OPENID CONNECT 101
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EXECUTIVE OVERVIEW

Many organizations are migrating to cloud services, launching mobile apps and implementing Internet of Things (IoT) programs to improve employee and partner productivity as well as consumer engagement. As these digital business initiatives gain traction, keeping identity data secure can be challenging. A new generation of identity protocols is emerging to meet these challenges by streamlining authentication capabilities for the bandwidth and feature constraints of digital endpoints.

OpenID Connect 1.0 (OIDC or Connect) creates a singular, cohesive framework that promises to secure all APIs, mobile native applications and browser applications on today’s web. Based on REST and JSON, it uses the same building blocks as the modern application architectures and APIs it secures. Connect profiles and extends OAuth 2.0 to logically add an identity layer to OAuth. As more companies focus on digital consumer engagement and the IoT, OAuth and Connect are likely to be valuable in securing identity data in an increasingly complex ecosystem.

This paper introduces Connect, detailing its influences, features and applicable use cases.
WHAT IS OPENID CONNECT?

OpenID Connect is a simple JSON-/REST-based identity protocol built on top of the OAuth 2.0 and JSON Web Token (JWT) family of protocols. Its design philosophy is to “keep simple things simple and make complicated things possible.”

The goal was to develop a single protocol that provides:

- Mobile-friendly support for native applications and generally restricted bandwidth and capabilities of feature phones.
- A single, seamless flow for integrating API authorization and user authentication.
- Lightweight implementation for applications and relying party (RP) websites, replacing proprietary last-mile integrations.

Connect reflects years of experience with the strengths and weaknesses of earlier and existing protocols. It’s strongly influenced by the enterprise experiences of SAML, ID-WSF and the WS* stack (including information cards), but it uses more modern components like REST and JSON rather than SOAP and XML.

Connect also reflects community experiences in dynamic configuration and connection scalability, learned from the consumer-centric specifications of OpenID 1.0 and 2.0 specifications. For example, whereas SAML deployments are typically based on static and pre-established trust, OpenID allows for a trust relationship to be dynamically established between identity providers (IdPs) and RPs.

The following diagram represents Connect’s influences, showing that its development has been driven by both consumer-centric and enterprise-centric requirements. As a result, it promises to address the requirements of both deployment models.
Motivated by the encouraging adoption of Connect by RPs, part of Connect’s design philosophy was to push deployment complexity to the IdP wherever possible. This is an improvement for native mobile use cases compared to SAML, where the burden of supporting the protocol is much more evenly shared between the IdP and the service provider. Because of this asymmetry in support complexity, Connect can be more easily applied to securing native mobile applications, which are far more constrained than server implementations.

One of the key areas of simplification from SAML was the migration from XML to JSON. Because JSON is the data representation format used by JavaScript in all modern web browsers, JSON has wide support in modern programming environments and far fewer issues than XML in formatting.

The JWT format, including related specifications for signing and encryption (referred to as JOSE), allows for more compact security tokens than are possible with XML (and realized by SAML). Small security tokens are particularly relevant for addressing the URL and header size constraints in mobile environments. The JWT format also avoids the problems that XML signing and encryption have been plagued with over their history.

The Connect protocol suite is modular, and only a subset needs to be implemented. Basic and implicit client profiles are quickstart guides for those who want to build Connect client capabilities into their applications.

Connect was developed under a mutual non-assert IPR agreement by all of the participants in the specification, including Ping Identity®, Google Inc., Microsoft®, PayPal™, Facebook®, IBM®, CA® and many others. This allows implementations to be built royalty-free by developers.
CONNECT TERMINOLOGY

Because it’s built on top of OAuth 2, Connect uses much of the same terminology and definitions as does OAuth 2.0.

- **Subject**: The user requesting access to a protected resource, either through a web interface or via API calls.
- **Resource Server (RS)**: The server hosting the protected API resources.
- **Authorization Server (AS)**: The server issuing access and identity tokens after successfully authenticating the subject.
- **Client**: An application requesting tokens from the AS (identity tokens to enable subject access to client-hosted resources, or access tokens to enable access to an RS-hosted resources).
- **Discovery Endpoint**: Makes configuration information available that describes the Connect AS and how to interact with it.
- **Registration Endpoint**: Allows new clients to dynamically register with the Connect AS.
- **Access Token**: Identity and authorization assertion issued by the AS and consumed by the RS.
- **ID Token**: Identity and authentication assertion issued by the AS and consumed by the client.

