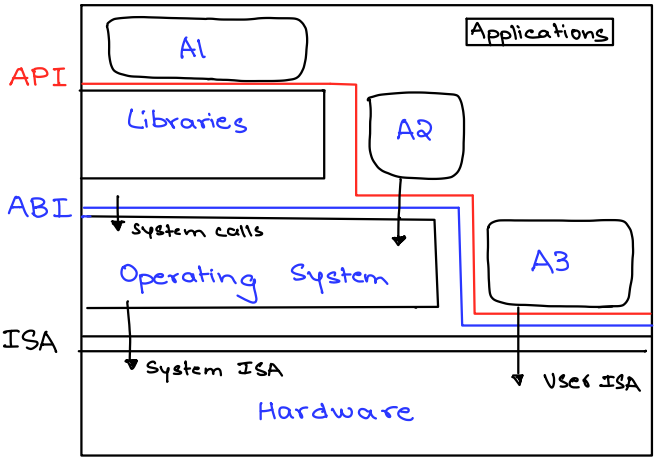
UNIT 3

LAYERING

- managing system complexity - layering
- minimizes interactions
- 2 modes → user & privileged



- 1st interface – ISA – boundary b/w s/ware & h/ware – processor's set of instructions
- ABI (App^n Binary Int.) – H/ware access to the app^n's & library modules. Doesn't include privileged instructions.
- API – defines set of instr the h/ware was designed to execute – gives app^n access to the ISA.

CONDITIONS FOR EFFICIENT VIRTUALIZATION

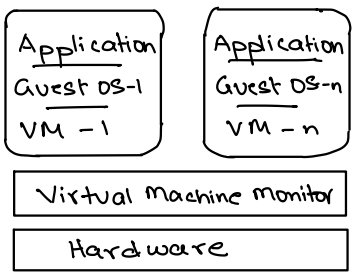
① A program running under the VMM must exhibit behaviour essentially similar to that demonstrated when the app^n runs directly on an equivalent machine.

② The VMM should be in complete control of the virtualized resources.

③ A statistically significant fraction of the machine instructions should be executed without the intervention of the VMM.

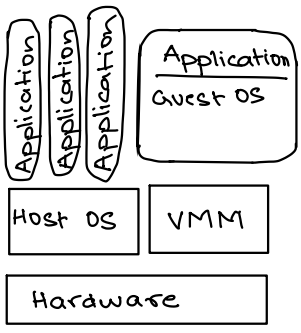
TRADITIONAL

- Thin layer of s/ware that runs directly on the host machine's h/ware
- Main adv. is performance



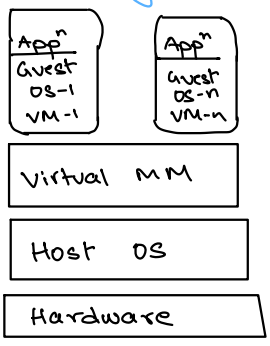
HYBRID

- Shares the h/ware w/ the existing OS.



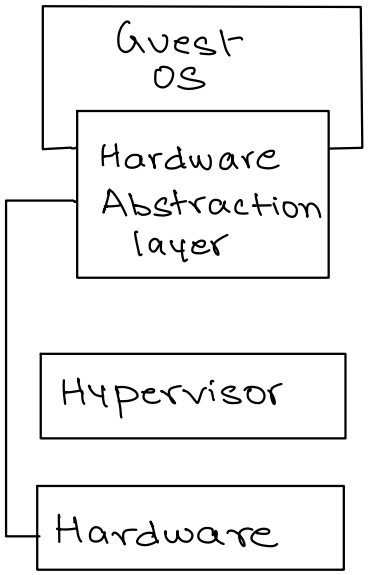
HOSTED

- The VM runs directly on top of the existing OS.



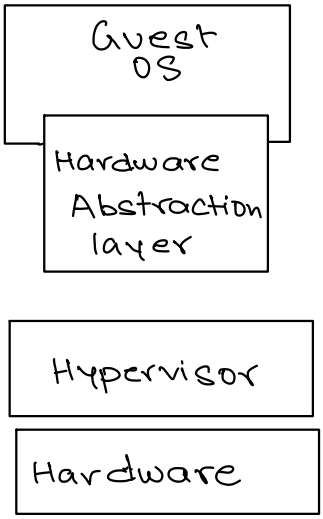
FULL VIRTUALIZATION

- Each VM runs on an exact copy of the actual hlware.
- Requires a fully virtualizable architecture; the hlware is fully exposed to the guest OS, that runs unchanged.



PARAVIRTUALIZATION

- VM runs on a modified copy of the actual hlware.
- It is done as some architectures are not easily virtualizable.
- Demands that the guest OS be modified to run under the VMM.



PROBLEMS FACED BY VIRTUALIZATION OF THE x86 ARCHITECTURE

① RING DEPRIVILEGING

VMM forces the guest sware, the OS, & the app's to run at a privilege level > 0 (not in 64 bit mode)
solns → (0/1/3) mode
→ (0/3/3) mode

② RING ALIASING

Problem when a guest OS is forced to run at a privilege level that it wasn't designed for.

③ ADDRESS SPACE COMPRESSION

VMM uses parts of the guest address space to store system DSs. These DS must be protected, but the guest sware must have access to them.

④ INTERRUPT VIRTUALIZATION

VMM generates a "virtual interrupt" in response to a physical interrupt & delivers it to the target guest OS. Guest OS's have the ability to mask interrupts - complicates the VMM & increases overhead.

⑤ ACCESS TO HIDDEN STATE

Elements of the system state are hidden; there is no mechanism for saving & restoring hidden components after a context switch from 1 VM to another

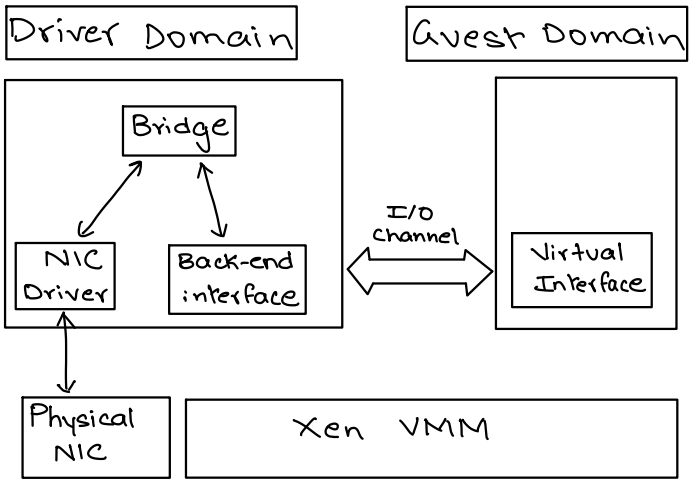
⑥ FREQUENT ACCESS TO PRIVILEGED RESOURCES INCREASES VMM OVERHEAD

The *TPR is frequently used by a guest OS. the VMM must protect access to this reg. & trap all attempts to access it. this can cause performance degradation.

