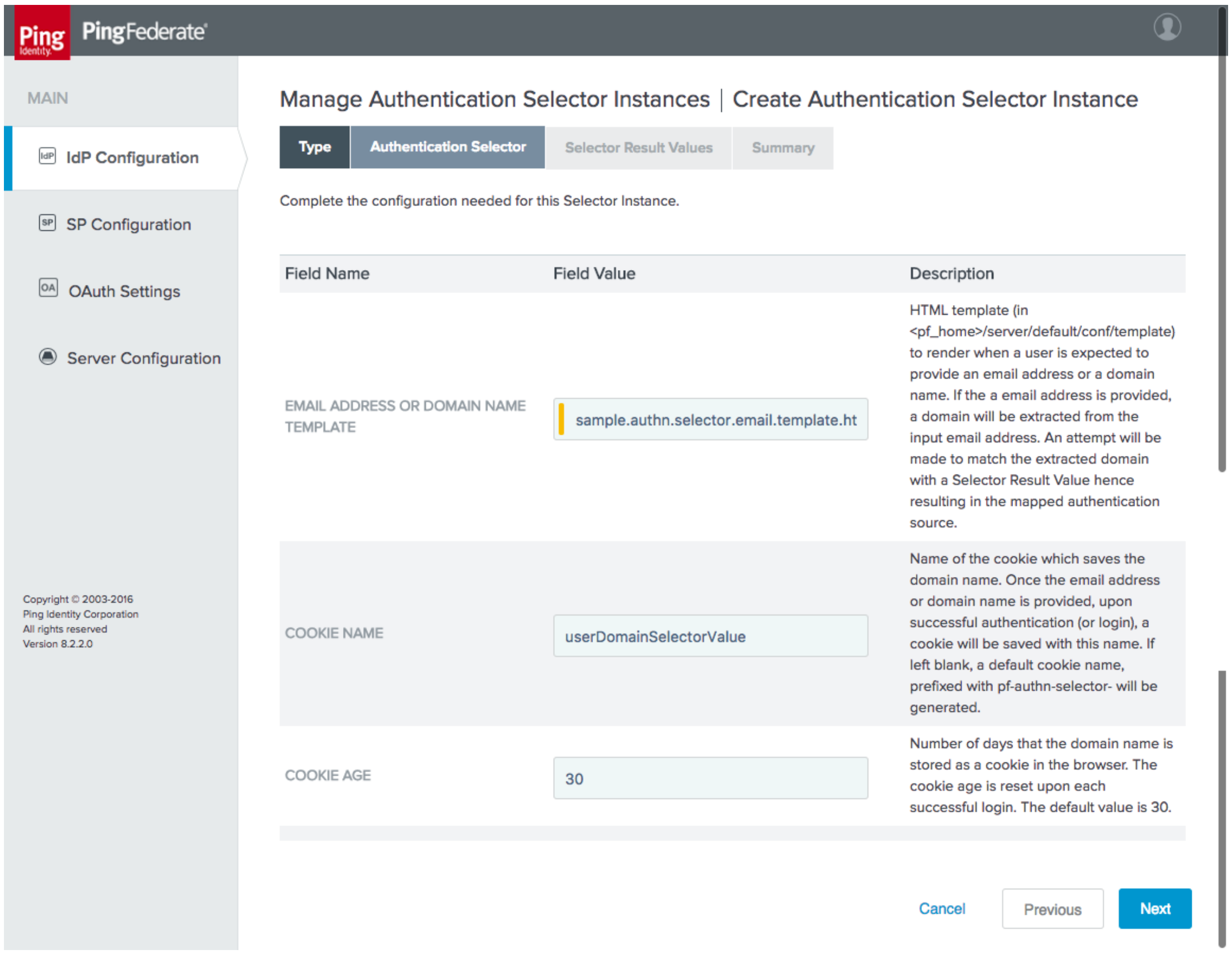
b. The next tab, **Authentication Selector**, prompts for the HyperText Markup Language (HTML) template for the page that will prompt the user to enter the domain or email address (Figure 3-38). The default value will use the template delivered with the adapter; if desired, a custom template can be used 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



Manage Authentication Selector Instances | Create Authentication Selector Instance

Complete the configuration needed for this Selector Instance.

Field Name	Field Value	Description
EMAIL ADDRESS OR DOMAIN NAME TEMPLATE	sample.authn.selector.email.template.ht	HTML template (in <pf_home>/server/default/conf/template) to render when a user is expected to provide an email address or a domain name. If the a email address is provided, a domain will be extracted from the input email address. An attempt will be made to match the extracted domain with a Selector Result Value hence resulting in the mapped authentication source.
COOKIE NAME	userDomainSelectorValue	Name of the cookie which saves the domain name. Once the email address or domain name is provided, upon successful authentication (or login), a cookie will be saved with this name. If left blank, a default cookie name, prefixed with pf-authn-selector- will be generated.
COOKIE AGE	30	Number of days that the domain name is stored as a cookie in the browser. The cookie age is reset upon each successful login. The default value is 30.

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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.

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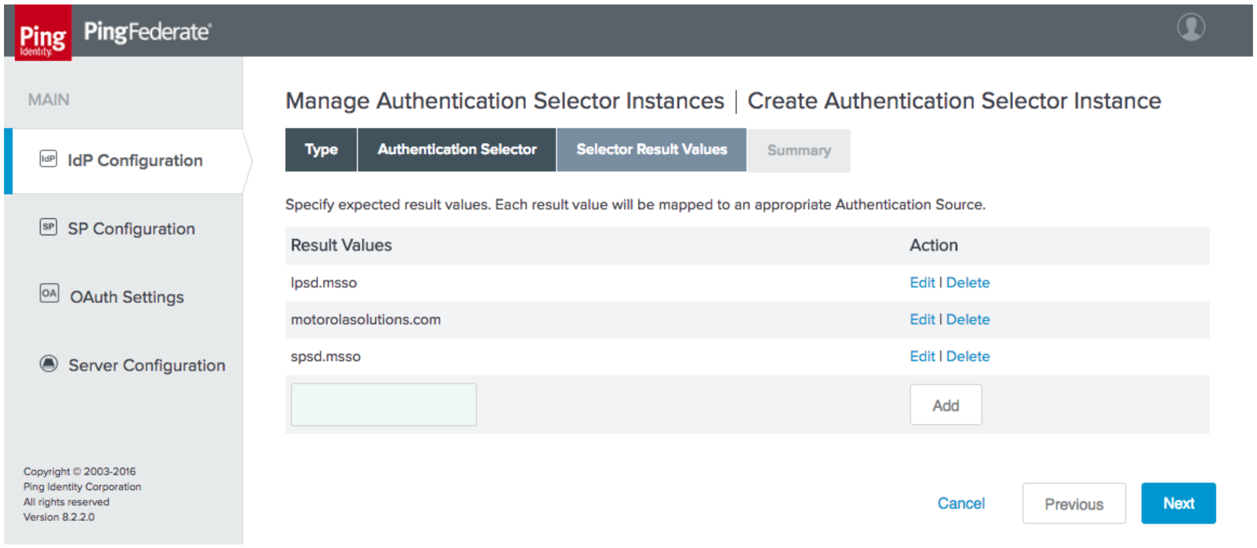
Figure 3-39 Selector Result Values



Manage Authentication Selector Instances | Create Authentication Selector Instance

Specify expected result values. Each result value will be mapped to an appropriate Authentication Source.

Result Values	Action
lpsd.msso	Edit I Delete
motorolasolutions.com	Edit I Delete
spsd.msso	Edit I Delete

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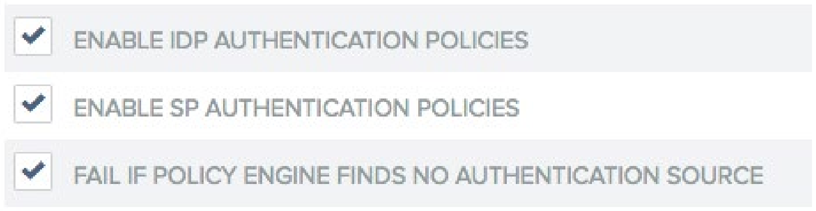
d. Click **Done**, and then click **Save** to complete the selector configuration.

3.4.4.2 Define the Authentication Policy

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

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

Figure 3-40 Policy Settings



- ✓ ENABLE IDP AUTHENTICATION POLICIES
- ✓ ENABLE SP AUTHENTICATION POLICIES
- ✓ FAIL IF POLICY ENGINE FINDS NO AUTHENTICATION SOURCE

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

      i. Select the corresponding authentication mechanism for each domain. The example shown in Figure 3-41 uses the IdP connections for the **lpsd.msso** and **spsd.msso**, as well as the "fidoonly" adapter for local authentication of users in the **motorolasolutions.com** domain.

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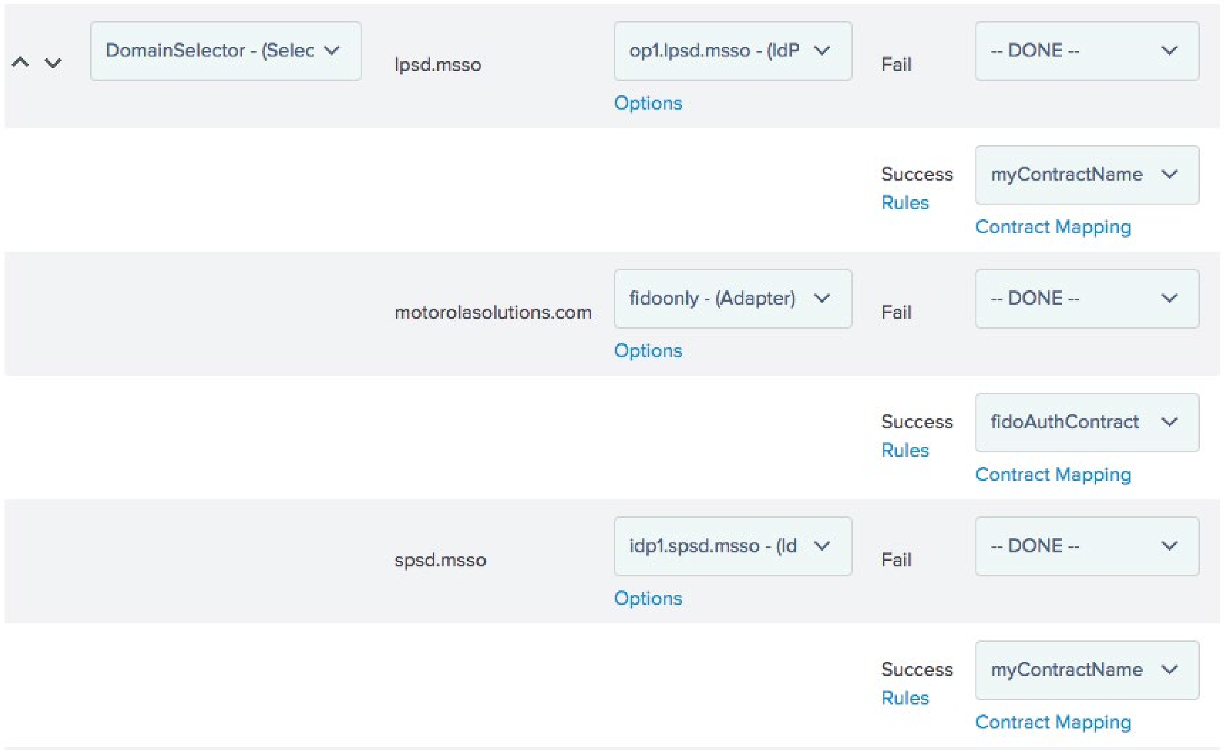
Figure 3-41 Authentication Policy



DomainSelector - (Selec	lpsd.msso	op1.lpsd.msso - (IdP Options	Fail	-- DONE --
			Success Rules	myContractName Contract Mapping
	motorolasolutions.com	fidoonly - (Adapter) Options	Fail	-- DONE --
			Success Rules	fidoAuthContract Contract Mapping
	spsd.msso	idp1.spsd.msso - (Id Options	Fail	-- DONE --
			Success Rules	myContractName Contract Mapping

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

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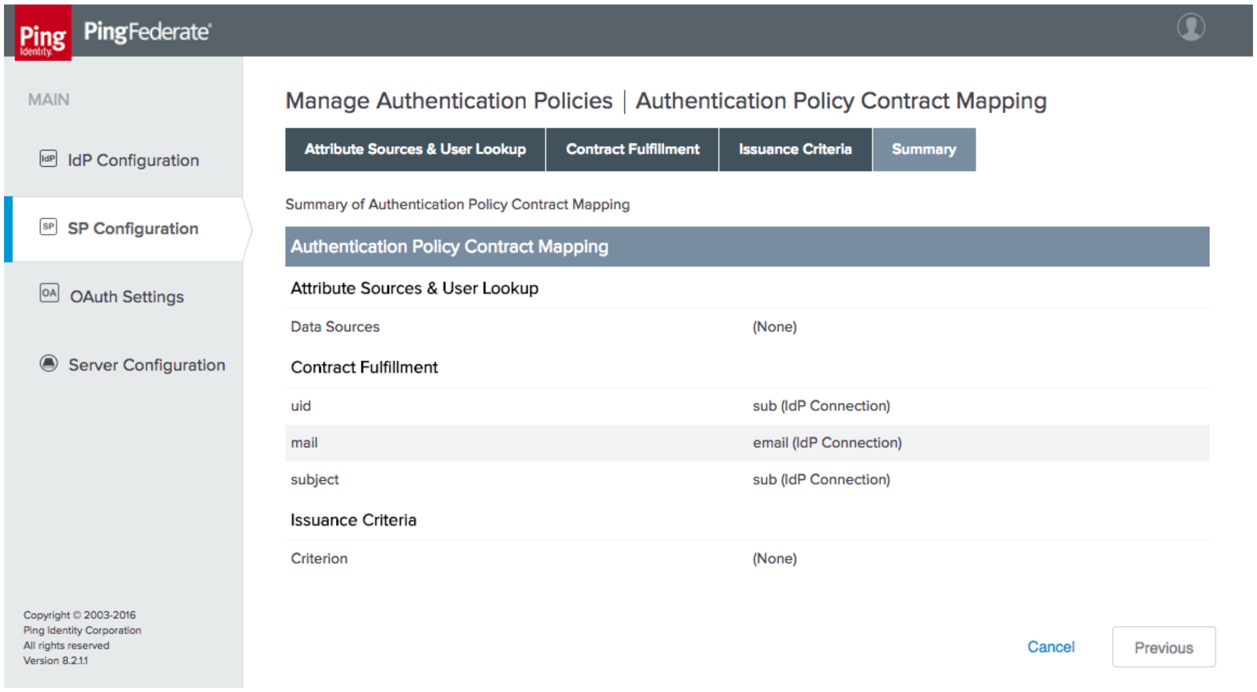
Figure 3-42 Policy Contract Mapping for IdP Connections



Manage Authentication Policies | Authentication Policy Contract Mapping

Summary of Authentication Policy Contract Mapping

Authentication Policy Contract Mapping

Attribute Sources & User Lookup

Data Sources	(None)

Contract Fulfillment

uid	sub (IdP Connection)
mail	email (IdP Connection)
subject	sub (IdP Connection)

Issuance Criteria

Criterion	(None)

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

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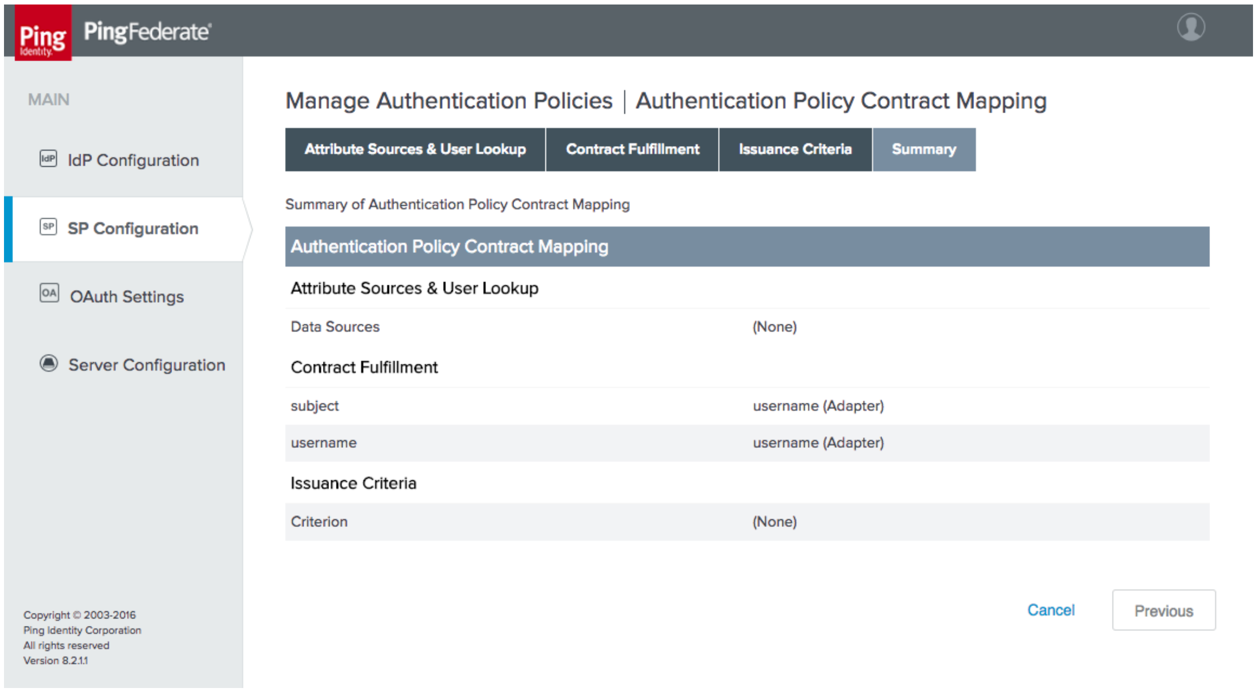
Figure 3-43 Policy Contract Mapping for Local Authentication



Manage Authentication Policies | Authentication Policy Contract Mapping

Summary of Authentication Policy Contract Mapping

Authentication Policy Contract Mapping

Attribute Sources & User Lookup

Data Sources	(None)

Contract Fulfillment

subject	username (Adapter)
username	username (Adapter)

Issuance Criteria

Criterion	(None)

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This completes the configuration of the AS.

4 How to Install and Configure the Identity Providers

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

4.1 How to Configure the User Store

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

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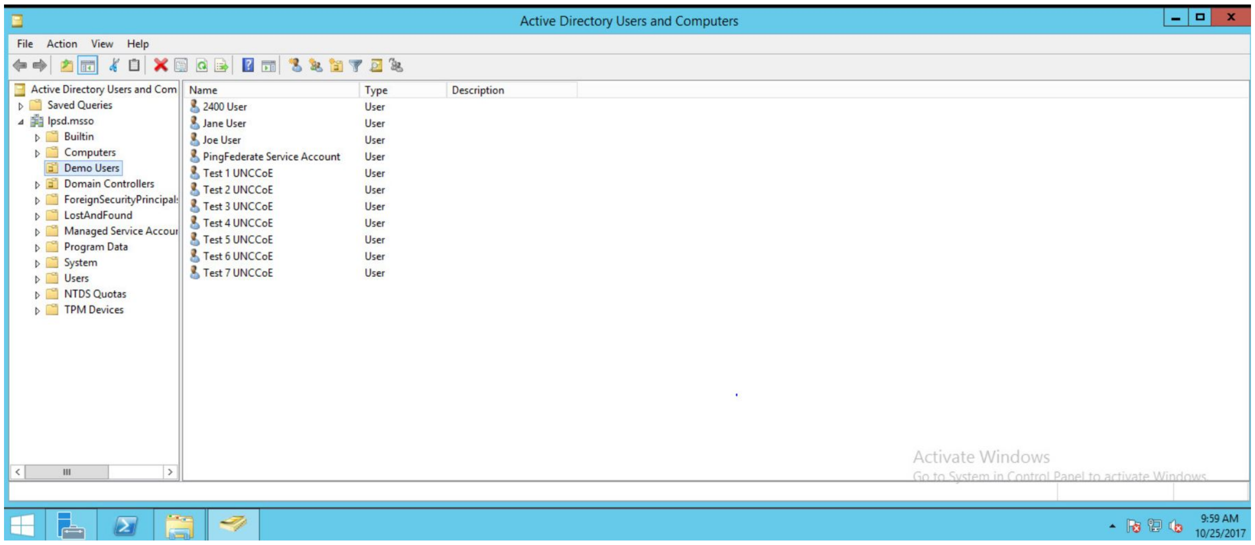
Figure 4-1 Active Directory Users and Computers



Name	Type	Description
2400 User	User	
Jane User	User	
Joe User	User	
PingFederate Service Account	User	
Test 1 UNCCoE	User	
Test 2 UNCCoE	User	
Test 3 UNCCoE	User	
Test 4 UNCCoE	User	
Test 5 UNCCoE	User	
Test 6 UNCCoE	User	
Test 7 UNCCoE	User	

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

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

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

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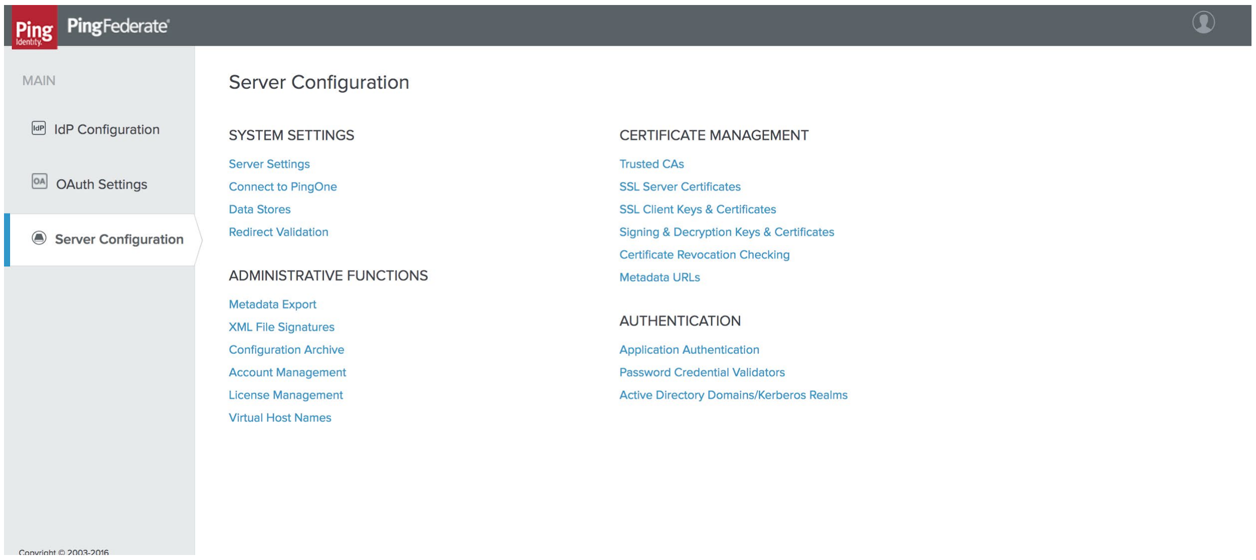
Figure 4-2 Server Configuration



2. Click **Data Stores** under **SYSTEM SETTINGS**.
3. On the next screen, click **Add New Data Store**.
    a. The screen shown in Figure 4-3 will appear. On the **Data Store Type** tab, select **LDAP** for the data store type.
        i. Click **Next**.

