MET's Institute of Engineering
Bhujbal Knowledge City, Adgaon, Nashik.
Computer Engineering

"Data Storage and Cloud Computing"

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Syllabus

Data Storage: Introduction to Enterprise Data Storage, Direct Attached Storage, Storage Area Network, Network Attached Storage, Data Storage Management, File System, Cloud Data Stores, Using Grids for Data Storage.

Cloud Storage: Data Management, Provisioning Cloud storage, Data Intensive Technologies for Cloud Computing. Cloud Storage from LANs to WANs: Cloud Characteristics, Distributed Data Storage.

Data Storage in Cloud Computing

- Cloud Storage is a service that allows to save data on offsite storage system managed by third-party and is made accessible by a **web services API.**

Storage Devices :

Storage devices can be broadly classified into two categories:
1. Block Storage Devices
2. File Storage Devices

Block Storage Devices :

The block storage devices offer raw storage to the clients. These raw storage are partitioned to create volumes.

File Storage Devices :

The file Storage Devices offer storage to clients in the form of files, maintaining its own file system. This storage is in the form of Network Attached Storage

Cloud Storage Classes

Cloud Storage Classes :

Cloud storage can be broadly classified into two categories:

1. Unmanaged Cloud Storage

2. Managed Cloud Storage

Unmanaged Cloud Storage

Unmanaged cloud storage means the storage is preconfigured for the customer. The customer can neither format, nor install his own file system or change drive properties.

Managed Cloud Storage

Managed cloud storage offers online storage space on-demand. The managed cloud storage system appears to the user to be a raw disk that the user can partition and format.

Creating Cloud Storage System

1. The cloud storage system stores many copies of data on many servers at the various locations.

2. The data is stored at various locations so that if one system fails it can change the pointer location to where the object is stored.

3. The cloud provider uses the virtualization software to aggregate the storage assets into cloud storage system. This system is called as StorageGRID.

4. StorageGRID creates a virtualization layer which fetches storage from various storage devices into a single management system.

5. It manages the data from CIFS and NFS file system over the Internet.

Creating Cloud Storage System
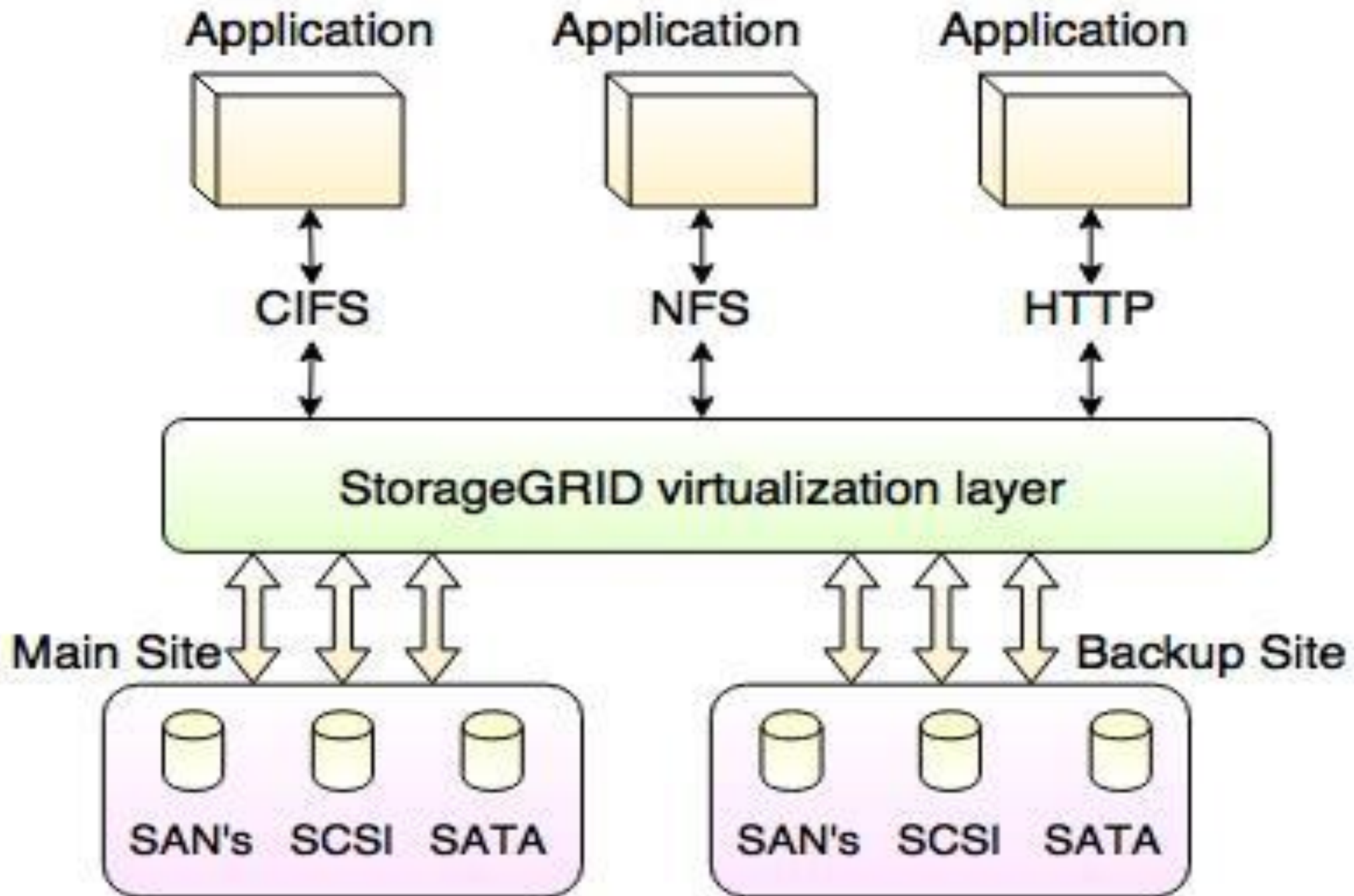
Virtual Storage Container