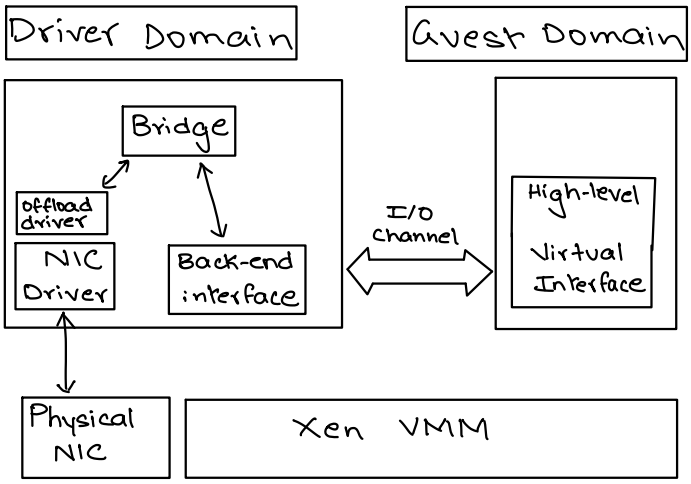
*TPR - Task Priority Register

XEN ARCHITECTURE

ORIGINAL



OPTIMIZED



XEN NETWORK OPTIMIZATIONS

(1) THE VIRTUAL INTERFACE

- The original " " network provides the guest domain w/ the abstraction of a simple low-level network interface supporting sending & receiving primitives.
- This design supports a wide range of physical devices attached to the driver domain but doesn't take advantage of the capabilities of some physical devices.
- These features are supported by the high-level virtual interface of the optimized system

(2) THE I/O CHANNEL

- Rather than copying a data buffer holding a packet, each packet is allocated in a new page & this physical page is remapped to the guest domain.
- This strategy contributes to a better than 4x increase in the send data rate.

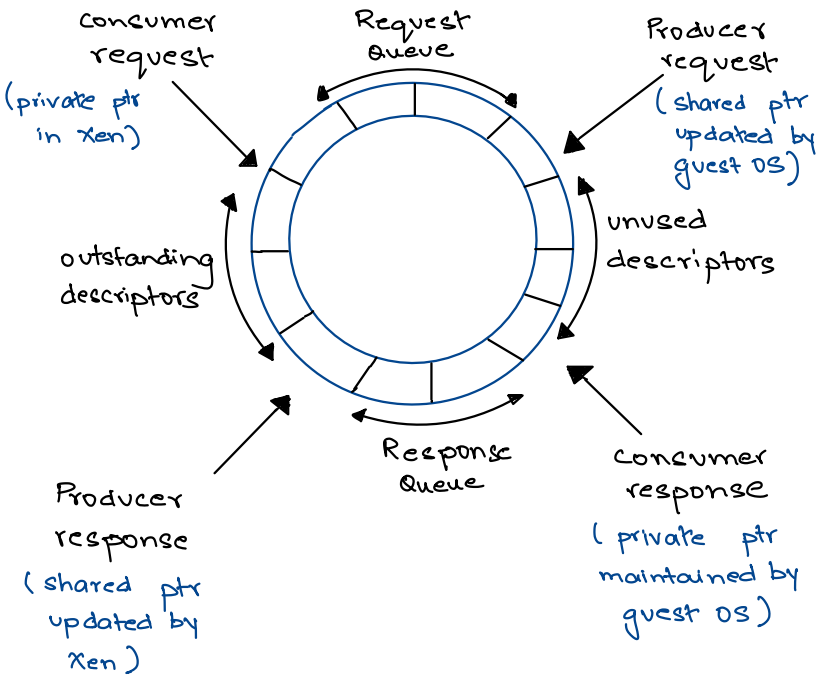
(3) VIRTUAL MEMORY

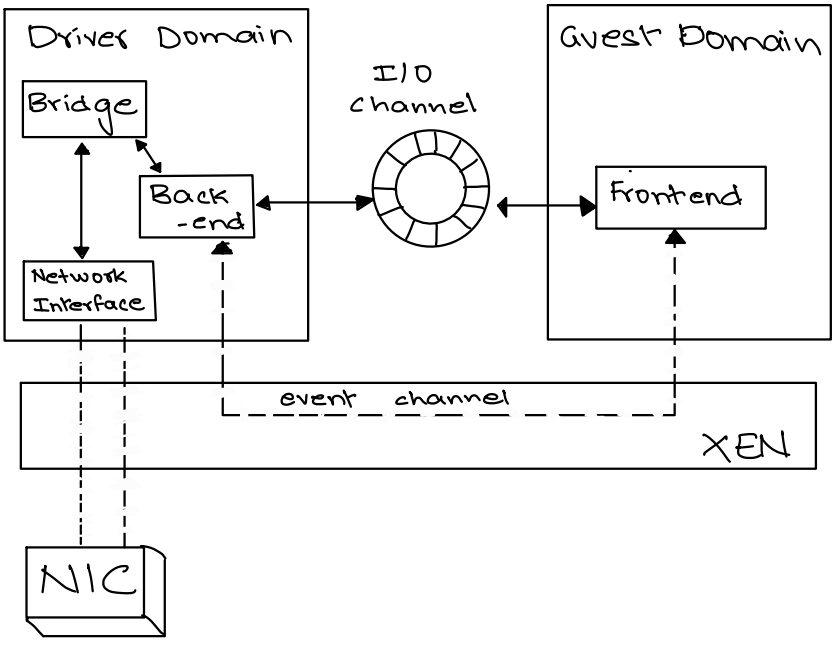
- " " in Xen 2.0 takes advantage of superpage & global page-mapping hardware features.
- A superpage increases the granularity of dynamic address translation – a superpage entry covers 1024 pages of physical memory, & address translation maps a set of contiguous pages to a set of contiguous physical pages.
- This reduces the no. of *TLB misses.
- The optimized version uses a special memory allocator to avoid the problem where the system is forced to use traditional page-mapping rather than superpage mapping

*Translation lookaside buffer: memory cache used to reduce the time taken to access a user memory location.

XEN ZERO-COPY SEMANTICS FOR DATA TRANSFER USING I/O RINGS

CIRCULAR RING OF BUFFERS





* IR → Instruction Register
* RSE → Register Stack Engine

vBlades project

- The Itanium processor supports 4 privilege rings – PL0, PL1, PL2, PL3.
- Privileged instructions can only be executed by the kernel at PL0.
- App^n^s run at PL3 & can execute only non-privileged instructions.
- The VMM uses ring compression & runs itself at PL0 & PL1 while forcing a guest OS to run at PL2.
- A problem – privilege leaking – several nonprivileged instructions allow an app^n^ to determine the current privilege level (CPL).
- Itanium was selected because of its multiple functional units & multithreading support.

