IBM Cloud App ID

Securing access and identity for cloud-hosted applications

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Introducing IBM Cloud App ID

Great apps are focused on making the customer experience better. Or making life easier for employees. In either case, no matter how great or transformative your idea is for an app, the success of your app depends on your ability to build trust with your users. This trust is built in part by protecting their data, and controlling access to resources and transactions. And trust is also built by delighting users with a tailored experience that simplifies, personalizes, or improves their efficiency.

Knowing who is using your app is central to both. It enables you to apply the right security controls, and also to actually go ahead and build an experience that is customized for your users. To achieve this you need to add authentication (sign-in) to your app, and authorization (access permissions), as well as manage digital identities (e.g. remember information that a user shared with you, like their preferred checkout method). But when it comes to security, designing it into an app is often frustrating for developers. It is both risky and complex and filled with edge cases. To fill the need for a simpler way to introduce authentication and authorization into your apps, we've developed IBM Cloud App ID.

Key takeaway

With App ID, developers can easily add authorization and authentication to their web, mobile, API, and back-end applications. App ID can also host user data -- such as preferences -- for use in building custom app experiences.

Ways the service makes the sign-in experience easy

1. Give your users the option of signing up directly from your application with their email address and thereafter use their email and password to sign-in.

2. Leverage the SAML 2.0 Identity Federation capabilities App ID provides and allow your users to sign-in with their existing enterprise credentials.

3. Alternatively, let your users use their existing social accounts such as Facebook or Google.

Regardless of the way your users sign-in, App ID enforces access policy requirements for your back-end applications and APIs, so only properly authenticated and authorized users will have access.

The Rising Need for Application Identity

Better serving customers and employees through digital apps and services requires unrelenting focus on customer experience. Since superior digital experiences start with knowing your users and building trust, being able to manage digital identities is critical.

Moreover, businesses need to move quickly to stay competitive, working to deliver Apps and APIs that keep them ahead of traditional competitors or industry disrupters.

- To meet a company's speed and agility needs, more customer facing interfaces are backed by microservices.
- Application user experience is increasingly becoming a decision making resource for consumers.
- To drive higher lifetime customer value, organizations want to continuously personalize dialog with users. To make this possible companies need to collect and analyzing user preferences as well as application usage data.

These trends challenge existing enterprise identity and security infrastructure and practices in multiple ways:

- **User experience** – Security should blend seamlessly into the user experience. Generic username and password screens no longer suffice. At the same time, your users must be confident that you're protecting their sensitive data.
- **Cross Channel Personalization** – Reaching users across digital channels requires more than managing cross-channel identities. Application developers need better access to user profiles and properties linked to these identities (with privacy and legal compliance) to create personalized experiences.
- **Solution TCO** – Many of the existing enterprise solutions are too expensive to serve digital channel patterns of use. Many digital consumers may use your application infrequently, or a few employees who use your application daily.

  Pricing schemes need to acknowledge this. An equally important cost consideration is that organizations can't afford to service a large number of digital consumers that flood their traditional support channels. To ease this traffic, customers need self-service support.
- **Programming Model Integration** – Security is traditionally enforced in the DMZ layer, while subsequent layers are considered more secure. This model assumes a rigid gateway and layering structure that fails to address the need for agility and the evolution of micro-services. Security infrastructure needs to be integrated into the new programming models and run times used to build the micro-services.
- **Scale and performance** – Demands on performance and scaling are much greater now that the number of consumers is growing constantly .
- **Cloud Deployment** – With your business logic running on the cloud, you need to accompany it with strong, cloud-based identity and security services to retain overall agility. The solution you pick should scale as your business grows.

All of the above, many emerging needs are addressed by the IBM Cloud App ID service, which is deeply integrated into the overall IBM Cloud programming model for mobile, web, back-end and micro-service based applications.

