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Cloud Storage Pluggable Access Control

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Agenda

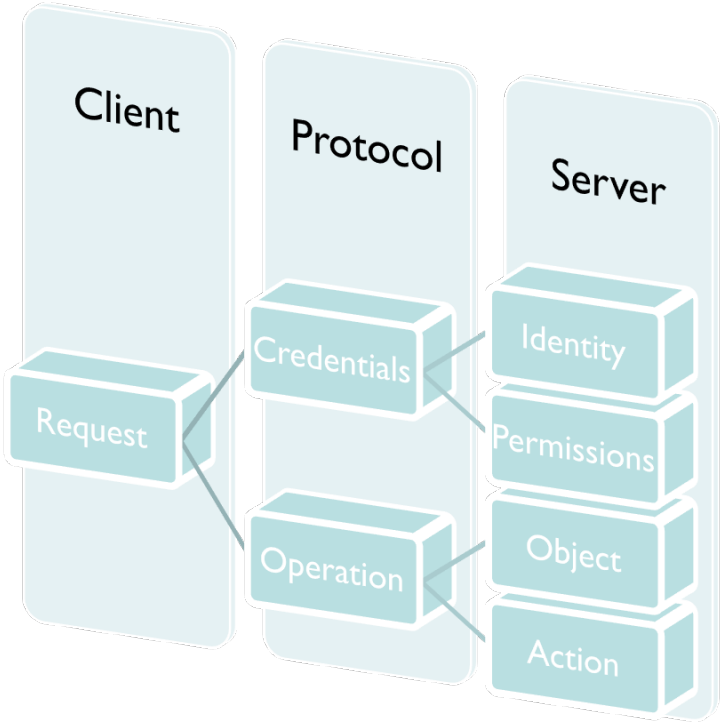
- Access Control
  - The classic models: DAC, MAC & RBAC
  - Emerging access control methodologies
- Access Control in Cloud Storage Systems
  - What's wrong with where we are?
  - Access Control in CDMI
- CDMI ACL Delegation
- Demo

What is Access Control?

- A subset of Authorization
- Determines WHAT the WHO can do to THIS
  - WHAT – Identity of the action (read, write, execute, delete, etc)
  - WHO – Identity of the subject (process, computer, human, etc)
  - THIS – Identity of the object (file, program, sensor, actuator, etc)
- Distinct from, but usually coupled with, authentication
  - Authentication is the means by which to determine the WHO
- Storage system provides the WHAT (actions) and the THIS (objects)

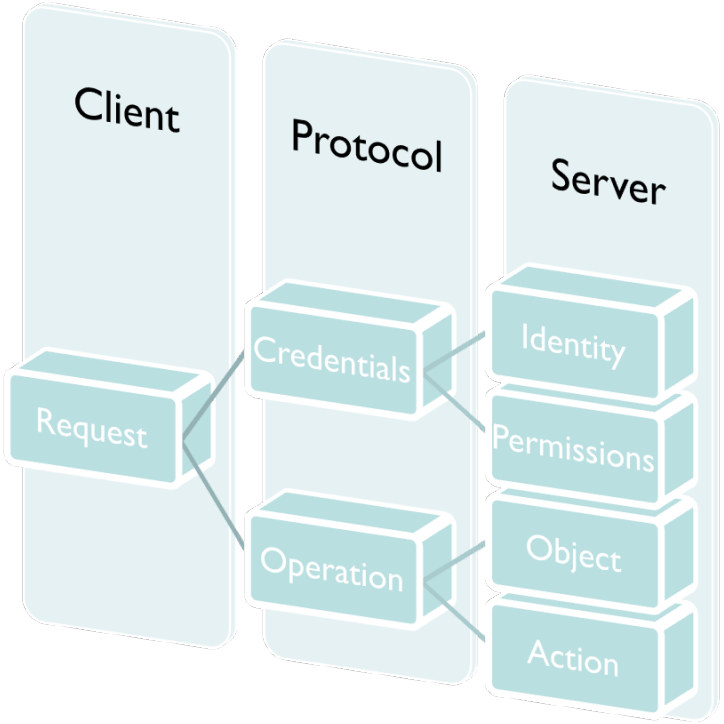
What is Access Control?

- A client issues a request
- A protocol encapsulates the client's credentials and the operation that is to be performed
- A server verifies client's identity from the presented credentials, and determines the permissions for the referenced object



What is Access Control?

