4. Conceptual and Logical Security Architecture

4.1 Introduction to Security Architecture for API Authorization

Security architecture forms the backbone of a robust API authorization system. It provides a structured approach to designing, implementing, and managing security controls that protect APIs while enabling business objectives. This section explores the conceptual and logical aspects of security architecture, with a focus on leveraging Ping Authorize for API authorization.

4.1.1 The Importance of a Well-Designed Security Architecture

A well-designed security architecture for API authorization:

- Ensures consistent application of security controls across the API ecosystem
- Facilitates scalability and adaptability to changing business needs
- Enhances visibility and manageability of security measures
- Supports compliance with regulatory requirements
- Enables efficient integration of security tools and processes

4.1.2 SABSA and Security Architecture

The SABSA framework provides a structured approach to developing security architecture:

- Conceptual Architecture: Defines high-level security concepts and principles
- Logical Architecture: Translates concepts into logical models and structures

This section will explore both the conceptual and logical aspects of security architecture for API authorization using Ping Authorize.

4.2 Conceptual Security Architecture

The conceptual security architecture defines the overarching security principles and concepts that guide the design and implementation of the API authorization system.

4.2.1 Core Security Principles for API Authorization

1. **Least Privilege**
    - Principle: Grant the minimum level of access required for each API consumer

  - Application: Use fine-grained policies in Ping Authorize to restrict access based on specific attributes and contexts
2. **Defense in Depth**
   - Principle: Implement multiple layers of security controls
   - Application: Combine Ping Authorize with API gateways, network security, and application-level controls
3. **Zero Trust**
   - Principle: Never trust, always verify
   - Application: Use Ping Authorize to validate every API request, regardless of its origin
4. **Separation of Duties**
   - Principle: Divide critical functions among different entities
   - Application: Separate policy administration, decision-making, and enforcement using Ping Authorize's distributed architecture
5. **Privacy by Design**
   - Principle: Embed privacy considerations into the design of systems
   - Application: Use Ping Authorize's attribute-based access control to enforce data minimization and purpose limitation
6. **Continuous Monitoring and Improvement**
   - Principle: Constantly monitor, evaluate, and enhance security measures
   - Application: Leverage Ping Authorize's logging and reporting capabilities for ongoing security analysis and improvement

4.2.2 Conceptual Model for API Authorization

Develop a high-level conceptual model for API authorization:

1. **Identity and Authentication**
   - Concept: Verify the identity of API consumers
   - Components: Identity Providers, Authentication Protocols (e.g., OAuth 2.0, OpenID Connect)
2. **Policy-Based Access Control**
   - Concept: Make access decisions based on predefined policies
   - Components: Policy Administration Point (PAP), Policy Decision Point (PDP), Policy Enforcement Point (PEP)
3. **Attribute-Based Decisions**
   - Concept: Use various attributes to make context-aware access decisions
   - Components: Attribute Sources, Attribute Providers, Context Evaluators
4. **Dynamic Authorization**
   - Concept: Make real-time access decisions based on current context

    - Components: Real-time Attribute Resolvers, Dynamic Policy Evaluators
5. **Centralized Policy Management**
    - Concept: Manage all authorization policies from a central point
    - Components: Policy Management Interface, Policy Repository, Policy Distribution Mechanism
6. **Audit and Compliance**
    - Concept: Track and report on all authorization activities
    - Components: Logging System, Audit Trail, Compliance Reporting Tools

4.2.3 Conceptual Security Zones

Define conceptual security zones for API authorization:

1. **Public Zone**
    - Description: Publicly accessible area where API requests originate
    - Security Considerations: Treat all incoming traffic as untrusted
2. **DMZ (Demilitarized Zone)**
    - Description: Intermediate zone hosting API gateways and initial security controls
    - Security Considerations: Implement rate limiting, initial request validation
3. **Authorization Zone**
    - Description: Area where Ping Authorize operates to make access decisions
    - Security Considerations: Secure communication channels, protect policy information
4. **Protected Resource Zone**
    - Description: Zone containing the actual API resources and data
    - Security Considerations: Enforce fine-grained access control, data encryption
5. **Management Zone**
    - Description: Area for administering policies and monitoring system health
    - Security Considerations: Strict access controls, secure management interfaces