Features, Capabilities and Technology

App ID provides a collection of authorization, authentication and identity related capabilities for developers. With App ID, you can easily introduce consumer and enterprise class authentication. You can enable progressive authentication for your cloud applications and microservices, to deliver engaging user experiences across multiple digital channels. The capabilities provided by App ID include:

User Authentication

Getting users to sign-up and sign-in to your applications is central to providing customized, tailored experiences and application protection, APIs and back-end resources. Therefore, user authentication is at the core of App ID.

While some might consider the subject of authentication to be simple, it can actually get complex once you dive into the implementation details. Typical questions you'll need to answer are: Do you implement a proprietary authentication mechanism, or do you comply with something like OpenID Connect or SAML? How do you federate identities from the identity provider or user repository? How do you ensure identity information is not compromised? How do you establish trust between your authentication mechanisms and back-ends?

App ID addresses all of the above concerns. With App ID, application developers can easily add user authentication to web and mobile applications without having specialized security knowledge, and protect backend APIs in their cloud applications in minutes.

App ID uses an industry-standard, customizable approach to ensure a high-level of trust between your application components. Your users can authenticate against an existing user registry, or start from scratch with Cloud Directory – a user registry provided by App ID.

JSON Web Tokens

App ID is built on industry-standard specifications such as OAuth2 and OpenID Connect. Under the hood, App ID provides a standardized way to obtain information about user authorization and authentication: access and identity tokens. The tokens are implemented as JSON Web Tokens (RFC7519) that clients received after a successful user authentication. Both tokens are digitally signed to prevent tampering and contain a set of claims that help developers customize application behavior and make business logic decisions.

An access token represents authorization to the bearer. It contains claims (JSON properties) that accomplish the following: describe who the token was issued by, who it was issued for, the intended audience, what is the token expiration timestamp, which authentication method was used, what is the authorization scope and more. Access tokens are used to understand what user is authorized for.

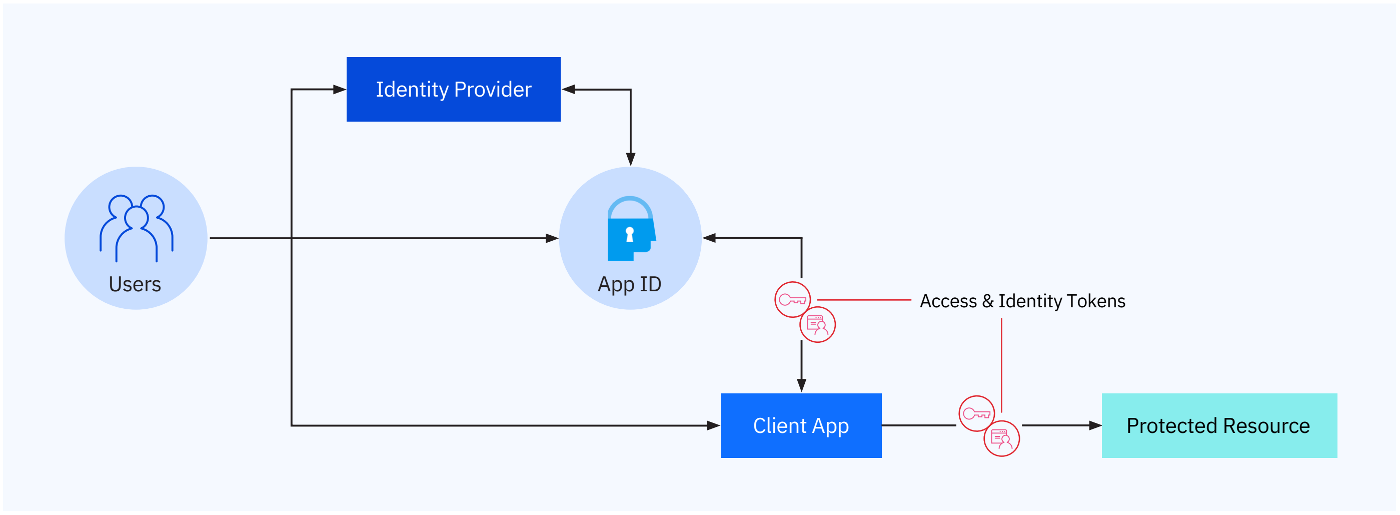

Figure 1. Accessing protected resources with App ID access and identity tokens

An identity token represents authentication. It contains most claims found within access tokens, but also includes user profile claims, such as: name, email, location, picture. Identity tokens are used to understand who the user is. User profile claims come from identity providers and depend on how you want your users to authenticate.