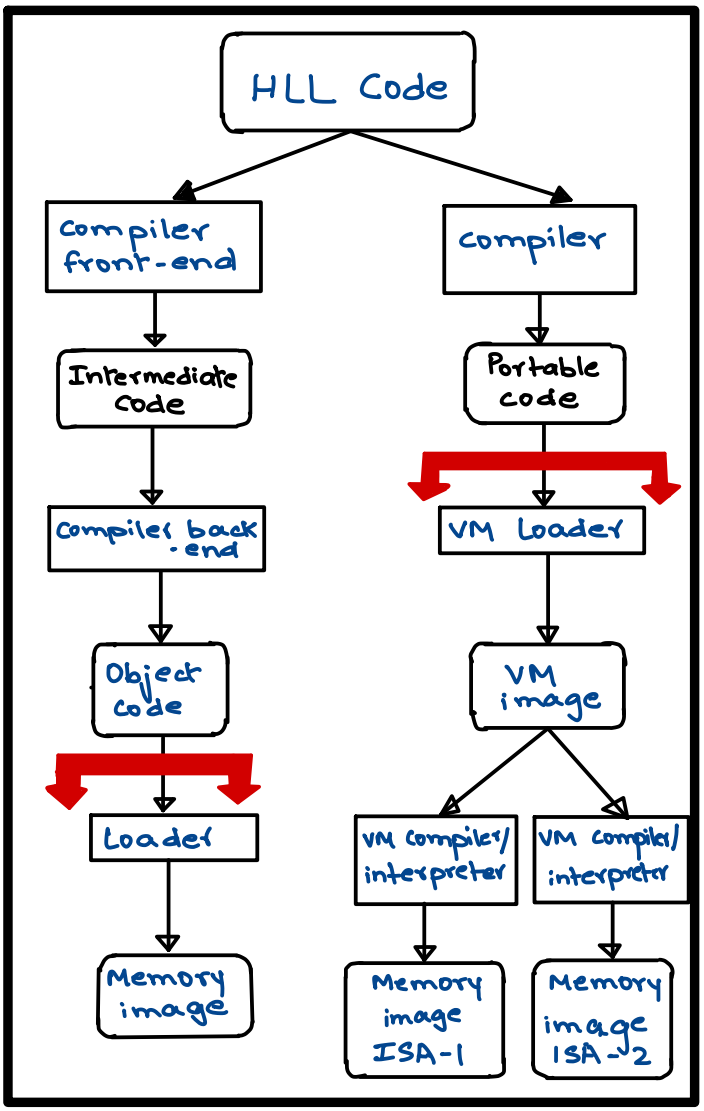
- CPU Virtvalization:
  when a guest OS attempts to execute a privileged instruction the VMM traps & emulates the instruction.
  - Complication – Itanium doesn't have an *IR & the VMM has to use state info to determine whether an instr. is privileged.
  - Complication – caused by *RSE, which operates concurrently wl the processor & may attempt to access memory & generate a page fault.

- A no. of privileged-sensitive instr. behave differently as a function of the privilege level. The VMM replaces each one of them wl a privileged instr. during the dynamic transformation of the instruction stream.

contd.

contd.

- Memory virtualization is guided by the realization that a VMM should not be involved in most read & write operations to prevent a significant degradation of performance, but at the same time the VMM should exercise tight control & prevent a guest OS from acting maliciously.
- The vBlades VMM doesn't allow a guest OS to access memory directly. It inserts an additional layer of indirection called metaphysical addressing b/w virtual & real addressing.
- A guest OS is placed in metaphysical addressing mode. If the address is virtual, the VMM first checks if the guest OS is allowed to access that address, & if it is, it provides the regular address translation. If the address is physical, the VMM is not involved.



UNIT-4

CLOUD RESOURCE MANAGEMENT - POLICIES

① **Admission Control**

The goal of this policy is to prevent the system from accepting workloads in violation of high-level system policies — eg: a system may not accept an additional workload that would prevent it from completing work already in progress. Limiting the workload requires some knowledge about the global state of the system.

② **Capacity Allocation**

It means to allocate resources for individual instances; an instance is an activation of a service

③ **Load Balancing**, ④ **Energy Optimization**

- It refers to evenly distributing the load to a set of servers. In CC, a critical goal is minimizing the cost of providing the service, & , in particular, minimizing the energy consumption.
- This gives us a diff meaning of LB - instead of having the load equally distributed to all servers, we want to concentrate it & use the smallest no. of servers while switching the others to standby mode(server uses less energy).
- LB & energy optimization are correlated & affect the cost of providing the service.

⑤ **QoS guarantees**

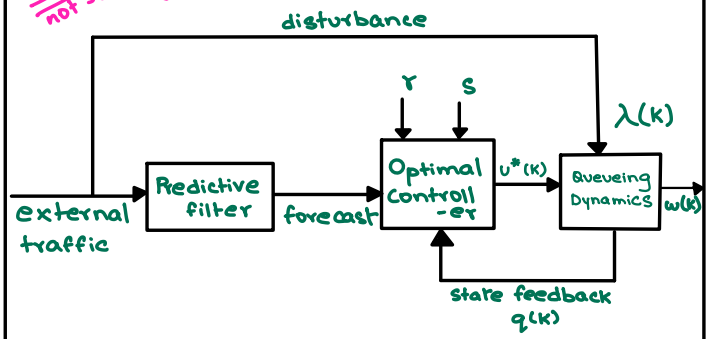
QoS is that aspect of resource management that is probably the most difficult to address &, at the same time, possibly the most critical to the future of CC.

(diagram)

- This is the case of a single processor serving a stream of input requests
- To compute the optimal inputs over a finite horizon, the controller uses feedback regarding the current state, as well as an estimation of the future disturbance due to the environment.

CONTROL THEORY PRINCIPLES — OPTIMAL RESOURCE ALLOCATION

not sure ↘



→ Optimal control generates a sequence of control inputs over a look-ahead horizon while estimating changes in operating conditions.

→ A **convex cost function** has arguments - x(K), the **state** at step K, & u(K), the **control vector**; this cost function is minimized, subject to the constraints imposed by system dynamics.

→ The discrete-time optimal control problem is to determine the sequence of control variables u(i), u(i+1), .. u(n-1) to minimize the expression:

$$J(i) = \phi(n, x(n)) + \sum_{K=i}^{n-1} L^K(x(K), u(K))$$

$\phi(n, x(n))$: cost function of the final step

$\sum_{K=i}^{n-1} L^K(x(K), u(K))$: Time-varying cost function at the intermediate step K ova [i,n]

→ The minimization is subject to :

$$x(K+1) = f^K(x(K), u(K))$$

$x(K+1)$: system state at time K+1; f^K: function of; $x(K)$: state at time K; $u(K)$: input at time K