- Resolution of credentials to identity is often delegated.
  - E.g. Active Directory
- Permissions have often been tightly coupled with the objects and actions themselves.



Access Control: The Classic Models

- DAC: Discretionary Access Control
  - Control strictly defined by administrator-defined policy
  - E.g. Classification (Secret, Top Secret, etc)
- MAC: Mandatory Access Control
  - Control defined by object's owner (or member of a group)
  - E.g. **storage ACLs**
- RBAC: Role-Based Access Control
  - Control defined by organizational role (identity -> role -> access)
  - ACL "groups" are often (ab)used for this purpose

Access Control: Emerging Methodologies

- ABAC: Attribute Based Access Control
  - Refinement to RBAC to take into account attributes (e.g. XACML)
- GBAC: Graph Based Access Control
  - Primarily found on social networks, e.g. “Friend of a friend”
  - Declarative access rights based on semantic graphs
- Biometric
  - Mixing of Identity and Access Control
- Location Based Access Control
  - Geofencing, etc.

Access Control: Emerging Methodologies

- CBAC: Context Based Access Control
  - Access allowed or disallowed based on context of surrounding operations
  - E.g. disallowing whole file replacement with high Shannon Entropy (ransomware protection)
- Capability Based Access Control
  - Operations allowed when an access token (capability) is possessed.
  - E.g. S3 signed URLs
- Risk Based Access Control
  - Takes into account risk of granting access. Deep learning, AI-based?

Access Control in Cloud Storage Systems

- Today's Cloud Storage Systems are built around the traditional storage model:
  - A series of operations (Create, Read, Update, Delete, Copy, etc)
  - Performed on objects
  - With identity determined by verifying credentials included in the request (typically as HTTP headers)
- All major cloud storage systems support authentication delegation
  - Active Directory, MFA, Social Networks, Customer systems, etc.
- No cloud storage system currently supports Access Control delegation

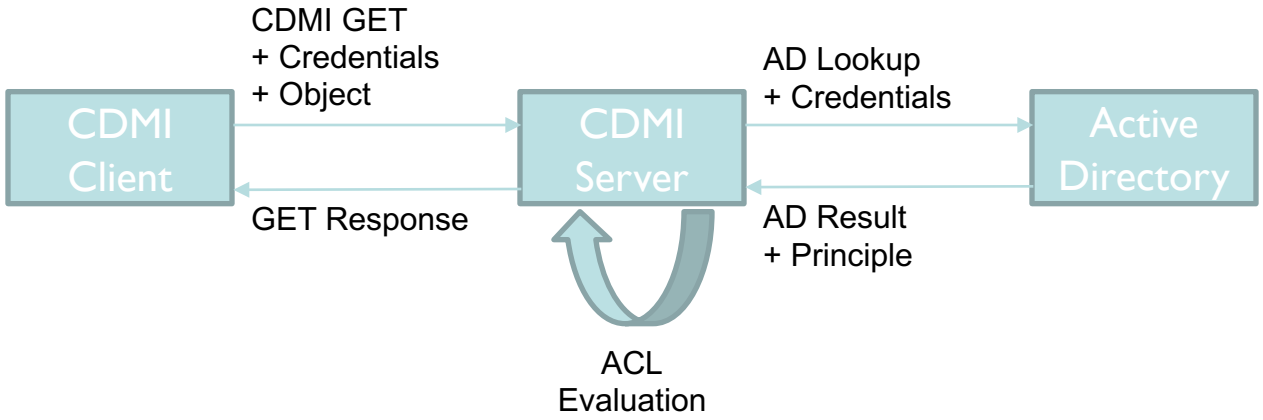
Access Control in Cloud Storage Systems

- Why is this a problem?
  - What if the provided access control system isn't suitable or sufficiently expressive or extensible? (e.g. DoD use cases)
  - What if the provided access control system isn't consistent across clouds? (e.g. Cross-cloud portability)
  - What if the provided access control system isn't sufficiently unchanging? (e.g. Unexpected software upgrades)
  - What if the provided access control system isn't functionality that should be in the cloud? (In-house decision making)

Access Control in Cloud Storage Systems

- NetApp has had access control delegation for file system operations since 2002:
  - `create`, `open`, `rename`, `delete`, `read`, `write`, `create_dir`, `rename_dir`, `delete_dir`, `getattr`, `setattr`
  - Sends additional details (file info, user info, etc)
  - Support for synchronous blocking calls and asynchronous notifications
- Fpolicy has enabled many different third-party integrations:
  - File screening, File access reporting, User and directory quotas, HSM, Archiving, File replication, Data governance