Different identity providers implement different authentication protocols and return different user profile claims. App ID normalizes those user profile claims in its identity token, so that you don't have to be concerned with differences in identity providers.

The above tokens are at the heart of App ID's authentication and authorization process. In most cases tokens are handled automatically by the App ID SDKs. However, developers have full access to these tokens should they need to implement highly customized, advanced business logic.

Custom User Attributes

As mentioned in the previous section, App ID provides identity token with claims about user's profile. However, in some cases you might want to add custom claims. These are highly specific to your application and as such App ID is not aware of them. Usually these claims are application specific user preferences, such as preferred text size, shopping cart content, application language, et cetera.

To address this use-case, App ID provides support for custom user attributes. Using a simple CRUD API, available as a REST API and as a programmatic API in the App ID SDKs, developers can store any custom properties associated with a user identity, that are then immediately available to all instances of your application. For example, if users access your application from both web and mobile, you can store a custom property in the web version of your application and it will be immediately available for retrieval in the mobile application.

Anonymous User Identity with Progressive Authentication

Authentication doesn't have to be first thing that pops-up on your application landing page. User experience research show that users should not be required to sign-up or sign-in prior to taking an action that actually requires it. But how can you provide a tailored experience to a user if you don't know anything about them? In order to address this use-case App ID supports anonymous user identities with progressive authentication. You can immediately assign your users an anonymous identity when they begin using you application and start anonymously saving their information - user or application preferences, shopping cart content et cetera. A user can return to your app at a later time and with experience tailored to them even though they never actually sign-in.

As users navigate your app, you can ask them to authenticate at any time. For example, when they need to make a payment. This is known as progressive authentication. After a user authenticates, the anonymous identity is converted to a known identity, and any information that was previously collected about that user remains accessible to you.

Identity Providers

Authenticating users implies being able to validate their credentials and retrieving information about an authenticated user identity. Information about user identities is supplied by Identity Providers – systems that allow to create, manage, and maintain identity information and provide ability for relying parties, such as App ID, to leverage that information for authentication.

App ID supports multiple Identity Provider types and allows seamless Identity Provider replacement and reconfiguration. You can reconfigure an existing Identity Provider or replace it with a different one without changing your code or redeploying your applications.

Cloud Directory

While App ID allows you to leverage existing enterprise and social user repositories, you might want to start building a new, scalable user repository from scratch and keep all of the information in the cloud. In order to address this use-case App ID provides the Cloud Directory – a cloud-hosted user repository that you can use to host accounts for your customers, employees, and users.

As you build out your digital channels and grow your user base, a demand for customer self-service will likely grow as well. You might be able to manually manage dozens of users, but when it comes to thousands and millions of users, providing self-service capabilities is key.

App ID Cloud Directory is based on the SCIM specification and is equipped with administrative management APIs. It also has user self-management capabilities such as sign-up, password change and reset, and update user profiles. You can configure Cloud Directory to allow or disallow user self-service, send confirmation and welcome emails and more.

When using App ID Cloud Directory, the user information is automatically encrypted with tenant-specific data encryption keys managed by a HSM and continuously backed up.

Enterprise Identity Providers

Many enterprises want to reuse their existing Identity Providers or User Repositories and federate them into the cloud. This is a common scenario for employee applications – you want to allow your employees to use existing credentials they're familiar with and use daily and have the sign-in experience they're used to.

App ID also allows organizations to bring their own Identity Providers and configure them with App ID using industry-standard SAML2 protocol. Once configured this newly enabled SAML2 identity provider becomes available for immediate use in new and existing applications instrumented with App ID.