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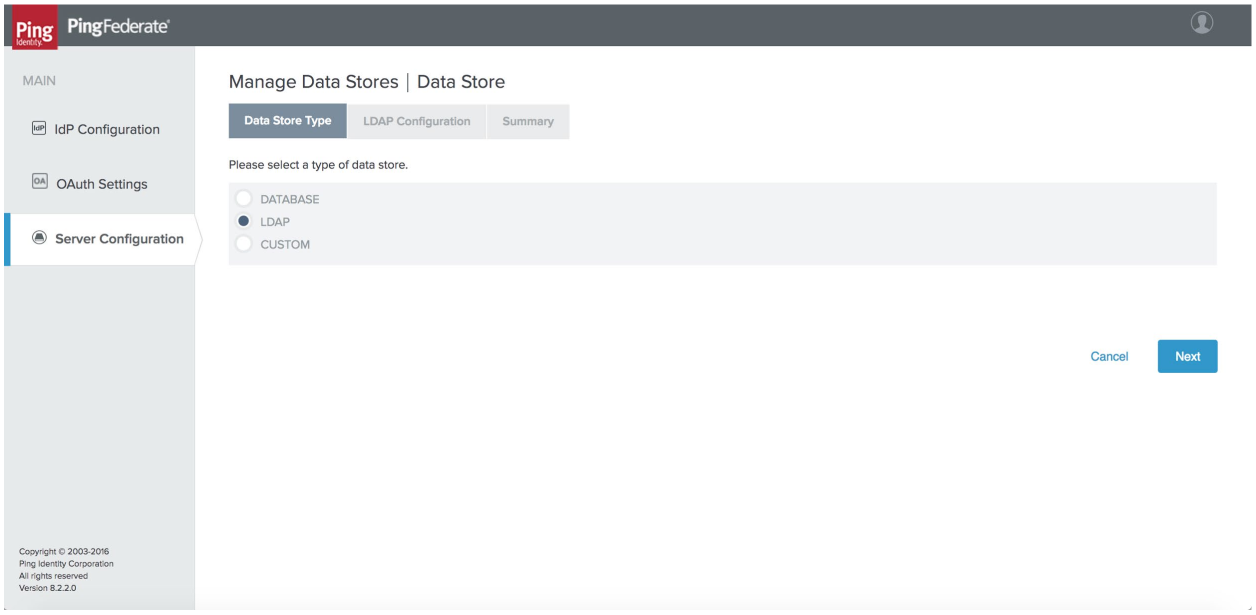
Figure 4-3 Data Store Type



Manage Data Stores | Data Store

Please select a type of data store.

DATABASE
● LDAP
CUSTOM

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

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

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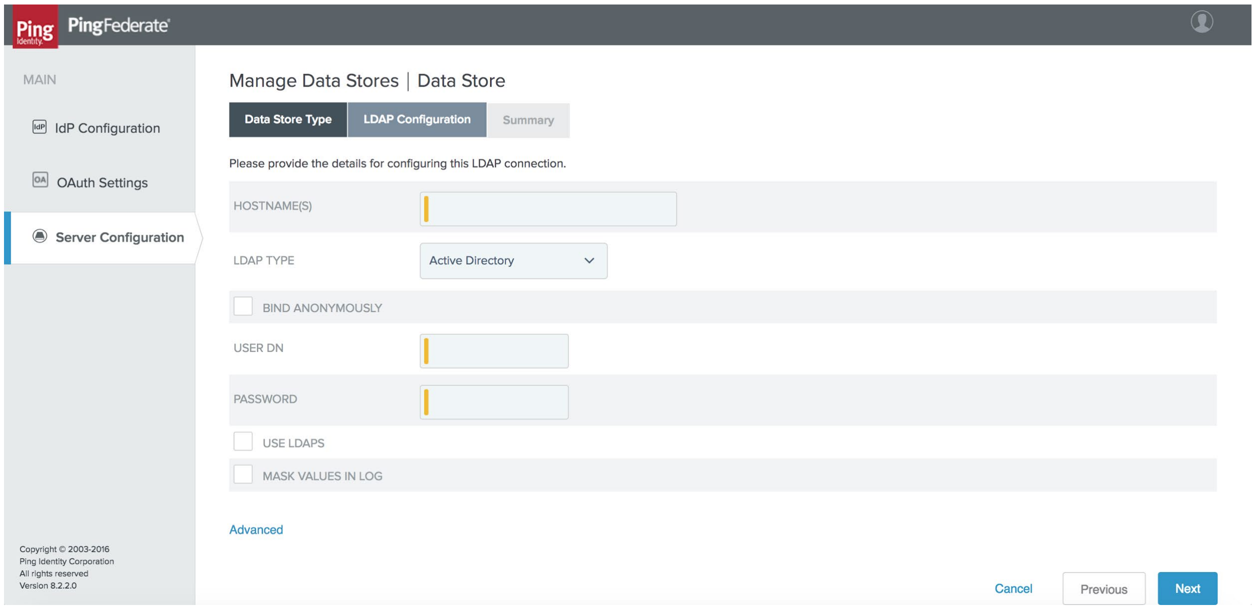
Figure 4-4 LDAP Data Store Configuration



Manage Data Stores | Data Store

Please provide the details for configuring this LDAP connection.

HOSTNAME(S)	
LDAP TYPE	Active Directory
BIND ANONYMOUSLY	☐
USER DN	
PASSWORD	
USE LDAPS	☐
MASK VALUES IN LOG	☐

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4.2 How to Install and Configure the SAML Identity Provider

1. On the **Server Configuration** screen, click **Server Settings**.
   a. On the **Roles & Protocols** tab, enable roles and protocols to configure the server as a SAML IdP (Figure 4-5).

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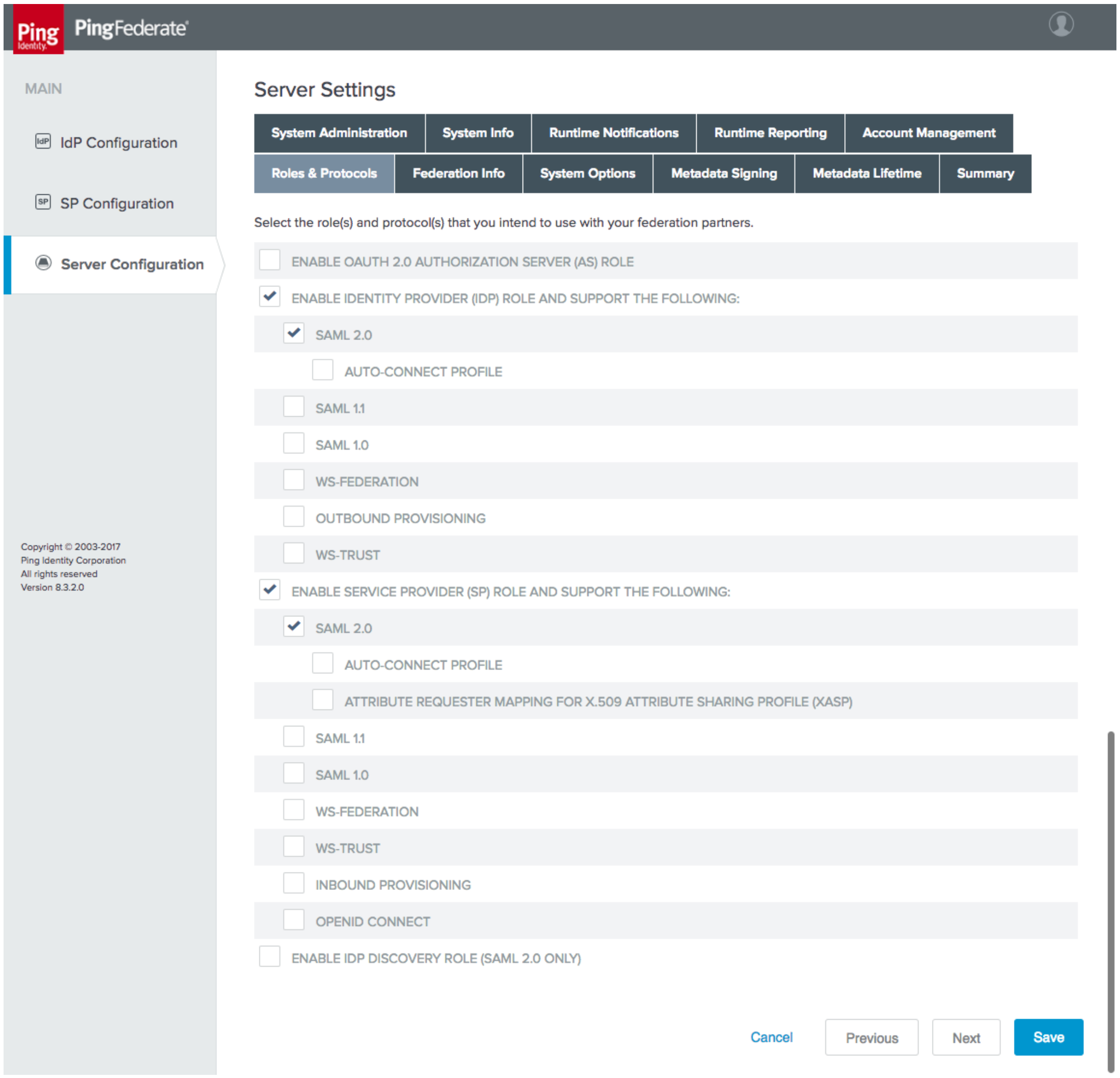
Figure 4-5 Server Roles for SAML IdP



Select the role(s) and protocol(s) that you intend to use with your federation partners.

- [ ] ENABLE OAUTH 2.0 AUTHORIZATION SERVER (AS) ROLE
- [✓] ENABLE IDENTITY PROVIDER (IDP) ROLE AND SUPPORT THE FOLLOWING:
  - [✓] SAML 2.0
    - [ ] AUTO-CONNECT PROFILE
  - [ ] SAML 1.1
  - [ ] SAML 1.0
  - [ ] WS-FEDERATION
  - [ ] OUTBOUND PROVISIONING
  - [ ] WS-TRUST
- [✓] ENABLE SERVICE PROVIDER (SP) ROLE AND SUPPORT THE FOLLOWING:
  - [✓] SAML 2.0
    - [ ] AUTO-CONNECT PROFILE
    - [ ] ATTRIBUTE REQUESTER MAPPING FOR X.509 ATTRIBUTE SHARING PROFILE (XASP)
  - [ ] SAML 1.1
  - [ ] SAML 1.0
  - [ ] WS-FEDERATION
  - [ ] WS-TRUST
  - [ ] INBOUND PROVISIONING
  - [ ] OPENID CONNECT
- [ ] ENABLE IDP DISCOVERY ROLE (SAML 2.0 ONLY)

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

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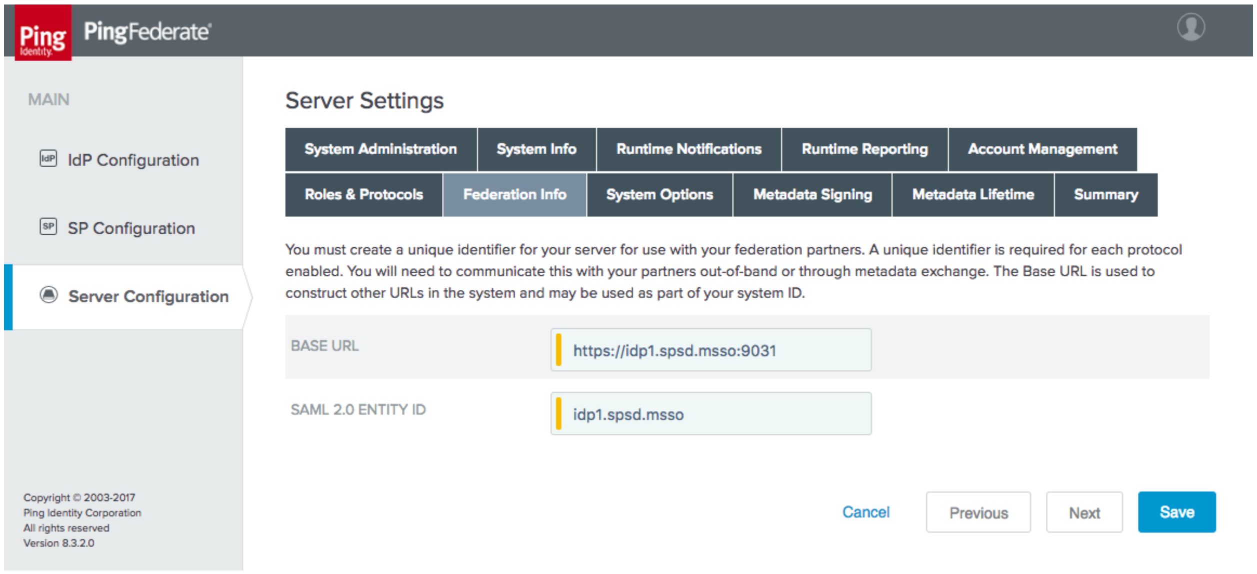
Figure 4-6 SAML IdP Federation Info



You must create a unique identifier for your server for use with your federation partners. A unique identifier is required for each protocol enabled. You will need to communicate this with your partners out-of-band or through metadata exchange. The Base URL is used to construct other URLs in the system and may be used as part of your system ID.

BASE URL	https://idp1.spsd.msso:9031
SAML 2.0 ENTITY ID	idp1.spsd.msso

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4.2.1 Configuring Authentication to the IdP

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

4.2.1.1 Configure the Password Validator

1. On the **Server Configuration** section tab, click **Password Credential Validators** under **Authentication**.
2. Click **Create New Instance**.
    a. On the **Type** tab, for the **TYPE**, choose **LDAP Username Password Credential Validator** (Figure 4-7). This example will authenticate AD usernames and passwords by using the AD data store defined in Section 4.1.

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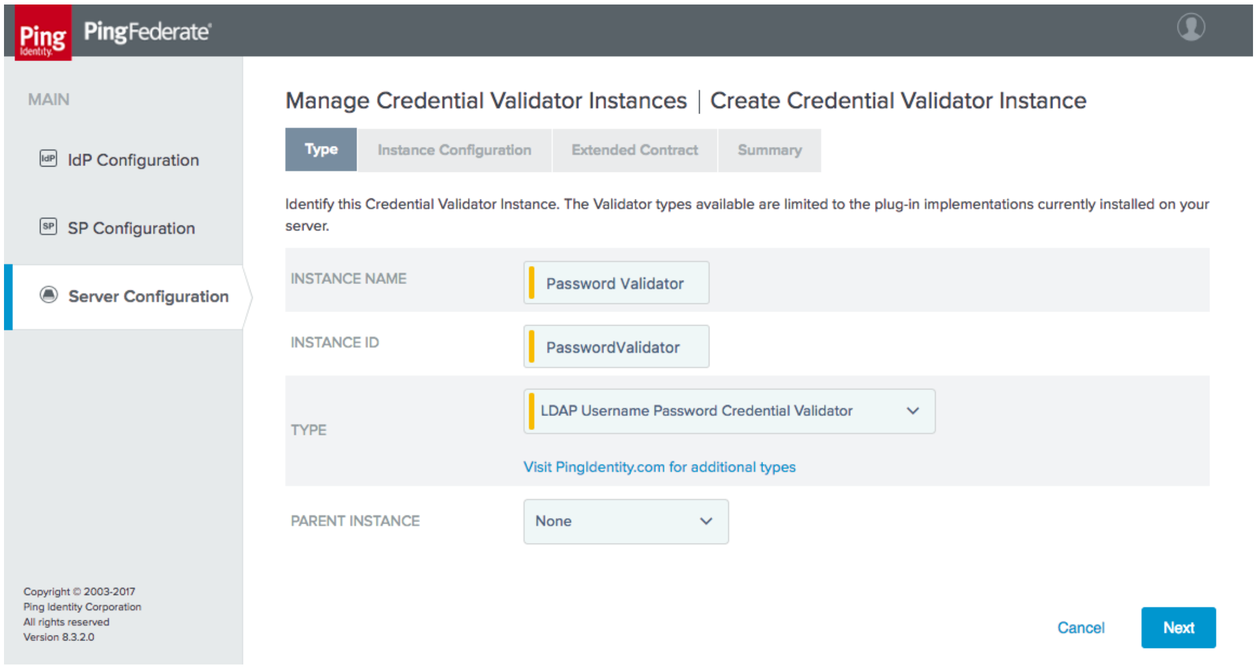
Figure 4-7 Create Password Credential Validator



Manage Credential Validator Instances | Create Credential Validator Instance

Identify this Credential Validator Instance. The Validator types available are limited to the plug-in implementations currently installed on your server.

INSTANCE NAME	Password Validator
INSTANCE ID	PasswordValidator
TYPE	LDAP Username Password Credential Validator
PARENT INSTANCE	None

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b. On the **Instance Configuration** tab, specify the parameters for searching the LDAP directory for user accounts (Figure 4-8). Select the data store created in Section 4.1, and enter the appropriate search base and filter. This example will search for a *sAMAccountName* matching the username entered on the login form.

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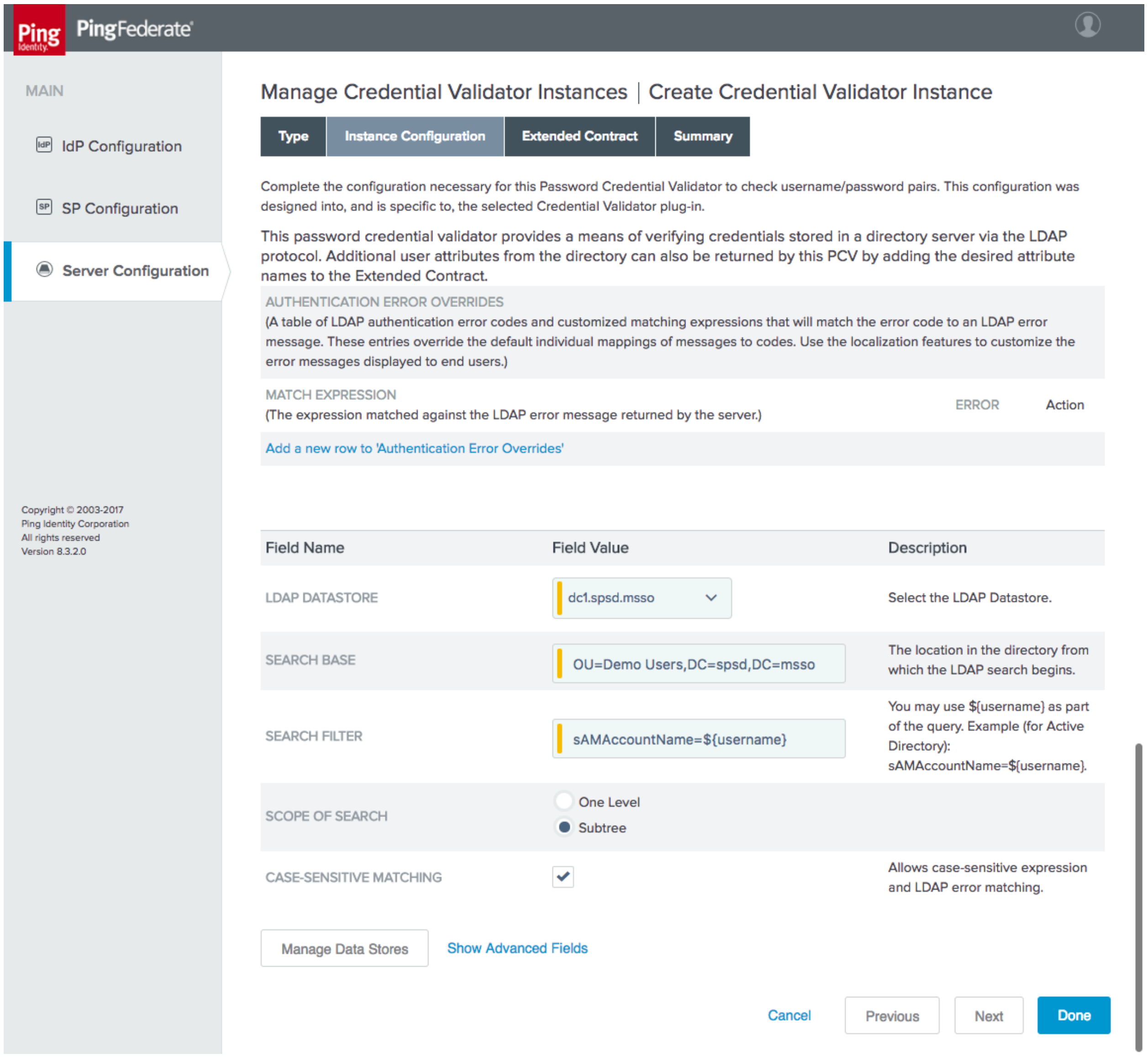
Figure 4-8 Credential Validator Configuration



Manage Credential Validator Instances | Create Credential Validator Instance

Complete the configuration necessary for this Password Credential Validator to check username/password pairs. This configuration was designed into, and is specific to, the selected Credential Validator plug-in.

This password credential validator provides a means of verifying credentials stored in a directory server via the LDAP protocol. Additional user attributes from the directory can also be returned by this PCV by adding the desired attribute names to the Extended Contract.

AUTHENTICATION ERROR OVERRIDES
(A table of LDAP authentication error codes and customized matching expressions that will match the error code to an LDAP error message. These entries override the default individual mappings of messages to codes. Use the localization features to customize the error messages displayed to end users.)

MATCH EXPRESSION (The expression matched against the LDAP error message returned by the server.)	ERROR	Action
Add a new row to 'Authentication Error Overrides'		

Field Name	Field Value	Description
LDAP DATASTORE	dc1.spsd.msso	Select the LDAP Datastore.
SEARCH BASE	OU=Demo Users,DC=spsd,DC=msso	The location in the directory from which the LDAP search begins.
SEARCH FILTER	sAMAccountName=${username}	You may use ${username} as part of the query. Example (for Active Directory): sAMAccountName=${username}.
SCOPE OF SEARCH	One Level [✓ Subtree]	
CASE-SENSITIVE MATCHING	✓	Allows case-sensitive expression and LDAP error matching.