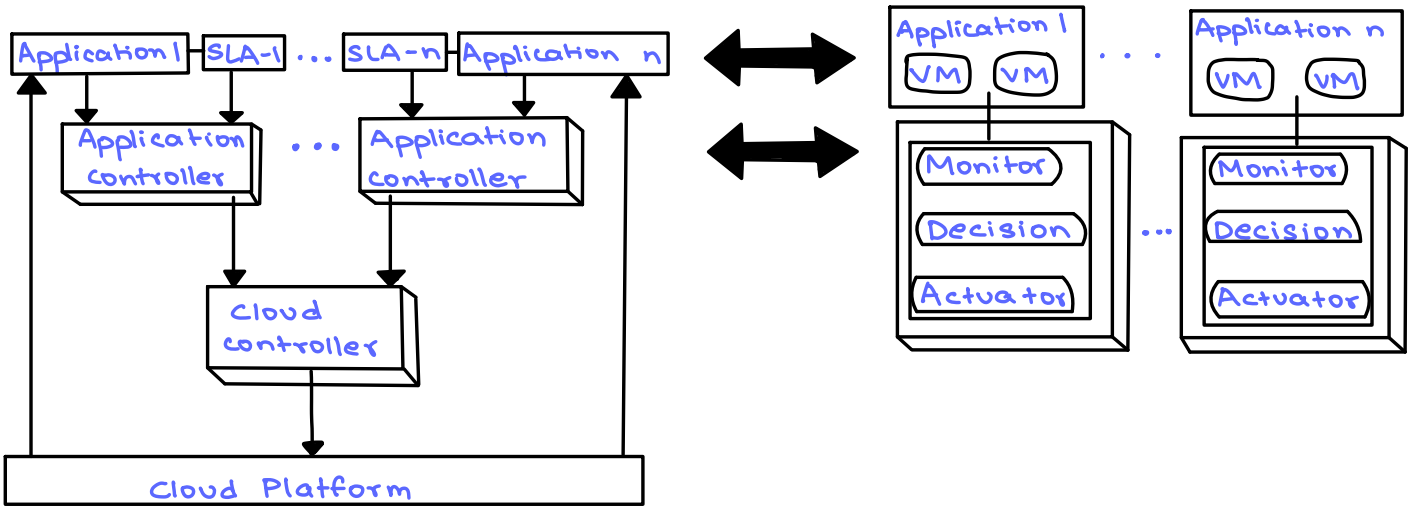
→ A technique to solve this problem - Lagrange multiplier(λ) method to maximize a function $g(x,y)$ subject to constraint $h(x,y) = K$

$$\Lambda(x, y, \lambda) = g(x,y) + \lambda \times [h(x,y) - K]$$

→ A necessary condition for optimality is that (x, y, λ) is a stationary point for $\Lambda(x, y, \lambda)$, or,

$$\nabla_{x,y,\lambda} \Lambda(x, y, \lambda) = 0$$

TWO-LEVEL CONTROL ARCHITECTURE

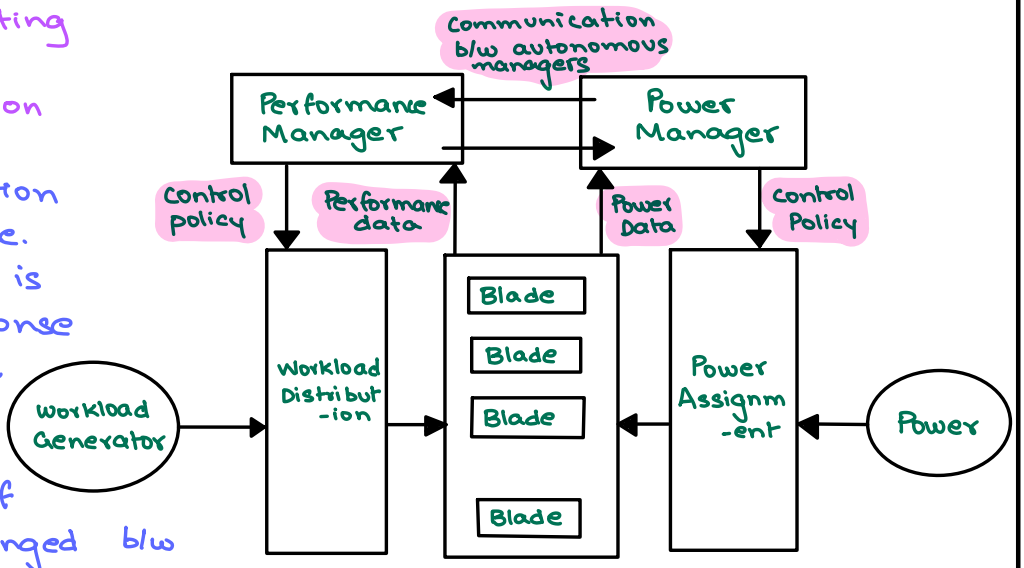


- The automatic resource management is based on 2 levels of controllers – one for the service provider & one for the application.
- The main components of a control system are the inputs, the control system components, & the outputs.
- The inputs in such models are the offered workload & the policies for admission control, the capacity allocation, the load balancing, the energy optimization, & the QoS guarantees in the cloud.
- The system components are sensors used to estimate relevant measures of performance & controllers that implement various policies.
- The output is the resource allocations to the individual applications.
- The controllers use the feedback provided by sensors to stabilize the system; stability is related to the change of the output.
- If the change is too large, the system may become unstable.

COORDINATION OF AUTONOMIC PERFORMANCE MANAGERS

* The approach to coordinating power & performance management is based on several ideas:
- Use a joint utility function for power & performance. This function, $U_{pp}(R,P)$ is a function of the response time R, & the power P.

$$U_{pp}(R,P) = \frac{U(R)}{P}$$



- Identify a minimal set of parameters to be exchanged b/w the 2 managers.
- Set up a power cap for individual systems based on the utility-optimized power management policy
- Use a std performance manager modified only to accept input from the power manager regarding the frequency determined according to

contd.

the power management policy.

- Use standard software systems.

utility function $U'(p_k, n_c) = U_{pp}(R(p_k, n_c), P(p_k, n_c))$

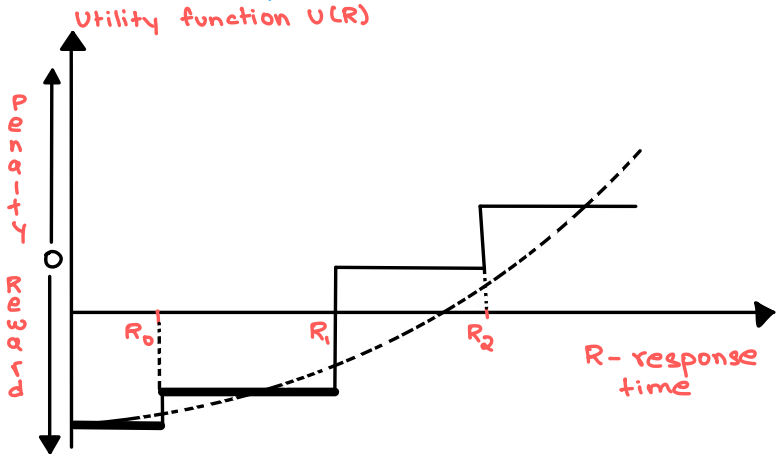
p_k: power cap; n_c: No. of clients

UTILITY FUNCTION – PERFORMANCE METRIC : RESPONSE TIM (R)

→ A utility function relates the "benefits" of an activity or service wl the "cost" to provide the service

→ A service-level-agreement (SLA) often specifies the rewards & penalties associated wl specific performance metrics.

When the performance metric is R: (R_0, R_1, R_2)



→ The largest reward can be obtained when $R \leq R_0$; a slightly lower reward corresponds to $R_0 < R \leq R_1$.

→ when $R_1 < R < R_2$, instead of gaining a reward, the provider of the service pays a small penalty; the penalty increases when $R > R_2$.

→ A utility function, U(R), which captures this behavior, is a sequence of step functions.

→ The utility function is sometimes approximated by a quadratic curve.