The virtual storage containers offer high performance cloud storage systems. Logical Unit Number (LUN) of device, files and other objects are created in virtual storage containers. Following diagram shows a virtual storage container, defining a cloud storage domain:
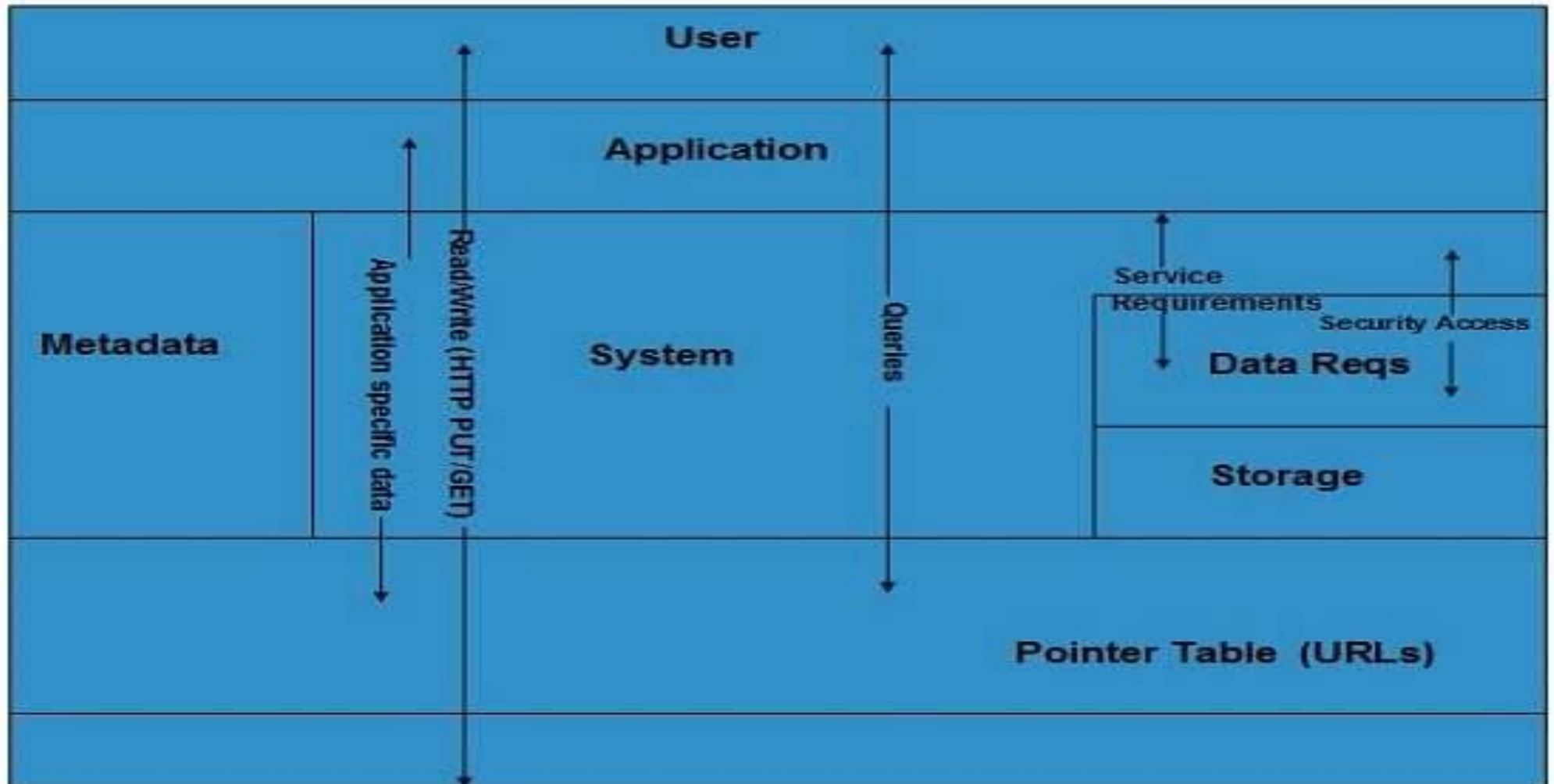
Virtual Storage Container

Challenges :

1. Storing the data in cloud is not that simple task. Apart from its flexibility and convenience, it also has several challenges faced by the customers. The customers must be able to:

2. Get provision for additional storage on-demand.

3. Know and restrict the physical location of the stored data.

4. Verify how data was erased.

5. Have access to a documented process for disposing of data storage hardware.

6. Have administrator access control over data.

Introduction of Enterprise Data Storage

"Enterprise storage is a centralized repository for business information that provides common data management, protection."

