Building Access Oblivious Storage Cloud for Enterprise

Sarit Mukherjee (with H. Chang, M. Kodialam, T.V. Lakshman, L. Wang)
Bell Labs Research, Alcatel-Lucent
Motivation: Service Provider and Enterprise eco-system
Enterprise leases VPN service from a service provider to interconnect multiple sites

- Each site gets a pre-specified bandwidth guaranteed VPN connection
- All enterprise resources are accessible from any site regardless of the resources’ location
  - Enterprise is able to aggregate IT resources in one or a few locations
VPN interconnection: Service Providers’ view

Service provider wants to provide enterprise-grade services leveraging its network

- VPN uses networking service
- Service provider intends to providing an enterprise-grade cloud solution from its network
  - Enterprise should be able to outsource IT resources and enjoy benefits of cloud service
Service providers are building data centers in their network

- Large number of small data centers spread all over the network
- Provide compute, storage, content and other bandwidth and latency sensitive services
- **We address service provider enabled storage services for enterprise**
Service Providers' Networked Cloud
From Centralized Cloud to Distributed Cloud
Enterprises’ expectation from Storage Cloud Service

Service Isolation

The enterprise's virtual resources in the cloud must be isolated from the other users of the cloud.
Enterprises’ expectation from Storage Cloud Service

Location independence

The enterprise users must be able to connect to the virtual resources in the cloud from any enterprise location.
An enterprise user must not see any difference between accessing an in-house resource vs. one in the cloud.
Enterprises’ expectation from Storage Cloud Service

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<th>Isolation</th>
<th>Location Independence</th>
<th>Seamlessness</th>
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<td>Solutions exist</td>
<td>Addressed in this paper</td>
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Enterprises A, B, and C are connected through a cloud network, indicating an expectation for isolation and location independence. Solutions exist and are addressed in this paper.
Distributed Storage Provisioning and File Access in Cloud

\[
\frac{\text{size}(P1)}{\text{size}(P2)} = \frac{\text{size}(Q1)}{\text{size}(Q2)} = \beta
\]

\[
\frac{\text{traffic}(U1,C1)}{\text{traffic}(U1,C2)} = \beta
\]

Files: P and Q
No. of chunks: 2
Replication: 2
Distributed storage cloud automation layer optimally provisions the customer

- Determines the customer’s attachment points into the Provider’s network
- Attachment points act as the Gateways into the distributed storage cloud
- Provisions storage for the customer at the optimal storage locations
- Built in Linux kernel as a Unix-based file system (Ceph)
- Exports NFS interface through the Gateway
Ceph Distributed File System Architecture

Clients

- Ceph process
  - LibFUSE
- FUSE module
  - Linux kernel

Monitor

- Mon Daemon

Metadata Cluster

- Mon Daemon
- MDS Daemon

Object Storage Cluster

- OSD Daemon

- Metadata Storage

File I/O Operations

- Operations runs in the Gateway

- Runs in the Cloud

- Runs in the Cloud
Data Placement in Distributed Storage Cloud

File

Objects

Placement Groups

Object Storage Devices

Ceph

Storage Cloud

ObjectID = (Inode, Object#)

PGID = hash (ObjectID)

Placement(Object) = (osd1, osd4, osd5)

ObjectID = (Inode, Object#)

PGID = UserLookup (UserID, MountLocation)

Placement(Object) = (osd1, osd4, osd5)
Experimental Results

- RocketFuel’s router-level ISP maps with uniform link capacity
- YouTube access traces containing 1000 distinct users and 7,465 distinct video sessions, covering 6 hours
- Simulated using GTNetS

- **Bandwidth-Aware Provisioning**: Determines the optimal chunking and replication per-file such that the maximum link utilization remains minimized with changing access patterns.

- **Proximity-Aware Provisioning**: Splits and places files as close as possible (in terms of network hops) to the edge nodes accessing them, without considering link capacity constraints.
Conclusion

- Enterprise-grade storage system tailor-made for a service provider’s cloud
  - Custom design and architecture to exploit service providers’ networked cloud
  - Implementation on Linux platform with popular file system interface for users

- Benefits of the proposed architecture
  - Storage provisioning with guaranteed performance using marginally extra bandwidth
    - New users can join easily at any location and new content can be ingested into the cloud so long as the bandwidth demands remain within the service limits
  - Significant reduction of operating costs of running a storage cloud by eliminating the need for shuffling content in the cloud to meet performance requirements with changing access patterns
  - Easy determination of provisioning request admission into the cloud