PRICING & ALLOCATION ALGORITH

This algo partitions the set of users into 2 disjoint sets — winners (W) & losers (L).

The algo should:

- ★ Be computationally tractable.
- ★ Scale well
- ★ Be objective. Partitioning should only be based on the price Π_u of a user's bid.
- ★ Be fair. Make sure that the prices are uniform. All winners wlin a given resource pool pay the same price.
- ★ Indicate clearly at the end of the auction the unit prices for each resource pool.
- ★ Indicate clearly to all participants the relationship b/w the supply & the demand in the system

ACSA COMBINATORIAL AUCTION ALGORITHM

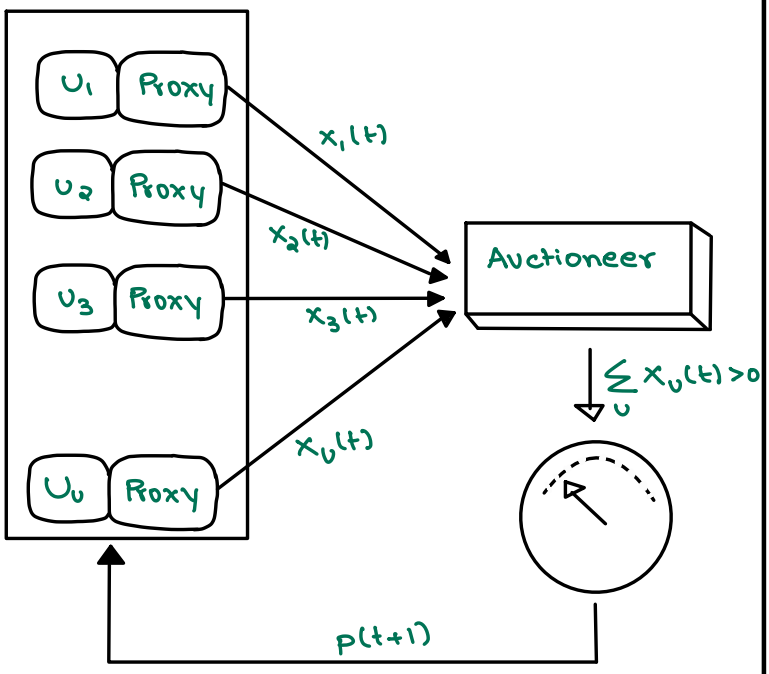
→ Here, the participants at the auction specify the resource & the quantity of that resource offered or desired at the price listed for that time slot.
→ Then the excess vector is calculated. If all its components are -ve, the auction stops. (Demand doesn't exceed the offer).
→ If Demand > Offer, the auctioneer increases the price for items & solicits bids at the new price.

Schematics:

$x_u(t) \rightarrow$ bids

$\sum_u x_u(t) \rightarrow$ excess demands

To allow for a single round, auction users are represented by proxies that place the bids $x_u(t)$. The auctioneer determines whether there is an excess demand, & in that case, raises the price of those resources.



FAIR QUEUEING

→ It introduces a bit-by-bit round-robin (BR) strategy; a single bit from each queue is transmitted & the queues are visited in a round-robin fashion.

$R(t)$ → No. of rounds of the BR algo up to time t

$N_{active}(t)$ → No. of active flows through the switch

t_i^a → Time when packet i of flow a, of size P_i^a arrives

S_i^a → Value of $R(t)$ when the 1st bit of packet i of flow a is transmitted

F_i^a → Value of $R(t)$ when the last bit of packet i of flow a is transmitted

then,

$$F_i^a = S_i^a + P_i^a$$
$$S_i^a = \max[F_{i-1}^a, R(t_i^a)]$$

→ The quantities $R(t)$, $N_{active}(t)$, S_i^a & F_i^a depend only on the arrival time of the packets, t_i^a, & not on their transmission time, provided that a flow a is active as long as:

$$R(t) \leq F_i^a,$$
$$\text{when } i = \max(j \mid t_j^a \leq t)$$

→ The next packet to be transmitted is the one w/ the smallest F_i^a.

START-TIME FAIR QUEUEING

* The basic idea is to organize the consumers of the CPU bandwidth in a tree-structure; the root node is the processor & the leaves are the threads of each application.
* A schedular acts at each level of the hierarchy. The fraction of the processor bandwidth, B, allocated to the intermediate node i is:

$$\frac{B_i}{B} = \frac{w_i}{\sum_{j=1}^{n} w_j}$$

(w_j: weight of the n children of the node i)

Rules an SFQ schedular follows:

R1: The threads are serviced in the order of their virtual start-up time

R2: The virtual start-up time of the i-th activation of thread x is:

$S_x^i(t) = \max[v(t^i), F_x^{(i-1)}(t)]$ & $S_x^0 = 0$

The condition for thread i to be started is that thread (i-1) has finished & that the scheduler is active.

R3: The virtual finish time of the ith activation of thread x is

$$F_x^i(t) = S_x^i(t) + \frac{q}{w_x}$$

(q: Time quantum of the thread)

A thread is stopped when its time quantum has expired.

R4: The virtual time of all threads is initially zero,

$v_x^0 = 0$

The virtual time v(t) at real time t is computed:

$$v(t) = \begin{cases} \text{Virtual start time of the thread in service at time } t, & \text{if CPU is busy} \\ \text{Max finish virtual time of any thread}, & \text{if CPU is idle} \end{cases}$$

SUM - SFQ

Q. There are 2 threads w/ weights $w_a = 1$ & $w_b = 4$. Time quantum $q = 12$. (Consider scheduling decisions at t=0 & t=3)

(pg 187-189 in the tb for more values of t)

Initially, $S_a^0 = 0$, $S_b^0 = 0$

$v_a(0) = 0$, $v_b(0) = 0$

① t = 0

$S_a^0 = S_b^0$ ⇒ tie

Thread b is arbitrarily chosen to run first.

The virtual finish time of thread b is:

$$F_b^0 = S_b^0 + \frac{q}{w_b}$$

$$= 0 + \frac{12}{4} = 3$$

② t = 3

Both threads are runnable & thread b was in service; thus, $v(3) = S_b^0 = 0$; then

