Authorization Federation in Multi-Tenant Multi-Cloud IaaS

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Dissertation Defense

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“Moving” to Cloud

Accessibility

Flexibility

Reliability

Mobility

Security

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Why Federation?

- Large organization with multiple tenants
- Distinct organizations’ federation

Service Provider

CERN

Software Development Tenant

Acme

Financial Tenant

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Why Multi-Cloud?

- Federation consist of multiple clouds or multiple tenants.

**ACME Multi-Cloud**

- London Private Cloud
- Amazon Public Cloud
- Shanghai Private Cloud

**Public Cloud**

- Finance Tenant
- Research & Dev. Tenant
- Sales Tenant
- Human Resource Tenant
- Software Testing Tenant
- Software Dev. Tenant

**ACME Multi-Tenant Circle-of-Trust**
Problem Statement

Current access control models provided by cloud platforms are not sufficient to cultivate effective peer-to-peer and circle-of-trust federation between tenants in a cloud or across multiple cloud platforms. Prior role-based and attribute-based access control models in distributed systems are not effectively applicable to cloud IaaS.

Thesis Statement

The problem of authorization federation in multi-tenant cloud IaaS can be partially solved by integrating multiple types of peer-to-peer and circle-of-trust relations between tenants in cloud and multi-cloud environments into role-based and attribute-based access control models.
What is Cloud Federation?

- **Multi-Cloud**, Federation of multiple cloud service providers (public or private) within different administrative domains (Cloud and Domain) to provide complex services at specified service model (Infrastructure, Platform and Software).

- **Cloud Federation**, Federation of cloud service providers and identity providers in order to share their services and resources based on trust agreements.

- **Hybrid Cloud**, “A composition of two or more distinct cloud infrastructures (private, community, or public) that remain unique entities.”
Federation in Cloud

Cloud Federation

Service
  - Heterogeneous
  - Homogeneous

Platform
  - Heterogeneous
  - Homogeneous

Trust
  - Circle-of-Trust
  - Peer-to-Peer

Identity
  - Authentication
  - Authorization

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Service in Cloud Federation

- **Service**
  - Heterogeneous
    - Google account (Open ID 2.0)
      - Heterogeneous within google.
  - Homogeneous
    - Eduroam federated network access.
    - OpenStack Federation.

Heterogeneous Service Federation

Homogeneous Service Federation
Platform in Cloud Federation

Heterogeneous Platform Federation

Amazon Public AWS Cloud

ICS Private OpenStack Cloud

**Platform**

- **Heterogeneous**
  - OpenStack federation with AWS.
- **Homogeneous**
  - Keystone to Keystone federation.

Homogeneous Platform Federation

Rackspace Public OpenStack Cloud

ICS Private OpenStack Cloud

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Peer-to-Peer vs Circle-of-Trust

**Peer-to-Peer Federation**
- Trust between a pair of tenants.
- Specific set of actions between tenants.
- Only trusted tenant.

**Circle-of-Trust Federation**
- Trust between a group of tenants.
- Similar policies and rules.
- Acceptance of all tenants in the circle.
Authentication vs Authorization

- **Authentication Federation**
  - Authenticating users (services and applications) in a cloud service provider other than their registered identity provider.
  - SAML, OAuth, OpenID, SSO.

- **Authorization Federation**
  - Determining federated users’ permissions to access federated resources and services.
  - SAML, OAuth.
  - Authorization federation is dependent on authenticated users.

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Scope of Contribution

- Cloud Federation
  - Service
    - SaaS
    - PaaS
    - IaaS
  - Platform
    - Homogeneous
    - Heterogeneous
  - Trust
    - Circle-of-Trust
    - Peer-to-Peer
  - Identity
    - Authentication
    - Authorization
Scope of Contributed Models

Cloud IaaS

Multi-Tenant Multi-Cloud
- Peer-to-Peer
  - MC MT-RBAC

Multi-Tenant Cloud
- Circle-of-Trust
  - Heterogeneous
    - MT-RABAC_c
- Peer-to-Peer
  - Homogeneous
    - MT-RBAC_c
- Peer-to-Peer
  - MT-ABAC
**Cloud Domain**
- Administration of services (compute, storage, network, and identity) and tenant domains.
- Cloud bursting.