4.2.4 Conceptual Data Flow for API Authorization

Outline the high-level data flow for API authorization:

1. API Consumer sends a request to access a protected resource
2. Request is intercepted by the API Gateway in the DMZ
3. API Gateway forwards the request to Ping Authorize for authorization
4. Ping Authorize evaluates the request against policies and attributes
5. Authorization decision is returned to the API Gateway
6. If authorized, the request is forwarded to the Protected Resource Zone

7. Protected resource applies any additional controls and processes the request
8. Response is sent back through the API Gateway to the API Consumer
9. All activities are logged for audit and compliance purposes

4.3 Logical Security Architecture

The logical security architecture translates the conceptual model into more detailed structures and processes, independent of specific technologies.

4.3.1 Logical Components of the API Authorization System

1. **Policy Administration Point (PAP)**
   - Function: Manage authorization policies
   - Key Features:
     - Policy creation and editing interface
     - Policy versioning and change management
     - Policy testing and simulation capabilities
2. **Policy Decision Point (PDP)**
   - Function: Evaluate access requests against policies
   - Key Features:
     - High-performance policy evaluation engine
     - Support for complex, attribute-based policies
     - Caching mechanism for improved performance
3. **Policy Enforcement Point (PEP)**
   - Function: Enforce authorization decisions
   - Key Features:
     - Integration with API Gateways and application servers
     - Support for various enforcement actions (permit, deny, filter)
     - Ability to handle policy obligations
4. **Policy Information Point (PIP)**
   - Function: Provide attributes for policy evaluation
   - Key Features:
     - Integration with various attribute sources (databases, directories, APIs)
     - Real-time attribute resolution
     - Attribute caching and prefetching capabilities
5. **Policy Retrieval Point (PRP)**
   - Function: Retrieve and cache policies for the PDP
   - Key Features:
     - Efficient policy distribution mechanism

        - Policy caching for improved performance
        - Support for policy hierarchies and inheritance
6. **Attribute Authority**
    - Function: Manage and provide authoritative attribute information
    - Key Features:
        - Centralized attribute management
        - Attribute validation and transformation
        - Support for derived and calculated attributes
7. **Audit and Logging System**
    - Function: Record and analyze authorization activities
    - Key Features:
        - Comprehensive logging of all authorization decisions
        - Real-time alerting for security events
        - Integration with SIEM systems

4.3.2 Logical Data Model for API Authorization

Define the key data entities and their relationships:

1. **User**
    - Attributes: UserID, Roles, Groups, Department, Location
    - Relationships: Belongs to Groups, Has Roles
2. **Application**
    - Attributes: AppID, AppType, OwnerDepartment, SecurityLevel
    - Relationships: Owns APIs, Used by Users
3. **API**
    - Attributes: APIID, Version, Sensitivity, DataClassification
    - Relationships: Belongs to Application, Has Operations
4. **Operation**
    - Attributes: OperationID, HTTPMethod, Endpoint
    - Relationships: Belongs to API, Requires Permissions
5. **Policy**
    - Attributes: PolicyID, Version, Priority, Status
    - Relationships: Applied to APIs, Contains Rules
6. **Rule**
    - Attributes: RuleID, Condition, Effect, Obligations
    - Relationships: Part of Policy, Uses Attributes
7. **Attribute**
    - Attributes: AttributeID, Source, DataType, UpdateFrequency
    - Relationships: Used in Rules, Describes Entities

8. **Permission**
    - Attributes: PermissionID, Scope, ActionAllowed
    - Relationships: Granted to Roles, Required by Operations

4.3.3 Logical Process Flows

Define the key process flows for API authorization:

1. **Policy Creation and Management Process**
   a. Policy author designs policy using PAP interface
   b. Policy undergoes review and approval process
   c. Approved policy is versioned and stored in policy repository
   d. Policy is distributed to relevant PDPs
   e. Policy changes are logged for audit purposes
2. **Authorization Decision Process**
   a. PEP intercepts API request
   b. PEP constructs authorization request with relevant attributes
   c. PDP receives authorization request
   d. PDP retrieves applicable policies from PRP
   e. PDP requests additional attributes from PIP if needed
   f. PDP evaluates request against policies
   g. PDP returns decision (Permit/Deny) and any obligations
   h. PEP enforces decision and fulfills any obligations
   i. Decision is logged for audit purposes
3. **Attribute Management Process**
   a. Attribute Authority defines attribute schema
   b. Attribute sources are configured and connected
   c. PIP is configured to retrieve attributes from sources
   d. Attributes are cached based on update frequency
   e. PDP requests attributes from PIP during evaluation
   f. PIP resolves attributes in real-time if not cached
   g. Attribute usage is logged for audit purposes
4. **Audit and Compliance Reporting Process**
   a. Authorization activities are continuously logged
   b. Log aggregation system collects logs from all components
   c. Real-time analysis identifies security events and anomalies
   d. Periodic compliance reports are generated
   e. Audit logs are securely archived for future reference