An Enterprise Storage System is **a centralized repository for business information**. It provides a common resource for data sharing, management and protection via connections to other computer systems. Enterprise storage systems are designed to process heavy workloads of business-critical information.

Types of Enterprise Storage :
1. Direct-Attached Storage.
2. Network-Attached Storage.
3. Storage Area Networks.

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Types of Enterprise Storage :
1. Direct-Attached Storage.
2. Network-Attached Storage.
3. Storage Area Networks.

Direct Attached Storage

DAS stands for Direct Attached Storage. It is a digital storage device connected directly to the server, workstation, or personal computer via the cable. In Direct Attached Storage, applications use the block-level access protocol for accessing the data.

There is no need for any network to attach the device to the server or workstation. So, DAS (Direct Attached Storage) is not a part of the storage network. Some examples of this storage device are solid-state drive, hard drives, tape libraries, and optical disk drives.

The System of DAS is attached directly to the computer through the HBA (Host Bus Adapter. As compared to NAS devices, its device attaches directly to the server without the network. The modern systems of this storage device include the integrated controllers of a disk array with the advanced features.

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Direct Attached Storage

Types of DAS

Following are the two types of Direct Attached Storage (DAS):

1. Internal DAS

2. External DAS

Internal DAS

Internal DAS is a DAS in which the storage device is attached internally to the server or PC by the HBA. In this DAS, HBA is used for high-speed bus connectivity over a short distance.

External DAS

External DAS is a DAS in which the external storage device is directly connected to the server without any device. In this type of DAS, FCP and SCSI are the protocols which act as an interface between server and the storage device.

Network Attached Storage

Network-attached Storage (Commonly known as NAS) is a file storage device which is connected to the network and enables multiple users to access data form the centralized disk capacity. The users on a LAN access the shared storage by the ethernet connection.

This storage is fast, low-cost and offers all the advantages of a public cloud on the site. It uses file access protocols such as NFS, SMB, NCP, or AFP.

NFS is a file-based protocol which is popular on Unix systems. SMB stands for Server Message Block, which is used with the Microsoft Windows systems. AFP is also a file access protocol that is used with the Apple computers.

It is basically designed for those network systems, which may be processing

Network Attached Storage

It is basically designed for those network systems, which may be processing millions of operations per minute. It supports the storage device for the organization, which need a reliable network system. It is more economical than the file servers and more versatile than the external disks.

Advantages :

1. The architecture of NAS is easy to install and configure.

2. Every user or client in the network can easily access to Network Attached Storage.

3. A main advantage of NAS is that it is more reliable than the simple hard disks.

4. The performance is good in serving the files.

5. The devices of NAS are scalable and can be easily accessed remotely.

Network Attached Storage

Disadvantages of NAS

Following are the disadvantages or limitations of a Network Attached Storage (NAS):

1. The speed of transferring the data is not as fast as DAS.

2. Users also require basic knowledge of computer networks to use the NAS efficiently.

3. Those users or clients who want to back up their data, then they cannot proceed directly. They can do it by using the installed operating system only.

Storage Area Network

SAN is an abbreviation of the Storage Area Network. Storage Area Network is a dedicated, specialized, and high-speed network which provides block-level data storage. It delivers the shared pool of storage devices to more than one server.

The main aim of SAN is to transfer the data between the server and storage device. It also allows for transferring the data between the storage systems.

Storage Area networks are mainly used for accessing storage devices such as tape libraries and disk-based devices from the servers.

It is a dedicated network which is not accessible through the LAN. It consists of hosts, switches, and storage devices which are interconnected using the topologies, protocols, and technologies.

Storage Area Network

Protocols of SAN

Following are the most common protocols of SAN (Storage Area Network):

1. FCP (Fibre Channel Protocol)

2. iSCSI

3. FCoE

4. NVMe

FCP (Fibre Channel Protocol)

It is the most commonly used protocol of the Storage Area Network. It is a mapping of SCSI command over the Fibre Channel (FC) network.

Storage Area Network

ISCSI

It stands for Internet SCSI or Internet Small Computer System Interface. It is the second-largest block or SAN protocol. It puts the SCSI commands inside an ethernet frame and then transports them over an Internet protocol (IP) ethernet.

FCoE

FCoE stands for "Fibre Channel Over Internet". It is a protocol which is similar to the iSCSI. It puts the Fibre channel inside the ethernet datagram and then transports over an IP Ethernet network.