Social Identity Providers

Social identity providers, such as Facebook and Google, have been adopted by a very large number of users, and while the jury is still out on their security value, they allow for easy sign-in to applications using existing Social Identities. Social identity providers allow you to glean additional profile information, with user permission, to build personalized experiences and make internal business decisions.

App ID comes pre-integrated with a collection of social identity providers available for instant out-of-the box use without any pre-configuration. App ID supports multiple identity providers, so that you can allow your users to decide which social identity provider they want to sign-in with.

Personalized Digital Experience

Application users expect consistent, personalized, and relevant experiences when they interact with various digital channels - web, mobile, bots, API, ect. To achieve this, you need to have a centralized view of the user that spans across all of your channels, including their preferences and engagement status. App ID lets you access this information when building business logic into applications. This includes:

- Normalized user information such as their name, email, and picture are usually obtained from an identity provider
- Organizational information and user preferences such as an address, or contact preferences
- Custom business-related data that is important in the context of your applications that you might want to persist between invocations

By requiring sign in through an identity provider, social or cloud directory, organizations can build user profiles that contain personal data and app preferences. Using the SCIM standard as the main connection, helps to access and manage personal user information and preferences.

SDKs and Authorization Filters

App ID provides a set of easy to use open-sourced SDKs for iOS and Android applications, as well as web applications and back-ends that are implemented in Node.js, Java, and Swift. Developers can easily install the App ID SDKs into new or existing applications using industry-standard package managers, such as Cocoapods, Gradle, NPM, Swift Package Manager.

The App ID SDKs abstract technical complexity by implementing all the supported OAuth2 and OpenID Connect flows, as well as App ID specific features, such as the login widget, anonymous user identity, progressive authentication custom user attributes, user self-service and more.

Our server-side SDKs (Node.js, Swift, Java) provide authorization filters that can be used by developers to protect their APIs and web applications. With a few lines of code you can define policies in a language they feel comfortable with to protect their applications (e.g. passport.js strategy for Node.js applications), and then leave the complexity of validating authorized requests and managing authentication flows to the App ID SDKs.

Using App ID SDKs developers can instrument their applications with authentication and authorization functionality with few lines of code without learning all the details on how things work “under the hood”.

If you’re building an application in a language we do not have SDK for yet, you can still use App ID. Since App ID is OAuth2 and OpenID Connect compliant you can chose to either leverage an existing 3rd party OAuth2/OpenID Connect SDK available for the language you’re using or alternatively consume App ID REST API directly, as will be described below.

Login Widget and UI Customization

At the heart of the App ID SDK is the App ID Login Widget; a dynamic authentication UI component, that’s available for both web and mobile applications. The Login Widget UI is built dynamically, based on your identity provider configuration. The login widget picks up any changes that you make automatically which means that you can update your authentication configuration without re-building and re-distributing new versions of your applications.

The Login Widget allows users to sign-in with any configured Identity Provider. In addition, the Login Widget provides Cloud Directory self-service UI, such as sign-up, password reset and more.

For applications that require a fully branded UI, App ID provides a set of easy-to-use REST APIs that conform to industry-standards. With Cloud Directory as your identity provider and these APIs at your fingertips, you can implement a fully customized self-service UI where your users can sign-up, sign-in, change or reset their password, update their profile and more.

As previously described, the Login Widget is available both as part of App ID SDK and via REST API, which allows you to leverage it regardless of the language you’ve your web application is implemented with.

Using Gateways: IBM API Connect, IBM Container Service

App ID is integrated with other IBM Cloud components, such as IBM API Connect, IBM Container Service, and IBM Cloud Functions.

You can use App ID to seamlessly protect your APIs managed by IBM API Connect, or enforce protection on your actions in IBM Cloud Functions. Both will honor and validate access and identity tokens provided by App ID.