$S_b^1 = \max[v(3), F_b^0]$

$= \max(0, 3)$

$= 3$

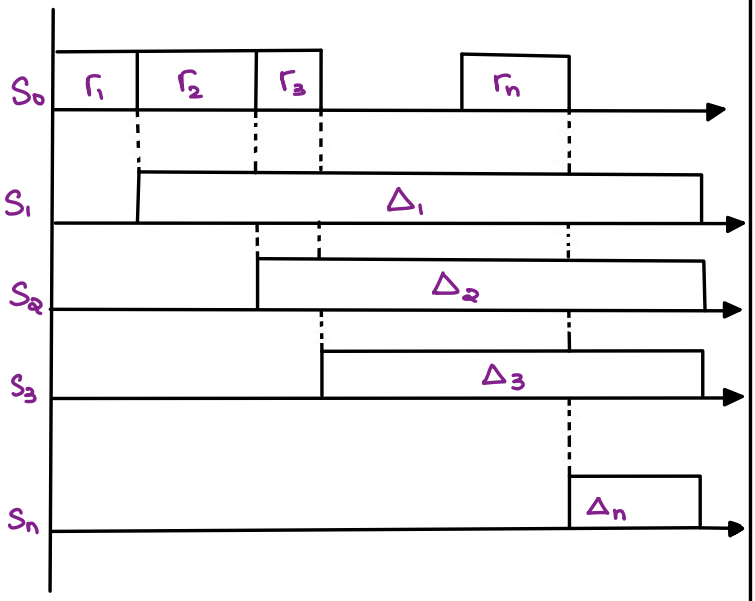
But $S_a^0 < S_b^1$, thus thread a is selected to run. Its virtual finish time:

$$F_a^0 = S_a^0 + \frac{q}{w_a}$$

$$= 0 + \frac{12}{1} = 12$$

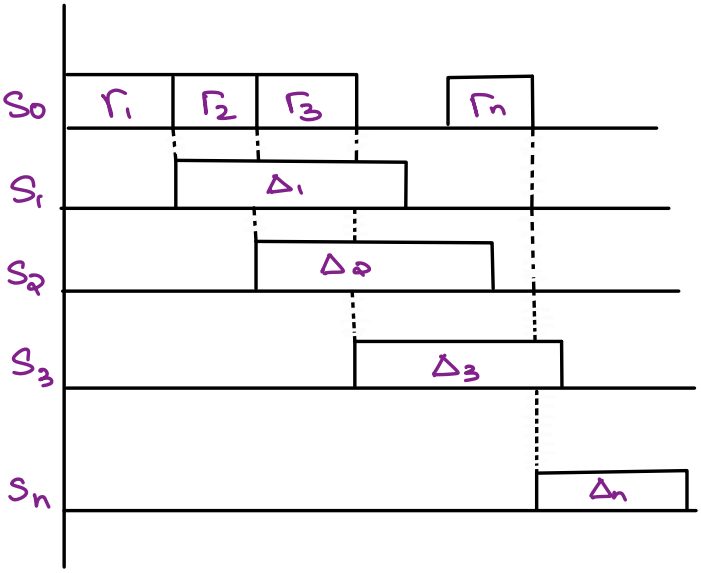
OPTIMAL PARTITIONING RULE

- The workload is partitioned to ensure the earliest possible completion time
- The algorithm requires worker nodes to complete to complete execution at the same time.
- The head node, S_0, distributes sequentially the data to individual worker nodes.



EQUAL PARTITIONING RULE

- EPR assigns an equal workload to individual worker nodes.
- The head node, S_0, distributes sequentially the data to individual worker nodes.



UNIT-5

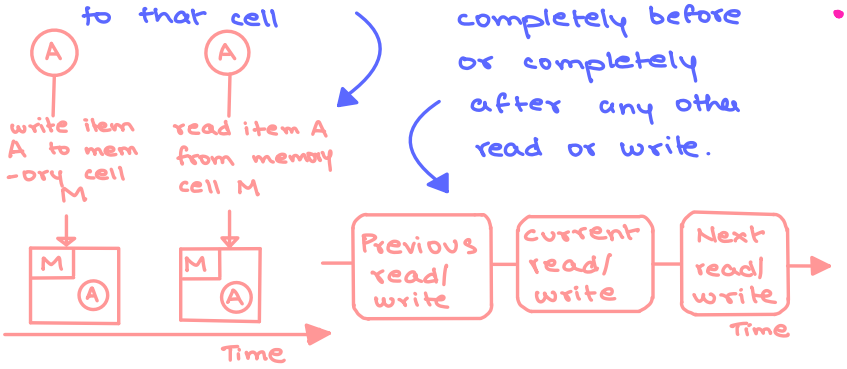
TWO ABSTRACT MODELS OF STORAGE

① CELL STORAGE

- Assumes that the storage consists of cells of the same size & that each object fits exactly in one cell.
- This model reflects the physical organization of several storage media; a secondary storage device is organized in sectors or blocks read & written as a unit.
- **read/write coherence** & **before-or-after atomicity** are 2 highly desirable properties of any storage model & in particular of cell storage.

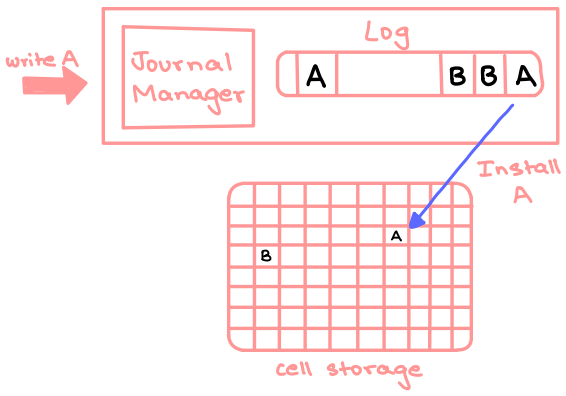
The result of a read of memory cell M should be the same as the most recent write to that cell

The result of every read or write is the same as if that read or write occurred either completely before or completely after any other read or write.



② JOURNAL STORAGE

- It is a fairly elaborate organi-zation for storing composite objects such as records consisting of multiple fields.
- Consists of a manager & cell storage, where the entire history of a variable is maintained, rather than just the current value.
- A log contains a history of all variables in cell storage.
- The user doesn't have direct access to the cell storage; instead the user can request the journal manager to,
  (i) start a new action
  (ii) read the value of a cell, (iii) write " "
  (iv) commit an action, (v) abort an "
- The journal manager translates user requests to commands sent to the cell storage:
  (i) read a cell, (ii) write " "
  (iii) allocate " ", (iv) deallocate " "



CHARACTERISTICS OF UFS (UNIX FILE SYSTEM)

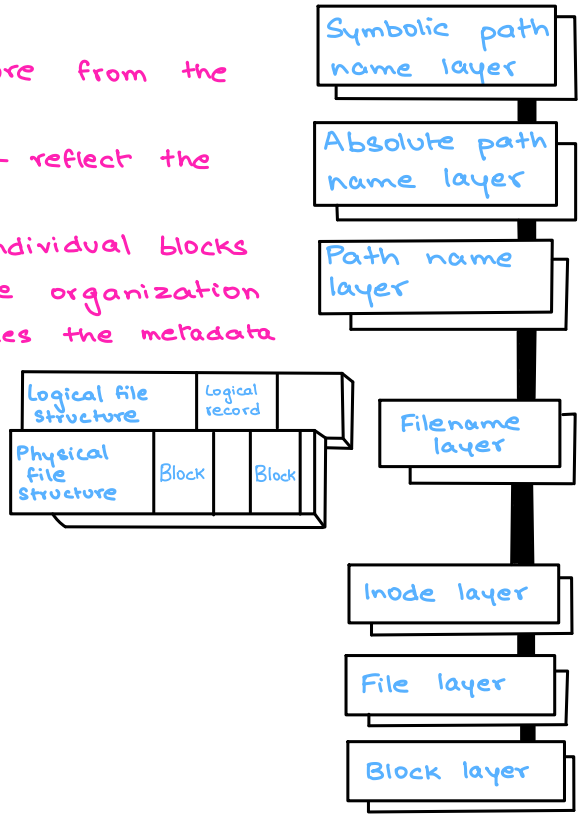
→ The layered design provides the necessary **flexibility** for the file system; **layering** allows seperation of concerns & **minimization** of the **interaction** among the modules. The addition of vnode layer allowed the UFS to treat **local** & **remote file access** uniformly.

