Cloud Storage: Managed File Systems

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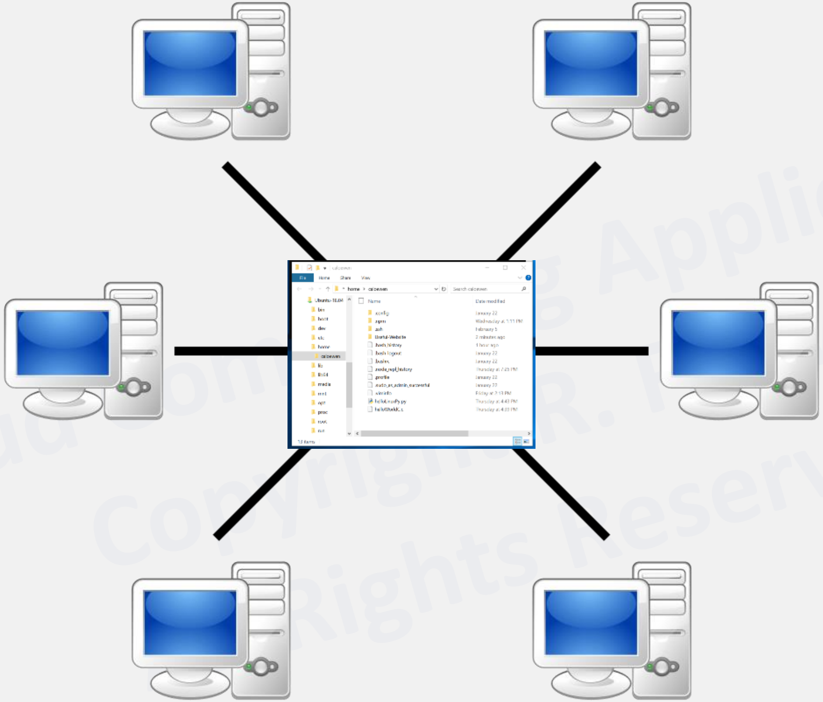
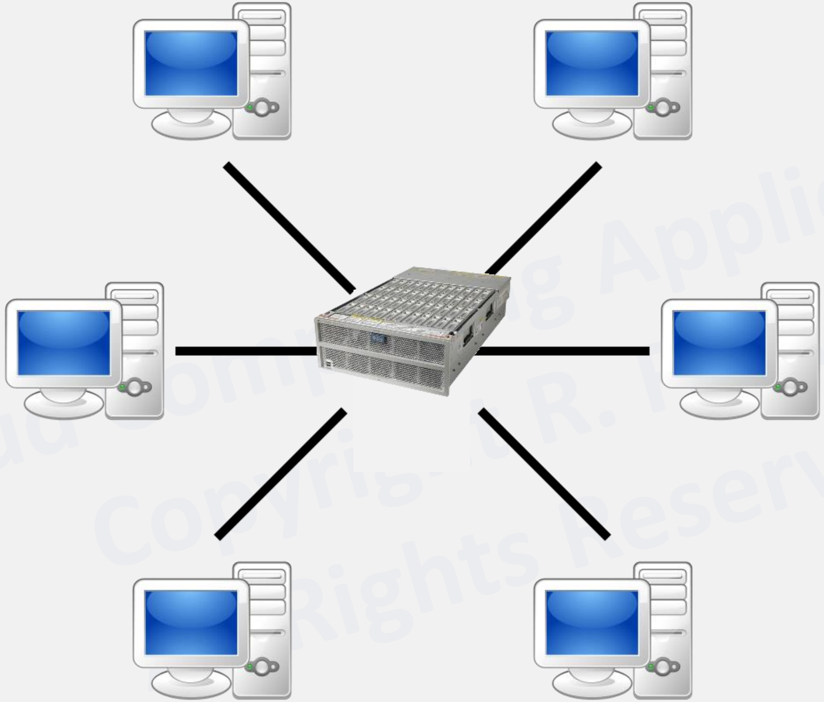
CLOUD COMPUTING APPLICATIONS

Logical View Networked File System



Network Attached Storage (NAS)