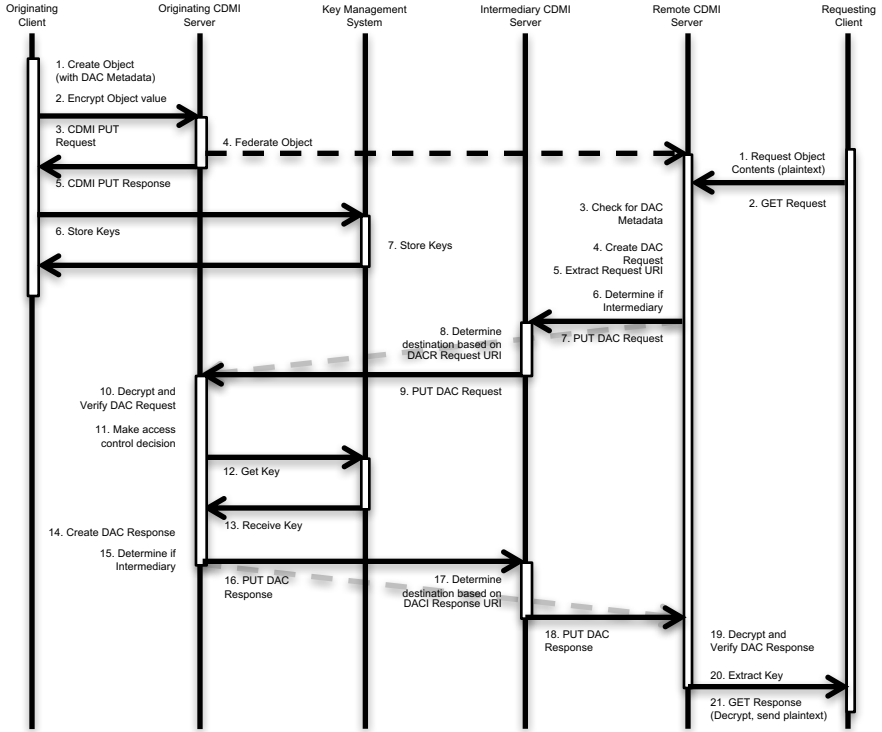
CDMI Access Control



CDMI Access Control Delegation

- CDMI introduced a form of Delegated Access Control in 2015/2016, known as the Delegated Access Control (DAC) Extension
  - Primarily intended to be used with encrypted objects
  - Specifies metadata indicating how to submit a DAC request to a DAC provider, which returns a DAC response
  - Assumes asynchronous responses
  - Assumes moderate to high latency
  - Complements ACLs
- More details can be found by searching for “CDMI DAC Extension”
- Need a simpler approach that replaces ACLs altogether

