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Hybrid IAM Deployments: Bridging On-Premises Security with Cloud Identity Services

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ABSTRACT

As organizations shift toward hybrid IT environments, the integration of on-premises identity and access management (IAM) systems with cloud-based identity services has become a strategic imperative. This paper explores architectural models, security implications, and operational challenges associated with hybrid IAM deployments. We propose a layered reference architecture that enables seamless identity federation, policy orchestration, and lifecycle management across cloud and legacy systems. Real-world use cases and technical patterns are presented to guide the deployment of resilient, scalable, and secure hybrid IAM infrastructures.

KEYWORDS: *Hybrid IAM, Identity Federation, Cloud IAM, Active Directory, Azure AD, Policy Orchestration, Zero Trust*

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1. INTRODUCTION

Digital transformation has introduced a heterogeneous mix of on-premises, cloud, and edge computing environments, fundamentally altering the enterprise technology landscape. Organizations are no longer confined to single, monolithic infrastructures; instead, they now operate in distributed ecosystems that span internal data centers, public clouds, SaaS applications, and mobile endpoints. This technological shift supports innovation, flexible workforces, and cost optimization—but it also introduces new complexities for security, particularly around identity and access management.

The decentralization of IT environments requires new mechanisms for asserting identity and managing access consistently across disparate platforms. Traditional Identity and Access Management (IAM) frameworks were architected for static, centralized enterprise environments where trust was implicitly granted within the network perimeter. These systems often relied on directory-based authentication, static group-based access controls, and heavily manual processes. In an era where users, devices, and services operate outside traditional boundaries, such models fall short in scalability, visibility, and risk management.

As enterprises embrace Software-as-a-Service (SaaS) applications, adopt multi-cloud platforms (such as AWS, Microsoft Azure, and Google Cloud Platform), and support hybrid or fully remote work models, legacy IAM solutions become a bottleneck to operational efficiency and security assurance. The inability to enforce consistent identity policies across environments results in duplicated identity stores, inconsistent access provisioning, unmanaged privileges, and audit gaps. These weaknesses are often exploited in modern attacks that target user credentials, privilege escalation, and lateral movement.

2. Background and Motivation

Many organizations still rely on legacy IAM infrastructures such as on-premises Active Directory or custom LDAP implementations for managing authentication, role assignments, and group-based entitlements. These systems are deeply embedded within enterprise IT environments, particularly for internal applications, regulated workloads, and business-critical legacy systems. Despite their reliability, they lack the agility and extensibility required to support modern access control paradigms demanded by today's cloud-first strategies.

At the same time, modern workloads—such as cloud-native applications, SaaS platforms, and remote workforces—require advanced identity capabilities including federated login, dynamic role mapping, API-based access, and Just-In-Time (JIT) provisioning. Cloud-native identity services like Azure AD, Okta, and Ping Identity offer these capabilities, enabling scalable access control, real-time user onboarding, and contextual access decisions based on device health, user location, and behavior.

However, when legacy and modern IAM systems operate in isolation, identity silos form. These silos manifest as:

- Inconsistent user identities across environments
- Redundant or conflicting access policies
- Manual reconciliation of entitlements
- Delayed provisioning or deprovisioning workflows
- Fragmented audit and compliance visibility

These issues increase the attack surface, raise the likelihood of privilege misuse, and complicate compliance with frameworks such as ISO 27001, NIST, and PCI-DSS. Threat actors increasingly exploit these gaps through credential stuffing, lateral movement, and privilege escalation attacks.

The growing need to manage hybrid workforces, enforce zero trust principles, and comply with evolving regulations has made hybrid IAM a top priority. Analysts from Gartner and Forrester have consistently highlighted hybrid IAM as a foundational enabler of Zero Trust architectures, emphasizing its role in:

- Establishing a unified identity perimeter
- Bridging cloud and on-premise policy enforcement
- Supporting identity threat detection and response (ITDR)
- Enabling adaptive access control across heterogeneous environments

Therefore, the motivation for hybrid IAM is not merely architectural, but operational and strategic. It addresses both the immediate need to modernize access governance and the long-term goal of building resilient, intelligent, and context-aware identity infrastructures. **Hybrid IAM** has emerged as a pragmatic and strategic response to these challenges. Rather than pursuing a wholesale replacement of legacy systems, hybrid IAM embraces the integration of on-premises IAM (e.g., Microsoft Active Directory, LDAP directories) with modern, cloud-native identity platforms (e.g., Azure Active Directory, Okta, Ping Identity, Google Workspace). This coexistence supports interoperability between old and new systems, while enabling the gradual adoption of modern identity governance practices such as conditional access, adaptive authentication, and Just-In-Time (JIT) provisioning.