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

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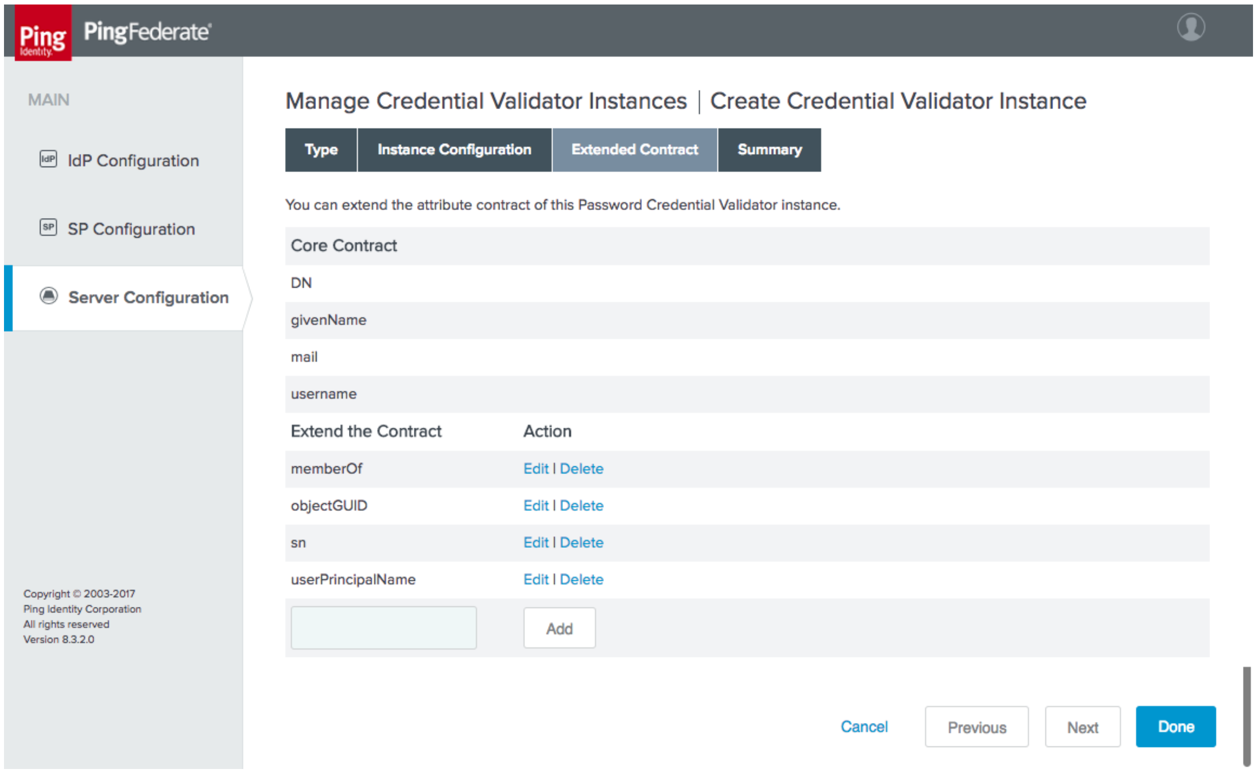
Figure 4-9 Password Credential Validator Extended Contract



You can extend the attribute contract of this Password Credential Validator instance.

Core Contract	
DN	
givenName	
mail	
username	
Extend the Contract	**Action**
memberOf	Edit | Delete
objectGUID	Edit | Delete
sn	Edit | Delete
userPrincipalName	Edit | Delete

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

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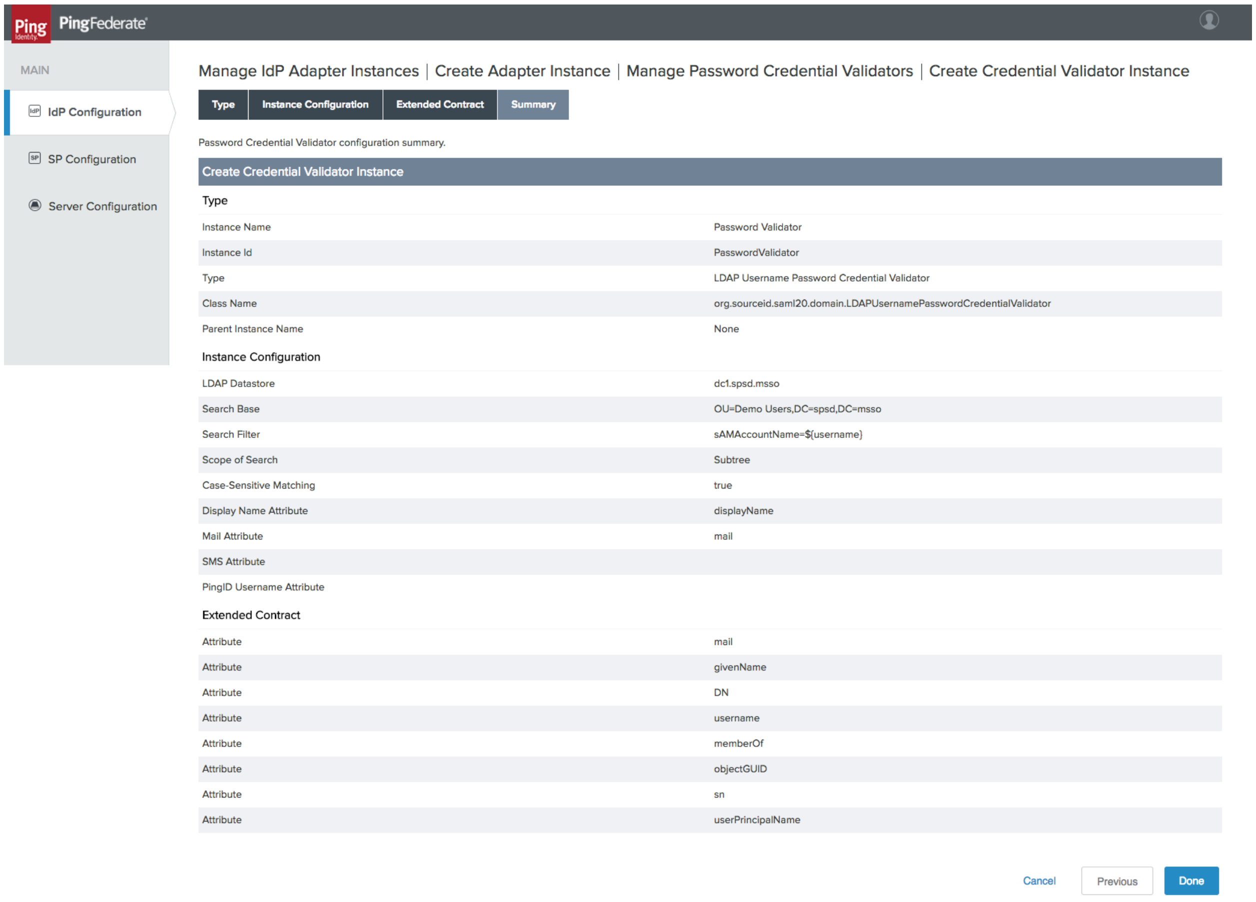
Figure 4-10 Password Validator Summary



Password Credential Validator configuration summary.

Create Credential Validator Instance

Type	
Instance Name	Password Validator
Instance Id	PasswordValidator
Type	LDAP Username Password Credential Validator
Class Name	org.sourceid.saml20.domain.LDAPUsernamePasswordCredentialValidator
Parent Instance Name	None
Instance Configuration	
LDAP Datastore	dc1.spsd.msso
Search Base	OU=Demo Users,DC=spsd,DC=msso
Search Filter	sAMAccountName=${username}
Scope of Search	Subtree
Case-Sensitive Matching	true
Display Name Attribute	displayName
Mail Attribute	mail
SMS Attribute	
PingID Username Attribute	
Extended Contract	
Attribute	mail
Attribute	givenName
Attribute	DN
Attribute	username
Attribute	memberOf
Attribute	objectGUID
Attribute	sn
Attribute	userPrincipalName

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

4.2.1.2 Configure the HTML Form Adapter

1. On the **IdP Configuration** section tab, click **Adapters**.
2. Click **Create New Instance**.
   a. On the **Type** tab, create the name and ID of the adapter, and select the **HTML Form IdP Adapter** for the **TYPE** (Figure 4-11).

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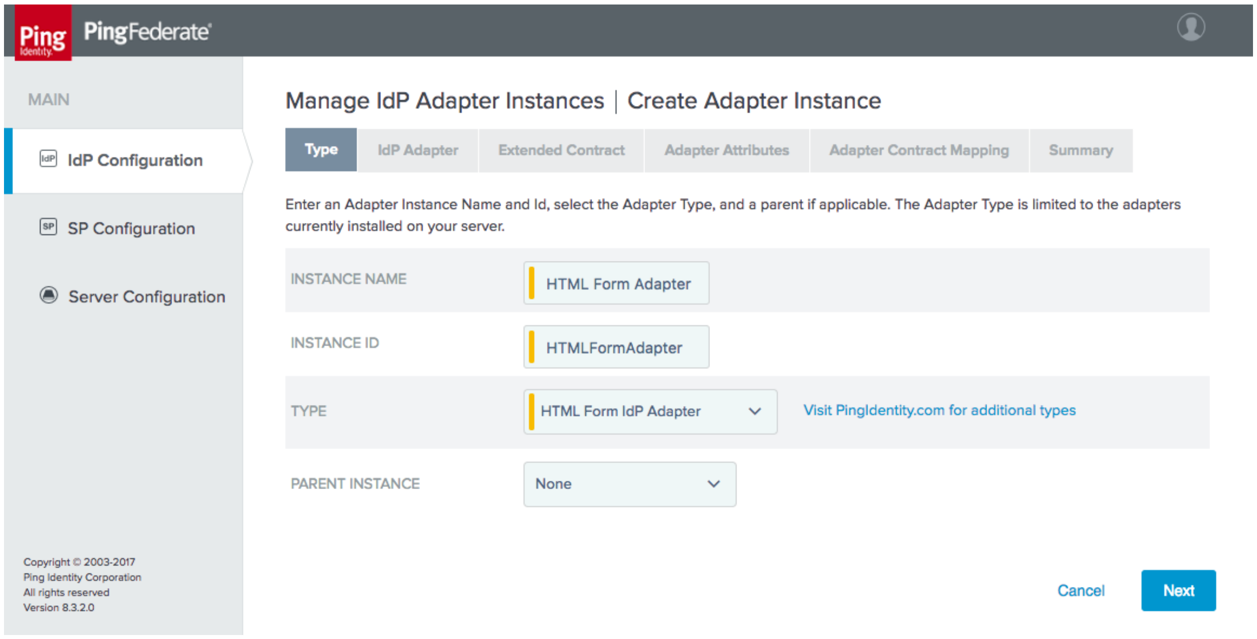
Figure 4-11 HTML Form Adapter Instance



Manage IdP Adapter Instances | Create Adapter Instance

Enter an Adapter Instance Name and Id, select the Adapter Type, and a parent if applicable. The Adapter Type is limited to the adapters currently installed on your server.

INSTANCE NAME	HTML Form Adapter
INSTANCE ID	HTMLFormAdapter
TYPE	HTML Form IdP Adapter
PARENT INSTANCE	None

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

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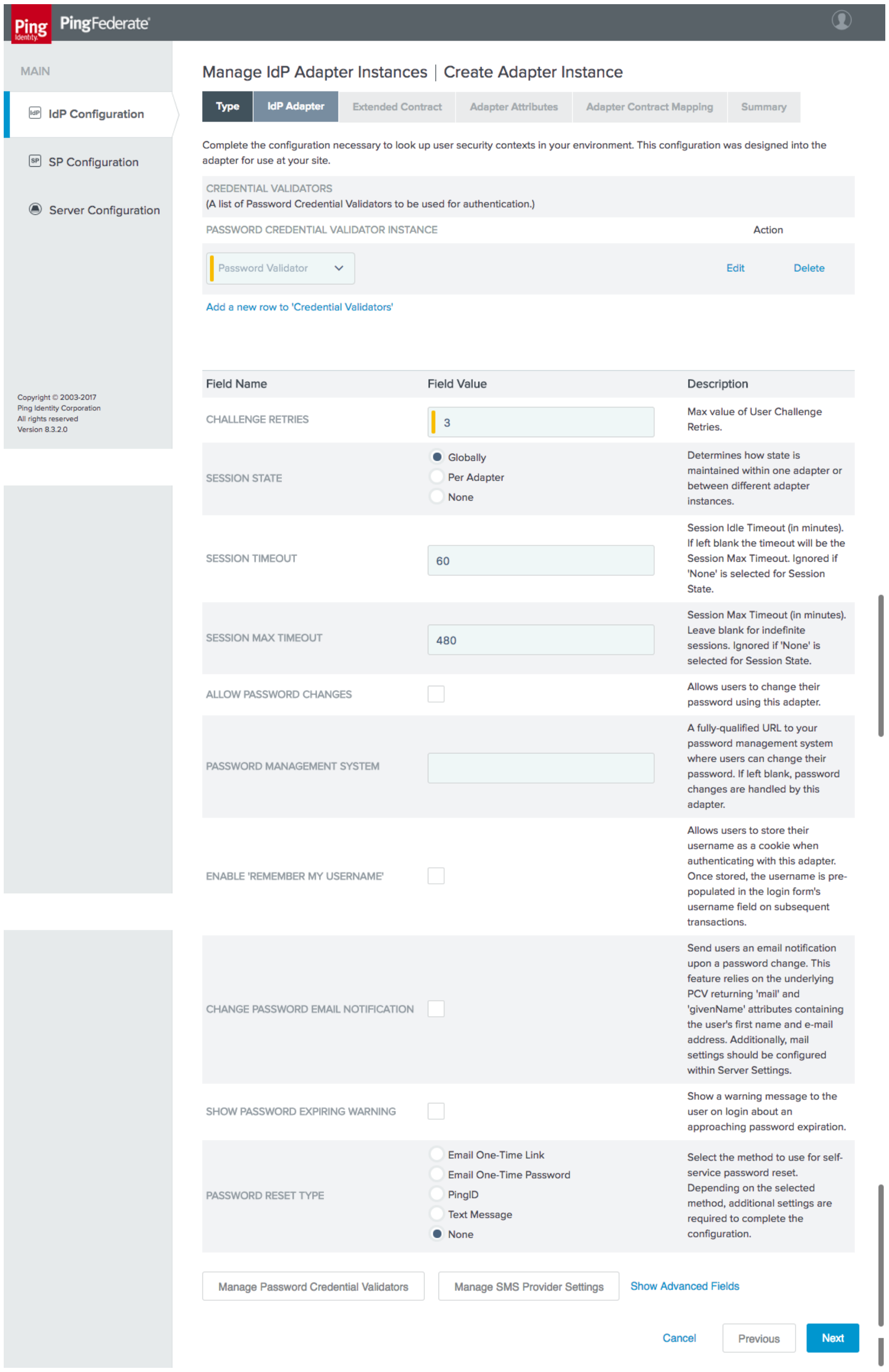
Figure 4-12 Form Adapter Settings



Manage IdP Adapter Instances | Create Adapter Instance

Complete the configuration necessary to look up user security contexts in your environment. This configuration was designed into the adapter for use at your site.

CREDENTIAL VALIDATORS
(A list of Password Credential Validators to be used for authentication.)

PASSWORD CREDENTIAL VALIDATOR INSTANCE	Action	
Password Validator	Edit	Delete

Add a new row to 'Credential Validators'

Field Name	Field Value	Description
CHALLENGE RETRIES	3	Max value of User Challenge Retries.
SESSION STATE	● Globally ○ Per Adapter ○ None	Determines how state is maintained within one adapter or between different adapter instances.
SESSION TIMEOUT	60	Session Idle Timeout (in minutes). If left blank the timeout will be the Session Max Timeout. Ignored if 'None' is selected for Session State.
SESSION MAX TIMEOUT	480	Session Max Timeout (in minutes). Leave blank for indefinite sessions. Ignored if 'None' is selected for Session State.
ALLOW PASSWORD CHANGES	☐	Allows users to change their password using this adapter.
PASSWORD MANAGEMENT SYSTEM		A fully-qualified URL to your password management system where users can change their password. If left blank, password changes are handled by this adapter.
ENABLE 'REMEMBER MY USERNAME'	☐	Allows users to store their username as a cookie when authenticating with this adapter. Once stored, the username is pre-populated in the login form's username field on subsequent transactions.
CHANGE PASSWORD EMAIL NOTIFICATION	☐	Send users an email notification upon a password change. This feature relies on the underlying PCV returning 'mail' and 'givenName' attributes containing the user's first name and e-mail address. Additionally, mail settings should be configured within Server Settings.
SHOW PASSWORD EXPIRING WARNING	☐	Show a warning message to the user on login about an approaching password expiration.
PASSWORD RESET TYPE	○ Email One-Time Link ○ Email One-Time Password ○ PingID ○ Text Message ● None	Select the method to use for self-service password reset. Depending on the selected method, additional settings are required to complete the configuration.

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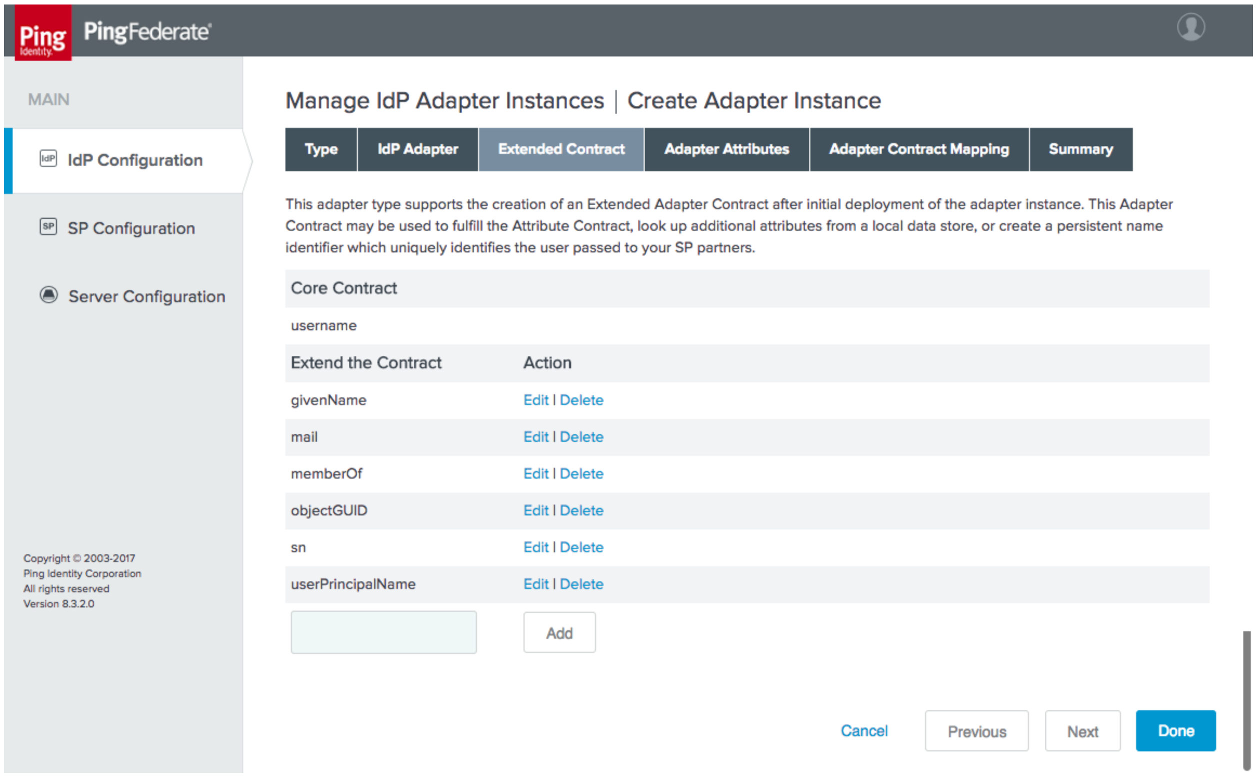
c. On the **Extended Contract** tab, the same attributes returned from AD by the Password Validator are added to the adapter contract to make them available for further use by the IdP (Figure 4-13).

Figure 4-13 Form Adapter Extended Contract



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Manage IdP Adapter Instances | Create Adapter Instance

This adapter type supports the creation of an Extended Adapter Contract after initial deployment of the adapter instance. This Adapter Contract may be used to fulfill the Attribute Contract, look up additional attributes from a local data store, or create a persistent name identifier which uniquely identifies the user passed to your SP partners.

Core Contract	
username	
Extend the Contract	**Action**
givenName	Edit | Delete
mail	Edit | Delete
memberOf	Edit | Delete
objectGUID	Edit | Delete
sn	Edit | Delete
userPrincipalName	Edit | Delete

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, StrongKey CryptoEngine (SKCE), must be installed and configured, and the StrongKey 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**.

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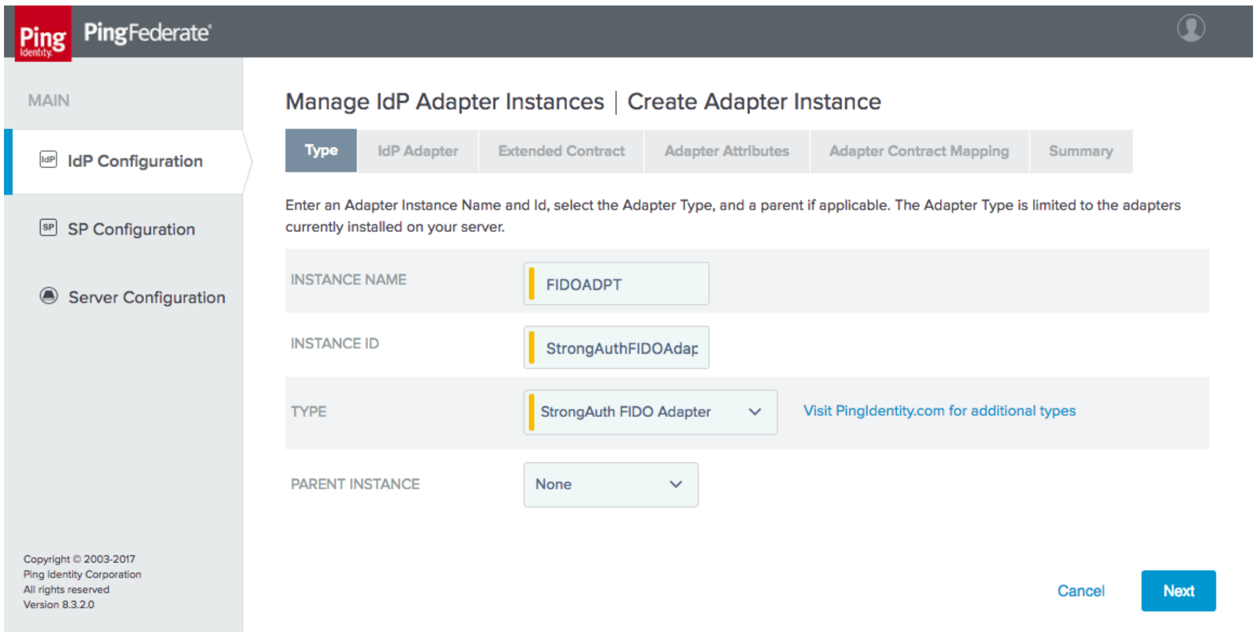
a. Enter meaningful values for **INSTANCE NAME** and **INSTANCE ID**. For the **TYPE,** select "StrongAuth FIDO Adapter." Click **Next**.