NVMe

NVMe stands for Non-Volatile Memory Express. It is also a protocol of SAN, which access the flash storage by the PCI Express bus.

Storage Area Network

Advantages :

1. It is more scalable.

2. Security is also a main advantage of SAN. If users want to secure their data, then SAN is a good option to use. Users can easily implement various security measures on SAN.

3. Storage devices can be easily added or removed from the network. If users need more storage, then they simply add the devices.

4. The cost of this storage network is low as compared to others.

5. Another big advantage of using the SAN (Storage Area Network) is better disk utilization.

NAS Vs DAS

NAS	DAS
1. NAS is a short form of Network Attached Storage.	1. DAS is a short form of Direct Attached Storage.
2. It uses files for backup and recovery.	2. It uses sectors for backup and recovery.
3. This storage Device is complex than the DAS device.	3. This storage device is simple, not complex.
4. Network Attached Storage is slightly difficult to set up.	4. Direct attached Storage is easy to set up and install.
5. The cost of this storage device is higher than the DAS device.	5. Its cost is low as compared to NAS.
6. The capacity of NAS is 109 to 1012 bytes.	7. The capacity of DAS is only 109 bytes.
7. This storage device allows users to share the files on different OS.	7. This storage device does not allow users to share the files on different OS.
8. It uses Ethernet and TCP/IP for transmission of data.	8. It uses IDE/SCSI for the transmission of data.

DAS Vs SAN

DAS	SAN
1. DAS is a short form of Direct Attached Storage.	1. SAN is a short form of Storage Area Network.
2. It uses sectors for backup and recovery.	2. It uses block by block copying technique for backup and recovery.
3. This storage device is simple, not complex.	3. This storage Device is complex than the DAS device.
4. Direct attached Storage is easy to set up and install.	4. Storage Area Network is slightly difficult to install and set up.
5. Its cost is low as compared to SAN.	5. The cost of this storage device is higher than the DAS device.
7. The capacity of DAS is only 109 bytes.	6. The capacity of SAN is more than the 1012 bytes.
7. This storage device does not allow users to share the files on different OS.	7. This storage device allows users to share the files on different OS.
8. It uses IDE/SCSI for the transmission of data.	8. It uses Internet Protocol and Fibre Channel for transmission of data.

Data Storage Management

Cloud data management is **a way to manage data across cloud platforms, either with or instead of on-premises storage**. The cloud is useful as a data storage tier for disaster recovery, backup and long-term archiving. With cloud data management, resources can be purchased as needed.

Storage management ensures data is available to users when they need it.

Data storage management is typically part of the storage administrator's job. Organizations without a dedicated storage administrator might use an IT generalist for storage management.

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File System in Cloud

A file system in the cloud is a hierarchical storage system that provides shared access to file data. Users can create, delete, modify, read, and write files and can organize them logically in directory trees for intuitive access.
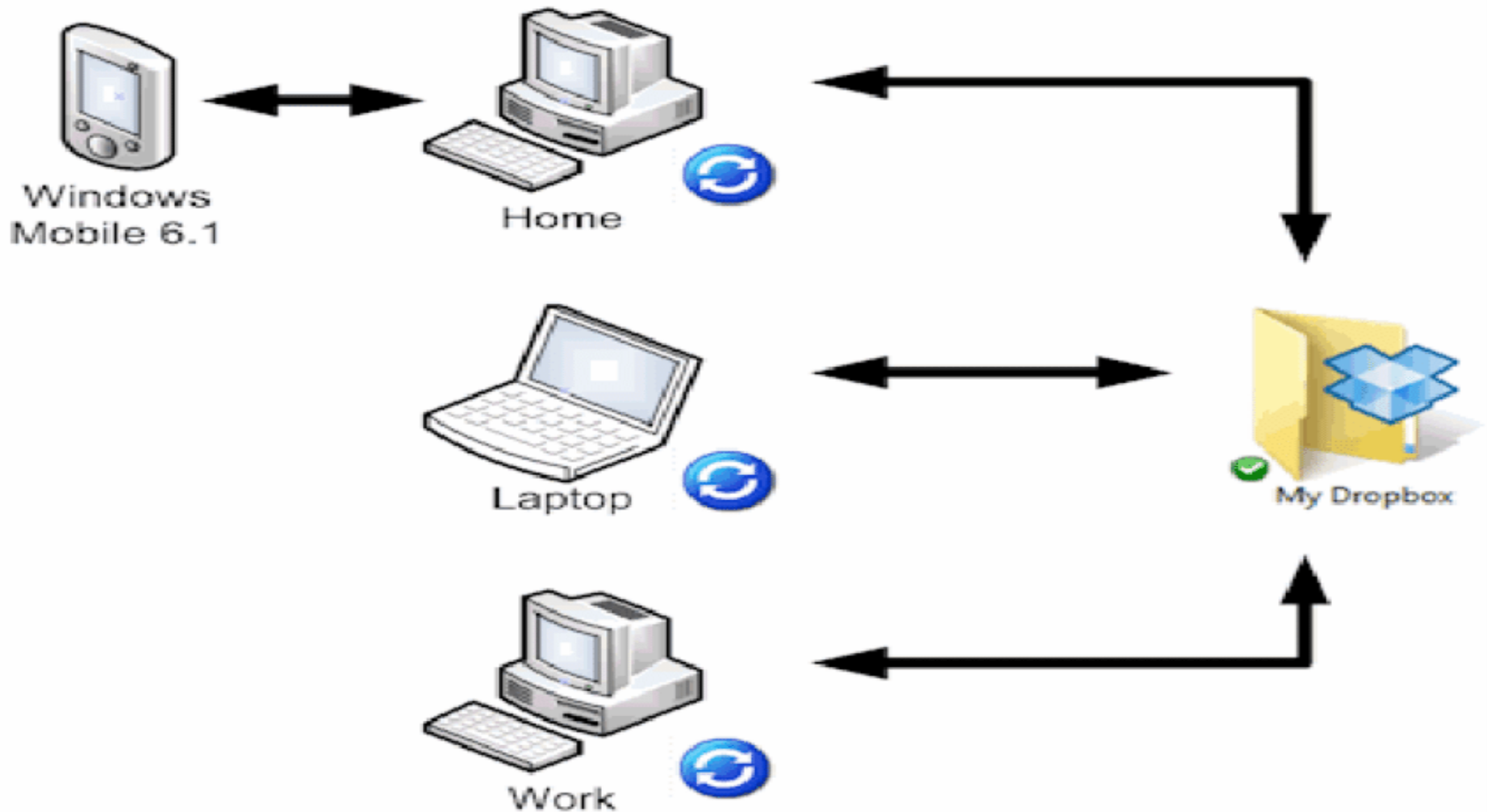
File System in Cloud