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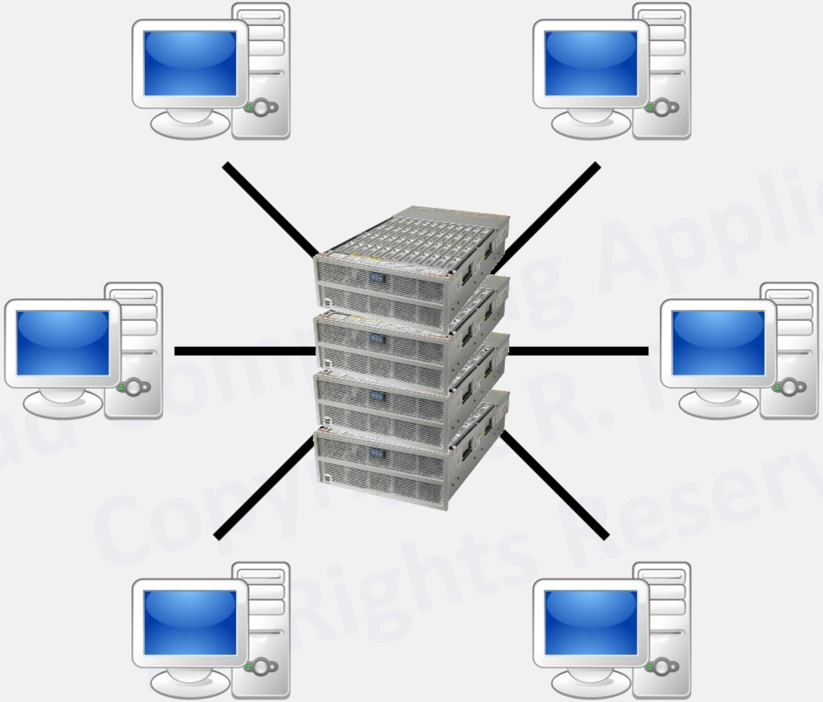

Clustered File Systems

- A clustered file system allows files to be accessed using the same interfaces and semantics as local files – for example, mounting/unmounting, listing directories, read/write at byte boundaries, system's native permission model.
  - Fencing
  - Concurrency
  - Consistency
- Examples
  - NFS
    - Unix
    - V4 , V4.1 (pNFS extension)
  - SMB
    - Windows
  - Lustre
    - HPC
  - Ceph
    - Many OpenStack implementations use Ceph as the storage substrate
  - Gluster
    - Classic file serving, second-tier storage, and deep archiving

Clustered File System Consistency

- Ideally, a parallel file system would completely hide the complexity of distributed storage and exhibit a behavior as it is specified by POSIX
  - Fencing
- Relatively easy on one Machine
- Much harder on a cluster of servers
- Maintaining CAP is extremely hard
  - **Consistency**: Every read receives the most recent write or an error
  - **Availability**: Every request receives a (non-error) response, without the guarantee that it contains the most recent write
  - **Partition tolerance**: The system continues to operate despite an arbitrary number of messages being dropped (or delayed) by the network between nodes

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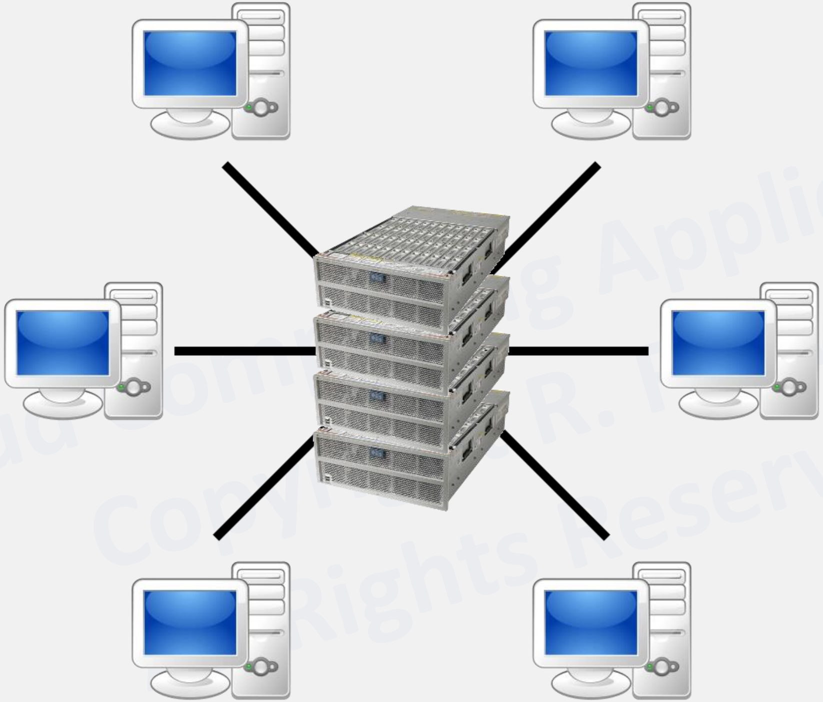