**Tenant Domain**
- Administration of resources (users, groups and projects in OpenStack).
- Resource federation (cross-tenant access).
Peer-to-Peer Federation Models

- Cloud IaaS
  - Multi-Tenant Multi-Cloud
    - Peer-to-Peer
      - MC MT-RBAC
    - Heterogeneous
      - MT-RABAC<sub>c</sub>
  - Multi-Tenant Cloud
    - Circle-of-Trust
      - Homogeneous
        - MT-RBAC<sub>c</sub>
    - Peer-to-Peer
      - MT-ABAC
Peer-to-Peer Federation Trust

- **Tenant-Trust**
  - Unilateral, Unidirectional, and Non-Transitive.
**UTSA and BoA contract**

- BoA employees can get UTSA courses at discounted rates.
- UTSA students can get student accounts at BoA.
- BoA can select courses for its employee students at UTSA.
**UTSA and BoA contract**

- **BoA employees can get UTSA courses at discounted rates.**
  - UTSA can assign BoA employees to courses.
- **UTSA students can get student accounts at BoA.**
- **BoA can select courses for its employee students at UTSA.**
UTSA and BoA contract

- BoA employees can get UTSA courses at discounted rates.
  - BoA can assign employees to UTSA courses.
- UTSA students can get student accounts at BoA.
- BoA can select courses for its employee students at UTSA.
**UTSA and BoA contract**

- BoA employees can get UTSA courses at discounted rates.
- UTSA students can get student accounts at BoA.
- BoA can select courses for its employee students at UTSA.

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**Type – β:**

- UTSA
- BoA
- **UTSA and BoA contract**
  - BoA employees can get UTSA courses at discounted rates.
  - UTSA students can get student accounts at BoA.
  - BoA can select courses for its employee students at UTSA.
Multi-Cloud Multi-Tenant Role-Based Access Control

- Homogeneous multi-cloud IaaS (OpenStack).
- Peer-to-Peer federation between tenants across cloud service providers.
- User-role assignments.
- Trust is defined as tenant-trust.
- Trust types $\alpha$, $\beta$, $\gamma$, and $\delta$ authorizes user-role assignments.
Keystone to Keystone Federation

A. Add public cloud as service provider

B. Add Private Cloud as Identity Provider

1. Ask for SAML Assertion

2. Return SAML Assertion

3. Present SAML Assertion

4. Return a Keystone token that can be used on Public Cloud

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Multi-Cloud MT-RBAC OpenStack

Cloud 1

Domain A

Project-Role-Pair

Type-β

Cloud 2

Domain B

domain_admin

Project-Role-Pair

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Attribute-Based Access Control ($ABAC_0$)

- Attributes are name:value pairs.
  - Represents user and resource properties.

- Associated with
  - Users
  - Objects
  - Tenants
  - Contexts

- Converted to rights by authorization policies
  - In-time
  - Entity attributes
  - Set of actions

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Multi-Tenant Attribute-Based Access Control (MT – ABAC<sub>0</sub>)

- Multi-tenant cloud IaaS.
- Peer-to-Peer Federation.
- Attribute assignments.
- Trust is defined as tenant-trust.
- Trust types α, β, γ, and δ authorize attribute assignments.
Homogeneous Circles
- Multilateral, Bidirectional, Transitive.

Heterogeneous Circles
- Multilateral, Unidirectional, Non-Transitive.
UT System CoT Federation.

- UT system students can take courses at any UT campus.
- Students can access to libraries in UT system.

CoT Trust Types Use Case

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CoT Trust Types Use Case

➢ UT System CoT Federation.
  ▶ UT system students can take courses at any UT campus.
    ○ UTSA can assign students in UT to its courses.
- **UT System CoT Federation.**
  - Students can access to libraries in UT system.
    - UTA can assign its students to libraries in UT system.
Multi-Tenant Role-Based Access Control in Circle (MT − RBAC\textsubscript{c})

- Multi-tenant cloud IaaS.
- Circle-of-Trust Federation.
- Homogeneous circles.
- User-role assignments.
- Trust is defined as tenant-trust.
- Trust types $\varepsilon$ and $\zeta$ authorizes user-role assignments.
Heterogeneous Circle of BoA, Chase, UTSA, Geico, Allstate.

- Each tenant can make user-role assignment based on its type to a domain.
- UTSA can assign its students to discounted insurance offers and student accounts.
Multi-Tenant Role-Centric Attribute-Based Access Control (MT – RABAC<sub>c</sub>)

- Multi-tenant cloud IaaS.
- Circle-of-Trust Federation.
- Heterogeneous circles.
- Attributes are associated with
  - Tenants
  - Users
  - Objects
- Tenant attributes separate tenants with tenant type attribute.
Questions?

- **Peer-to-Peer Policy**
  - Multi-cloud multi-tenant role-based model.
  - Multi-tenant attribute-based model.

- **Circle-of-Trust Policy**
  - Multi-tenant role-based access control model in circle.
  - Multi-tenant role-centric attribute-based access control model.

- **Implementation**
  - Federated-cloud role-based tenant trust.