IBM Container Service allows to enforce policy-driven security in a consistent way using declarative configuration of the Ingress Controller to add App ID protection for web applications, APIs and back-ends. Using this approach, you don’t have to instrument each of your applications separately - all the authorization and authentication flows will be handled automatically for you.

Easy App ID configuration and management

App ID comes with a simple to use web-based dashboard where you can configure authentication properties, setup identity providers, download samples, customize Login Widget, manage Cloud Directory and more.

The management functionality provided by the App ID dashboard is also available as a set of secured REST APIs that you can use to automate management activities in your DevOps processes, such as exporting and importing your configuration on demand or updating test and production instances of the service with the latest from development streams.

App ID supports the automation of these activities and their integration into a cohesive DevOps pipeline via REST interfaces. Everything that can be done with App ID via a browser, can also be done with REST APIs, and can be automated and integrated to match the needs of the development and operations team.

App ID Tenets

RFC Compliances

App ID is based on a set of well-known, industry standard protocols and specifications frequently found in both consumer-facing and enterprise-facing applications. Being compliant with industry-standard specifications is crucial and we want developers to leverage compatible SDKs and consume our APIs in a way that they're already familiar with.

At the core of App ID you'll find The OAuth 2.0 Authorization Framework (RFC 6749), and Open ID Connect. The former allows applications to obtain and verify authorization for accessing protected resources, while the latter is responsible for adding an authentication and identity layer on top of that.

Being compliant with these two major specifications allows App ID to integrate seamlessly into many existing authorization / authentication eco-systems.

Some of the other specifications App ID is based on include:

- The OAuth 2.0 Authorization Framework: Bearer Token Usage RFC 6750,
- OAuth 2.0 Dynamic Client Registration Protocol RFC 7591
- OpenID Connect
- JSON Web Algorithm (JWA) RFC 7518
- JSON Web Token (JWT) RFC 7519
- JSON Web Signature (JWS) RFC 7515
- Proof Key for Code Exchange by OAuth Public Clients RFC 7636
- OAuth 2.0 Token Introspection RFC 7662
- Assertion Framework for OAuth 2.0 Client Authentication and Authorization Grants RFC 7521
- JSON Web Token (JWT) Profile for OAuth 2.0 Client Authentication and Authorization Grants RFC 7523
- Security Assertion Markup Language (SAML) 2.0 Profile for OAuth 2.0 Client Authentication and Authorization Grants RFC 7522
- System for Cross-domain Identity Management: Definitions, Overview, Concepts, and Requirements RFC 7642
- System for Cross-domain Identity Management: Core Schema RFC 7643
- System for Cross-domain Identity Management: Protocol RFC 7644

Being compliant with the above specifications is not easy as they constantly evolve. App ID lets you implement authentication and authorization without being a security expert. You can focus on bringing business value to your customers.

API documentation and open-sourced SDKs

App ID goes beyond the above specifications in order to bring more value. Many of the above specifications allow extending functionality and describe facilities to do so.

While App ID tries to build on these specifications, in some cases we're actually adding capabilities that are not yet described in any existing specification. For this reason we've decided to take an open approach – App ID server side APIs are well documented using OpenAPI Specification (also referenced as Swagger) and all of the App ID SDKs are open sourced at https://github.com/ibm-cloud-security.

We won't re-invent the wheel, but we'll certainly be working to make it better.

Cloud-Native Operations

App ID is a cloud-native service implemented according to the best practices of a 12-factor application. We're working to ensure that App ID is a scalable, highly available cloud-native service.

App ID is built as a suite of containerized micro-services orchestrated by Kubernetes, provided by the IBM Cloud Container Service. To achieve high availability, we have multiple Kubernetes clusters deployed in different availability zones in each geographical region. Each of our clusters have at least three worker nodes. We use Global Load Balancer, CDN, and DDoS protection layers in front of App ID Kubernetes clusters. In addition, each App ID Kubernetes cluster is protected by a dedicated network router and firewall.