Hybrid IAM empowers organizations to:

- Extend single sign-on (SSO) and multi-factor authentication (MFA) capabilities uniformly across on-premises and cloud environments, reducing friction and improving security.
- Synchronize identity attributes, credentials, and entitlements between multiple identity providers to maintain consistency and reduce provisioning delays.
- Enforce centralized policy decisions using policy-as-code models, with distributed enforcement points placed across networks, applications, and APIs.
- Support zero trust access strategies by continuously validating users and devices regardless of location.
- Maintain compliance with regulations such as GDPR, HIPAA, and SOX by ensuring auditability, logging, and access certification across hybrid platforms.

3. Architectural Patterns for Hybrid IAM

3.1. Directory Synchronization

Directory synchronization is the foundational pattern in hybrid IAM architecture. It establishes an identity bridge between on-premises directory services, such as Microsoft Active Directory (AD), and cloud-based directories like Azure Active Directory (Azure AD), enabling consistent identity presence across both environments. This model is widely adopted due to its ability to preserve existing identity investments while enabling access to modern cloud services.

In a typical setup, synchronization tools such as **Azure AD Connect**, **Okta Universal Sync**, or **Google Cloud Directory Sync** are used to:

- Synchronize user accounts, groups, and attributes
- Maintain password hashes or pass-through authentication
- Detect changes in the source directory and propagate them to the cloud

This synchronization ensures that any identity created or modified in the on-premises directory is reflected in the cloud directory, maintaining parity across both systems. Organizations often configure filters, attribute mappings, and synchronization intervals to meet operational and compliance requirements.

A key feature of directory synchronization is support for **Single Sign-On (SSO)**. Users authenticate once with their on-premises credentials and gain seamless access to cloud resources without reauthentication, improving the user experience and reducing helpdesk load related to password resets. Password hash sync, pass-through authentication (PTA), and federation via Active Directory Federation Services (AD FS) are common mechanisms used in this context.

Benefits:

- Enables phased migration to cloud identity
- Reduces friction for end users with unified credentials
- Supports SSO and MFA without major disruptions
- Simplifies policy enforcement and group-based access provisioning

Challenges:

- Ensuring synchronization consistency during outages or latency events
- Securely handling password hashes and credential replication
- Managing attribute conflicts and schema mismatches between systems
- Providing adequate logging and alerting for sync operations

This pattern lays the groundwork for more advanced hybrid IAM scenarios by ensuring that identities are consistently and reliably available in both legacy and cloud ecosystems.

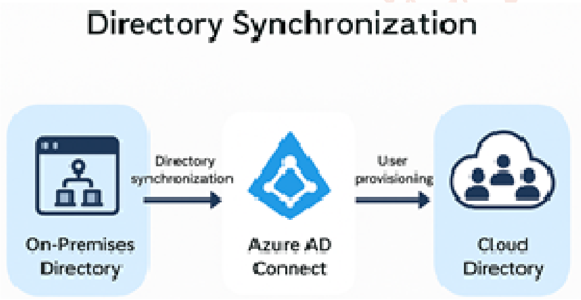


Figure 1: Directory Synchronization Architecture

The following diagram illustrates a typical hybrid directory synchronization architecture:

- On-prem AD acts as the identity source
- Azure AD Connect synchronizes users, groups, and passwords
- Federated applications use SSO via Azure AD or Okta
- Authentication can be routed through on-prem AD or cloud IdP depending on policy

3.2. Identity Federation and Trust Establishment

As enterprises extend their IT ecosystems across multiple domains, platforms, and partner organizations, the need for secure and seamless cross-domain authentication becomes paramount. Identity federation addresses this need by enabling trust relationships between different identity systems—both internal and external—through standardized protocols. It allows users to access applications and services across organizational and technological boundaries without duplicating identities or requiring redundant authentication.