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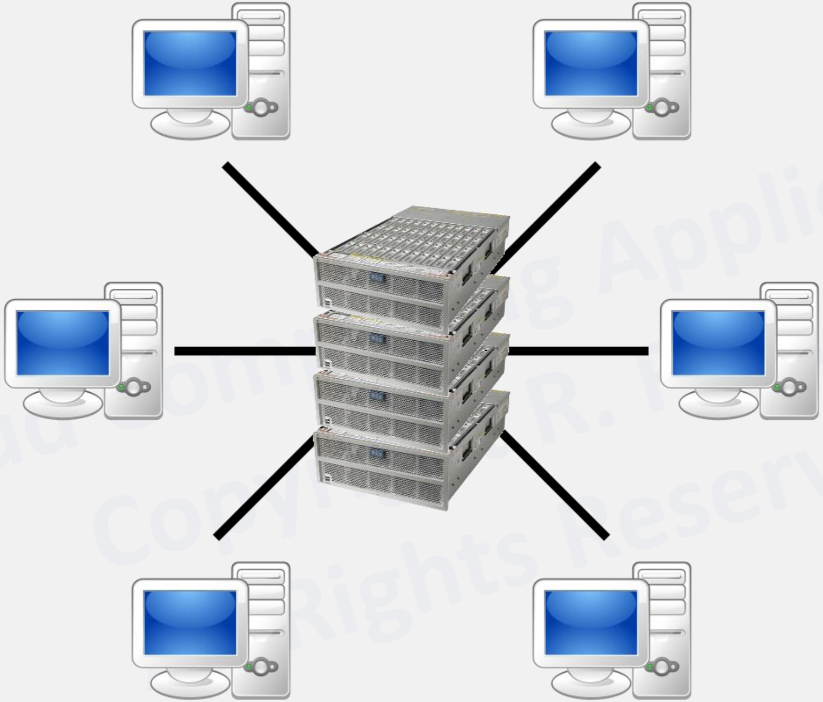

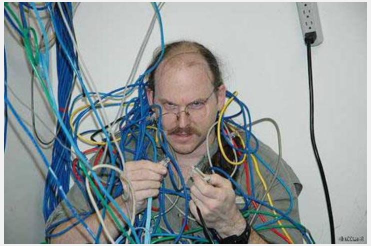

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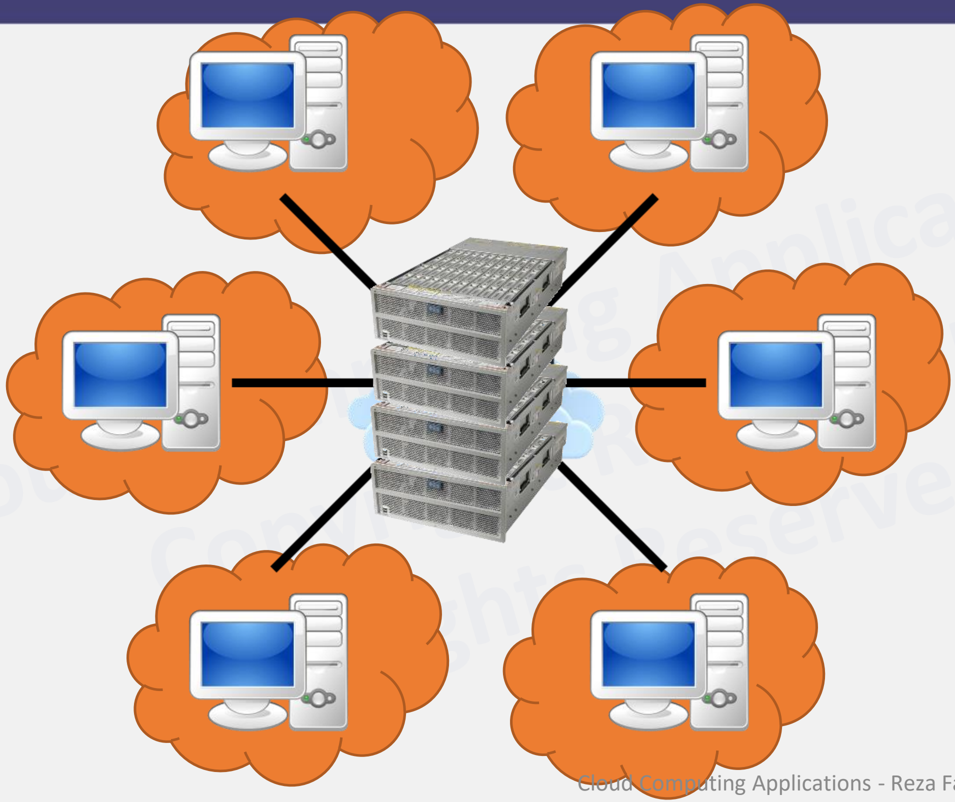
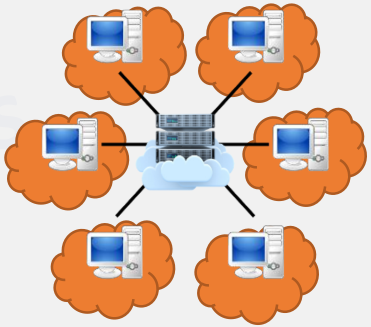