App ID Kubernetes clusters are monitored using New Relic and Prometheus. For each microservice we run a deployment with an auto-scaler, liveness probe, and a minimum of three pods. Every single container running in our clusters is monitored by two systems – IBM Cloud internal monitoring and New Relic. Whenever a component fails – it is automatically recycled with zero customer impact.

All of the App ID microservices are fully stateless. We use NoSQL databases and Redis instances hosted in the same geographical regions to store and cache data. All the incoming and outgoing App ID traffic is encrypted (data-in-motion). All the databases App ID uses are encrypted by default (data-at-rest). In addition to full database encryption, App ID also ensures full per-tenant data isolation by encrypting the data with tenant-specific keys thus making it accessible to a particular service tenant only. App ID uses HSM based service to manage root keys and data encryption keys. All databases used by App ID are continuously replicated and backed up. App ID stores data on a regional basis, meaning data for US service instances is kept in US, data for EU service instances is kept in EU et cetera.

App ID uses HashiCorp Vault to store the internal credentials required to access its dependencies. As mentioned above, each region has its own set of dependencies, with different credentials. We employ a very fine-grain access control system that allows only a particular microservice in a particular region to gain access to the dependency credentials. This allows us to ensure that credentials are kept safe, and no unauthorized party can access them.

Being a cloud-native service is all about continuous integration and continuous delivery, and we are heavy CI/CD advocates. We have fully automated the App ID delivery process from source code to production deployment. We use GitHub Enterprise with Pull Requests to manage our source code, Jenkins for Continuous Integration and Continuous Delivery, a set of IBM-internal and industry standard tools for quality control (such as SonarQube, Coveralls, Codacy and more). Our build cycles are short and test coverage is sky-high. In many cases it's easier and faster for us to fix a component and deploy a new version to production than to roll back to a previous version.

We use the Green/Blue deployment model to ensure that the updated environment is fully tested before accepting requests. Whenever a new version of a component is deployed we run an integration test cycle to validate there are no regression defects and to test new functionality. To ensure continuous service consumability and full system functionality we're running an automated sanity check test suite multiple times a-day. In addition, we employ a 3rd party company to run periodical penetration tests on all of our systems.

As mentioned above, we use several monitoring techniques to ensure we're aware of everything that happens in our environments. While most of the issues are addressed automatically, sometimes human intervention is required. When automation alone can't fix the problem, it will notify the always available IBM Cloud Support team and App ID team on-call personnel. We use a combination of Slack and PagerDuty to ensure timely issue resolution. For every issue that required human intervention we perform a root cause analysis to understand what the core of the issue was, how did it happen and how can we prevent the same problem from happening again.

With a proper cloud native, microservice based architecture, we minimize the blast radius, ensuring secure and effective operations, through fully automated CI/CD cycles as well as an exhaustive monitoring system.

Using App ID in your Applications

Developers can incorporate App ID and its capabilities into their applications in different ways, as described below.

App ID SDKs

While the REST APIs provide a flexible interface, the developers using them need to code the interactions on their own, including responding to challenges, presenting UIs, caching tokens, and associating them with requests. To abstract away the technicalities of underlying specifications, App ID provides client and server-side SDKs for iOS, Android, Swift, Java and Node.js applications. Developers can use these SDKs to easily incorporate user sign-in into their applications, make use of user profile claims in application logic, and add security and personalization logic into their micro-services.

REST APIs

App ID provides a well-documented REST API based on specifications such as OIDC, OAuth2 and SCIM. Developers can invoke REST interfaces directly, or use an available, standard compliant library to incorporate App ID into an application or micro-service. To support this option, App ID provides Swagger based documentation that can also be used as an interactive exploration and test tool.

IBM Cloud Environment

App ID is integrated with multiple other products in IBM Cloud, such as IBM API Connect, IBM Cloud Functions, and IBM Cloud Container Service. This integration can be used to enforce policy-driven security in a consistent manner using declarative approach at the general gateway entry point instead of managing each application separately.