CDMI Access Control Delegation



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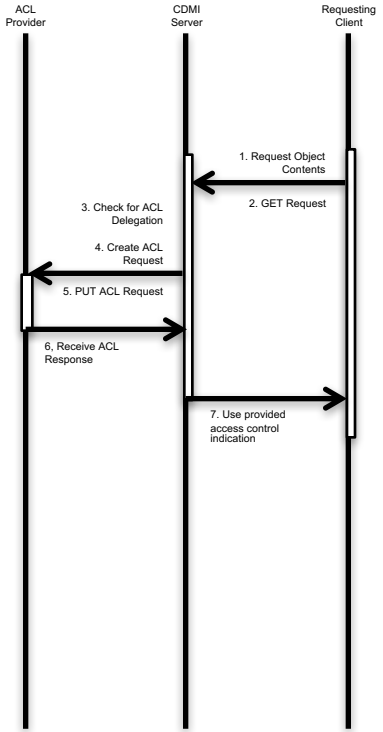
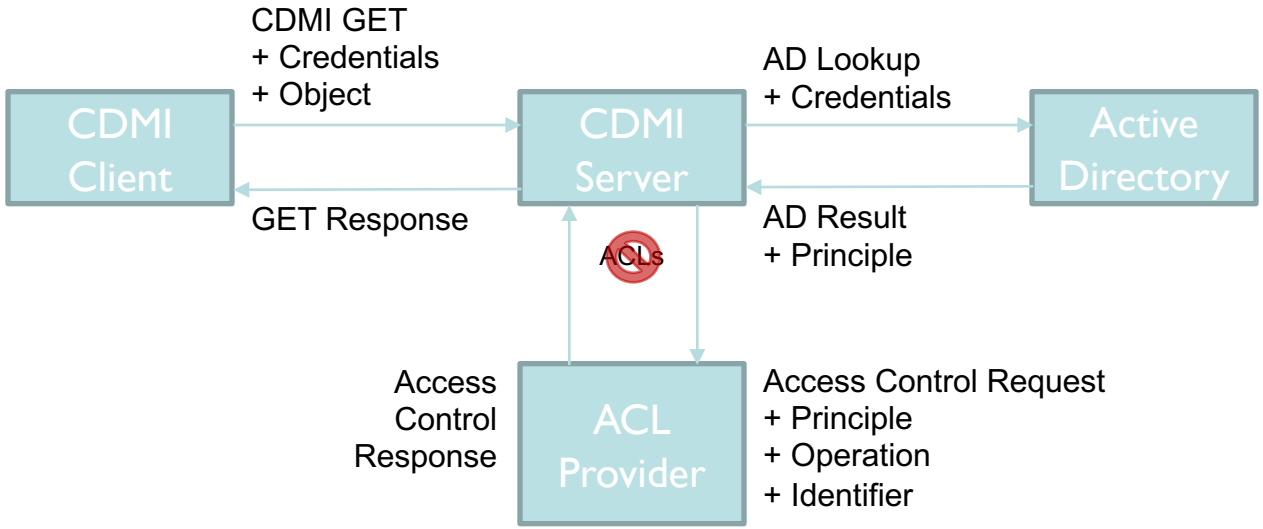


CDMI ACL Delegation



CDMI ACL Delegation

- With CDMI Authentication Delegation, delegation is controlled by the CDMI domain
  - Each CDMI Object belongs to a domain
  - Domain configuration indicates if, and to which external system, authentication is delegated
- This approach can also work for Access Control Delegation
  - But Access Control Delegation and Authentication Delegation can be orthogonal, and can require different granularities

CDMI Access Control Delegation

- Option 1: Domain specifies an ACL delegation provider, similar to how an authentication delegation provider is configured:

access control

Table 64 — Required settings for ~~domain member~~ delegation objects

Metadata name	Type	Description	Requirement
cdmi_~~member~~_enabled	JSON string	If true, this field indicates that requests associated with this domain ~~member~~ are allowed. If false, all requests performed by this domain ~~member~~ shall result in an HTTP status code of `403 Forbidden`.	Mandatory
cdmi_~~member~~_type	JSON string	This field indicates the type of ~~member~~ record. Values include "user" and "delegation".	Mandatory
cdmi_delegation_URI	JSON string	This field contains the URI of an external identity resolution provider (such as ~~LDAP or Active Directory~~) or the URI of a domain membership container object. External delegations are expressed in the form of ldap:// or ad://.	Mandatory

CDMI Access Control Delegation

- Option 2: A new ACE type field “DELEGATE”, which instructs the server to delegate to the system specified in the ACE identifier field.
- This makes the delegation “sticky”, as it survives data movement and archiving, even if the domain changes.
- This also allows fallback permissions when the delegation is unavailable or unsupported.

```
"cdmi_acl":  [ {
        "acetype": ”DELEGATE",
        "identifier": ”https://127.0.0.1/delegate/",
        "aceflags": "OBJECT_INHERIT, CONTAINER_INHERIT",
        "acemask": "ALL_PERMS"
}, {
        "acetype": ”DENY",
        "identifier": ” EVERYONE@",
        "aceflags": "OBJECT_INHERIT, CONTAINER_INHERIT",
        "acemask": "ALL_PERMS"
} ]
```

CDMI Access Control Delegation

- Simple proof of concept was implemented in a CDMI testing server to demonstrates that these concepts work
- The following gaps were identified that would need to be addressed if standardized:
  - Support for fallback and load balancing across multiple delegation servers
  - Using CDMI scopes for restricting delegations when specified in domains

Live Demo

Open Policy Agent

Concluding Thoughts

- This is a simple approach
- This can be standardized into any system that uses ACLs
  - S3 ACLs
  - Google Cloud storage
  - NFSv4, CIFS, etc
- Provides portable Access control delegation

* Azure blobs only support ACLs at a container granularity

Questions?

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