Federation relies on open standards such as SAML (Security Assertion Markup Language), which is widely used in enterprise environments for web-based SSO across domains; OIDC (OpenID Connect), a modern identity layer built on OAuth 2.0, commonly used for cloud and mobile applications; and WS-Federation, primarily used in Microsoft-centric environments for token-based access to web applications.

By implementing these protocols, organizations can establish bidirectional trust between on-premises IAM systems (such as Active Directory Federation Services - AD FS) and cloud-based Identity Providers (IdPs) like Azure AD, Okta, Ping Identity, or Google Workspace. This trust allows users from one domain to authenticate and access resources hosted in another domain without re-entering credentials. It also enables guest and partner access for external users, Just-In-Time (JIT) provisioning, and seamless SSO experiences that abstract away system boundaries for the end user.

The architecture of identity federation typically includes an Identity Provider (IdP), which authenticates users and issues security tokens; a Service Provider (SP), which consumes those tokens and grants access based on the asserted identity claims; and a Metadata Exchange mechanism, which involves exchanging configuration files between IdP and SP to define trusted endpoints, cryptographic certificates, and supported bindings.

The advantages of this model are significant. Federation reduces identity sprawl by allowing users to authenticate using a single identity across systems. It centralizes authentication and access policy enforcement, enhances the user experience with reduced login prompts, and simplifies access control across multi-tenant and cross-organizational use cases. However, it also introduces challenges such as managing trust validity and cryptographic key rotation, handling token lifecycles and session timeouts, and ensuring secure MFA integration across heterogeneous identity systems.

The included diagram (Figure 2) illustrates a typical federation setup. On-prem AD FS is configured as the

IdP, while Azure AD and external SaaS applications serve as SPs. Users authenticate once to AD FS and receive SAML or OIDC tokens, which grant access to cloud services. Trust metadata ensures that token exchanges and signature validations are securely managed.

This model enables secure collaboration between internal employees, external contractors, and partner domains, supporting both business continuity and robust access governance in distributed, hybrid IT environments.

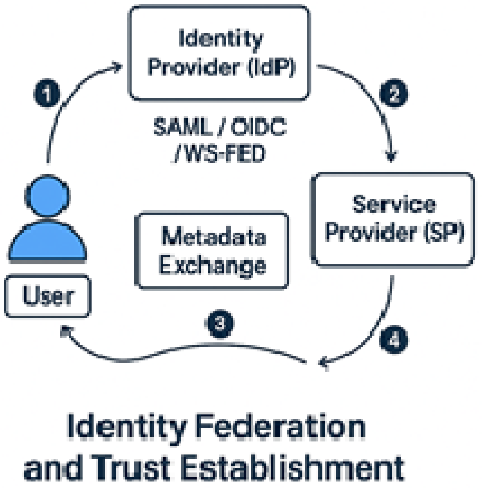


Figure 2: Identity Federation and Trust Establishment

3.3. Policy Centralization with Distributed Enforcement

Hybrid IAM deployments require a unified policy framework to ensure consistent access control across both cloud-native and on-premises environments. However, the diverse and geographically distributed nature of hybrid systems poses challenges for centralized enforcement. To address this, organizations are increasingly adopting architectures that leverage **centralized policy engines** in conjunction with **distributed enforcement points**.

Centralized policy engines, such as **Microsoft Conditional Access**, **Open Policy Agent (OPA)**, and **PingOne Authorize**, are responsible for defining and evaluating access rules based on identity attributes, device health, geolocation, risk scores, and contextual signals. These policies are written in declarative formats (e.g., Rego for OPA), enabling clear, version-controlled, and auditable access logic. The central engine acts as the single source of truth for evaluating policies while supporting integration with multiple identity providers and application platforms.

The **distributed enforcement model** involves deploying Policy Enforcement Points (PEPs) at various locations throughout the hybrid infrastructure. These include:

- **Cloud Proxies**: Gateways such as Azure Application Proxy or Zscaler ZPA that enforce access policies before traffic reaches the internal network.
- **API Gateways**: Tools like Kong or AWS API Gateway that intercept requests and validate user entitlements and tokens.
- **VPNs and Firewalls**: Traditional perimeter devices enhanced with identity-aware rules to restrict access based on policy decisions.
- **Application Middleware**: Web servers or custom agents that consult the central engine before granting access to protected resources.