A file system in the cloud is exactly what it sounds like. The vendor creates a file system that offers traditional file protocols like NFS or SMB to cloud hosted applications. Essentially, the vendor provides an instance of their file system and the organization implements it in the cloud provider of their choice. It then allocates the appropriate storage compute performance and the storage IO.

The goal with these file systems is to speed the migration of applications to the cloud. By using a file system in the cloud the organization does not need to re-write the storage IO components of the application

Cloud Data Stores

Cloud storage is a cloud computing model that stores data on the Internet through a cloud computing provider who manages and operates data storage as a service.

In this fast-moving world it become necessary to store data on the **cloud storage.** The biggest advantage of cloud storage is that we can store any type of data in digital form on the cloud. Another advantage of cloud storage is that we can access data from anywhere, anytime on any device. There are many cloud storage providers such as, **Google Drive, Dropbox, OneDrive, iCloud,** etc. They provide free service for limited storage but if you want to store beyond the limit, you have to pay.

How does Cloud Storage Works?

Cloud storage is purchased from a third party cloud vendor who owns and operates data storage capacity and delivers it over the Internet in a pay-as-you-go model. These cloud storage vendors manage capacity, security and durability to make data accessible to your applications all around the world.

Applications access cloud storage through traditional storage protocols or directly via an API. Many vendors offer complementary services designed to help collect, manage, secure and analyze data at massive scale.

Cloud Vs Grid Computing

| Cloud Computing	Grid Computing
Cloud Computing follows client-server computing architecture.	Grid computing follows a distributed computing architecture.
Scalability is high.	Scalability is normal.
Cloud Computing is more flexible than grid computing.	Grid Computing is less flexible than cloud computing.
Cloud operates as a centralized management system.	Grid operates as a decentralized management system.
In cloud computing, cloud servers are owned by infrastructure providers.	In Grid computing, grids are owned and managed by the organization.
Cloud computing uses services like Iaas, PaaS, and SaaS.	Grid computing uses systems like distributed computing, distributed information, and distributed pervasive.
Cloud Computing is Service-oriented.	Grid Computing is Application-oriented.
It is accessible through standard web protocols.	It is accessible through grid middleware.

Cloud Storage

Cloud storage is a data deposit model in which digital information such as documents, photos, videos and other forms of media are stored on virtual or cloud servers hosted by third parties. It allows you to transfer data on an offsite storage system and access them whenever needed.

Cloud storage is a cloud computing model that allows users to save important data or media files on remote, third-party servers. Users can access these servers at any time over the internet. Also known as utility storage, cloud storage is maintained and operated by a cloud-based service provider.

How Cloud Storage Works?