Figure 4-14 Create U2F Adapter Instance



Manage IdP Adapter Instances | Create Adapter Instance

Enter an Adapter Instance Name and Id, select the Adapter Type, and a parent if applicable. The Adapter Type is limited to the adapters currently installed on your server.

INSTANCE NAME	FIDOADPT
INSTANCE ID	StrongAuthFIDOAdap
TYPE	StrongAuth FIDO Adapter
PARENT INSTANCE	None

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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 StrongKey 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.

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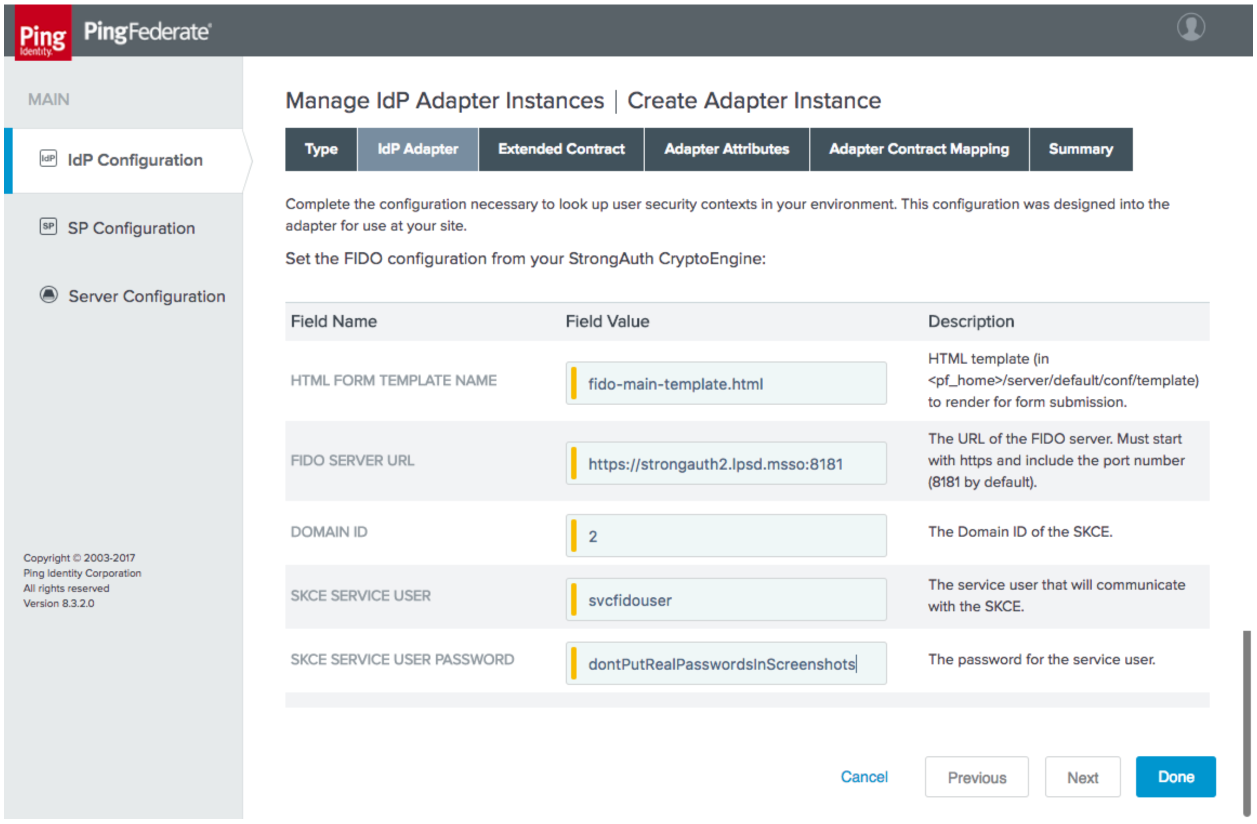
Figure 4-15 U2F Adapter Settings



Manage IdP Adapter Instances | Create Adapter Instance

Complete the configuration necessary to look up user security contexts in your environment. This configuration was designed into the adapter for use at your site.

Set the FIDO configuration from your StrongAuth CryptoEngine:

Field Name	Field Value	Description
HTML FORM TEMPLATE NAME	fido-main-template.html	HTML template (in <pf_home>/server/default/conf/template) to render for form submission.
FIDO SERVER URL	https://strongauth2.lpsd.msso:8181	The URL of the FIDO server. Must start with https and include the port number (8181 by default).
DOMAIN ID	2	The Domain ID of the SKCE.
SKCE SERVICE USER	svcfidouser	The service user that will communicate with the SKCE.
SKCE SERVICE USER PASSWORD	dontPutRealPasswordsInScreenshots	The password for the service user.

c. There is no need to extend the contract for the U2F adapter; therefore, skip the **Extended Contract** tab.

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

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

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

4.2.1.4 Configure the Authentication Policies

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

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

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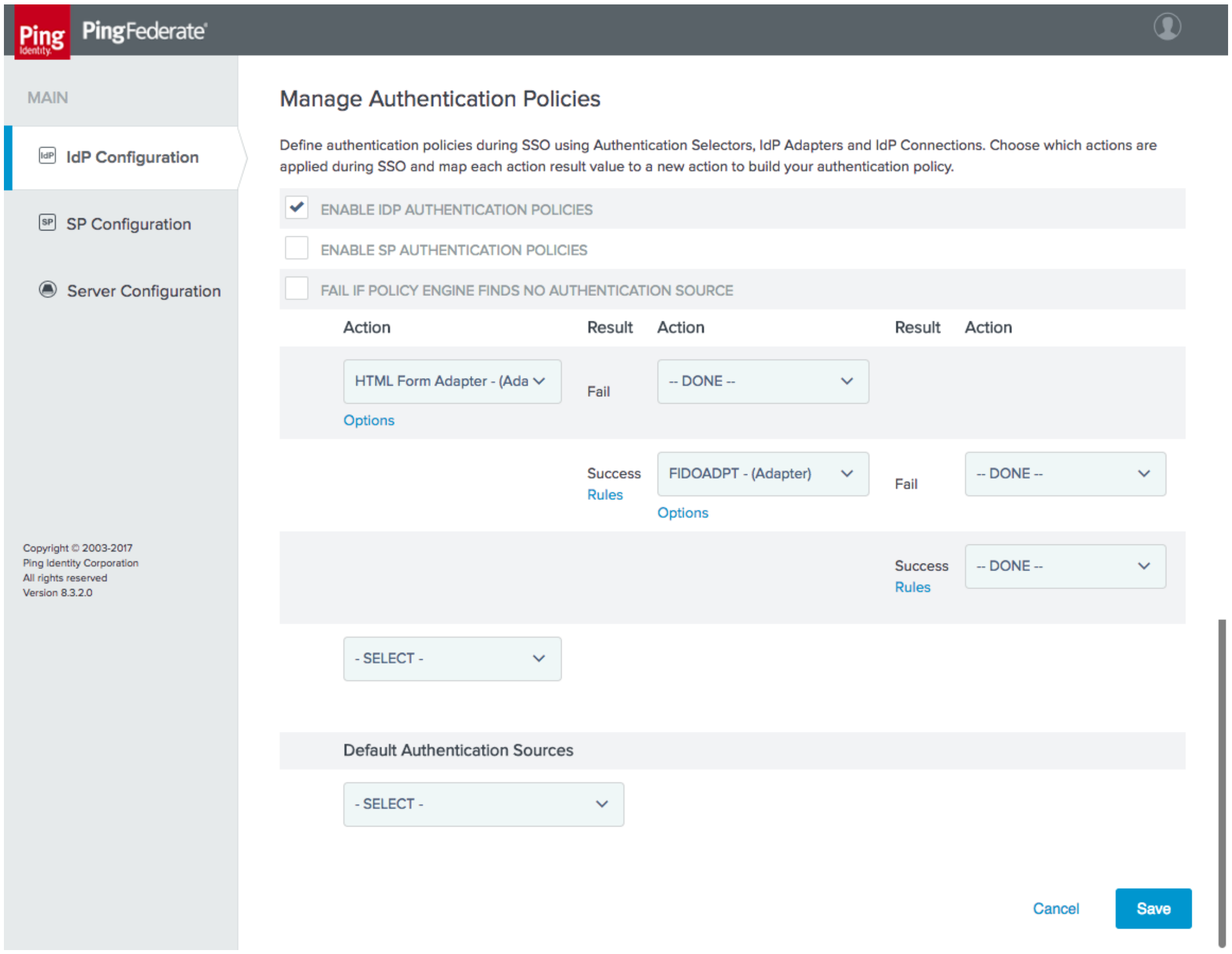
i. On the **Success** branch, add the FIDO U2F adapter (**FIDOADPT**) for the **Action**.

ii. Click **Save**.

Figure 4-16 IdP Authentication Policy



Manage Authentication Policies

Define authentication policies during SSO using Authentication Selectors, IdP Adapters and IdP Connections. Choose which actions are applied during SSO and map each action result value to a new action to build your authentication policy.

- [✓] ENABLE IDP AUTHENTICATION POLICIES
- [ ] ENABLE SP AUTHENTICATION POLICIES
- [ ] FAIL IF POLICY ENGINE FINDS NO AUTHENTICATION SOURCE

Action	Result	Action	Result	Action
HTML Form Adapter - (Ada / Options	Fail	-- DONE --		
	Success / Rules	FIDOADPT - (Adapter) / Options	Fail	-- DONE --
			Success / Rules	-- DONE --
- SELECT -				

Default Authentication Sources

- SELECT -

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.

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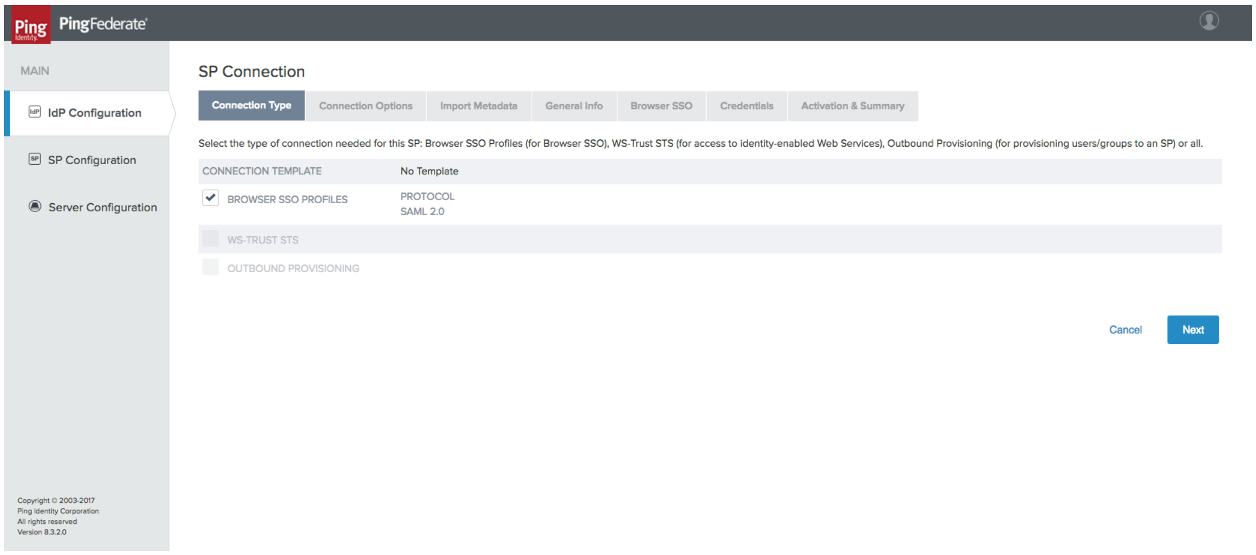
1. To create a new SP connection, click the **IdP Configuration** section tab, and then click **Create New** under **SP Connections**.

    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



Select the type of connection needed for this SP: Browser SSO Profiles (for Browser SSO), WS-Trust STS (for access to identity-enabled Web Services), Outbound Provisioning (for provisioning users/groups to an SP) or all.

CONNECTION TEMPLATE No Template

✓ BROWSER SSO PROFILES PROTOCOL SAML 2.0

WS-TRUST STS

OUTBOUND PROVISIONING

    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.

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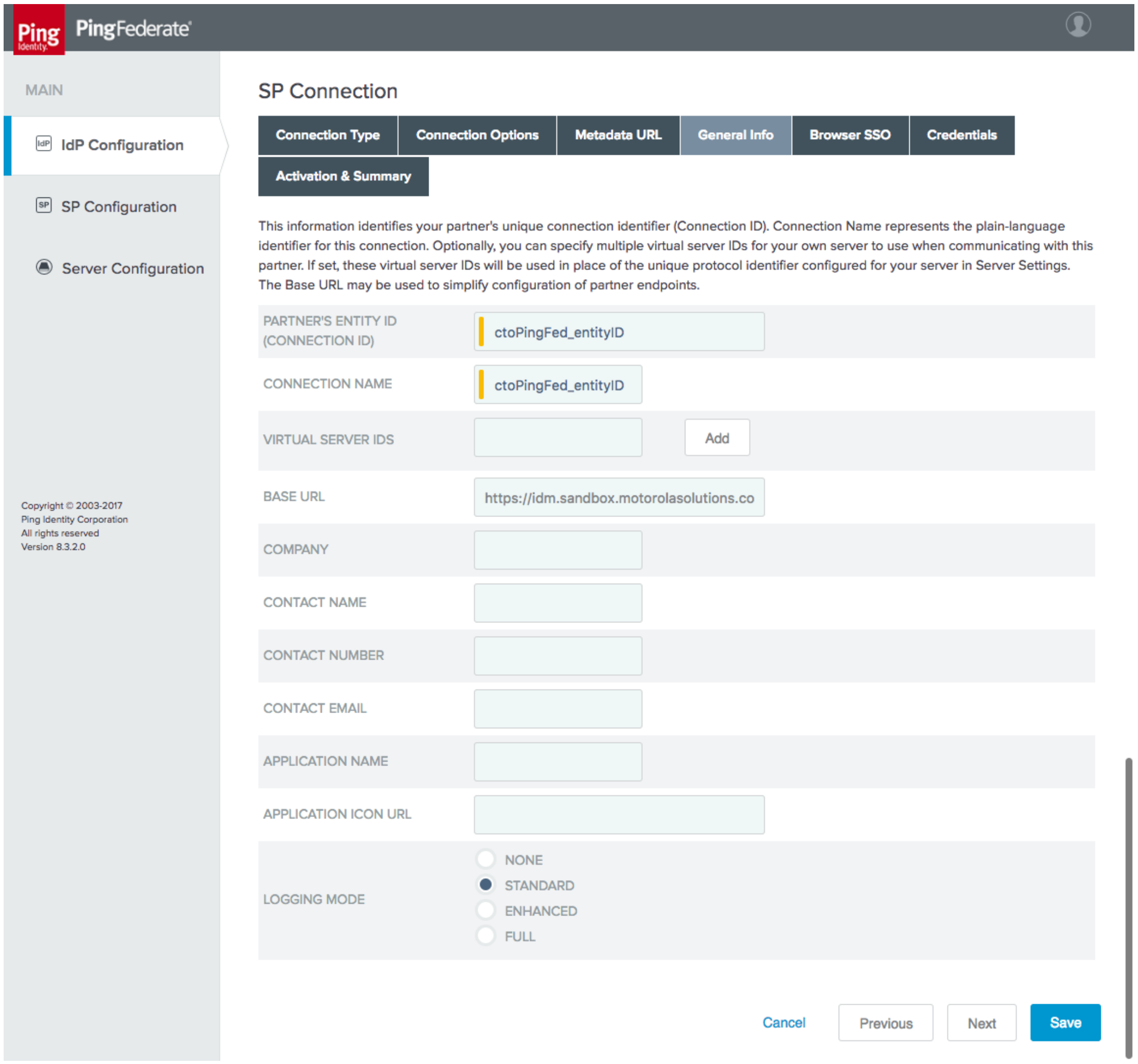
Figure 4-18 SP Connection General Info



This information identifies your partner's unique connection identifier (Connection ID). Connection Name represents the plain-language identifier for this connection. Optionally, you can specify multiple virtual server IDs for your own server to use when communicating with this partner. If set, these virtual server IDs will be used in place of the unique protocol identifier configured for your server in Server Settings. The Base URL may be used to simplify configuration of partner endpoints.

PARTNER'S ENTITY ID (CONNECTION ID)	ctoPingFed_entityID
CONNECTION NAME	ctoPingFed_entityID
VIRTUAL SERVER IDS	
BASE URL	https://idm.sandbox.motorolasolutions.co
COMPANY	
CONTACT NAME	
CONTACT NUMBER	
CONTACT EMAIL	
APPLICATION NAME	
APPLICATION ICON URL	
LOGGING MODE	NONE [✓ STANDARD] ENHANCED FULL

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

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

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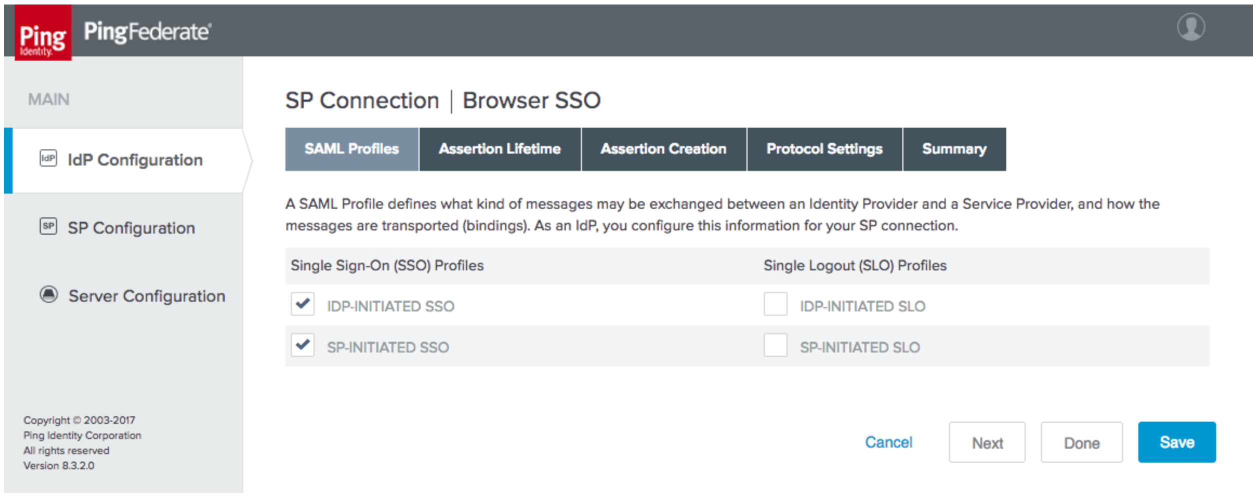
Figure 4-19 SP Browser SSO Profiles



SP Connection | Browser SSO

A SAML Profile defines what kind of messages may be exchanged between an Identity Provider and a Service Provider, and how the messages are transported (bindings). As an IdP, you configure this information for your SP connection.

Single Sign-On (SSO) Profiles	Single Logout (SLO) Profiles
✓ IDP-INITIATED SSO	☐ IDP-INITIATED SLO
✓ SP-INITIATED SSO	☐ SP-INITIATED SLO

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

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

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

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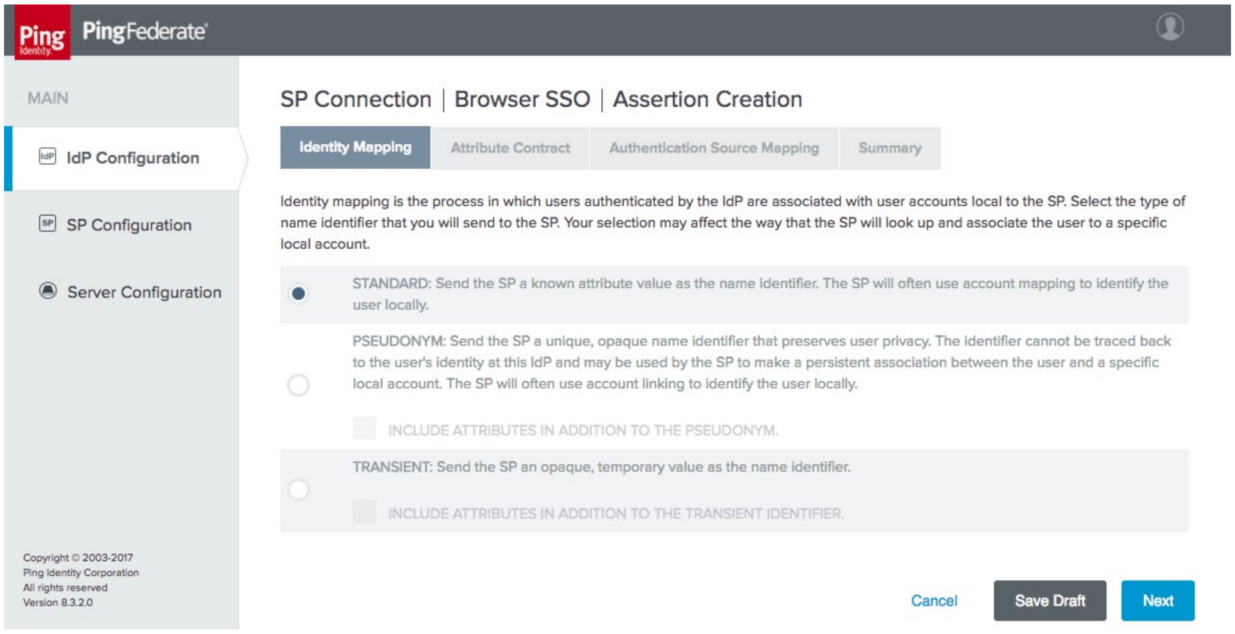
Figure 4-20 Assertion Identity Mapping



SP Connection | Browser SSO | Assertion Creation

Identity mapping is the process in which users authenticated by the IdP are associated with user accounts local to the SP. Select the type of name identifier that you will send to the SP. Your selection may affect the way that the SP will look up and associate the user to a specific local account.