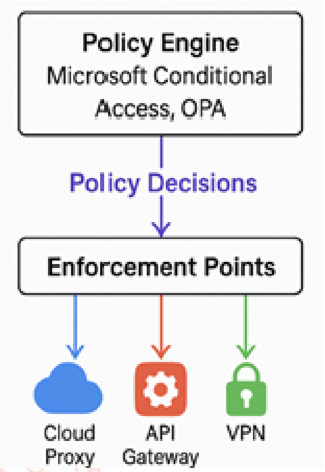


Figure 3: Centralized Policy Decision with Distributed Enforcement Architecture

By separating the decision-making logic (centralized) from the enforcement layer (distributed), this model ensures that access control is:

- **Consistent**: Users are subject to the same policies regardless of where they access resources.
- **Scalable**: Enforcement scales horizontally without burdening the central engine.
- **Resilient**: Outage in one enforcement point does not impact others; fallback policies can apply locally.
- **Context-Aware**: Policies can adapt to context such as time of day, device trust, or real-time risk posture.

A typical use case involves a user accessing a SaaS application from an unmanaged device. The cloud proxy intercepts the session and queries the central policy engine, which evaluates contextual risk and mandates MFA. Simultaneously, an on-prem API access request from the same user may be validated via an API gateway, ensuring consistent enforcement regardless of endpoint.

This architectural pattern aligns with Zero Trust principles by enforcing **explicit verification**, **least privilege**, and **continuous validation** across hybrid environments. It also supports compliance initiatives by centralizing audit logs, policy revisions, and access reviews in a unified governance layer.

4. Challenges in Hybrid IAM

While hybrid IAM architectures offer flexibility and support for diverse environments, they also introduce unique challenges that must be addressed to ensure seamless operation and robust security.

One of the primary concerns is **latency and availability**. Directory synchronization and identity federation depend on multiple interdependent services, including network connectivity between on-premises and cloud environments. Any delay in synchronization or failure in federation components can lead to authentication delays, degraded user experience, or complete access outages. For mission-critical applications, even brief disruptions in identity services can significantly impact business operations.

Another critical challenge is **configuration drift**. Hybrid IAM systems often require complex policy definitions that span both cloud-native and legacy platforms. Over time, discrepancies can emerge between these environments due to asynchronous updates, inconsistent attribute mappings, or platform-specific limitations. This drift can result in conflicting entitlements, policy misalignment, and unintended access, making it difficult to maintain a unified access governance model.

Security blind spots are also a growing concern in hybrid IAM. Many legacy identity systems lack the monitoring capabilities, telemetry support, and fine-grained controls available in modern cloud platforms. Without integrated visibility across all identity domains, security teams may overlook anomalous behaviors, dormant accounts, or excessive privileges that can be exploited by attackers. These blind spots weaken an organization's ability to detect and respond to identity-based threats in real time.

Finally, **licensing and compliance** introduce operational complexity. Hybrid IAM often spans multiple vendors, each with different service-level agreements (SLAs), licensing models, and audit requirements. Ensuring end-to-end compliance with regulatory frameworks such as GDPR, HIPAA, or SOX requires careful coordination of logging, access certification, and policy enforcement across all identity systems. Organizations must also manage cost implications and contractual obligations associated with maintaining both cloud and on-prem identity infrastructure.

Understanding and proactively addressing these challenges is critical for the successful deployment and ongoing management of hybrid IAM solutions. In the following sections, we explore architectural best practices and mitigation strategies to overcome these limitations and enhance the reliability, security, and scalability of hybrid identity environments.

5. Reference Architecture

The proposed hybrid IAM reference model provides a structured and scalable framework to unify identity services across on-premises and cloud environments. It supports secure identity management, federated authentication, policy orchestration, and centralized monitoring—while allowing for decentralized enforcement and extensibility.

At the core of the architecture are the **Identity Sources**, which typically include on-premises Active Directory (AD), Human Resource Management Systems (HRMS), and external Identity Providers (IdPs) such as partner domains or federated directories. These sources serve as the authoritative repositories of user identities, roles, and attributes. The ability to ingest and correlate identities from multiple systems is crucial for accurate provisioning and lifecycle management.