RELATIONSHIP TO OAUTH

OAuth 2.0 is a framework for API authentication and authorization. It defines how an API client can obtain security tokens that express a set of permissions against the resources fronted by that API. These permissions often reflect the consent of the user that ‘owns’ those resources. These tokens are attached by the client to its API messages, and so serve as proof of the client’s authorizations relative to the requests it makes of the resources.

OpenID Connect provides identity semantics and constructs on top of OAuth, logically layering identity onto the OAuth base. Connect specifies how to use OAuth to ‘do’ identity, as opposed to other non-identity centric applications that are possible with OAuth.

Connect introduces two notable identity constructs on top of the OAuth base protocol:

1. **The id_token**: a structured JWT that allows the AS to assert the authentication status of a subject to the client (and possibly other identity attributes). The delivery of the id_token from the AS to the client enables web single sign-on (SSO) for the subject when they visit the client. The id_token typically includes:
   - The unique subject (user) identifier.
   - The issuing authority (the AS URI).
   - The intended audience (the client application).
   - Issue and expiration times.
   - How the user was authenticated (e.g., password vs. MFA).

2. **The UserInfo endpoint**: a standardized REST API for identity attributes. By calling this OAuth-protected API, the client can obtain the identity attributes it would otherwise collect from the user in a registration form, such as email, name, address, etc. The UserInfo endpoint is a regular OAuth 2.0 resource that returns a JSON document when fetched via HTTP. The client constructs an HTTPS “GET” request to the UserInfo endpoint and includes the access token previously obtained from the AS in the authorization header.
In addition to the above identity constructs, Connect closes some of the interoperability and scaling gaps that OAuth doesn’t directly address.

The typical OAuth deployment model has one AS issuing tokens for some number of protected RS that are in the same administrative domain. Because of this assumption, OAuth initially defines no standardized mechanisms by which an RS can validate access tokens on the API calls it receives. This was effectively left as a deployment exercise. But in practice, it means that deployments and commercial implementations of OAuth create their own proprietary introspection mechanisms that the RS can call back to the local AS to validate access tokens. Connect’s definition of how to use structured JWT for identity tokens helped spur the OAuth group to standardize structured access tokens that don’t require introspection; the RS can validate access tokens locally through cryptographic checks.

Additionally, clients in OAuth are typically registered at the AS through a manual administrative process via an AS-hosted web page. Through this process, (a) the AS issues credentials to the client for use on the OAuth messages to follow, and (b) the client obtains the relevant AS metadata (like endpoint URLs) necessary for it to interact with that AS. Connect allows for both of these steps to be conducted in a more automated and dynamic fashion—dynamic registration allows clients to register themselves at the AS without manual intervention, and a discovery mechanism allows clients to dynamically obtain the necessary AS configuration information.

RELATIONSHIP TO SAML

SAML and Connect have similar SSO flows, supporting both the redirection of assertions through the browser and through a back channel via an artifact dereferencing step. Both use a signed assertion to convey claims about a subject and session information such as the authentication method and context.

Connect also has many features that allow both easy connection between partners and the acceptance of external social identities via connections that are dynamically provisioned on demand.

Connect also provides the client/SP with API access tokens in the same flow, allowing it to support dynamic provisioning of account information and to make ongoing API calls on behalf of the user. This is similar to, but more REST friendly than, the SAML attribute query.

Connect also includes a cross-organization trust model similar to SAML, allowing it to be used in place of SAML between organizations for federation. Existing SAML-based federation may transition to Connect over time.
TRUST MODEL

The Connect trust model between the AS and the client is similar to that of SAML. The subject’s authentication status is expressed in the JWT-based id_token, which is signed by the AS. The default signature mechanism is an RSA signature (as in SAML), though other types of signatures may be used for performance and size if necessary. Upon delivery of the id_token to the client, the client validates the signature before making an authorization decision regarding the subject’s access request.

The main difference between the SAML and Connect trust models is the use of dynamically discovered and provisioned metadata.

The trust model between the RS and AS is similar to that of OAuth, although Connect’s support for JWT-formatted access tokens allows for an RS to validate tokens locally, as opposed to an introspection step.