[✓ STANDARD: Send the SP a known attribute value as the name identifier. The SP will often use account mapping to identify the user locally.]

PSEUDONYM: Send the SP a unique, opaque name identifier that preserves user privacy. The identifier cannot be traced back to the user's identity at this IdP and may be used by the SP to make a persistent association between the user and a specific local account. The SP will often use account linking to identify the user locally.

INCLUDE ATTRIBUTES IN ADDITION TO THE PSEUDONYM.

TRANSIENT: Send the SP an opaque, temporary value as the name identifier.

INCLUDE ATTRIBUTES IN ADDITION TO THE TRANSIENT IDENTIFIER.

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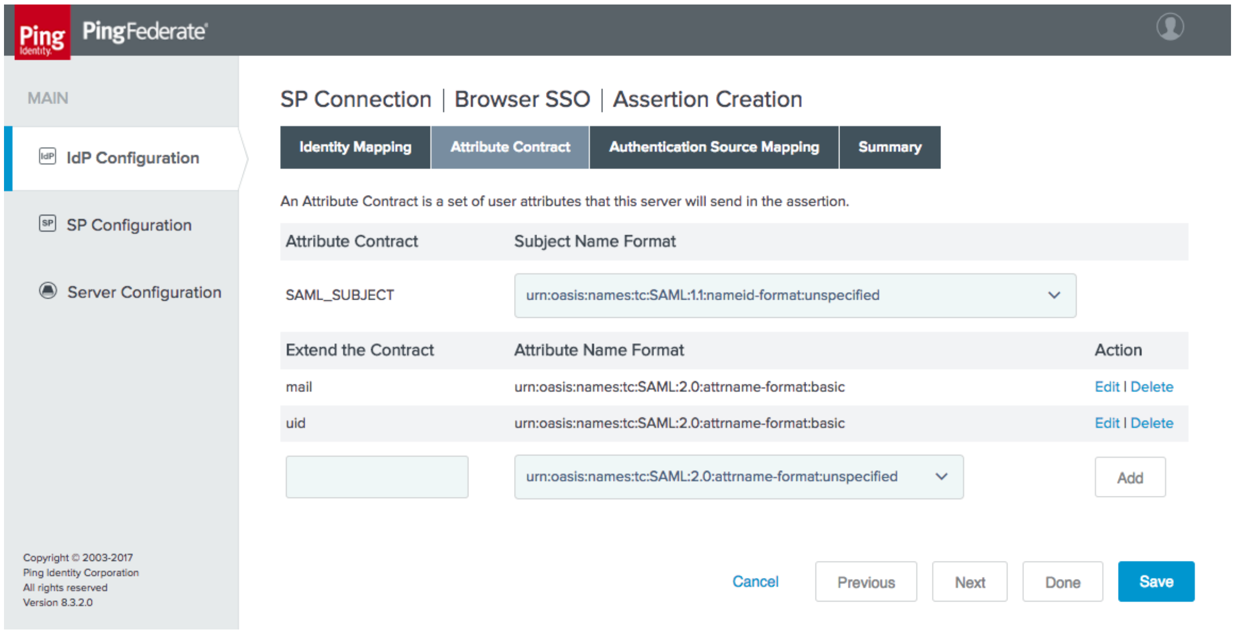
2) On the **Attribute Contract** tab, extend the contract to include the **mail** and **uid** attributes with the basic name format (Figure 4-21). Other attributes can be added here as needed.

Figure 4-21 Assertion Attribute Contract



SP Connection | Browser SSO | Assertion Creation

An Attribute Contract is a set of user attributes that this server will send in the assertion.

Attribute Contract	Subject Name Format
SAML_SUBJECT	urn:oasis:names:tc:SAML:1.1:nameid-format:unspecified

Extend the Contract	Attribute Name Format	Action
mail	urn:oasis:names:tc:SAML:2.0:attrname-format:basic	Edit | Delete
uid	urn:oasis:names:tc:SAML:2.0:attrname-format:basic	Edit | Delete
	urn:oasis:names:tc:SAML:2.0:attrname-format:unspecified	Add

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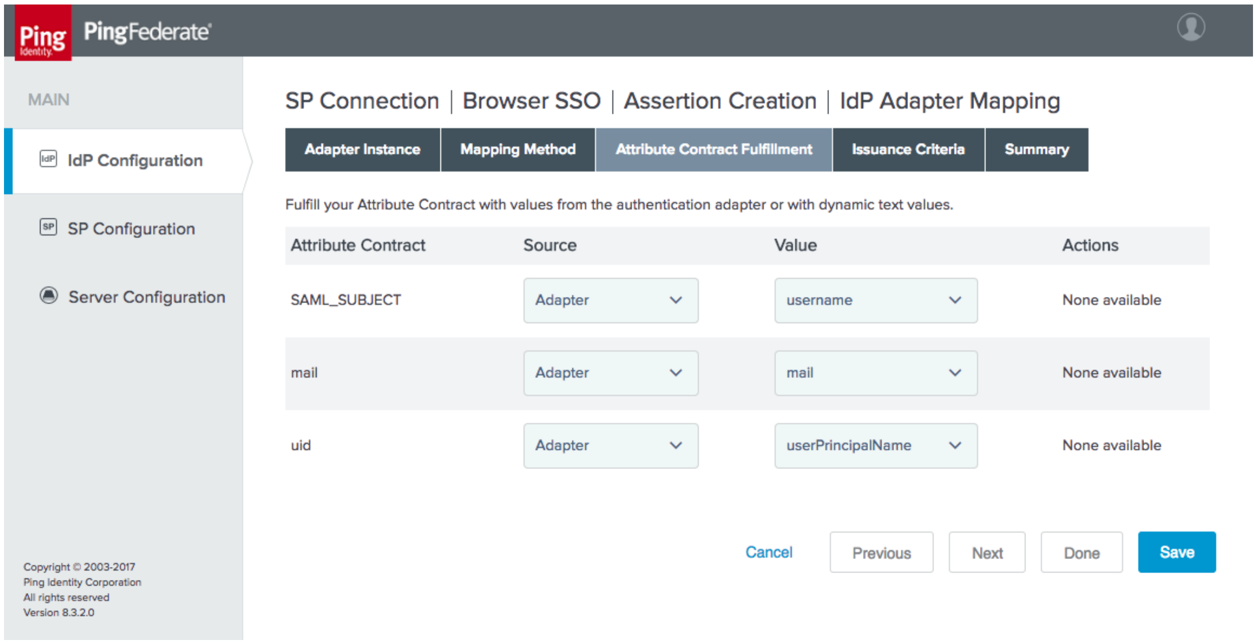
3) On the **Authentication Source Mapping** tab, attributes provided by authentication adapters and policy contracts can be mapped to the assertion attribute contract, identifying which data will be used to populate the assertions. The FIDO U2F adapter and the HTML Form Adapter should appear under **Adapter 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



SP Connection | Browser SSO | Assertion Creation | IdP Adapter Mapping

Fulfill your Attribute Contract with values from the authentication adapter or with dynamic text values.

Attribute Contract	Source	Value	Actions
SAML_SUBJECT	Adapter	username	None available
mail	Adapter	mail	None available
uid	Adapter	userPrincipalName	None available

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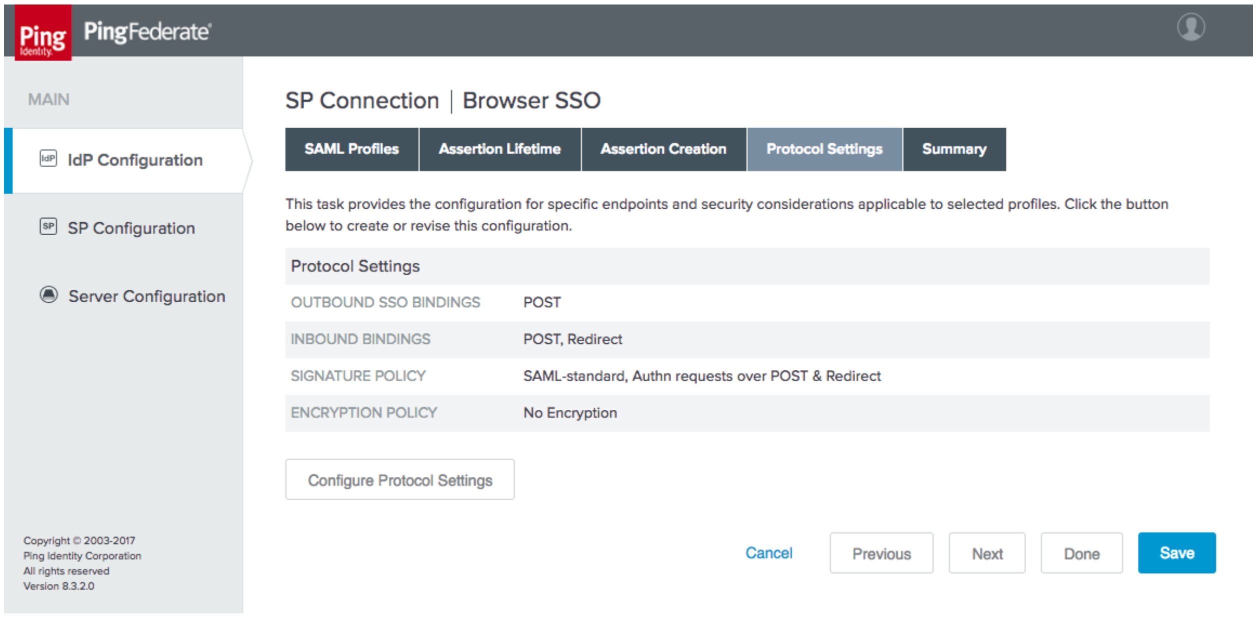
d) No **Issuance Criteria** are required; therefore, skip the **Issuance Criteria** tab.

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 stayed at their default settings.

Figure 4-23 Browser SSO Protocol Settings



This task provides the configuration for specific endpoints and security considerations applicable to selected profiles. Click the button below to create or revise this configuration.

Protocol Settings	
OUTBOUND SSO BINDINGS	POST
INBOUND BINDINGS	POST, Redirect
SIGNATURE POLICY	SAML-standard, Authn requests over POST & Redirect
ENCRYPTION POLICY	No Encryption

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.

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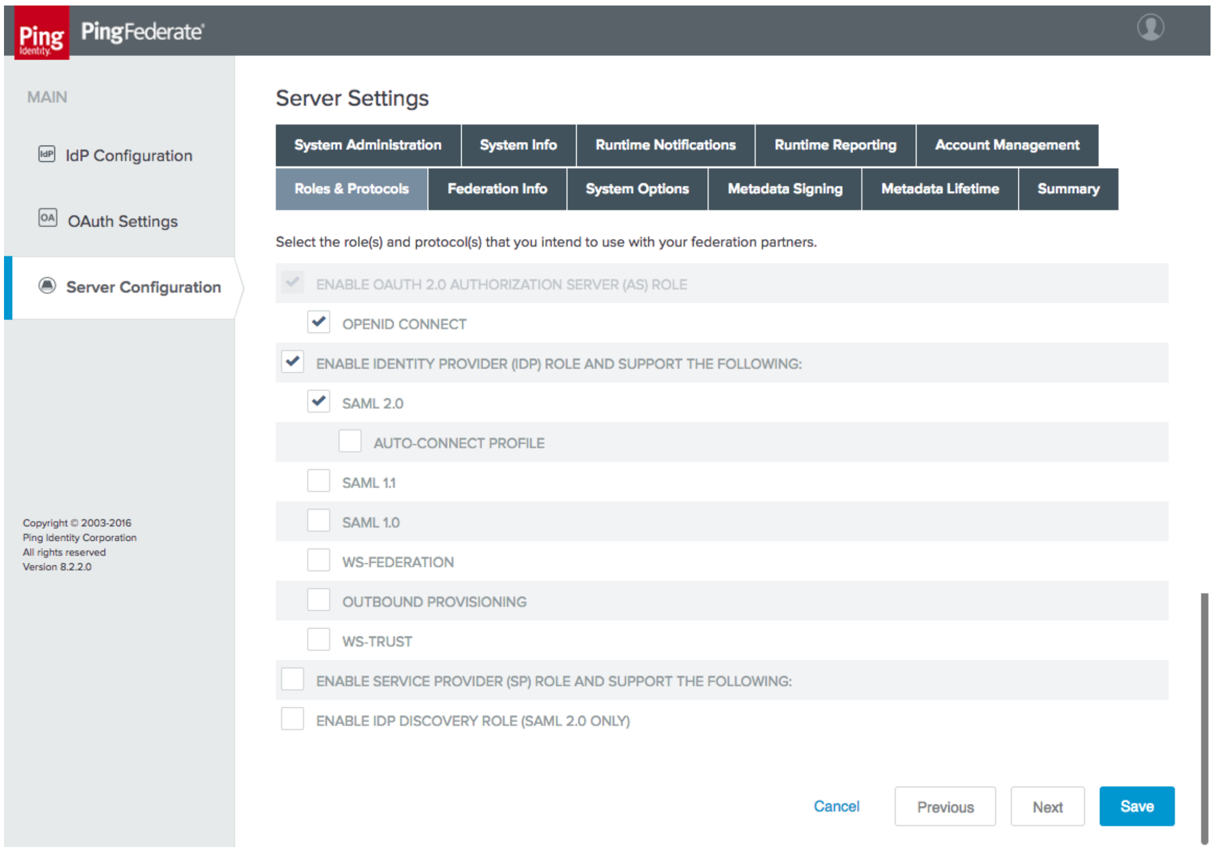
4.3 How to Install and Configure the OIDC Identity Provider

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



Select the role(s) and protocol(s) that you intend to use with your federation partners.

- [✓] ENABLE OAUTH 2.0 AUTHORIZATION SERVER (AS) ROLE
  - [✓] OPENID CONNECT
- [✓] ENABLE IDENTITY PROVIDER (IDP) ROLE AND SUPPORT THE FOLLOWING:
  - [✓] SAML 2.0
    - [ ] AUTO-CONNECT PROFILE
  - [ ] SAML 1.1
  - [ ] SAML 1.0
  - [ ] WS-FEDERATION
  - [ ] OUTBOUND PROVISIONING
  - [ ] WS-TRUST
- [ ] ENABLE SERVICE PROVIDER (SP) ROLE AND SUPPORT THE FOLLOWING:
- [ ] ENABLE IDP DISCOVERY ROLE (SAML 2.0 ONLY)

    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.

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3. On the **OAuth Settings** section tab, click **Scope Management**. Add the scopes defined in the OpenID Connect Core specification [25]:

   - 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**.

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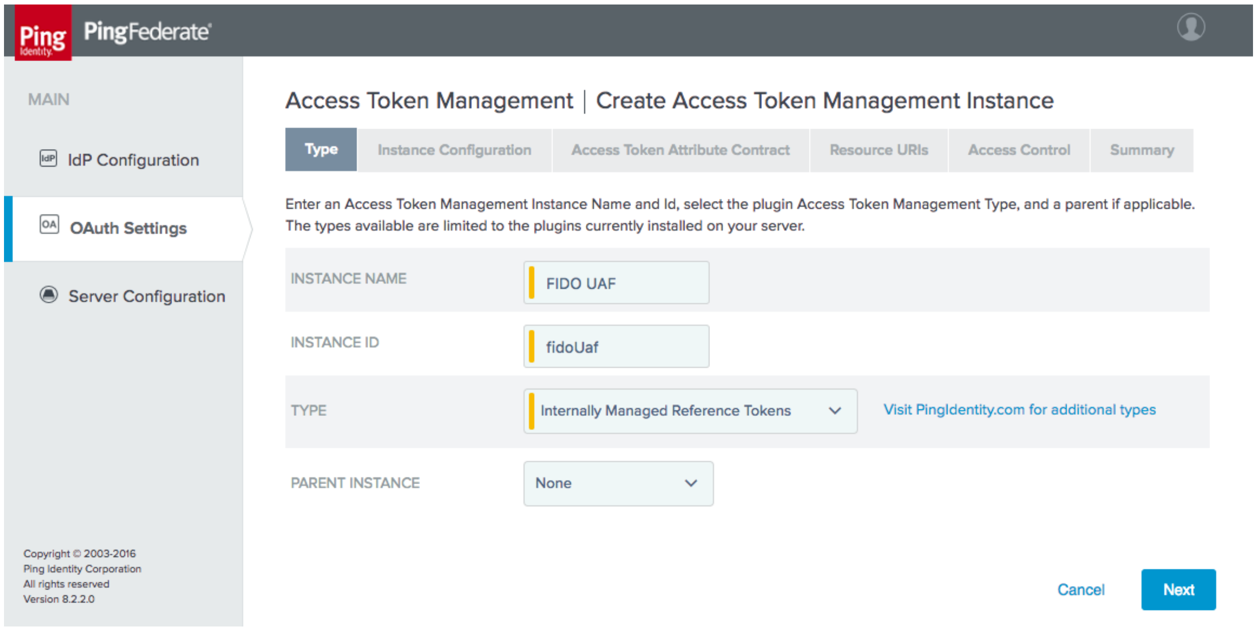
Figure 4-25 Create Access Token Manager



Access Token Management | Create Access Token Management Instance

Enter an Access Token Management Instance Name and Id, select the plugin Access Token Management Type, and a parent if applicable. The types available are limited to the plugins currently installed on your server.

INSTANCE NAME	FIDO UAF
INSTANCE ID	fidoUaf
TYPE	Internally Managed Reference Tokens
PARENT INSTANCE	None

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

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

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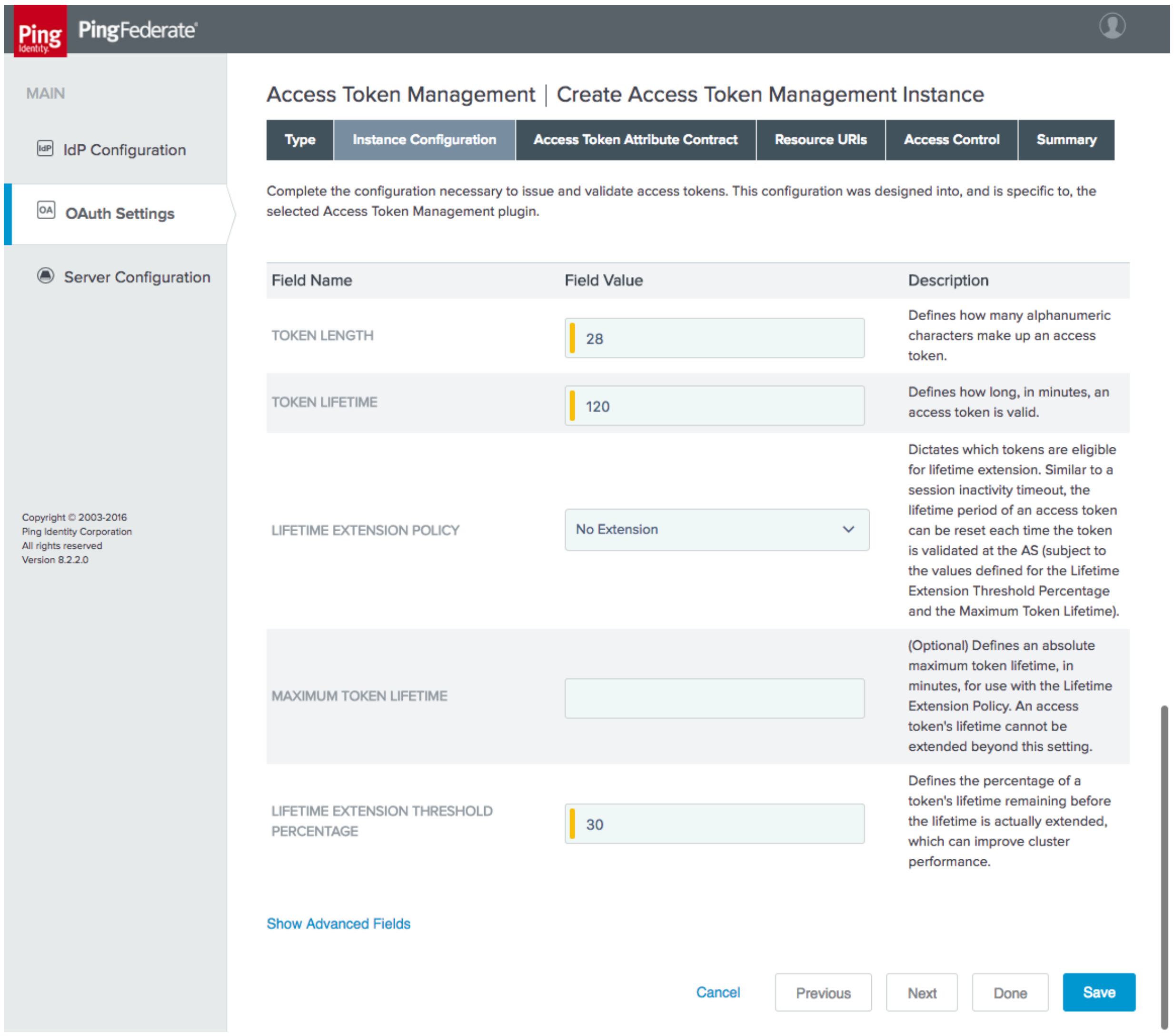
Figure 4-26 Access Token Manager Configuration



Access Token Management | Create Access Token Management Instance

Complete the configuration necessary to issue and validate access tokens. This configuration was designed into, and is specific to, the selected Access Token Management plugin.

Field Name	Field Value	Description
TOKEN LENGTH	28	Defines how many alphanumeric characters make up an access token.
TOKEN LIFETIME	120	Defines how long, in minutes, an access token is valid.
LIFETIME EXTENSION POLICY	No Extension	Dictates which tokens are eligible for lifetime extension. Similar to a session inactivity timeout, the lifetime period of an access token can be reset each time the token is validated at the AS (subject to the values defined for the Lifetime Extension Threshold Percentage and the Maximum Token Lifetime).
MAXIMUM TOKEN LIFETIME		(Optional) Defines an absolute maximum token lifetime, in minutes, for use with the Lifetime Extension Policy. An access token's lifetime cannot be extended beyond this setting.
LIFETIME EXTENSION THRESHOLD PERCENTAGE	30	Defines the percentage of a token's lifetime remaining before the lifetime is actually extended, which can improve cluster performance.