→ The **hierarchical design** supports **scalability** of the file system; it allows grouping of files into directories & supports multiple levels of directories.

→ The **metadata** supports a **systematic** rather than an ad hoc design philosophy. inodes contain info about individual files & directories. Metadata includes the file owner, access rights, creation time or time of last modif., file size & storage device cells.

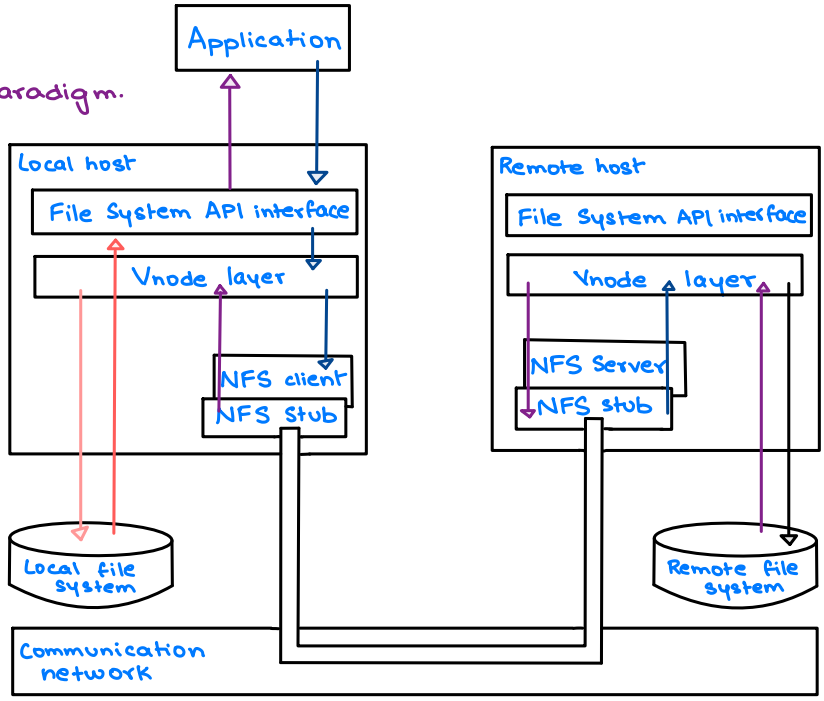
LAYERED DESIGN OF UFS

- This design seperates the physical file structure from the logical one
- The lower 3 layers – the block, file & inode layer – reflect the physical organization.
- The block layer allows the system to locate individual blocks on the physical device; the file layer reflects the organization of blocks into files; & the inode layer provides the metadata for the objects.
- The upper 3 layers reflect the logical organization.
- The filename layer mediates blw the machine-oriented & the user-oriented views of the file system.

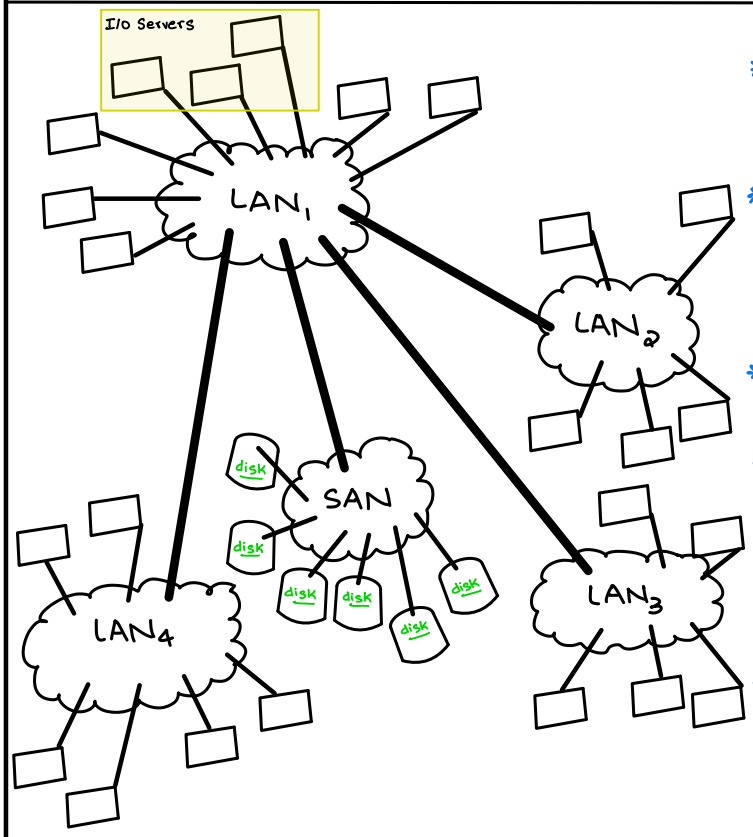


NETWORK FILE SYSTEM

- NFS is based on a client-server paradigm.
- The client runs on the local host while the server is at the site of the remote file system, & they interact by means of remote procedure calls (RPCs).
- The API interface of the local file system distinguishes file operations on a local file from the ones on a remote file, & in the latter case, invokes the RPC client.
- NFS uses a vnode layer to distinguish blw operations on local & remote files.



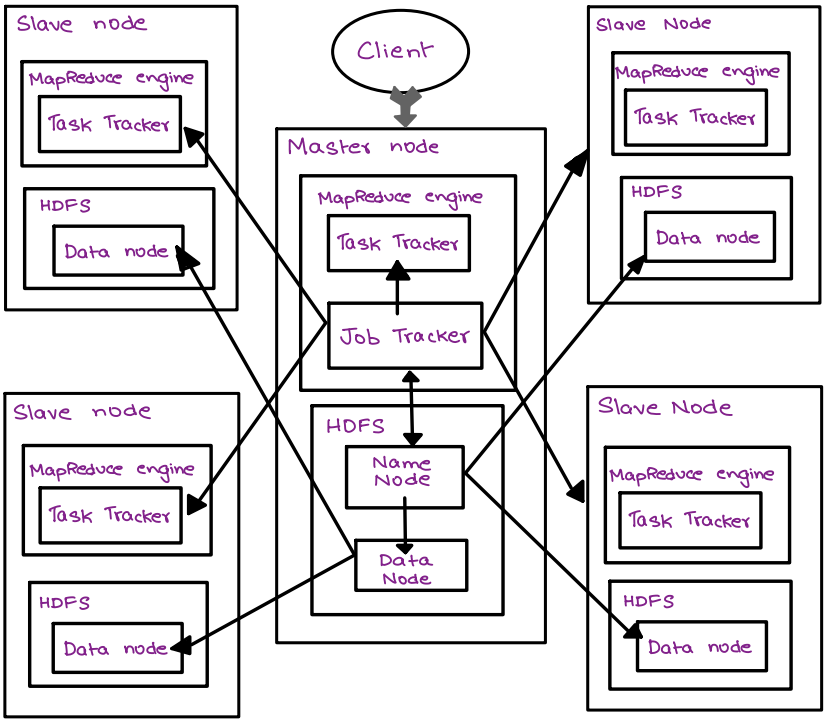
General Parallel File System



* Parallel file systems allow multiple clients to read & write concurrently from the same file.
* GPFS is a parallel file system that emulates closely the behavior of a general-purpose POSIX system running on a single system.
* It was designed for optimal performance of large clusters.
* Reliability is a major concern in a system wl many physical components.
* To recover from system failure, GPFS records all metadata updates in a write-ahead log file.
* The log files are maintained by each I/O node for each file system it mounts.
* GPFS uses disk maps to manage disk space

HADOOP - HDFS

- Hadoop supports distributed app^n's handling extremely large volumes of data.
- A Hadoop system has 2 components — a MapReduce engine & a database. The database could be HDFS, Amazon S3, or CloudStore.