4.3.4 Logical Security Patterns for API Authorization

Define reusable security patterns for common authorization scenarios:

1. **Multi-Factor Authentication Step-Up**
   - Pattern: Require additional authentication factors for sensitive operations
   - Implementation:
     - PDP evaluates operation sensitivity and user's authentication level
     - If step-up is required, PDP returns obligation for additional authentication
     - PEP enforces obligation by triggering MFA process
2. **Delegated Authorization**
   - Pattern: Allow users to delegate access rights to other users or applications
   - Implementation:
     - PAP provides interface for users to define delegation rules
     - PIP maintains delegation information
     - PDP considers delegation rules during policy evaluation
3. **Adaptive Access Control**
   - Pattern: Adjust access decisions based on real-time risk assessment
   - Implementation:
     - PIP integrates with risk scoring engine
     - PDP incorporates risk score in policy evaluation
     - Policies define thresholds for different access levels based on risk
4. **Data Minimization**
   - Pattern: Return only the minimum necessary data based on user's permissions
   - Implementation:
     - Policies define data fields accessible for different roles/permissions
     - PDP returns permitted data fields as part of authorization decision
     - PEP filters API response to include only permitted fields
5. **Consent-Based Access**
   - Pattern: Enforce access based on user's explicit consent
   - Implementation:
     - PAP provides interface for defining consent-based policies
     - PIP integrates with consent management system
     - PDP evaluates user's consent as part of policy evaluation

4.3.5 Integration Points with Ping Authorize

Identify key integration points between the logical architecture and Ping Authorize:

1. **Policy Management**
   - Ping Authorize Component: Policy Administration Point (PAP)
   - Integration: Use Ping Authorize's policy management interface for policy creation, testing, and deployment
2. **Decision Making**

   - Ping Authorize Component: Policy Decision Point (PDP)
   - Integration: Deploy Ping Authorize's PDP to handle authorization requests from PEPs
3. **Attribute Resolution**
   - Ping Authorize Component: Attribute Retrieval and Caching
   - Integration: Configure Ping Authorize to retrieve attributes from various sources (LDAP, databases, APIs)
4. **Policy Distribution**
   - Ping Authorize Component: Policy Distribution Service
   - Integration: Use Ping Authorize's mechanism to distribute policies to multiple PDP instances
5. **Logging and Auditing**
   - Ping Authorize Component: Logging and Reporting Module
   - Integration: Configure Ping Authorize's logging to feed into the centralized audit and compliance reporting system
6. **API Gateway Integration**
   - Ping Authorize Component: PEP SDK or API
   - Integration: Integrate API Gateways with Ping Authorize using provided SDKs or APIs
7. **Identity Provider Integration**
   - Ping Authorize Component: Authentication Adapter
   - Integration: Configure Ping Authorize to work with existing identity providers for user authentication and attribute retrieval

4.3.6 Scalability and Performance Considerations

Address scalability and performance in the logical architecture:

1. **Distributed Deployment**
   - Design: Support deployment of multiple PDP instances
   - Benefit: Horizontal scalability to handle increased authorization requests
2. **Caching Strategies**
   - Design: Implement multi-level caching (policy cache, attribute cache, decision cache)
   - Benefit: Reduced latency and improved throughput for repeated requests
3. **Asynchronous Processing**
   - Design: Use asynchronous communication for non-critical operations (e.g., logging, analytics)
   - Benefit: Improved response times for critical authorization paths
4. **Load Balancing**