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

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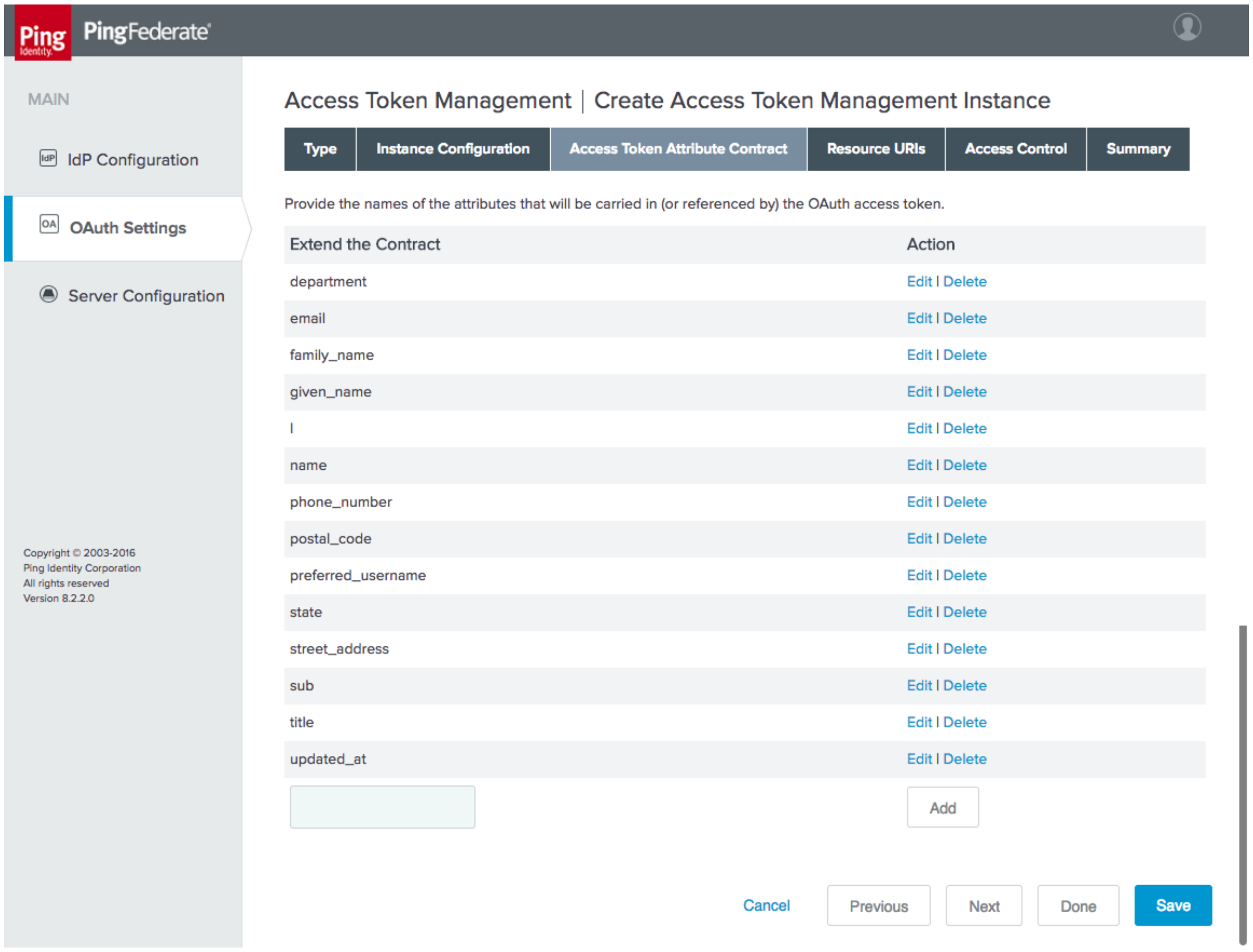
Figure 4-27 Access Token Attribute Contract



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Access Token Management | Create Access Token Management Instance

Provide the names of the attributes that will be carried in (or referenced by) the OAuth access token.

Extend the Contract	Action
department	Edit | Delete
email	Edit | Delete
family_name	Edit | Delete
given_name	Edit | Delete
l	Edit | Delete
name	Edit | Delete
phone_number	Edit | Delete
postal_code	Edit | Delete
preferred_username	Edit | Delete
state	Edit | Delete
street_address	Edit | Delete
sub	Edit | Delete
title	Edit | Delete
updated_at	Edit | Delete

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

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

4.3.1.3 Configure an IdP Adapter Mapping

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

1. Click the **OAuth Settings** section tab, and then click **IdP Adapter Mapping**.
2. Select the UAF adapter instance created in Section 4.3.1.1, and then click **Add Mapping**.

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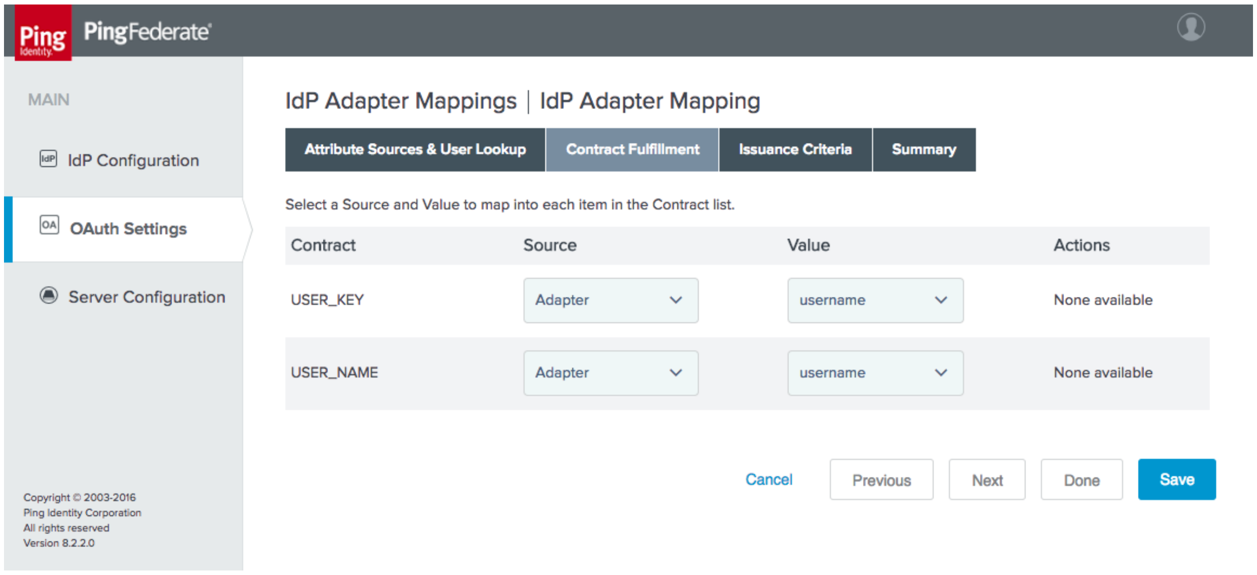
a. On the **Contract Fulfillment** tab, map both **USER_KEY** and **USER_NAME** to the **username** value returned from the adapter (Figure 4-28).

Figure 4-28 Access Token Contract Fulfillment



Select a Source and Value to map into each item in the Contract list.

Contract	Source	Value	Actions
USER_KEY	Adapter	username	None available
USER_NAME	Adapter	username	None available

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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.

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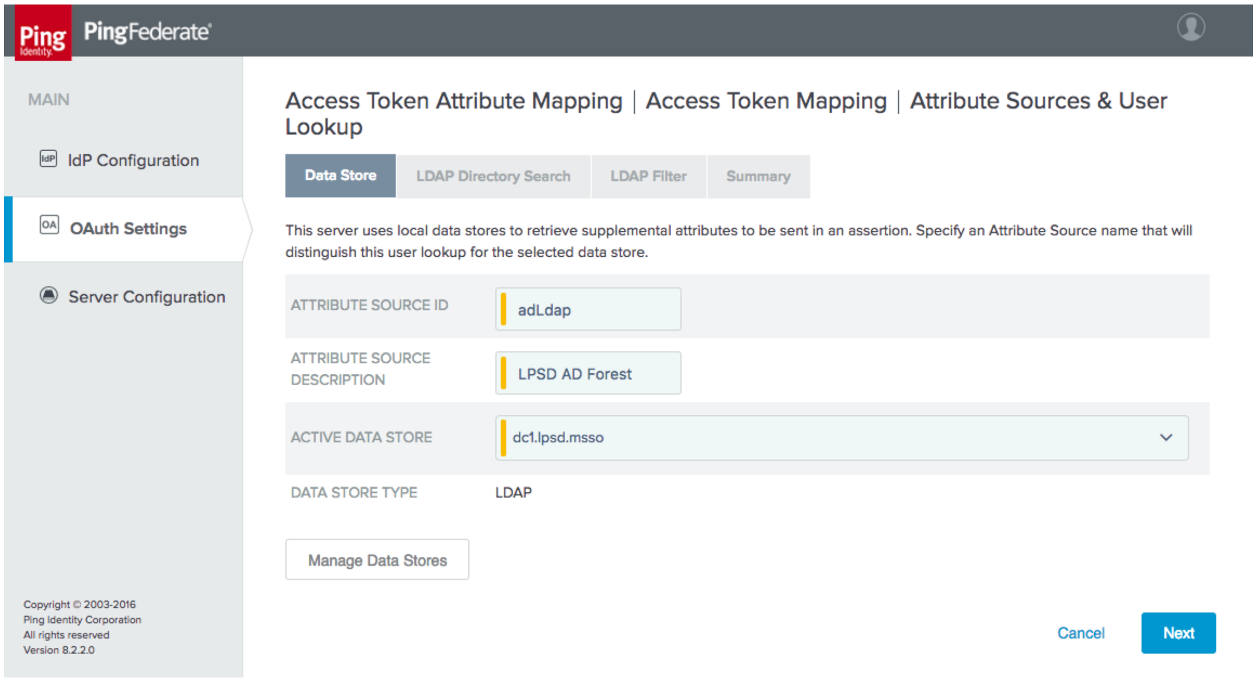
Figure 4-29 Data Store for User Lookup



Access Token Attribute Mapping | Access Token Mapping | Attribute Sources & User Lookup

This server uses local data stores to retrieve supplemental attributes to be sent in an assertion. Specify an Attribute Source name that will distinguish this user lookup for the selected data store.

ATTRIBUTE SOURCE ID	adLdap
ATTRIBUTE SOURCE DESCRIPTION	LPSD AD Forest
ACTIVE DATA STORE	dc1.lpsd.msso
DATA STORE TYPE	LDAP

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ii. On the **LDAP Directory Search** tab, specify the **BASE DN** and **SEARCH SCOPE**, and add the AD attributes to be retrieved (Figure 4-30). When specifying attributes, it is necessary to first select the root object class that contains the attribute. Common attributes associated with user accounts may be derived from the **User** or **OrganizationalPerson** class, for example. Refer to Microsoft's AD Schema documentation [26] to identify the class from which a given attribute is derived.

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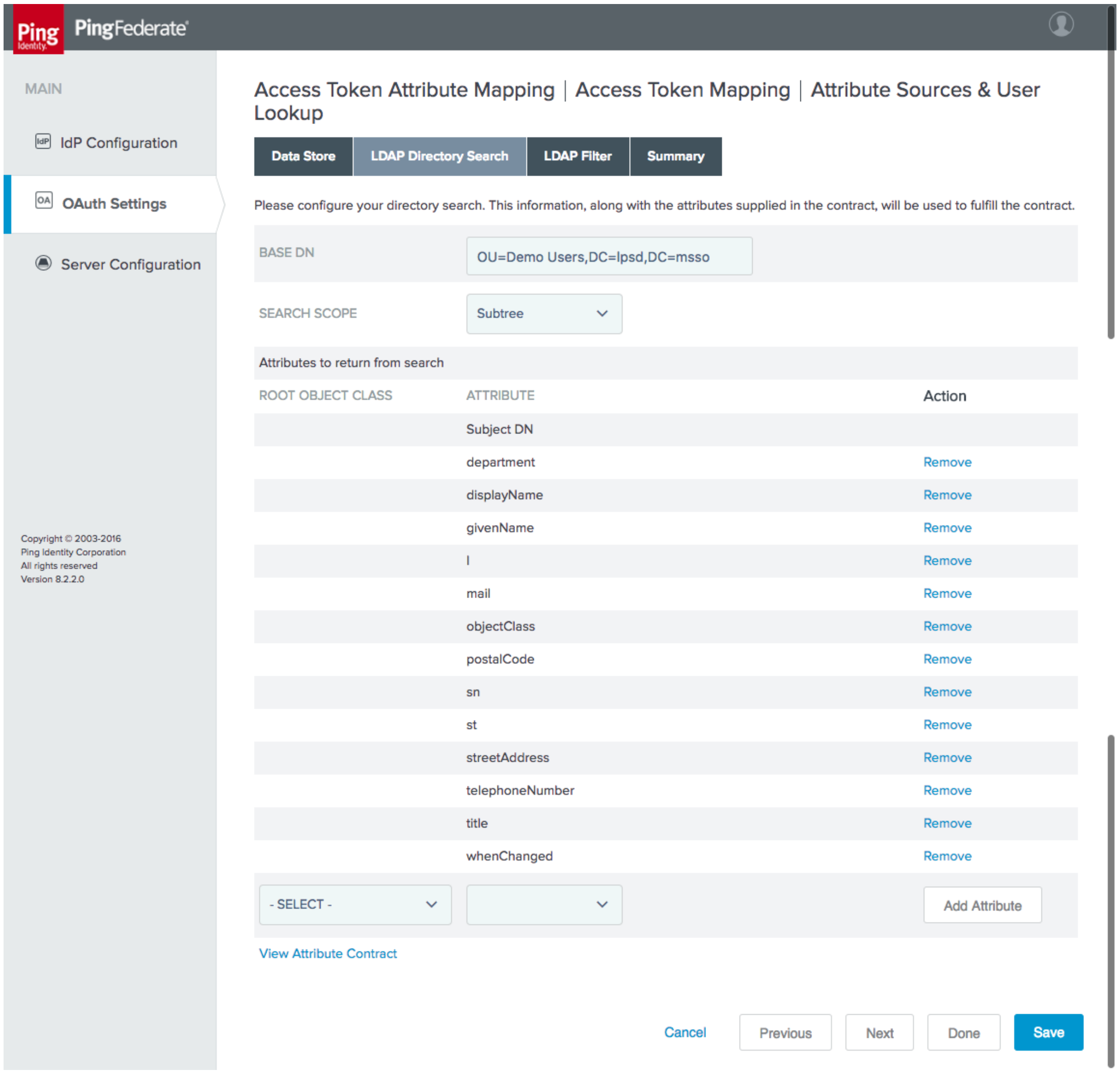
Figure 4-30 Attribute Directory Search



Access Token Attribute Mapping | Access Token Mapping | Attribute Sources & User Lookup

Please configure your directory search. This information, along with the attributes supplied in the contract, will be used to fulfill the contract.

BASE DN: OU=Demo Users,DC=lpsd,DC=msso

SEARCH SCOPE: Subtree

Attributes to return from search

ROOT OBJECT CLASS	ATTRIBUTE	Action
	Subject DN	
	department	Remove
	displayName	Remove
	givenName	Remove
	l	Remove
	mail	Remove
	objectClass	Remove
	postalCode	Remove
	sn	Remove
	st	Remove
	streetAddress	Remove
	telephoneNumber	Remove
	title	Remove
	whenChanged	Remove
- SELECT -		Add Attribute

View Attribute Contract

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

```
sAMAccountName=${adapter.username}
```

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

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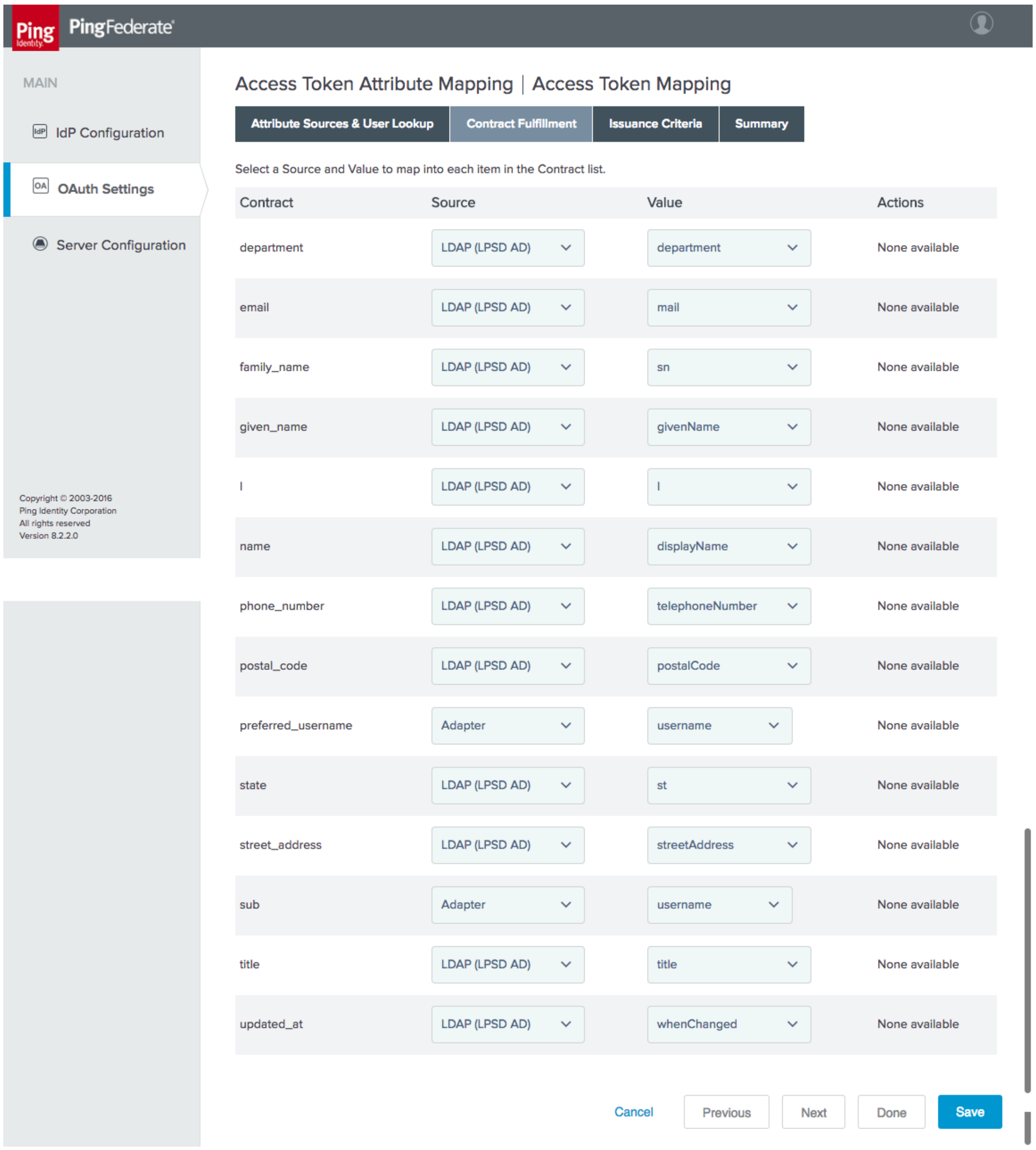
b. On the **Contract Fulfillment** tab, specify the source and value to use for each attribute in the access token attribute contract (Figure 4-31).

Figure 4-31 Access Token Contract Fulfillment



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Access Token Attribute Mapping | Access Token Mapping

Select a Source and Value to map into each item in the Contract list.

Contract	Source	Value	Actions
department	LDAP (LPSD AD)	department	None available
email	LDAP (LPSD AD)	mail	None available
family_name	LDAP (LPSD AD)	sn	None available
given_name	LDAP (LPSD AD)	givenName	None available
l	LDAP (LPSD AD)	l	None available
name	LDAP (LPSD AD)	displayName	None available
phone_number	LDAP (LPSD AD)	telephoneNumber	None available
postal_code	LDAP (LPSD AD)	postalCode	None available
preferred_username	Adapter	username	None available
state	LDAP (LPSD AD)	st	None available
street_address	LDAP (LPSD AD)	streetAddress	None available
sub	Adapter	username	None available
title	LDAP (LPSD AD)	title	None available
updated_at	LDAP (LPSD AD)	whenChanged	None available

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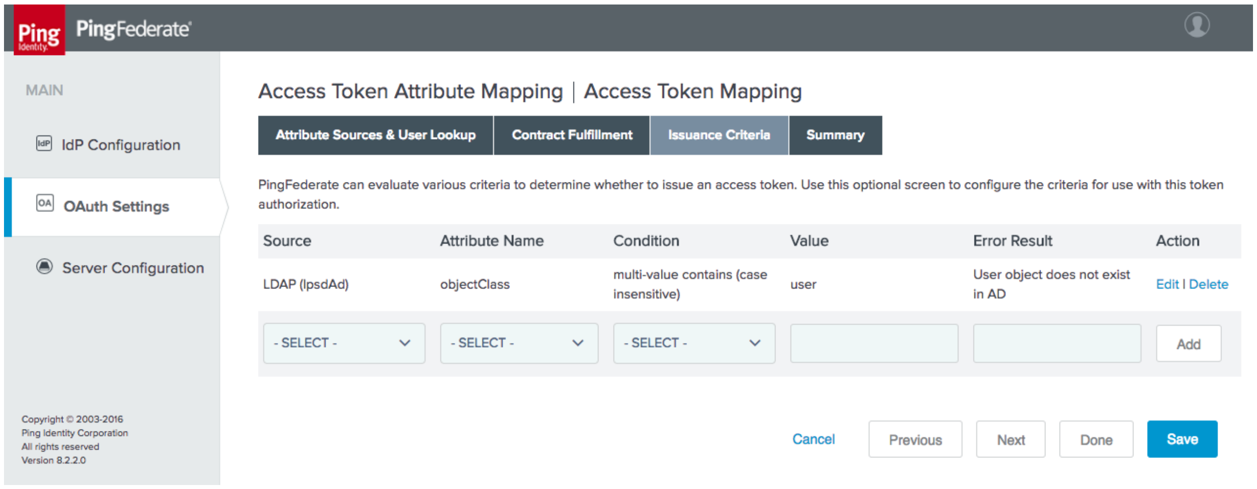
c. On the **Issuance Criteria** tab, define a rule that will prevent token issuance if the user account doesn't exist in AD (Figure 4-32). In this case, the **objectClass** attribute, which all AD objects have, is checked for the **Value** called **user**. If no user account is found in AD, this attribute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



PingFederate can evaluate various criteria to determine whether to issue an access token. Use this optional screen to configure the criteria for use with this token authorization.