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DISCOVERY

For all web SSO protocols, a fundamental challenge for the RP is to determine which is the appropriate IdP for a given user. In Connect, the client must work out the relevant AS for a given subject. Generally, the client depends on the subject to facilitate this step. A variety of approaches exist, from the NASCAR model of multiple icons for the user to pick from (implying that the client may have already worked out the technical details with the AS) or, more flexibly, asking the subject to provide their email address or some other identifier to the client.

This happens in the SaaS world when enterprise employees present themselves to the SaaS login page (as opposed to following a link). The challenge for the SaaS is three-fold:

1. Is this employee from an enterprise customer that leverages SSO (as opposed to passwords)?
2. What SSO protocol does the enterprise use (e.g., SAML or Connect)?
3. If they use Connect, what’s the address of the enterprise AS authorization endpoint to direct the browser to?

Connect discovery defines how to leverage the web finger specification to turn a user-provided identifier into the address of the corresponding AS configuration file that includes the addresses for the different Connect endpoints with which the client will interact.

DYNAMIC REGISTRATION

Dynamic registration allows the client to register with the AS and receive a client identifier and secret (the credentials used when making subsequent authorization and token requests to the AS). The registration endpoint can be restricted to authorized clients via an access token.

Typically, to enable a Connect link to a SaaS in support of enterprise employees being able to web SSO into the SaaS, the enterprise would provide the SaaS with its AS URI and a registration token as part of an administrative registration process provided by the SaaS. The SaaS would then perform discovery on the issuer URI to find the registration endpoint. Using the registration token provided by the enterprise, the SaaS would push its configuration to the registration endpoint and receive a confirmation of its client identifier, secret and configuration details.

As Connect clients can register directly with the AS, Connect allows for automated negotiation of features and parameters on a per-AS basis.
FLOWS

Below is a typical Connect flow. The AS issues two different tokens to the client. The id_token enables SSO for the subject into the client, and the access token allows the client to make API calls to both the Connect-defined UserInfo API as well as other application APIs.

The identity features that Connect introduces to the normal OAuth 2 flow are highlighted below:

1. The transfer of the id_token from the AS to the client enables web SSO.
2. The UserInfo endpoint is a standardized REST API from which the client can obtain profile data for the user.
A more complicated scenario would have the client use the registration and discovery mechanisms before interacting with the AS authorization endpoint, as shown below. From this point on, the flow would be the same as shown in the previous diagram.
The following use cases illustrate the flexibility of Connect.

OUTBOUND WEB SSO

Partners or SaaS that have traditionally allowed enterprise SSO via SAML are now allowing enterprise users to sign on to SSO-enabled SaaS using Connect. In this use case, enterprise users access Connect-enabled SaaS web applications and enable SaaS access to enterprise APIs with a single login.

1. User signs on to the enterprise using corporate credentials.
2. Enterprise AS delivers an id_token and access token to the SaaS client.
3. SaaS provides application access to the subject.
4. OPT SaaS client uses access token on API calls to enterprise.

This model:

- Provides employees access to partner or SaaS web applications.
- Avoids exposing enterprise passwords.
- Simplifies employee enrollment into SaaS.
- Optionally provides the SaaS with secure access to enterprise APIs.
Users with social identities can access consumer-facing, web-based applications (provided by banks, ISPs, retailers, etc.) via a browser using Connect. Such enterprises might choose to allow this scenario to minimize the burden associated with initial interactions with a potential customer with the goal of driving customer acquisition. By leveraging the user’s existing social identities, the enterprise makes it easier for that potential customer to browse personalized offerings. If and when the user becomes a (paying) customer, the enterprise may choose to issue their own identity and credentials, and either cancel the connection to the social provider or maintain it for the attribute-sharing component (if not, for SSO alone).

1. User logs in to their preferred social provider using existing credentials.
2. Social provider AS delivers an id_token and access token to the enterprise client.
3. Enterprise provides application access to the subject.
4. Enterprise client uses an access token on API calls to the social provider requesting data or, for instance, posting a tweet on behalf of the user.

This model:

- Enables third-party access to web applications.
- Avoids storing passwords for external users.
- Avoids costs of managing user passwords.
- Allows users to select their preferred social provider for different contexts.