HOW DOES CLOUD STORAGE WORK?
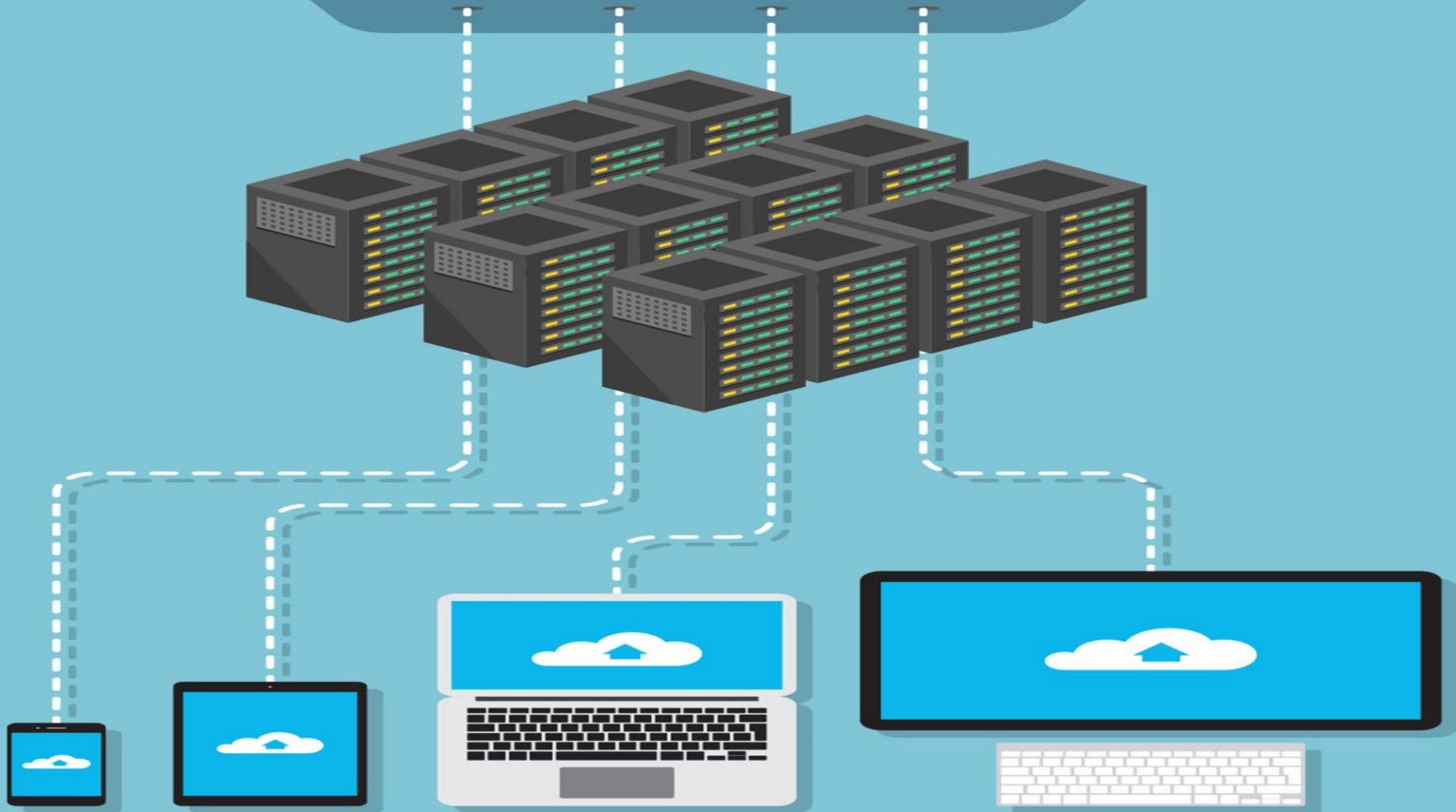
How Cloud Storage Works?

Cloud storage works as a virtual data center. It offers end users and applications virtual storage infrastructure that can be scaled to the application's requirements. It generally operates via a web-based API implemented remotely through its interaction with in-house cloud storage infrastructure.

Cloud storage includes at least one data server to which a user can connect via the internet. The user sends files to the data server, which forwards the message to multiple servers, manually or in an automated manner, over the internet. The stored data can then be accessed via a web-based interface.

Types of Cloud Storage

TYPES OF CLOUD STORAGE

Private cloud storage

- Secure
- Scalable
- Greater user control
- Expensive
- Suitable for large enterprises

Public cloud storage

- Easily scalable
- Affordable
- Reliable
- Seamless monitoring
- Zero maintenance
- Suitable for individual users and mid-size companies

Hybrid cloud storage

- Easy customizations
- Affordable
- Greater user control
- Secure
- Scalable
- Suitable for small and mid-size companies

Community cloud storage

- Secure
- Affordable
- Scalable
- Suitable for financial, health, and legal or compliance companies

Types of Cloud Storage

Note : Theory part , we have already covered in Unit-1

i.e. Public, Private, Hybrid and Community Cloud/

Benefits of Cloud Storage :

1. Cost Saving

2. Data Redudancy and Replication

3. Scalability

4. Speed

Data Management in Cloud Storage

Cloud data management is the practice of storing a company's data at an offsite data center that is typically owned and overseen by a vendor who specializes in public cloud infrastructure, such as AWS or MicrosoftAzure. Managing data in the cloud provides an automated backup strategy, professional support, and ease of access from any location.