The **Synchronization Layer** bridges on-premises and cloud identity systems. Tools like **Azure AD Connect**, **Okta Universal Sync**, and **ForgeRock Directory Services Sync** are used to synchronize user accounts, group memberships, and credential data. This layer ensures that any change in the source system—such as a new hire or departmental change—is reflected in all connected systems in near real-time. Synchronization may also include custom attribute mapping, filtering, and conflict resolution logic.

The **Federation Layer** enables cross-domain authentication by implementing standard protocols such as **SAML 2.0**, **OpenID Connect (OIDC)**, and **WS-Federation**. Identity federation is achieved through brokers or services that facilitate Single Sign-On (SSO) and Multi-Factor Authentication (MFA) across systems. For example, users authenticated through on-prem AD FS can access SaaS applications federated through Azure AD or Okta without re-authentication. This layer abstracts the authentication mechanisms and allows seamless access across trust boundaries.

The **Policy Engine** acts as the brain of the architecture. It is responsible for evaluating access control decisions based on predefined rules and contextual inputs such as user risk scores, device posture, geolocation, and login behavior. Solutions like **Microsoft Conditional Access**, **PingOne Authorize**, and **Open Policy Agent (OPA)** can centralize these decisions. Local enforcement is handled by **Policy Enforcement Points (PEPs)** embedded in API gateways, proxies, and applications, ensuring that policy compliance is maintained even in decentralized architectures.

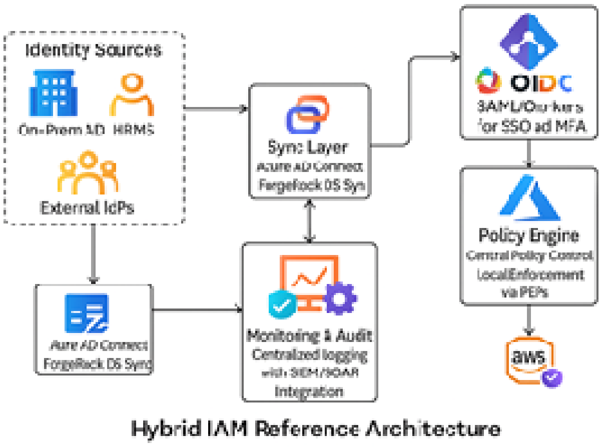


Figure 4: Hybrid IAM Reference Architecture Diagram

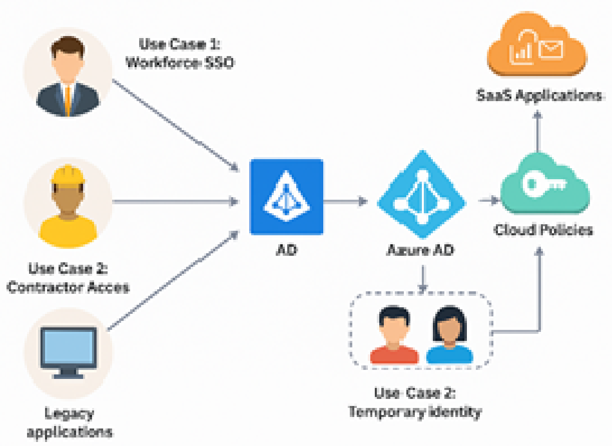
The **Monitoring and Audit Layer** integrates with Security Information and Event Management (SIEM) and Security Orchestration, Automation, and Response (SOAR) platforms to provide end-to-end visibility. Centralized logging ensures that all authentication attempts, policy evaluations, and enforcement actions are recorded. This enables real-time alerting, forensic investigations, and audit compliance across hybrid environments. Integration with tools like **Splunk**, **Microsoft Sentinel**, and **Elastic Stack** allows security teams to correlate identity events with broader threat intelligence and operational metrics.

Together, these layers form a comprehensive hybrid IAM architecture that balances centralized governance with distributed control. It enables secure, scalable, and compliant access across diverse IT environments while supporting zero trust principles, continuous monitoring, and policy-driven automation.