    - Design: Implement load balancing for PDP instances
    - Benefit: Even distribution of authorization requests across available resources
5. **Policy Optimization**
    - Design: Support for policy analysis and optimization tools
    - Benefit: Identify and optimize complex or inefficient policies
6. **Attribute Prefetching**
    - Design: Implement predictive attribute fetching based on usage patterns
    - Benefit: Reduced latency for attribute-heavy policy evaluations
7. **Segmentation and Isolation**
    - Design: Support logical segmentation of policies and attributes
    - Benefit: Improved performance and scalability for large, complex environments

4.4 Mapping Logical Architecture to Ping Authorize

Demonstrate how the logical architecture maps to Ping Authorize's features and components:

Logical Component	Ping Authorize Feature
Policy Administration Point (PAP)	Policy Management Console
Policy Decision Point (PDP)	PingAuthorize Server
Policy Enforcement Point (PEP)	PingAuthorize SDK for API Gateways
Policy Information Point (PIP)	Attribute Retrieval and Caching Service
Policy Retrieval Point (PRP)	Policy Distribution Service
Attribute Authority	Attribute Management and Mapping Tools
Audit and Logging System	Logging and Reporting Module

4.5 Case Study: Logical Architecture for GlobalMart's API Authorization

Continuing with our GlobalMart example, let's apply the logical architecture concepts:

1. **Policy Structure**
    - Global Policies:
        - Authentication requirements
        - General data protection rules
    - API-Specific Policies:
        - Customer API policies
        - Inventory API policies
        - Order Processing API policies

- Role-Based Policies:
    - Customer access policies
    - Partner access policies
    - Employee access policies

2. **Attribute Model**
    - User Attributes:
        - UserID, Role, Department, Location, SecurityClearance
    - Resource Attributes:
        - APIID, Endpoint, DataClassification, OwnerDepartment
    - Environmental Attributes:
        - TimeOfDay, ClientIPAddress, DeviceType
3. **Policy Evaluation Flow**
   a. API Gateway receives request for Order Processing API
   b. Request is forwarded to Ping Authorize PDP
   c. PDP retrieves applicable policies (Global, Order Processing, Role-Based)
   d. PDP requests user attributes from HR system
   e. PDP requests resource attributes from API catalog
   f. PDP evaluates policies using retrieved attributes
   g. Decision is returned to API Gateway
   h. API Gateway enforces decision and applies any obligations (e.g., data filtering)
4. **Integration Points**
    - Identity Provider: Integration with GlobalMart's existing OAuth 2.0 server
    - API Gateway: Deploy Ping Authorize SDK on existing gateway
    - Attribute Sources: Integrate with HR system, customer database, and partner Certainly! I'll continue with the case study for GlobalMart's API Authorization and then move on to the next sections of the Logical Architecture.

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5. **Scalability Approach**
    - Deploy multiple Ping Authorize PDP instances behind a load balancer
    - Implement a distributed cache for frequently used attributes and policy decisions
    - Use asynchronous logging to minimize impact on authorization performance
6. **Audit and Compliance**
    - Configure Ping Authorize to send detailed logs to GlobalMart's SIEM system
    - Implement real-time alerting for suspicious authorization patterns
    - Create scheduled compliance reports for GDPR and PCI-DSS requirements

4.6 Security Patterns Implementation with Ping Authorize

Let's explore how to implement the previously defined security patterns using Ping Authorize:

4.6.1 Multi-Factor Authentication Step-Up

Implementation in Ping Authorize:

1. Define an attribute `authenticationLevel` in the user context
2. Create a policy that checks the `authenticationLevel` against the required level for the resource
3. If step-up is needed, return an obligation in the policy decision
4. Configure the PEP (API Gateway) to interpret this obligation and trigger MFA

Example Policy:

```
IF (Resource.sensitivityLevel >= 'HIGH' AND User.authenticationLevel < 2)
THEN
    DENY
    WITH OBLIGATION "requireMFA"
ELSE
    PERMIT
```

4.6.2 Delegated Authorization

Implementation in Ping Authorize:

1. Create a `delegations` attribute in the user context
2. Develop a custom attribute provider that fetches delegation information
3. Include delegation checks in authorization policies

Example Policy:

```
IF (Action == 'READ' AND
    (Resource.owner == User.id OR User.id IN Resource.owner.delegations))
THEN
    PERMIT
ELSE
    DENY
```

4.6.3 Adaptive Access Control

Implementation in Ping Authorize:

1. Integrate a risk scoring engine as an attribute provider
2. Include the risk score in the authorization context
3. Create policies that adapt based on the risk score

Example Policy:

```
IF (User.riskScore < 30)
THEN
    PERMIT
ELSE IF (User.riskScore < 70)
THEN
    PERMIT
    WITH OBLIGATION "additionalLogging"
ELSE
    DENY
```

4.6.4 Data Minimization

Implementation in Ping Authorize:

1. Define data sensitivity levels for API response fields
2. Create policies that return allowed fields based on user permissions
3. Configure the PEP to filter API responses based on the returned allowed fields

Example Policy:

```
PERMIT
WITH OBLIGATION "allowedFields"
SET TO
    CASE
        WHEN User.role == 'ADMIN' THEN ["*"]
        WHEN User.role == 'MANAGER' THEN ["id", "name", "department",
"salary"]
        ELSE ["id", "name", "department"]
    END
```

4.6.5 Consent-Based Access

Implementation in Ping Authorize:

1. Integrate with a consent management system as an attribute provider
2. Include user consent information in the authorization context
3. Create policies that check for appropriate consent

Example Policy:

```
IF (Resource.type == 'PERSONAL_DATA' AND
    User.consentGiven CONTAINS Resource.requiredConsent)
THEN
    PERMIT
ELSE
    DENY
```

4.7 Performance Optimization Strategies

To ensure that the API authorization system can handle high volumes of requests with low latency, consider the following optimization strategies in Ping Authorize:

4.7.1 Policy Optimization

1. **Policy Structure**
   - Use a hierarchical policy structure to minimize the number of policies evaluated for each request
   - Place frequently used or critical policies earlier in the evaluation order
2. **Attribute Fetching**
   - Implement lazy attribute fetching to only retrieve attributes when needed during policy evaluation
   - Use attribute caching with appropriate TTL (Time To Live) values
3. **Policy Simplification**
   - Regularly review and simplify complex policies
   - Use built-in policy analysis tools to identify redundant or conflicting rules

4.7.2 Caching Strategies

1. **Decision Caching**
   - Enable decision caching for frequently occurring request patterns
   - Carefully set cache expiration times based on the volatility of attributes and policies
2. **Attribute Caching**
   - Implement multi-level attribute caching (in-memory, distributed cache)

    - Use different caching strategies for static and dynamic attributes
3. **Policy Caching**
    - Cache compiled policies to reduce policy retrieval and parsing overhead
    - Implement an efficient policy update mechanism to invalidate caches when policies change

4.7.3 Distributed Deployment

1. **Load Balancing**
    - Deploy multiple PDP instances behind a load balancer
    - Use session affinity for related requests to maximize cache hit rates
2. **Geographical Distribution**
    - Deploy PDP instances in different geographical regions to reduce latency for global applications
    - Implement a strategy for policy synchronization across regions
3. **Scaling Strategies**
    - Implement auto-scaling based on request volume and performance metrics
    - Use containerization (e.g., Docker) for easier deployment and scaling

4.7.4 Asynchronous Processing

1. **Logging and Auditing**
    - Use asynchronous logging to minimize the impact on request processing
    - Implement a separate logging service to handle high-volume log storage and analysis
2. **Analytics and Reporting**
    - Perform resource-intensive analytics and report generation offline
    - Use event streaming platforms for real-time data processing without impacting core authorization flows

4.8 Monitoring and Observability

To maintain the health and performance of the API authorization system, implement comprehensive monitoring and observability:

4.8.1 Key Performance Indicators (KPIs)

1. **Authorization Latency**
    - Average, 95th percentile, and maximum latency for authorization decisions

- Target: < 50ms average, < 100ms 95th percentile

2. **Throughput**
   - Number of authorization requests processed per second
   - Target: Able to handle peak load with < 80% resource utilization
3. **Error Rate**
   - Percentage of authorization requests resulting in errors or timeouts
   - Target: < 0.1% error rate
4. **Cache Hit Rate**
   - Percentage of requests served from cache (decision cache, attribute cache)
   - Target: > 80% cache hit rate for high-volume APIs
5. **Policy Evaluation Time**
   - Average time taken to evaluate policies for a request
   - Target: < 10ms average policy evaluation time