Usage Patterns

Each of these patterns represent a separate scenario, however they can be combined to create a more robust authorization and authentication flows. Using several patterns in synergy will provide additional value and, depending on your use-case, helps improve your overall security posture.

Identity Only

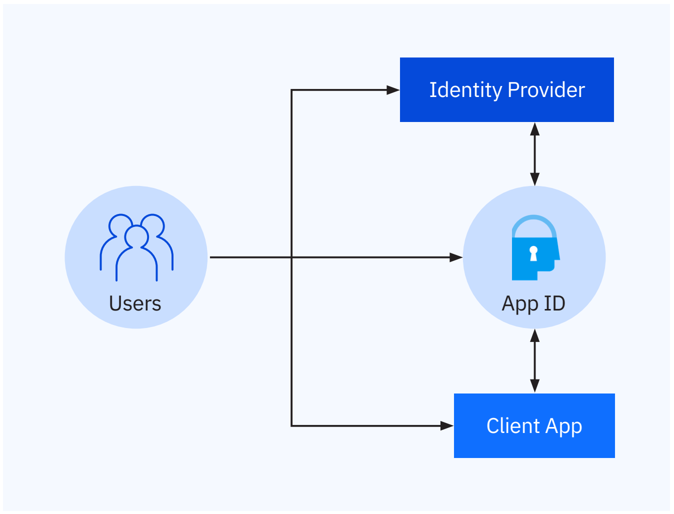

Figure 2. Accessing user identity

Some applications may only leverage the authentication and identity capabilities of App ID. An example is an application that doesn't need to access protected back-end APIs, but still wants to customize the application experience for users based on user identity.

Such an application, web or mobile, can use the App ID SDK to invoke the Login Widget, and after a successful authentication will use the claims from the identity token. You can decide whether the Login Widget should be invoked immediately on application load, or at a later stage, for instance when a user explicitly clicks a sign-in button.

In other cases, applications will likely need to access protected resources, such as back-ends and micro-services that run on cloud. App ID SDKs support this pattern as well.

Client to Protected Resource on Behalf of User

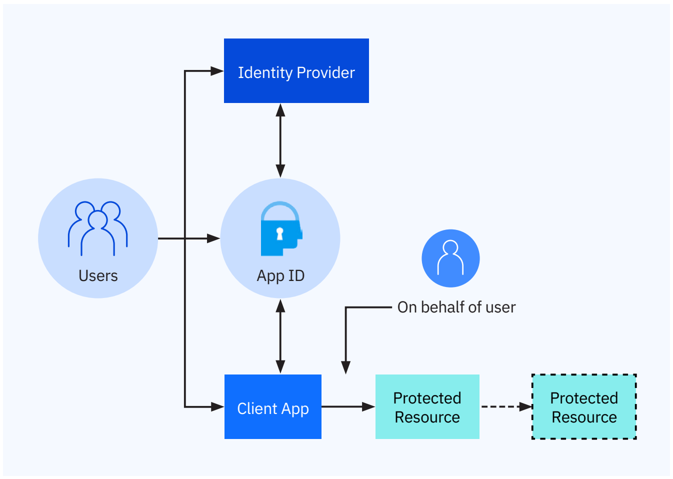

Figure 3. Accessing protected resources on behalf of user from client applications

This pattern includes a client-side agent, such as a mobile application, that invokes a protected resource, such as back-end API, on behalf of the end user. When using the App ID SDK, after a successful authentication the access and identity tokens provided by App ID are automatically added to the protected resource requests, meaning that subsequently the client application makes requests to the protected backend resources on behalf of the user.

Upon receiving these tokens, a protected resource can easily validate them with authorization filters provided by the App ID SDK, or by following guidelines described in specification documents and using JWT/JWS encoded claims. In addition, as mentioned above, when using a protect-at-gateway approach, e.g. with IBM API Connect or IBM Container Service, the token validation will be done automatically for you.

Note that resources can propagate user authorization access in additional downstream layers of protected resources. This can be done by using the received access and identity tokens in further resource requests. This allows all services to use the same standard security and identity logic, independent of where they are located in the micro-service architecture, and provide an easy way for downstream services to get user information.