Benefit of Cloud Data Management

1. Security: Modern cloud data management often delivers better data protection than on-premises solutions. In fact, 94% of cloud adopters report security improvements. Why? First of all, cloud data management reduces the risk of data loss due to device damage or hardware failure. Second, companies specializing in cloud hosting and data management employ more advanced security measures and practices to protect sensitive data than companies that invest in their on-premises data.

2. Scalability and savings: Cloud data management lets users scale services up or down as needed. More storage or compute power can be added when needed to accommodate changing workloads. Companies can then scale back after the completion of a big project to avoid paying for services they don't need.

Benefit of Cloud Data Management

3. Governed access: With improved security comes greater peace of mind regarding governed data access. Cloud storage means team members can access the data they need from wherever they are. This access also supports a collaborative work culture, as employees can work together on a dataset, easily share insights, and more.

4. Automated backups and disaster recovery: The cloud storage vendor can manage and automate data backups so that the company can focus its attention on other things, and can rest assured that its data is safe. Having an up-to-date backup at all times also speeds up the process of disaster recovery after emergencies, and can help mitigate the effects of ransomware attacks.

Benefit of Cloud Data Management

5. Improved data quality: An integrated, well-governed cloud data management solution helps companies tear down data silos and create a single source of truth for every data point. Data remains clean, consistent, up-to-date, and accessible for every use case, from real-time data analytics to advanced machine learning applications to external sharing via APIs.

6. Automated updates: Cloud data management providers are committed to providing the best services and capabilities. When applications need updating, cloud providers run these updates automatically. That means your team doesn't need to pause work while they wait for IT to update everyone's system.

Cloud Provisioning

Cloud provisioning means allocating a cloud service provider's resources to a customer. It is a key feature of cloud computing. It refers to how a client gets cloud services and resources from a provider. The cloud services that customers can subscribe to include infrastructure-as-a-service (IaaS), software-as-a-service (SaaS), and platform-as-a-service (PaaS) in public or private environments.

Benefits of Cloud Provisioning

Scalability: A company makes a huge investment in its on-site infrastructure under the conventional IT provisioning model. This requires immense preparation and prophesying infrastructure needs. However, in the cloud provisioning model, cloud resources can scale up and scale down which is entirely dependant on the short-term consumption of usage. This way scalability can help the organizations.

Speed: Speed is another factor of the cloud's provisioning which can benefit the organizations. For this, the developers of the organization can schedule the jobs which in turn removes the need for an administrator who provisions and manages resources.

Cost Savings: It is another potential benefit of cloud provisioning. Traditional technology can incur a huge cost to the organizations while cloud providers allow customers to pay only for what they consume. This is another major reason why cloud provisioning is preferred.

Types of Cloud Provisioning

Network Provisioning: Network Provisioning in the telecom industry is a means of referring to the provisions of telecommunications services to a client.

Server Provisioning: Datacenter's physical infrastructure, installation, configuration of the software, and linking it to middleware, networks, and storage.

User Provisioning: It is a method of identity management that helps us in keeping a check on the access and privileges of authorization. Provisioning is featured by the artifacts such as equipment, suppliers, etc.

Service Provisioning: It requires setting up a service and handling its related data.

Tools and Softwares Used in Cloud Provisioning

Several enterprises can provide the services and resources manually as per their need, whereas public cloud providers offer tools to provide various resources and services such as:

1. IBM Cloud Orchestrator

2. Cloud Bolt

3. Morpheus Data

4. Flexera

5. Cloud Sphere

6. Scalr

7. Google Cloud Deployment manager

Data Intensive Technology in Cloud Computing

Data Intensive Computing is a class of parallel computing which uses data parallelism in order to process large volumes of data. The size of this data is typically in terabytes or petabytes. This large amount of data is generated each day and it is referred to Big Data.

Data intensive computing has some characteristics which are different from other forms of computing. They are:

1. In order to achieve high performance in data intensive computing, it is necessary to minimize the movement of data. This reduces system overhead and increases performance by allowing the algorithms to execute on the node where the data resides.

2. The data intensive computing system utilizes a machine independent approach where the run time system controls the scheduling, execution, load balancing, communications and the movement of programs.

Data Intensive Technology in Cloud Computing

Data intensive computing has some characteristics which are different from other forms of computing. They are:

3. Data intensive computing hugely focuses on reliability and availability of data. Traditional large scale systems may be susceptible to hardware failures, communication errors and software bugs, and data intensive computing is designed to overcome these challenges.

4. Data intensive computing is designed for scalability so it can accommodate any amount of data and so it can meet the time critical requirements. Scalability of the hardware as well as the software architecture is one of the biggest advantages of data intensive computing.

Cloud Storage from LANs to WANs:

Characteristics :

1. Computer power is elastic, when it can perform parallel operations. In general, applications conceived to run on the peak of a shared-nothing architecture are well matched for such an environment. Some cloud computing goods, for example, Google's App Engine, supply not only a cloud computing infrastructure, but also an entire programs stack with a constrained API so that software developers are compelled to compose programs that can run in a shared-nothing natural environment and therefore help elastic scaling.