Of course, the model isn’t limited to third-party social providers. It also applies to more general third-party provided identity, such as from business partners and customers.
EMPLOYEE ACCESSES ON-PREMISES API VIA NATIVE MOBILE APPLICATION

1. User logs in to the enterprise using corporate credentials in a browser window.
2. Enterprise AS delivers an access token to the native application client.
3. Native application client uses the access token on API calls to the on-prem API.
4. Enterprise API returns the application data to the native application.

EMPLOYEE ACCESSES SAAS API VIA NATIVE MOBILE APPLICATIONS

Enterprise employees are accessing SaaS functionality via APIs accessed from a native mobile application more frequently. In this scenario, two different Connect flows are sequenced. The first is a web SSO flow from the enterprise to a SaaS. The second is an API authorization flow from the same SaaS to its own native application installed on an employee’s device.

1. User signs on to the enterprise using their corporate credentials within a browser window.
2. Enterprise AS delivers an id_token to the SaaS client.
3. SaaS AS creates and delivers an access token to its native application client.
4. SaaS native application client uses the access token on API calls to the SaaS API.
5. SaaS API returns the application data to the native application.
The first Connect flow (step #2 above) could also be a SAML flow. They're effectively interchangeable in this context, and they're independent of the OAuth flow that follows.

If distributed through the public application stores, a SaaS native application will be unlikely to have a unique client secret to use to authenticate to the AS when obtaining tokens (step #3 above). Consequently, there's a risk of a malicious native application inserting itself into the issuance flow and gaining possession of access tokens and the permissions associated with them. The Proof Key Code Exchange (PKCE) specification mitigates this risk by effectively allowing the native application to dynamically generate transient client secrets that can be used to authenticate to the AS.

The AppAuth model recommends that native applications use either iOS View Controllers or Android Custom Tabs for step #1 above and not an embedded web view. If different SaaS native applications do so, then the enterprise employee will be able to enjoy an SSO experience across those multiple native applications.

USE WITH PROVISIONING PROTOCOLS

The System for Cross-domain Identity Management (SCIM) 2.0 defines a REST protocol for user attribute management. When used to read user attributes, SCIM is comparable to Connect’s UserInfo API, although using a different JSON schema. SCIM also allows for its API calls to be protected through OAuth access tokens, so it would be possible to use the Connect authorization flow to deliver an access token to the client. This access token is then used on a SCIM API call.

CONSUMER ENGAGEMENT

Many of OpenID Connect’s technical aspects are similar whether you’re implementing an enterprise deployment or a consumer identity and access management (CIAM) platform but certain features are particularly relevant to CIAM:

1. Connect supports large-scale consumer deployments.
2. Connect features, particularly its discovery and dynamic client registration mechanisms, offer a more flexible means of establishing trust that’s often relevant in CIAM deployments.
3. Connect can provide users with a privacy enabling control point through the consent ceremony. Giving users control over how their personally identifiable information (PII) is shared is more critical in CIAM than in the enterprise.
4. Connect supports social login from multiple providers (e.g., Twitter, Facebook, etc).

INTERNET OF THINGS

Connect’s value proposition for the authentication and authorization of users and applications on the current web remains relevant for the emerging IoT. If the IoT is to ever be more than multiple silos of devices talking to their own cloud platforms through proprietary protocols, it’ll require standard mechanisms by which identities of devices and users can be represented and communicated—exactly the capabilities which OAuth and Connect provide.

One challenge is that OAuth and Connect have only been bound to HTTP so far, and HTTP is seen as inappropriately heavy for many of the interactions in the IoT (particularly those between things/devices and other actors). A new class of protocols has emerged that promises to be better suited than HTTP to such interactions, including MQ Telemetry Transport (MQTT) and Constrained Application Protocol (CoAP). Fortunately, the work has already begun to define how to bind OAuth and Connect to this new category of IoT-optimized protocols.
CONCLUSION

OpenID Connect logically combines the functionality of SAML and OAuth into a single, cohesive and comprehensive framework. While SAML has enjoyed significant success as an SSO protocol in the enterprise, SaaS and higher education, it has limited support for dynamic trust and configuration. Additionally, SAML has seen no adoption in the consumer space, and its attribute-sharing mechanisms haven’t been widely deployed.

OAuth has emerged as a powerful authorization mechanism for APIs in both the consumer and enterprise spaces, but it also presumes a static trust and configuration model and has no explicit concept of identity. Connect addresses these limitations of SAML and OAuth—and does so with a modern REST and JSON-based architecture.