Server to Protected Resource on Behalf of User

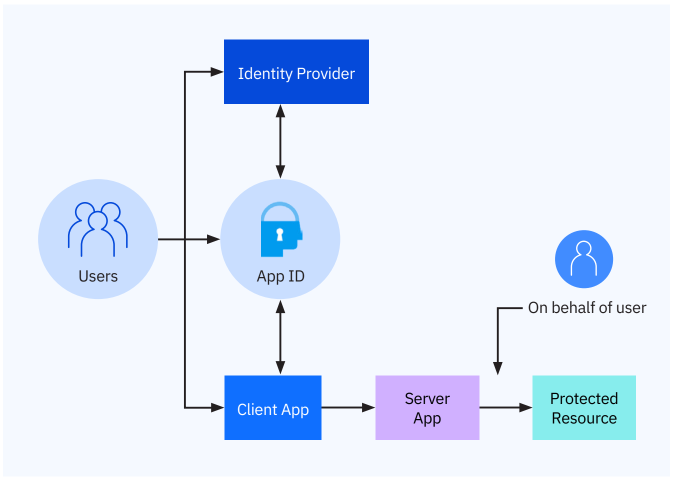

Figure 4. Accessing protected resources on behalf of user from server applications

Not all client applications should be blindly trusted with access and identity tokens. Depending on your use-case you may want tokens to remain at the server side in order to not expose them.

With this pattern, a user operates a client application, which communicates with the application server. Whenever access to a protected resource is required, the client application makes request to the server application, which in turn makes a request to the protected resource on a user's behalf.

Similar to the previous use-case, access and identity tokens received by a protected resource can be further propagated by making requests on a user's behalf down the stream to other protected resources.

This pattern is suitable for client-side agents with a lower level of trust, such as browser applications (including single page applications, or SPAs). Depending on the use-case, developers can still decide to expose tokens to browser applications, but reduce the token expiration time for better security.

A common way for developers to implement the above patterns is to use the App ID SDKs that are available for iOS, Android, Node, Java, and Swift. Another way is to follow a language agnostic approach and use the REST APIs directly.

Summary and Next Steps

Today's digital ambitions require more robust identity and personalization capabilities than traditional enterprise identity management solutions provide. Organizations need to protect access to sensitive resources for a wide range of customers and employees without affecting their users' experience, and build a unified view of the customer so they can provide consistent and engaging interactions across channels.

Capabilities provided by App ID cover the key requirements driven by the new digital channel workloads, and the technologies that App ID uses facilitate integration into any existing or new eco-system. App ID makes it easy to interact with users across digital touch points, while securing their access with the latest industry-standards. The service provides:

- An easy way to identify users through your choice of identity providers
- The ability to personalize engagements via user profiles
- SDKs and standard based REST interfaces to enhance developer productivity
- Cloud-based agility, speed, and TCO, while reusing existing investments in identity.

As you build your apps and microservices, check out IBM Cloud App ID, available in the IBM Cloud Services Catalog.

For technical questions at StackOverflow.com using the "ibm-appid" tag, or for non-technical questions use the "appid" tag on IBM developerWorks.

For support use the Support section in the IBM Cloud menu.

Useful links

- Create new App ID instance in the IBM Cloud Services Catalog
- App ID documentation
- App ID SDK for iOS
- App ID SDK for Android
- App ID SDK for Node.js
- App ID SDK for Swift Kitura

Videos and blogs

- Introducing IBM Cloud App ID
- IBM Cloud App ID Demo
- Webinar: Secure your Mobile Serverless Backend with App ID
- Simple and Fast Login with API Connect and App ID
- Add sign-up and sign-in to your apps with IBM Cloud App ID

For more information

To learn more about building a chain of trust for container security, visit ibm.com/cloud/container-service

Interested in Security + DevOps? Join our Slack channel and compare notes with the developers on the IBM Cloud Container Service product team.

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