4.8.2 Logging and Tracing

1. **Decision Logs**
   - Log detailed information for each authorization decision
   - Include request context, applied policies, and resulting decision
2. **Error Logs**
   - Capture detailed error information, including stack traces for exceptions
   - Implement log correlation to track errors across components
3. **Performance Logs**
   - Log performance metrics for each request (latency, cache hits/misses, attribute fetch times)
   - Use structured logging for easier analysis and alerting
4. **Distributed Tracing**
   - Implement distributed tracing across API gateway, Ping Authorize, and backend services
   - Use correlation IDs to track requests through the entire system

4.8.3 Alerting and Dashboards

1. **Real-time Alerting**
   - Set up alerts for SLA violations (e.g., high latency, error rates)
   - Implement anomaly detection for unusual authorization patterns
2. **Operational Dashboards**
   - Create dashboards for real-time monitoring of KPIs
   - Include visualizations for request volume, latency distribution, and error rates

3. **Capacity Planning Dashboards**
    - Develop dashboards for long-term trend analysis
    - Include projections for future capacity needs based on historical data

4.8.4 Health Checks and Self-Healing

1. **Component Health Checks**
    - Implement health check endpoints for each Ping Authorize component
    - Include checks for policy repository connectivity, attribute source availability
2. **Automated Recovery**
    - Implement automatic restarts for failed components
    - Use circuit breakers for dependent services to prevent cascading failures
3. **Failover and Redundancy**
    - Implement automated failover for PDP instances
    - Maintain redundant copies of policy and attribute data

4.9 Security Considerations for the Authorization System

While the authorization system itself is a security component, it's crucial to ensure its own security:

4.9.1 Securing Communication Channels

1. **TLS Encryption**
    - Use TLS 1.2 or later for all communications between components
    - Implement proper certificate management and rotation
2. **Mutual TLS**
    - Use mutual TLS for communication between Ping Authorize components
    - Implement certificate-based authentication for API clients

4.9.2 Access Control for Administration

1. **Role-Based Access Control**
    - Implement fine-grained RBAC for access to Ping Authorize administration interfaces
    - Use the principle of least privilege for admin accounts
2. **Multi-Factor Authentication**
    - Require MFA for all administrative access to Ping Authorize
    - Implement IP whitelisting for admin access

4.9.3 Protecting Sensitive Data

1. **Attribute Encryption**
   - Encrypt sensitive attributes at rest and in transit
   - Use hardware security modules (HSMs) for key management
2. **Policy Confidentiality**
   - Implement access controls on policy repositories
   - Consider encrypting sensitive parts of policies

4.9.4 Audit and Compliance

1. **Immutable Audit Logs**
   - Store audit logs in a tamper-evident, immutable format
   - Implement log forwarding to a secure, centralized log management system
2. **Regular Audits**
   - Conduct regular audits of policy changes and administrative actions
   - Implement automated compliance checks for policy content

4.9.5 Threat Modeling and Penetration Testing

1. **Continuous Threat Modeling**
   - Regularly update threat models for the authorization system
   - Conduct threat modeling exercises for new features and integrations
2. **Penetration Testing**
   - Perform regular penetration testing on the authorization system
   - Include API authorization bypass attempts in the scope of penetration tests

4.10 Future-Proofing the Authorization Architecture

To ensure the authorization architecture remains effective and adaptable:

1. **Extensibility**
   - Design the system to easily incorporate new attribute sources and policy types
   - Use plugin architectures for custom integrations and extensions
2. **Standards Compliance**
   - Align with industry standards (e.g., XACML, OAuth 2.0, OpenID Connect)
   - Participate in relevant standards bodies to stay informed of future developments
3. **AI and Machine Learning Integration**
   - Plan for integration of AI/ML models for adaptive access control

    - Consider privacy and explainability requirements for AI-driven decisions
4. **Quantum-Safe Security**
    - Stay informed about post-quantum cryptography developments
    - Plan for migration to quantum-safe algorithms when they become standardized
5. **Blockchain and Decentralized Identity**
    - Explore integration with decentralized identity systems
    - Consider blockchain for immutable audit logs or consent management

By implementing these strategies and considerations, organizations can create a robust, scalable, and future-proof logical architecture for API authorization using Ping Authorize. This architecture will provide a solid foundation for securing APIs while enabling business agility and innovation.