6. Use Case Scenarios

Hybrid IAM deployments are best understood through real-world use cases that highlight how identity synchronization, federation, and policy enforcement work in practical settings. Below are three representative scenarios that illustrate the functional value of hybrid IAM architecture.

Use Case 1: Workforce Single Sign-On (SSO) In this scenario, a company leverages its existing on-premises Active Directory (AD) infrastructure to authenticate employees for internal systems while extending secure access to cloud-based applications via Azure AD. When an employee logs in using their domain credentials, the authentication request is validated against the local AD. Simultaneously, directory synchronization tools like Azure AD Connect ensure that user identities and attributes are mirrored in Azure AD. This enables seamless SSO experiences for employees when accessing cloud SaaS applications such as Microsoft 365, Salesforce, and ServiceNow. Policies such as Conditional Access ensure that access is granted based on real-time signals such as user location, device compliance, and risk profile, thereby enhancing both user convenience and security posture.



Use Case 2: Contractor and Vendor Access Organizations often need to provide limited and temporary access to external contractors, vendors, or consultants. In this scenario, hybrid IAM facilitates the provisioning of temporary cloud-native identities using Azure AD B2B or Okta Workforce Identity. These identities are typically created with time-bound entitlements and limited access rights. While these users do not exist in the on-premises AD, they can still be granted secure access to specific internal resources through reverse proxy mechanisms or application gateways. Policy controls restrict access based on IP address, time of day, or device trust level, ensuring contractors have access only to what they need—and only for the duration they need it.

Use Case 3: Legacy Application Integration with Modern Policies Many enterprises still rely on legacy, on-premises applications that do not natively support modern authentication protocols. In this scenario, employees authenticate against the traditional Active Directory, which handles the authentication logic. However, access to these legacy applications is now governed by centralized cloud-based policy engines, such as Microsoft Conditional Access or PingOne Authorize. This allows the organization to layer on modern access policies—such as risk-based access, MFA enforcement, and geo-location restrictions—on top of legacy systems without rewriting the applications themselves. Through this hybrid model, legacy resources benefit from the same security controls as cloud-native applications, ensuring policy consistency and governance.

These use cases demonstrate how hybrid IAM bridges operational gaps between traditional and modern IT environments, offering scalable, secure, and user-friendly identity services across the enterprise.

7. Best Practices

Successfully managing a hybrid IAM environment requires careful planning, consistent policy implementation, and proactive monitoring. The following best practices can help organizations build a secure, reliable, and future-proof identity architecture.

Standardize Naming Conventions and Attribute Schemas Establish consistent naming conventions and attribute schemas for user accounts, groups, and roles across all identity systems. A standardized schema ensures seamless synchronization and minimizes errors in attribute mapping. Uniform naming also aids in policy enforcement, audit readiness, and integration with cloud applications that rely on consistent identity metadata.

Use Certificate-Based Trust for Federation When establishing federated trust relationships between on-premises and cloud identity systems, use digital certificates for secure token signing and validation. Certificate-based trust enhances security by ensuring that assertions and authentication responses are cryptographically verifiable. Regularly rotate and manage certificates to maintain integrity and compliance with industry standards.

Implement Conditional Access and Risk-Based Authentication Deploy conditional access policies that evaluate multiple factors—such as device posture, geographic location, time of access, and user role—before granting access. Integrate risk-based authentication engines that can dynamically step up authentication requirements when suspicious activity is detected. These controls enable more adaptive, context-aware access decisions that align with Zero Trust principles.

Regularly Audit Synchronization and Federation Configurations Maintain a routine schedule for auditing directory synchronization jobs, federation trust settings, and identity mappings. Validate that synchronization tools are functioning as intended and that there is parity between source and target directories. For federated environments, verify metadata exchange, token validity settings, and session timeouts to ensure secure, uninterrupted access and reduced risk of misconfiguration.

These best practices collectively strengthen identity governance, reduce operational risks, and enhance user experience across hybrid IAM environments. As organizations scale, adherence to these principles ensures consistent policy enforcement and long-term IAM agility.

8. Future Directions

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Explore Emerging Technologies to Future-Proof IAM The hybrid IAM landscape is evolving rapidly, and organizations must stay ahead of emerging technologies to remain secure and competitive.