Cloud Storage from LANs to WANs:

Characteristics :

2. Data is retained at an unknown host server. In general, letting go off data is a threat to many security issues and thus suitable precautions should be taken. The very title 'loud computing' implies that the computing and storage resources are being operated from a celestial position. The idea is that the data is physically stored in a specific host country and is subject to localized laws and regulations. Since most cloud computing vendors give their clientele little command over where data is stored, the clientele has no alternative but to expect the least that the data is encrypted utilizing a key unavailable with the owner, the data may be accessed by a third party without the customer's knowledge.

Cloud Storage from LANs to WANs:

Characteristics :

3. Data is duplicated often over distant locations. Data accessibility and durability is paramount for cloud storage providers, as data tampering can be impairing for both the business and the organization's reputation. Data accessibility and durability are normally accomplished through hidden replications. Large cloud computing providers with data hubs dispersed all through the world have the proficiency to provide high levels of expected error resistance by duplicating data at distant locations across continents. Amazon's S3 cloud storage service replicates data over 'regions' and 'availability zones' so that data and applications can survive even when the whole location collapses.

Cloud Storage from LANs to WANs:

Distributed Data Storage :

Distributed storage means are evolving from the existing practices of data storage for the new generation of WWW applications through organizations like Google, Amazon and Yahoo. There are some reasons for distributed storage means to be favoured over traditional relational database systems encompassing scalability, accessibility and performance. The new generation of applications require processing of data to a tune of terabytes and even peta bytes. This is accomplished by distributed services. Distributed services means distributed data. This is a distinct giant compared to traditional relational database systems. Several studies have proposed that this is an end of an architectural era and relational database systems have to take over. Emerging answers are Amazon Dynamo, CouchDB and ThruDB.

Cloud Storage from LANs to WANs:

13.3.1 Amazon Dynamo

Amazon Dynamo is a widely used key-value store. It is one of the main components of Amazon. com, the biggest e-commerce stores in the world. It has a primary-key only interface. This demands that data is retained as key-value in twos, and the only interface to get access to data is by identifying the key. Values are anticipated to be barely there (less than 1 MB).

Dynamo is said to be highly accessible for composing as opposed to reading, since malfunction of composing inconveniences the end-user of the application. Therefore any data confrontations are finalized at the time of reading than writing.

Cloud Storage from LANs to WANs:

13.3.2 CouchDB :

CouchDB is a document-oriented database server, accessible by REST APIs. Couch is an acronym for 'Cluster Of Unreliable Commodity Hardware', emphasizing the distributed environment of the database. CouchDB is designed for document-oriented applications, for example, forums, bug following, wiki, Internet note, etc. CouchDB is ad-hoc and schema-free with a flat address space.

CouchDB aspires to persuade the Four Pillars of Data Management by these methods:

Save: ACID compliant, save efficiently

See: Easy retrieval, straightforward describing procedures, fulltext search

Secure: Strong compartmentalization, ACL, connections over SSL

Share: Distributed means

Cloud Storage from LANs to WANs:

13.3.2 CouchDB :

The storage form is a Multiversion Concurrency Control (MVCC) scheme with hopeful locking. A purchaser sees a snapshot of the data and works with it even if it is altered at the same time by a distinct client.

CouchDB actually has no apparent authentication scheme, i.e., it is in-built. The replication is distributed. A server can revise others once the server is made offline and data is changed. If there are confrontations, CouchDB will choose a survivor and hold that as latest. Users can manually suspend this surviving alternative later. Importantly, the confrontation tenacity yields identical results comprehensively double-checking on the offline revisions. This also promises to compose a storage motor for MySQL founded on CouchDB.

13.3.3 ThruDB

ThruDB aspires to be universal in simplifying the administration of the up-to-date WWW data level (indexing, caching, replication, backup) by supplying a reliable set of services:

Thrucene for indexing

Throxy for partitioning and burden balancing

Thrudoc for article storage

ThruDB builds on top of some open source projects: Thrift, Lucene (indexing), Spread (message bus), Memcached (caching), Brackup (backup to disk/S3) and also values Amazon S3.

Cloud Storage from LANs to WANs:

13.3.3 ThruDB

Thrift is a structure for effective cross-language data serialization, RPC and server programming. Thrift is a programs library and set of code-generation devices conceived to expedite development and implementation of effective and scalable backend services. Its prime aim is to enhance effective and dependable connection over programming languages. This is finished by abstracting the portions of each dialect that are inclined to need the most customization into a widespread library that is applied in each language. Specifically, Thrift permits developers to characterise data types and service interfaces in a sole language-neutral document and develop all the essential cipher to construct RPC purchasers and servers.

Cloud Storage from LANs to WANs:

13.3.3 ThruDB

Thrudoc arrives with some data storage engines: Disk and S3. In this implementation, the data is persevered on localized computer disk, which bestows us an unbelievable throughput capability and a slave gist that calmly replays all of the instructions to the S3 backend as well, therefore giving us a provoke-free persistence and recovery form for virtual environments, for example, EC2.

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