Source	Attribute Name	Condition	Value	Error Result	Action
LDAP (lpsdAd)	objectClass	multi-value contains (case insensitive)	user	User object does not exist in AD	Edit I Delete

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.

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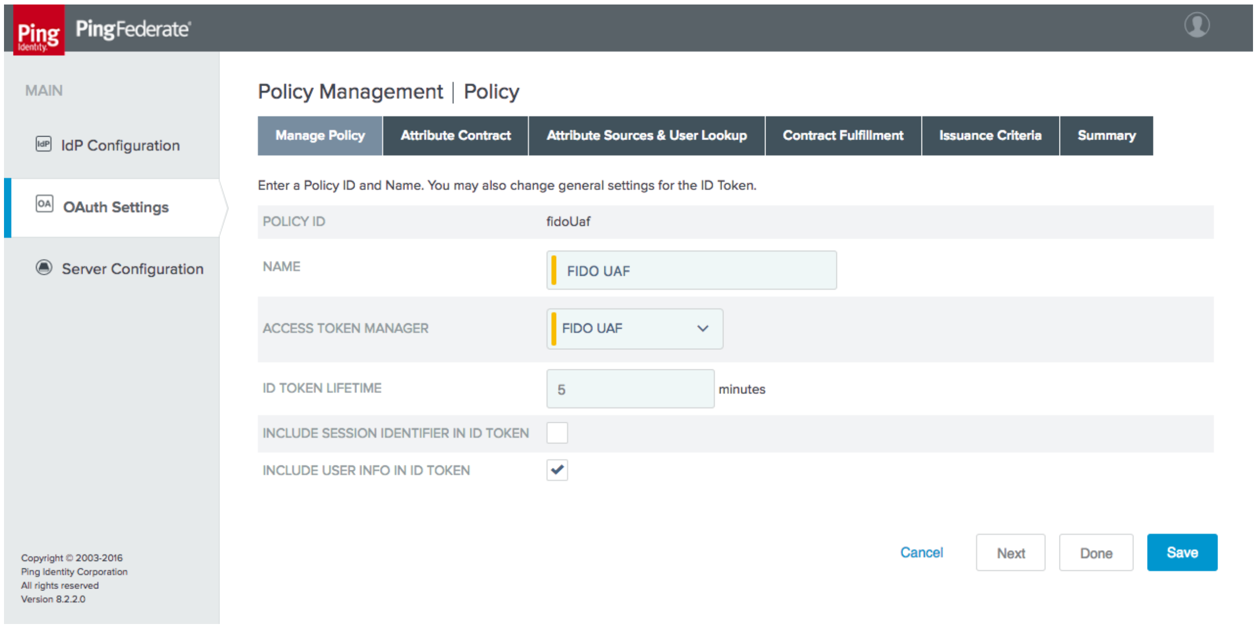
Figure 4-33 OIDC Policy Creation



Policy Management | Policy

Enter a Policy ID and Name. You may also change general settings for the ID Token.

POLICY ID	fidoUaf
NAME	FIDO UAF
ACCESS TOKEN MANAGER	FIDO UAF
ID TOKEN LIFETIME	5 minutes
INCLUDE SESSION IDENTIFIER IN ID TOKEN	☐
INCLUDE USER INFO IN ID TOKEN	✓

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

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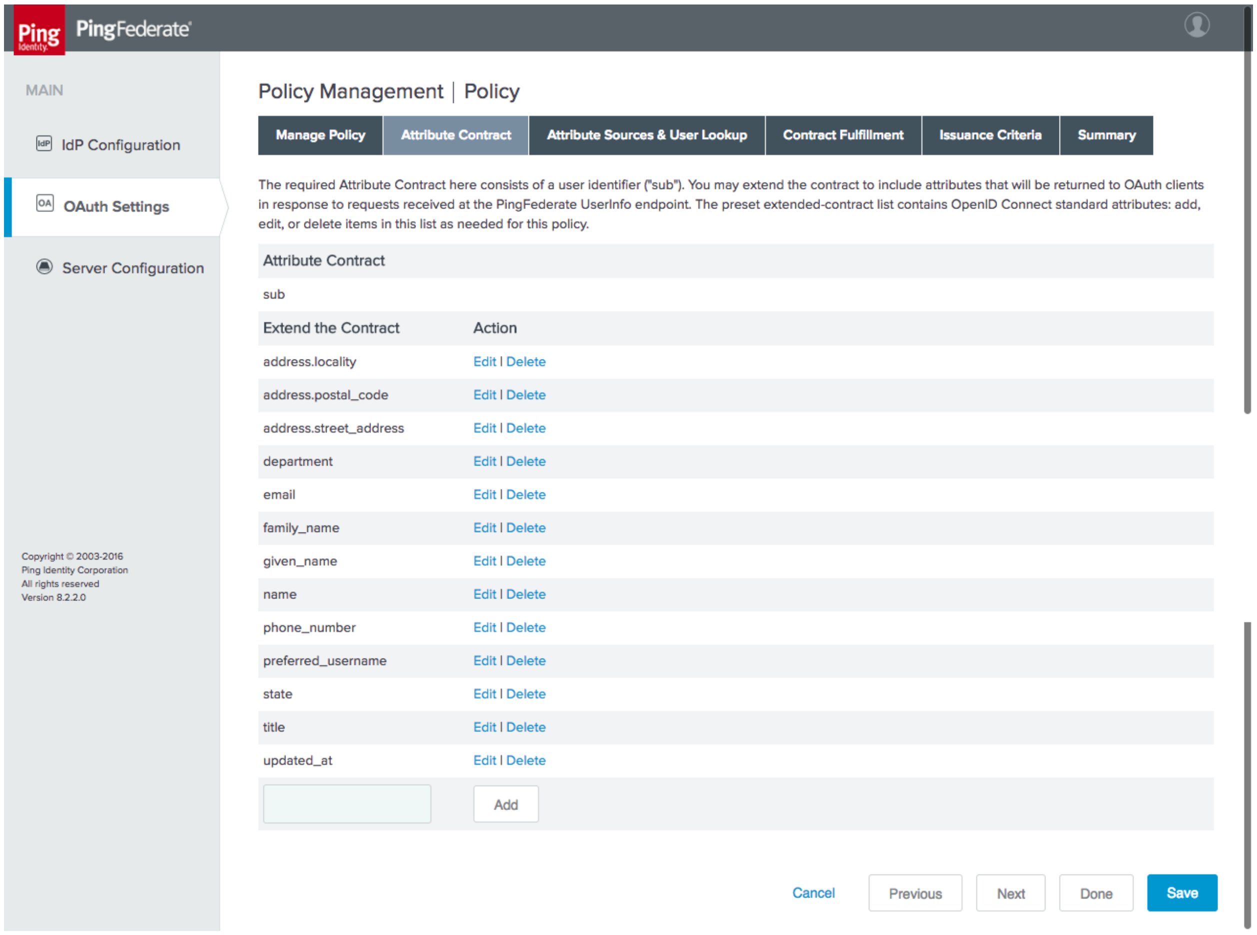
Figure 4-34 OIDC Policy Attribute Contract



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Policy Management | Policy

The required Attribute Contract here consists of a user identifier ("sub"). You may extend the contract to include attributes that will be returned to OAuth clients in response to requests received at the PingFederate UserInfo endpoint. The preset extended-contract list contains OpenID Connect standard attributes: add, edit, or delete items in this list as needed for this policy.

Attribute Contract	
sub	
Extend the Contract	**Action**
address.locality	Edit | Delete
address.postal_code	Edit | Delete
address.street_address	Edit | Delete
department	Edit | Delete
email	Edit | Delete
family_name	Edit | Delete
given_name	Edit | Delete
name	Edit | Delete
phone_number	Edit | Delete
preferred_username	Edit | Delete
state	Edit | Delete
title	Edit | Delete
updated_at	Edit | Delete
	Add

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

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

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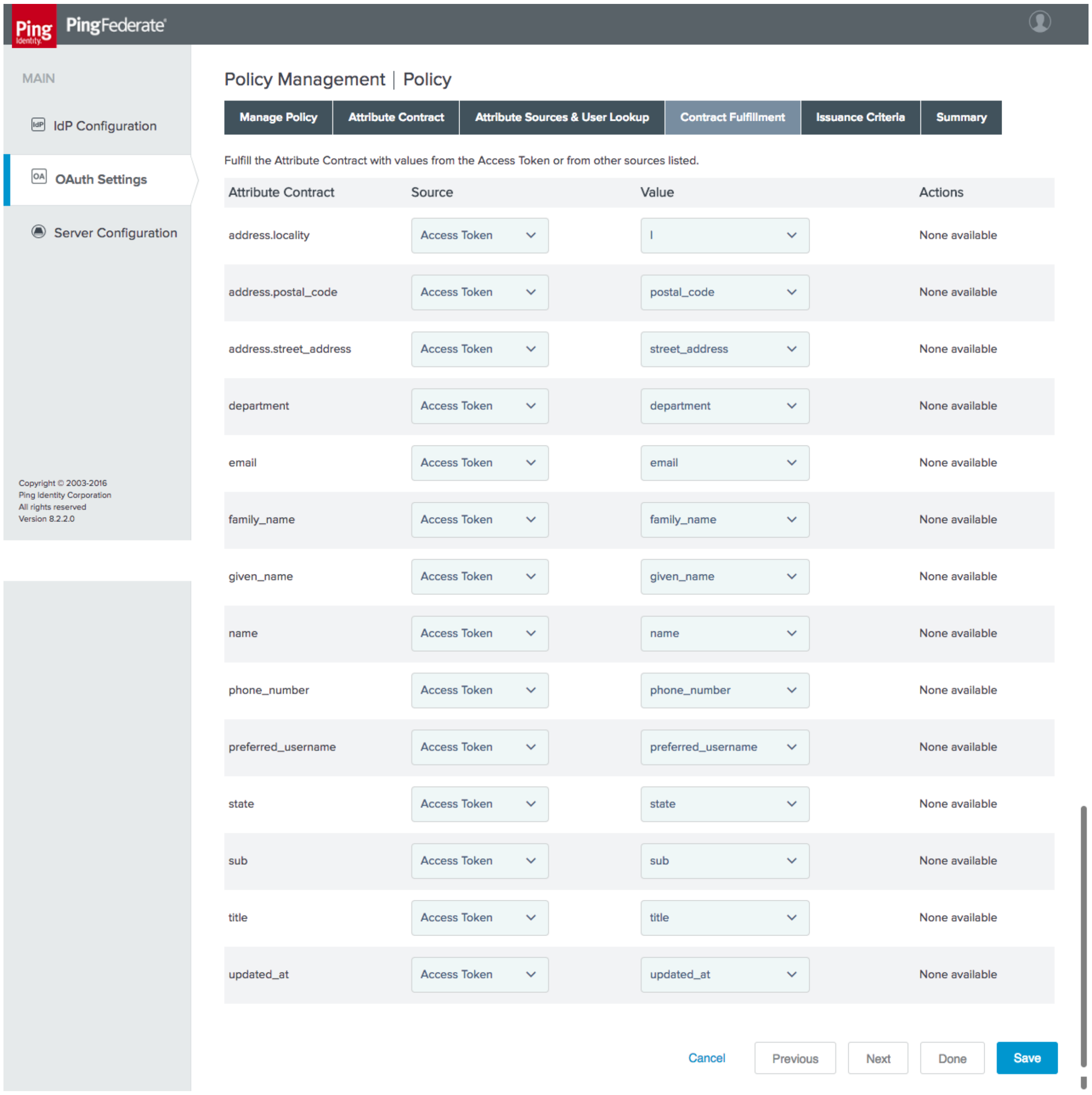
Figure 4-35 OIDC Policy Contract Fulfillment



Fulfill the Attribute Contract with values from the Access Token or from other sources listed.

Attribute Contract	Source	Value	Actions
address.locality	Access Token	l	None available
address.postal_code	Access Token	postal_code	None available
address.street_address	Access Token	street_address	None available
department	Access Token	department	None available
email	Access Token	email	None available
family_name	Access Token	family_name	None available
given_name	Access Token	given_name	None available
name	Access Token	name	None available
phone_number	Access Token	phone_number	None available
preferred_username	Access Token	preferred_username	None available
state	Access Token	state	None available
sub	Access Token	sub	None available
title	Access Token	title	None available
updated_at	Access Token	updated_at	None available

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

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

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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 applications.

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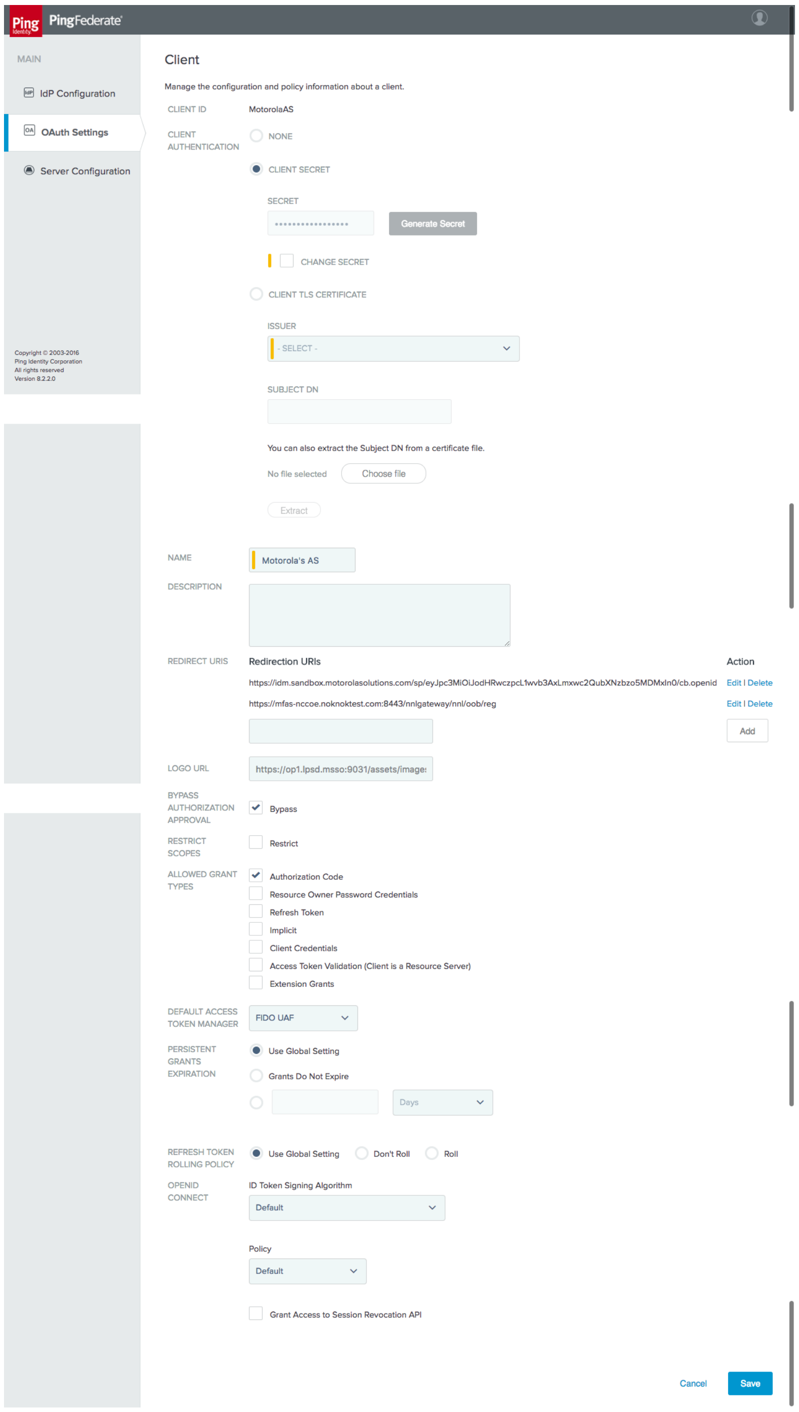
Figure 4-36 OIDC Client Configuration



Client

Manage the configuration and policy information about a client.

CLIENT ID: MotorolaAS

CLIENT AUTHENTICATION: ( ) NONE [✓ CLIENT SECRET]

SECRET: ••••••••••••••••• Generate Secret

☐ CHANGE SECRET

( ) CLIENT TLS CERTIFICATE

ISSUER: - SELECT -

SUBJECT DN:

You can also extract the Subject DN from a certificate file.

No file selected Choose file

Extract

NAME: Motorola's AS

DESCRIPTION:

REDIRECT URIS	Redirection URIs	Action
	https://idm.sandbox.motorolasolutions.com/sp/eyJpc3MiOiJodHRwczpcL1wvb3AxLmxwc2QubXNzbzo5MDMxIn0/cb.openid	Edit I Delete
	https://mfas-nccoe.noknoktest.com:8443/nnlgateway/nnl/oob/reg	Edit I Delete
		Add

LOGO URL: https://op1.lpsd.msso:9031/assets/image:

BYPASS AUTHORIZATION APPROVAL: ✓ Bypass

RESTRICT SCOPES: ☐ Restrict

ALLOWED GRANT TYPES:
- ✓ Authorization Code
- ☐ Resource Owner Password Credentials
- ☐ Refresh Token
- ☐ Implicit
- ☐ Client Credentials
- ☐ Access Token Validation (Client is a Resource Server)
- ☐ Extension Grants

DEFAULT ACCESS TOKEN MANAGER: FIDO UAF

PERSISTENT GRANTS EXPIRATION: [✓ Use Global Setting] ( ) Grants Do Not Expire ( ) Days

REFRESH TOKEN ROLLING POLICY: [✓ Use Global Setting] ( ) Don't Roll ( ) Roll

OPENID CONNECT: ID Token Signing Algorithm: Default

Policy: Default

☐ Grant Access to Session Revocation API

Cancel Save

This completes configuration of the OIDC IdP.

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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 [27]. This section briefly describes the overall deployment architecture used for this build.

The Nok Nok Labs SDKs can be directly integrated into mobile applications, providing UAF client functionality directly within the application. This deployment would be more suitable to use cases that do not involve federation, where the requirement is to authenticate users directly at the application 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 application running the Nok Nok Labs SDK by using mobile platform technologies to open links directly in mobile applications (*App Links* for Android, or *Universal Links* for iOS). The FIDO client that processes the OOB authentication request can be either a custom application incorporating the Nok Nok Labs SDK, or the Nok Nok Labs Passport application, 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 application session management infrastructure
- Nok Nok Labs Gateway Tutorial Application—a demonstration web application implementation that provides simple U2F and UAF authentication and registration workflows

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In a typical production implementation, the gateway functions for authenticator management (registration and de-registration) would 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* [28]. 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.

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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 application.
- 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 application, 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.
- Application link/universal link integration (optional)—In the lab, the default setting using an application link under https://app.noknok.com was used. This is acceptable for testing, but in a production deployment, an application link pointing to the IdP's actual domain name would typically be used. It should be noted that the FQDN for the application 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 stay 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.

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   - uaf.facet.id—There is no need to modify the Facet ID setting to enable the use of the Passport application for OOB authentication; however, if other custom applications 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 application 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 application 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* [29] 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

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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 StrongKey performs the FIDO U2F server functionality in the build architecture. StrongKey's main product is the StrongKey Tellaro 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://sourceforge.net/projects/skce/.

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

StrongKey'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 application, in theory it should be able to run on any OS that supports a compatible version of Java and the other required software. The application 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 application server. By default, the script will install MariaDB, OpenDJ, and Glassfish all on a single server. SKCE can also utilize AD for LDAP.

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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 StrongKey's scripted installation instructions for details and download links: https://sourceforge.net/p/skce/wiki/Install%20StrongKey%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

StrongKey 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 applications 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

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6.2 How to Install and Configure the FIDO U2F Authentication Server

StrongKey's scripted installation process is documented at https://sourceforge.net/p/skce/wiki/Install%20StrongKey%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, 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!
```

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```
SEARCH_LDAP_BIND_PASS=Abcd1234!
```

4. Set the Application ID URL: The Application 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://idp1.spsd.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 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.

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

   ```
   $ sudo systemctl restart glassfishd
   ```

10. Complete Steps 5.1 and 5.2 in the SKCE installation instructions to activate the cryptographic module.

11. Complete Step 5.3 in the SKCE installation instructions to create the domain signing key. When prompted for the Application ID, use the URL referenced above in the Application ID setting of the *install-skce.sh* script.

12. Complete Step 6 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/keystor
       e.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 in to 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.

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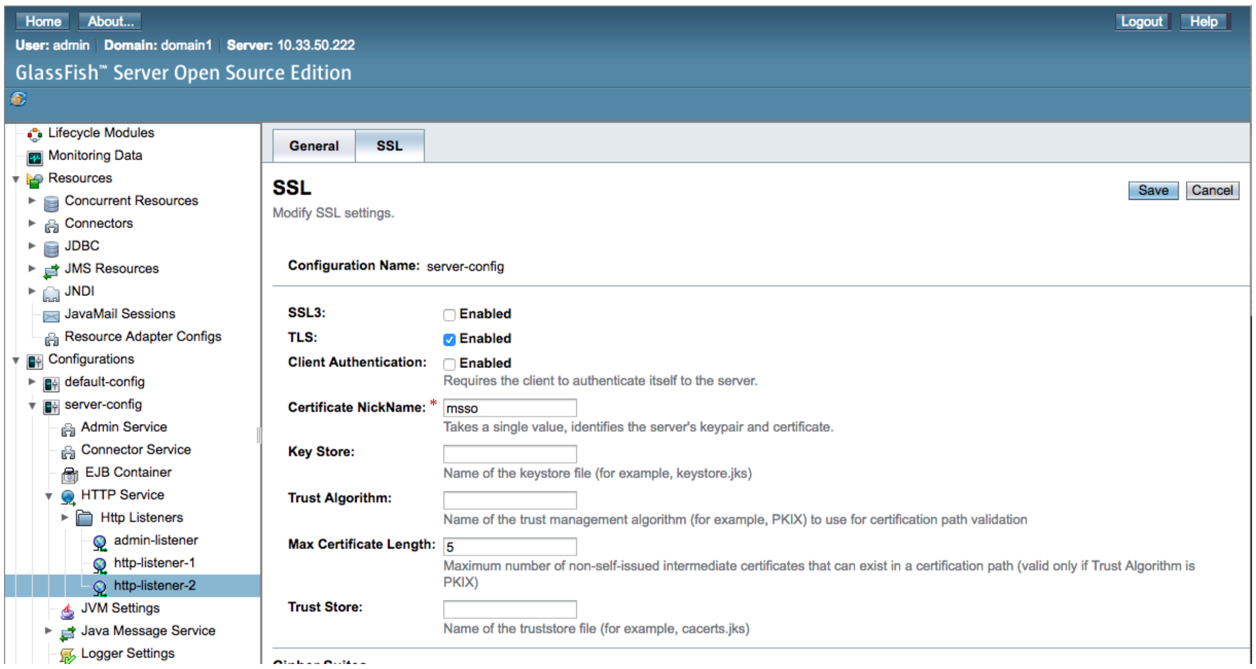
i. Navigate to *Configurations*, *server-config*, *HTTP Service*, *Http Listeners*, *http-listener-2*, as shown in Figure 6-1. On the **SSL** tab, set the **Certificate NickName** to the alias that was created with the "keytool -genkeypair" command above.