Decentralized Identifiers (DID), for example, offer a way for users to manage their own identities using blockchain-based verification, reducing reliance on centralized identity stores and enhancing privacy. **Cloud-native Identity Governance and Administration (IGA)** tools are also gaining traction, offering real-time access visibility, entitlement management, and policy automation for cloud resources.

Password less authentication technologies—such as biometrics, FIDO2 tokens, and device-bound credentials—are redefining how users prove their identity, reducing the attack surface created by passwords while streamlining user access.

Furthermore, **AI-driven policy enforcement** and **continuous access evaluation** are transforming how access decisions are made. These technologies enable dynamic, risk-adaptive controls that evaluate behavior, device health, and session context in real time. This allows identity systems to block, limit, or escalate access based on evolving risk rather than relying solely on static rules.

Adopting and experimenting with these innovations will help organizations design resilient, future-ready IAM architectures capable of withstanding evolving threat landscapes and scaling with business growth.

These best practices collectively strengthen identity governance, reduce operational risks, and enhance user experience across hybrid IAM environments. As organizations scale, adherence to these principles ensures consistent policy enforcement and long-term IAM agility.

9. Conclusion

Hybrid IAM deployments are essential for organizations undergoing digital transformation and operating across diverse IT landscapes. These deployments offer a pragmatic and scalable approach to modernizing identity systems by blending the strengths of on-premises infrastructure with the agility and advanced capabilities of cloud-native platforms. Rather than undertaking costly rip-and-replace strategies, hybrid IAM provides a transitional architecture that maximizes existing investments while enabling incremental adoption of future-ready technologies.

By embracing federated identity models, organizations can establish seamless and secure trust relationships between disparate systems, allowing users to authenticate once and gain access to both legacy and cloud resources. Centralized policy governance ensures that access decisions are uniformly enforced based on risk, context, and compliance requirements, while distributed enforcement mechanisms ensure low-latency and location-aware policy application.

Integrated monitoring and audit layers further enhance security by providing visibility into access behaviors, policy violations, and potential threats. These capabilities help security teams maintain continuous compliance with regulatory standards and detect anomalies in real time.

Ultimately, hybrid IAM supports a user-centric security model that adapts to evolving business needs, emerging threats, and technological innovation. When deployed with foresight and adherence to best practices, it empowers enterprises to build resilient, secure, and efficient identity ecosystems that bridge the gap between legacy operations and cloud-driven futures.

References

[1] National Institute of Standards and Technology (NIST), "Digital Identity Guidelines," NIST SP 800-63-3, June 2017.

[2] Organization for the Advancement of Structured Information Standards (OASIS), "Security Assertion Markup Language (SAML) V2.0 Technical Overview," March 2015.

[3] Cybersecurity & Infrastructure Security Agency (CISA), "Zero Trust Maturity Model," U.S. Department of Homeland Security, 2021.

[4] Microsoft Corporation, "Azure Active Directory Conditional Access: Zero Trust Controls," Microsoft Docs, March 2021. [Online]. Available: https://learn.microsoft.com/

[5] Forrester Research, "The Zero Trust eXtended (ZTX) Ecosystem," Forrester, April 2021.

[6] Gartner, "Market Guide for Identity Governance and Administration," Gartner Research, February 2021.

[7] U.S. Department of Commerce, "NIST Risk Management Framework for Information Systems and Organizations," NIST SP 800-37 Rev. 2, December 2018.

[8] Cloud Security Alliance, "Identity and Access Management for the Cloud," CSA Guidance, Version 4.0, January 2019.

[9] Internet Engineering Task Force (IETF), "OAuth 2.0 Authorization Framework," RFC 6749, October 2012.

[10] OpenID Foundation, "OpenID Connect Core 1.0 incorporating errata set 1," November 2014.

[11] Microsoft, "Hybrid Identity with Azure AD Connect," Microsoft Docs, February 2021.

[12] Ping Identity, "A Practical Guide to Zero Trust and Identity-Centric Security," Ping Identity Whitepaper, January 2021.

[13] ENISA, "Access Control – Good Practices for Security of IoT," European Union Agency for Cybersecurity, 2020.

[14] IBM Security, "Enabling Zero Trust Through Identity and Access Management," IBM Whitepaper, March 2021.