Cloud-Based File Systems

- Roll your own Clustered Distributed File System
  - Grab a number of “storage optimized” virtual machines, or metal machines
    - Each with large and fast instance block stores
      - A.k.a. SSDs / HDDs attached to the instance
    - Keep those instances on 24/7
    - Install a distributed file system on them
      - Lustre, MS DFS, NFS, Gluster, Ceph, Hadoop, etc.
- Managed filesystem deployed by the Cloud Provider



Cloud-managed file system

- Amazon
  - AWS FSx for Lustre
  - AWS FSx for Windows File Server
  - AWS EFS
- Azure
  - Azure Files
    - SMB access protocol
    - REST API
  - Azure DataLake Storage
    - Hadoop compatible file system
- Google
  - Cloud Filestore
    - NFS v3
    - Up to 64 TB

Google Filestore, IBM Cloud File Storage, AWS EFS

- Google Filestore

Simple commands to create a Filestore instance with gcloud.

```
gcloud filestore instances create nfs-server \
    --project=[PROJECT_ID] \
    --zone=us-central1-c \
    --tier=STANDARD \
    --file-share=name="vol1",capacity=1TB \
    --network=name="default"
```

Simple commands to install NFS, mount your file share, and set access permissions.

```
sudo apt-get -y update
sudo apt-get -y install nfs-common
sudo mkdir /mnt/test
sudo mount 10.0.0.2:/vol1 /mnt/test
sudo chmod go+rw /mnt/test
```

	Standard	Premium
Max read throughput	100 MB/s (1 TB), 180 MB/s (10+ TB)	1.2 GB/s
Max write throughput	100 MB/s (1 TB), 120 MB/s (10+ TB)	350 MB/s
Max IOPS	5,000	60,000
Max capacity per share	63.9 TB	63.9 TB
Typical customer availability	99.9%	99.9%
Protocol	NFSv3	NFSv3
Price	See Cloud Filestore pricing for more information	See Cloud Filestore pricing for more information

- IBM Cloud File Storage
  - Up to 12 TB
  - Up to 48,000 IOPS
- One beefy machine can handle them
  - AWS i3en.24xlarge: 8 x 7,500 NVMe SSD, 100 Gbps network
    - $60,405 / year per reserved instance
    - Cost of 64 TB standard storage EFS: $0.3*12*1024*64 = $235,929
    - Provisioned IO up to 1 GBps ~= 10 Gbps

Are Managed File Systems Distributed?

- FSx for Windows File Server
  - Max size: 64 TB
  - Can Utilize Microsoft DFS to unify data from many file servers for hundreds of petabytes
    - Shared namespace: Location transparency
    - Replication: Redundancy
- FSx for Lustre
  - Max size: 100 TB
  - Throughput: Read 50-200 MB/s per TB, can burst to 3,000 MB/s per TB
  - E.g. 50.4 TB runs on 22 file servers
    - Hundreds of GB/s of throughput
- AWS EFS
  - Maximum size: “Petabytes”
  - The throughput available to a file system scales as a file system grows
    - 50 MB/s per TB, can burst to 100 MB/s per TB
  - Supports NFS v4.1
- Azure
  - Azure Files
    - 100 TB
  - Data Lake Storage Gen 2
    - HDFS semantics
    - Built on top of Azure Blob Storage
    - Distributed file system
      - Can serve “many exabytes”
      - Throughput measured in gigabits per second (Gbps)

Distributed file Systems Design Goals

- *Access transparency*: clients are unaware that files are distributed and can access them in the same way as local files are accessed.
- *Location transparency*: a consistent namespace exists encompassing local as well as remote files. The name of a file does not give its location.
- *Concurrency transparency*: all clients have the same view of the state of the file system. This means that if one process is modifying a file, any other processes on the same system or remote systems that are accessing the files will see the modifications in a coherent manner.
- *Failure transparency*: the client and client programs should operate correctly after a server failure.
- *Heterogeneity*: file service should be provided across different hardware and operating system platforms.
- *Scalability*: the file system should work well in small environments (1 machine, a dozen machines) and also scale gracefully to bigger ones (hundreds through tens of thousands of systems).
- *Replication transparency*: Clients should be unaware of the file replication performed across multiple servers to support scalability.
- *Migration transparency*: files should be able to move between different servers without the client's knowledge.

Summary

- Clustered File Systems
- File Systems in the Cloud