Figure 6-1 Glassfish SSL Settings



SSL

Modify SSL settings.

Configuration Name: server-config

SSL3: ☐ Enabled

TLS: ☑ Enabled

Client Authentication: ☐ Enabled
Requires the client to authenticate itself to the server.

Certificate NickName: * msso
Takes a single value, identifies the server's keypair and certificate.

Key Store:
Name of the keystore file (for example, keystore.jks)

Trust Algorithm:
Name of the trust management algorithm (for example, PKIX) to use for certification path validation

Max Certificate Length: 5
Maximum number of non-self-issued intermediate certificates that can exist in a certification path (valid only if Trust Algorithm is PKIX)

Trust Store:
Name of the truststore file (for example, cacerts.jks)

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 4 at the following URL: https://sourceforge.net/p/skce/wiki/Test%20SKCE%202.0%20Using%20a%20Client%20Program%20%28Build%20163%29/#4test-skcefido-engine.

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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. StrongKey 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 StrongKey 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 StrongKey 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 *StrongKey – Ping Federate FIDO IdP Adapter Installation Guide* [30], 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 required only 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.

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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 StrongKey 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.

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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 Application supports testing of the registration, authentication, and transaction verification functions of FIDO UAF authenticators.

7.2 Testing FIDO Servers

The StrongKey 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 application 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 application 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
```

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```
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
nRlcj0iMjAxNy0xMS0xM1QxMzo1NDoxNy4xNTVaIj48c2FtbDpBdWRpZW5jZVJlc3RyaWN0aW9uPjxzYW1sOkF
1ZGllbmNlPmN0b1BpbmdGZWRfZW50aXR5SUQ8L3NhbWw6QXVkaWVuY2U+PC9zYW1sOkF1ZGllbmNlUmVzdHJpY
3Rpb24+PC9zYW1sOkNvbmRpdGlvbnM+PHNhbWw6QXV0aG5TdGF0ZW1lbnQgU2Vzc2lvbkluZGV4PSJIX20uV0h
Hb1VRUEQuM2NWUDQxWENVWHhiR0siIEF1dGhuSW5zdGFudD0iMjAxNy0xMS0xM1QxMzo0OToxNy4xNTNaIj48c
2FtbDpBdXRobkNvbnRleHQ+PHNhbWw6QXV0aG5Db250ZXh0Q2xhc3NSZWY+dXJuOm9hc2lzOm5hbWVzOnRjOlN
BTUw6Mi4wOmFjOmNsYXNzZXM6dW5zcGVjaWZpZWQ8L3NhbWw6QXV0aG5Db250ZXh0Q2xhc3NSZWY+PC9zYW1sO
kF1dGhuQ29udGV4dD48L3NhbWw6QXV0aG5TdGF0ZW1lbnQ+PHNhbWw6QXR0cmlidXRlU3RhdGVtZW50PjxzYW1
sOkF0dHJpYnV0ZSBOYW1lPSJ1aWQiIE5hbWVGb3JtYXQ9InVybjpvYXNpczpuYW1lczp0YzpTQU1MOjIuMDphd
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
```

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```
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
```

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```
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.

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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 application 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.

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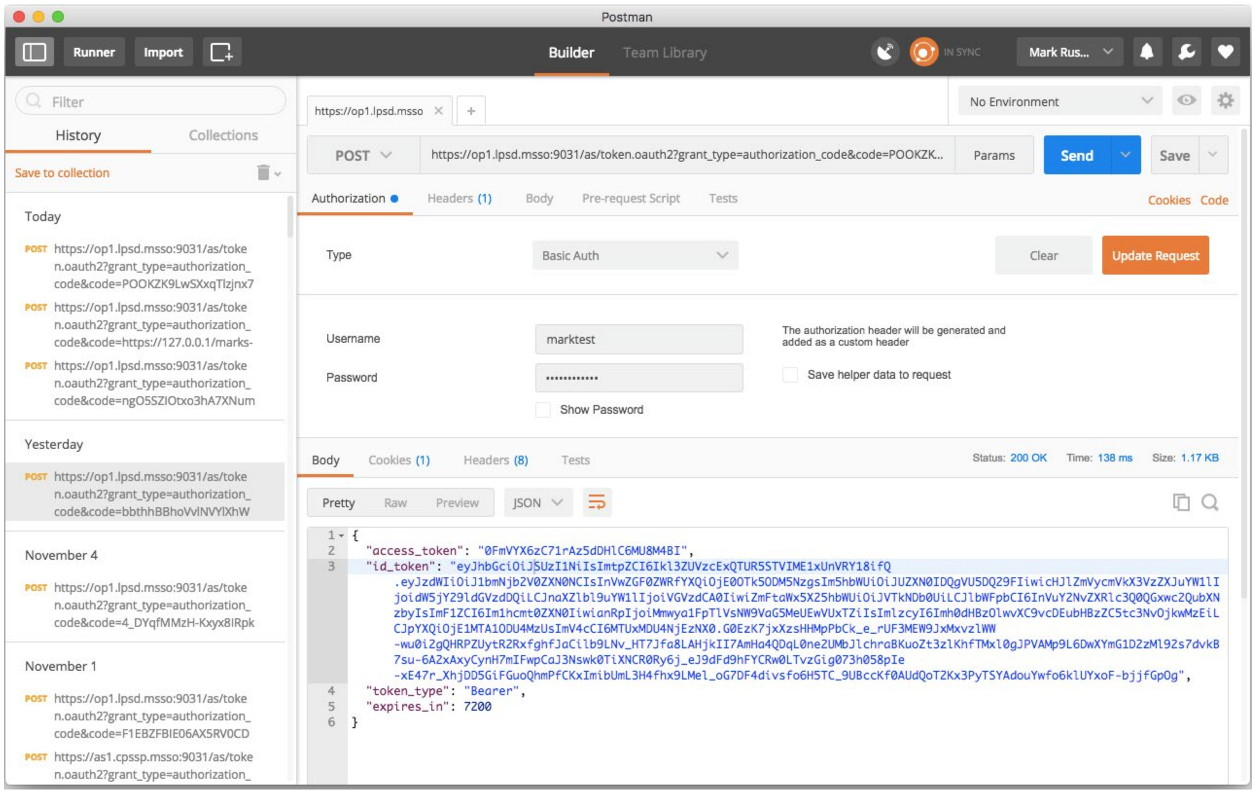
Figure 7-1 Using Postman to Obtain the ID Token



Today

POST https://op1.lpsd.msso:9031/as/token.oauth2?grant_type=authorization_code&code=POOKZK9LwSXxqTlzjnx7

POST https://op1.lpsd.msso:9031/as/token.oauth2?grant_type=authorization_code&code=https://127.0.0.1/marks-

POST https://op1.lpsd.msso:9031/as/token.oauth2?grant_type=authorization_code&code=ngO5SZIOtxo3hA7XNum

Yesterday

POST https://op1.lpsd.msso:9031/as/token.oauth2?grant_type=authorization_code&code=bbthhBBhoVvlNVYlXhW

November 4

POST https://op1.lpsd.msso:9031/as/token.oauth2?grant_type=authorization_code&code=4_DYqfMMzH-Kxyx8lRpk

November 1

POST https://op1.lpsd.msso:9031/as/token.oauth2?grant_type=authorization_code&code=F1EBZFBIE06AX5RV0CD

POST https://as1.cpssp.msso:9031/as/token.oauth2?grant_type=authorization_

POST https://op1.lpsd.msso:9031/as/token.oauth2?grant_type=authorization_code&code=POOKZK...

Type: Basic Auth

Username: marktest

Password: ••••••••••••

Show Password

The authorization header will be generated and added as a custom header

Save helper data to request

Status: 200 OK Time: 138 ms Size: 1.17 KB

```
{
  "access_token": "0FmVYX6zC71rAz5dDHlC6MU8M4BI",
  "id_token": "eyJhbGciOiJSUzI1NiIsImtpZCI6Ikl3ZUVzcExQTUR5STVIME1xUnVRY18ifQ
      .eyJzdWIiOiJ1bmNjb2V0ZXN0NCIsInVwZGF0ZWRfYXQiOjE0OTk5ODM5NzgsIm5hbWUiOiJUZXN0IDQgVU5DQ29FIiwicHJlZmVycmVkX3VzZXJuYW1lI
      joidW5jY29ldGVzdDQiLCJnaXZlbl9uYW1lIjoiVGVzdCA0IiwiZmFtaWx5X25hbWUiOiJVTkNDb0UiLCJlbWFpbCI6InVuY2NvZXRlc3Q0QGxwc2QubXN
      zbyIsImF1ZCI6Im1hcmt0ZXN0IiwianRpIjoiMmwya1FpTlVsNW9VaG5MeUEwVUxTZiIsImlzcyI6Imh0dHBzOlwvXC9vcDEubHBzZC5tc3NvOjkwMzEiL
      CJpYXQiOjE1MTA1ODU4MzUsImV4cCI6MTUxMDU4NjEzNX0.G0EzK7jxXzsHHMpPbCk_e_rUF3MEW9JxMxvzlWW
      -wu0i2gQHRPZUytR2RxfghfJaCilb9LNv_HT7Jfa8LAHjkII7AmHa4QDqL0ne2UMbJlchraBKuoZt3zlKhfTMxl0gJPVAMp9L6DwXYmG1D2zMl92s7dvkB
      7su-6A2xAxyCynH7mIFwpCaJ3Nswk0TiXNCR0Ry6j_eJ9dFd9hFYCRw0LTvzGig073h058pIe
      -xE47r_XhjDD5GiFGuoQhmPfCKxImibUmL3H4fhx9LMel_oG7DF4divsfo6H5TC_9UBccKf0AUdQoT2Kx3PyTSYAdouYwfo6klUYxoF-bjjfGpOg",
  "token_type": "Bearer",
  "expires_in": 7200
}
```

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.eyJzdWIiOiJ1bmN
jb2V0ZXN0NCIsInVwZGF0ZWRfYXQiOjE0OTk5ODM5NzgsIm5hbWUiOiJUZXN0IDQgVU5DQ29FIiwicH
JlZmVycmVkX3VzZXJuYW1lIjoidW5jY29ldGVzdDQiLCJnaXZlbl9uYW1lIjoiVGVzdCA0IiwiZmFta
Wx5X25hbWUiOiJVTkNDb0UiLCJlbWFpbCI6InVuY2NvZXRlc3Q0QGxwc2QubXNzbyIsImF1ZCI6Im1h
cmt0ZXN0IiwianRpIjoiMmwya1FpTlVsNW9VaG5MeUEwVUxTZiIsImlzcyI6Imh0dHBzOlwvXC9vcDE
ubHBzZC5tc3NvOjkwMzEiLCJpYXQiOjE1MTA1ODU4MzUsImV4cCI6MTUxMDU4NjEzNX0.G0EzK7jxXz
sHHMpPbCk_e_rUF3MEW9JxMxvzlWW-
wu0i2gQHRPZUytR2RxfghfJaCilb9LNv_HT7Jfa8LAHjkII7AmHa4QDqL0ne2UMbJlchraBKuoZt3zl
KhfTMxl0gJPVAMp9L6DwXYmG1D2zMl92s7dvkB7su-
6A2xAxyCynH7mIFwpCaJ3Nswk0TiXNCR0Ry6j_eJ9dFd9hFYCRw0LTvzGig073h058pIe-
xE47r_XhjDD5GiFGuoQhmPfCKxImibUmL3H4fhx9LMel_oG7DF4divsfo6H5TC_9UBccKf0AUdQoT2K
```

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```
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.

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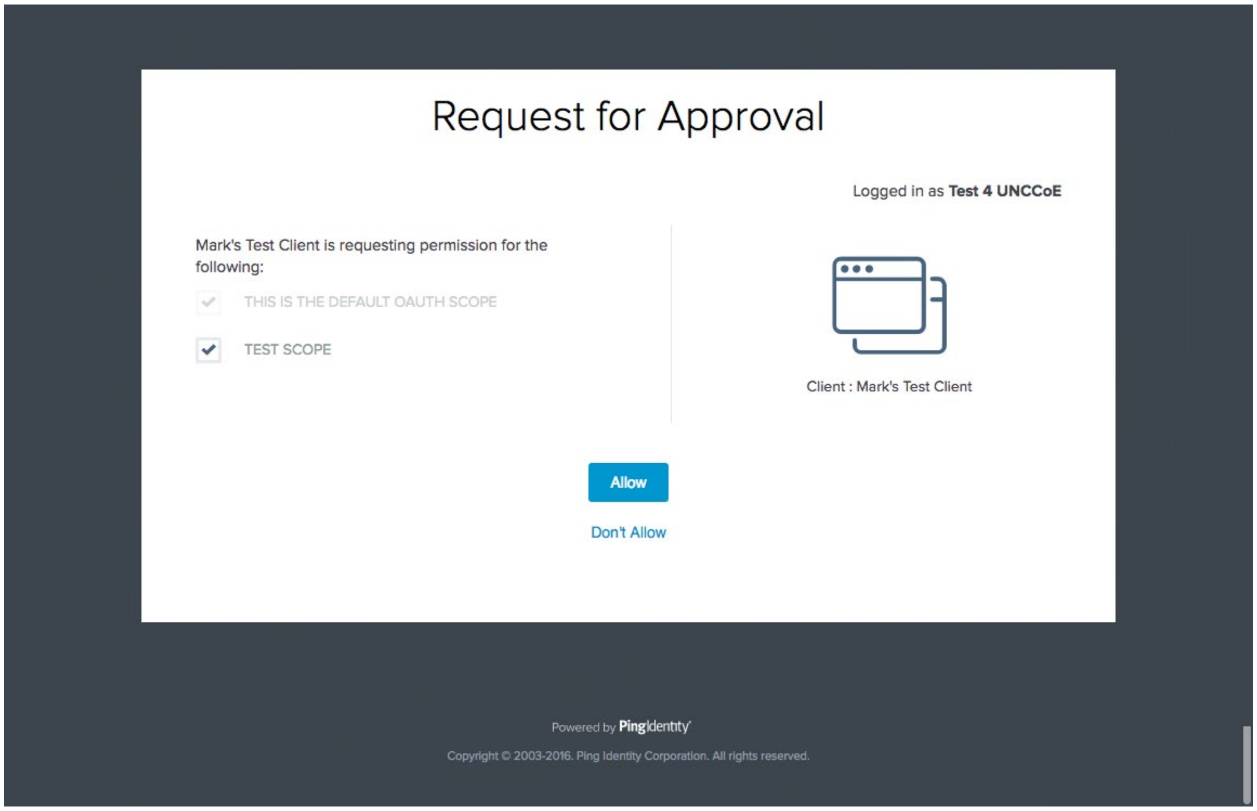
Figure 7-2 Authorization Prompt


Request for Approval

Logged in as **Test 4 UNCCoE**

Mark's Test Client is requesting permission for the following:

- ✓ THIS IS THE DEFAULT OAUTH SCOPE
- ✓ TEST SCOPE

Client : Mark's Test Client

Allow
Don't Allow
Powered by PingIdentity
Copyright © 2003-2016. Ping Identity Corporation. All rights reserved.

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

If the token is not a JWT (i.e., a Reference Token management scheme is in use), the access token can be submitted to the AS's introspection endpoint as specified in RFC 7662 [31]. The default location of the introspection endpoint for PingFederate is the base URL, followed by */as/introspect.oauth2*. The request is submitted as a POST, with the access token in a query parameter called **token**. Basic authentication can be used with the client ID and secret as a username and password. The client must be authorized to call the introspection endpoint by selecting **Access Token Validation (Client is a Resource Server)** under **Allowed Grant Types** in the client configuration on the AS.

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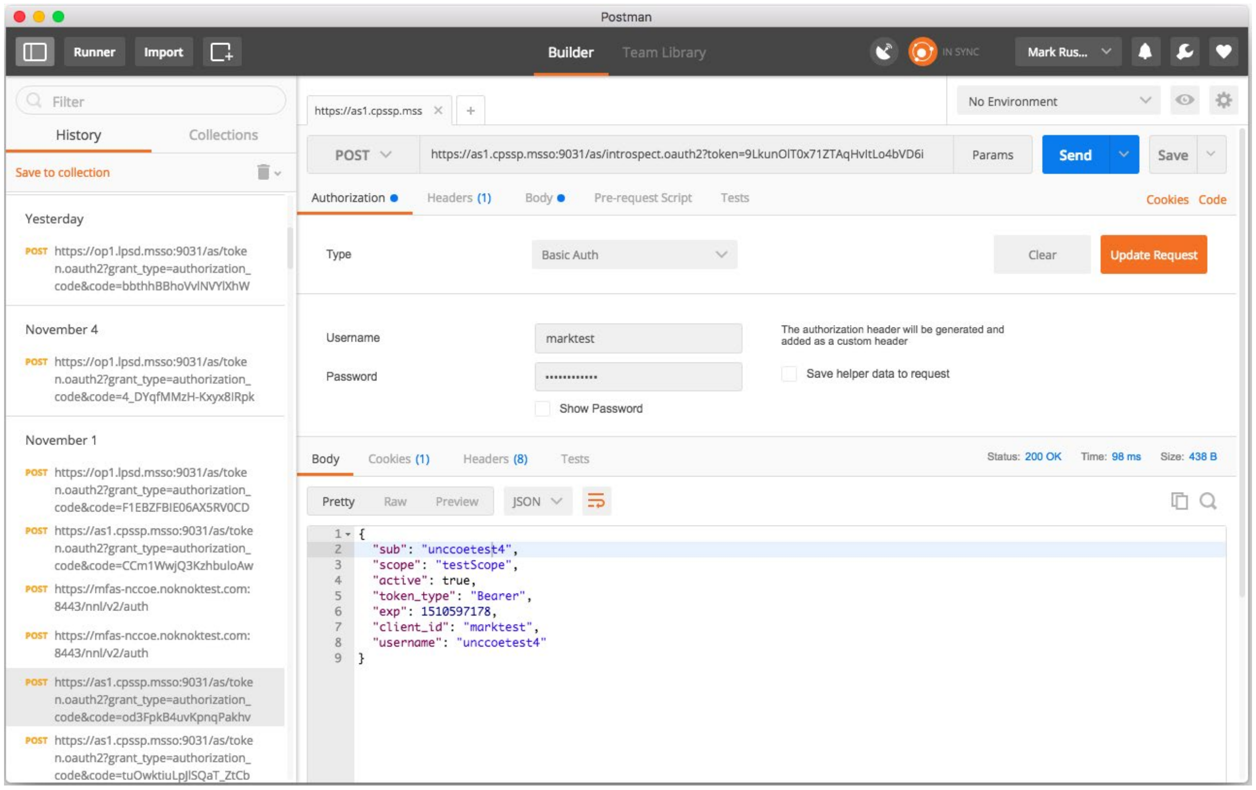
Figure 7-3 shows a token introspection request and response in Postman.

Figure 7-3 Token Introspection Request and Response


History

Yesterday

POST https://op1.lpsd.msso:9031/as/token.oauth2?grant_type=authorization_code&code=bbthhBBhoVvlNVYlXhW

November 4

POST https://op1.lpsd.msso:9031/as/token.oauth2?grant_type=authorization_code&code=4_DYqfMMzH-Kxyx8IRpk

November 1

POST https://op1.lpsd.msso:9031/as/token.oauth2?grant_type=authorization_code&code=F1EBZFBIE06AX5RV0CD

POST https://as1.cpssp.msso:9031/as/token.oauth2?grant_type=authorization_code&code=CCm1WwjQ3KzhbuloAw

POST https://mfas-nccoe.noknoktest.com:8443/nnl/v2/auth

POST https://mfas-nccoe.noknoktest.com:8443/nnl/v2/auth

POST https://as1.cpssp.msso:9031/as/token.oauth2?grant_type=authorization_code&code=od3FpkB4uvKpnqPakhv

POST https://as1.cpssp.msso:9031/as/token.oauth2?grant_type=authorization_code&code=tuOwktiuLpJlSQaT_ZtCb

POST https://as1.cpssp.msso:9031/as/introspect.oauth2?token=9LkunOlT0x71ZTAqHvltLo4bVD6i

Authorization: Type: Basic Auth

Username: marktest

Password: •••••••••••••

The authorization header will be generated and added as a custom header

Status: 200 OK Time: 98 ms Size: 438 B

```
{
  "sub": "unccoetest4",
  "scope": "testScope",
  "active": true,
  "token_type": "Bearer",
  "exp": 1510597178,
  "client_id": "marktest",
  "username": "unccoetest4"
}
```

7.5 Testing the Application

One last potential problem area in this SSO architecture is the back-end application, which must accept and validate access tokens. Troubleshooting methods there will depend on the design of the application. Building robust instrumentation and error reporting into RP applications will help identify problems. If the application 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.

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Appendix A Abbreviations and Acronyms

AD	Active Directory
API	Application Programming Interface
APNS	Apple Push Notification System
App ID	Application Identification
AppAuth	Application Authentication System
AS	Authorization Server
ASM	Authenticator-Specific Module
BCP	Best Current Practice
BIND	Berkeley Internet Name Domain
BLE	Bluetooth Low Energy
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
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

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JDK	Java Development Kit
JSON	JavaScript Object Notation
JWE	JSON Web Encryption
JWT	JSON Web Token
LDAP	Lightweight Directory Access Protocol
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 Authentication Server
NTP	Network Time Protocol
OIDC	OpenID Connect
OOB	Out-of-Band
OS	Operating System
PIN	Personal Identification Number
PKCE	Proof Key for Code Exchange
PSFR	Public Safety and First Responder
PSX	Public Safety Experience
PTT	Push to Talk
QR	Quick Response
RAM	Random Access Memory
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
SKCE	StrongKey CryptoEngine
SLO	Single Log-Out
SP	Service Provider, Special Publication

SPSD	State Public Safety Department
SQL	Structured Query Language
SSH	Secure Shell
SSO	Single Sign-On
TCP	Transmission Control Protocol
TLS	Transport Layer Security
U2F	Universal Second Factor
UAF	Universal Authentication Framework
URI	Uniform Resource Identifier
URL	Uniform Resource Locator
USB	Universal Serial Bus
VLAN	Virtual Local Area Network
VPN	Virtual Private Network
W3C	World Wide Web Consortium
WAR	Web Archive

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