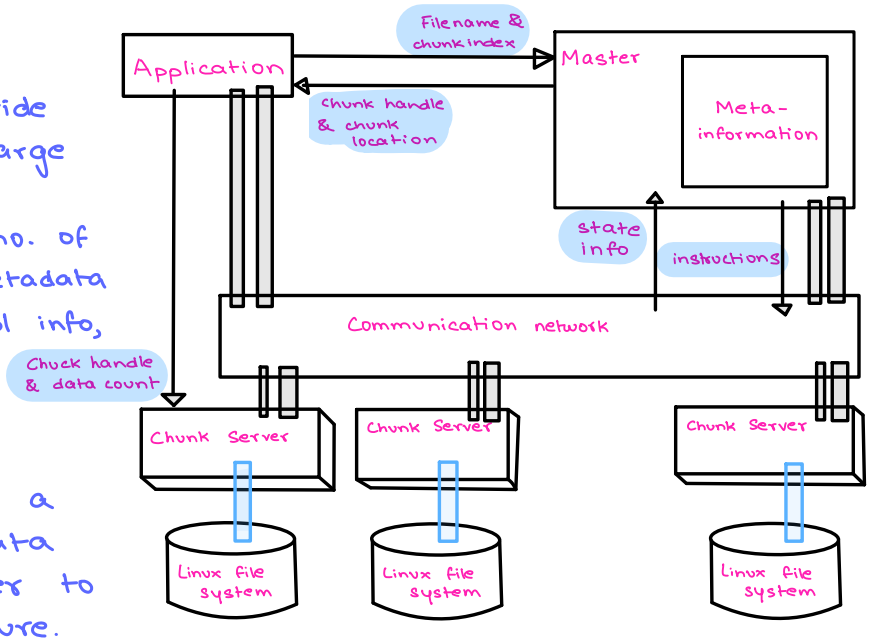


- The Hadoop engine on the master of a multinode cluster consists of a job tracker & a task tracker, whereas the engine on a slave has only a task tracker.
- The job tracker receives a MapReduce job from a client & dispatches the work to the task trackers running on the nodes of a cluster.
- The task tracker supervises the execution of the work allocated to the node.
- HDFS replicates data on multiple nodes — the default is 3 replicas.
- The name node running on the master manages the data distribution & data replication & communicates wl data nodes running on all cluster nodes

GOOGLE FILE SYSTEM (GFS)

* It uses thousands of storage systems built from inexpensive commodity components to provide petabytes of storage to a large user community.
* A master controls a large no. of chunk servers; it maintains metadata such as filenames, access control info, state of individual chunk servers & the location of all the replicas for every chunk.
* The operation log maintains a historical record of metadata changes, enabling the master to recover in case of a failure.

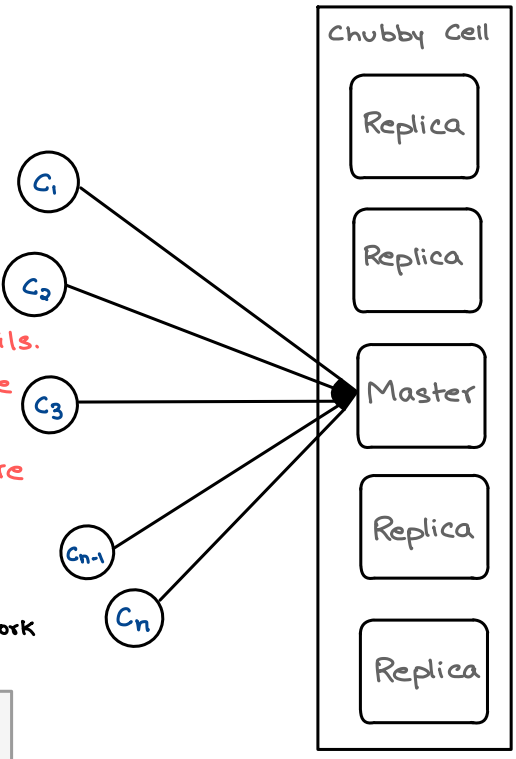
Architecture of a GFS cluster



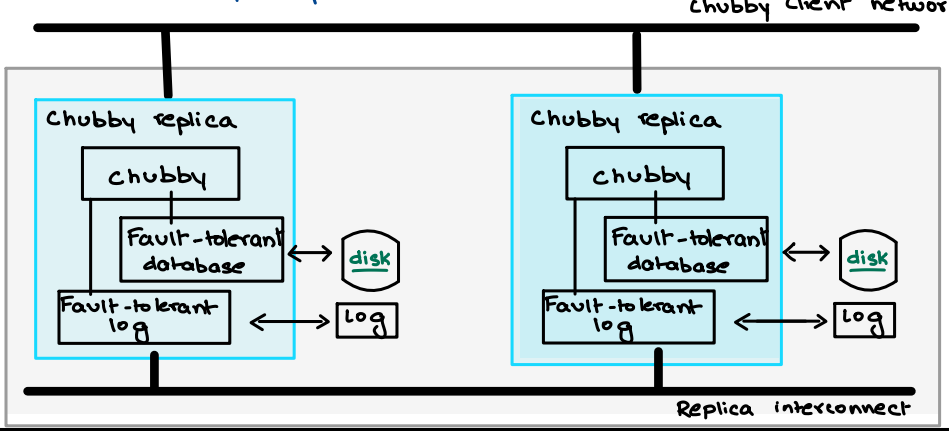
* Each chunk server is a commodity Linux system; it receives instructions from the master & responds with status info.
* To access a file, an app^n sends to the master the filename & the chunk index, the offset in the file for the read/write operation; the master responds w/ the chunk handle & the location of the chunk.

LOCKS & CHUBBY

- Locks enable controlled access to shared storage & ensure atomicity of read & write operations.
- A chubby cell typically serves 1 data center.
- The cell server includes several replicas.
- To reduce the probability of correlated failures, the servers hosting replicas are distributed across the campus of a data center.
- The replicas use a distributed consensus protocol to elect a new master when the current one fails.
- Clients use RPCs to request services from the master.
- The files & directories of the Chubby service are organized in a tree structure.



Chubby replica architecture



PAXOS ALGO

- It is used to reach consensus on sets of values. To ensure that the Paxos algo succeeds in spite of the occasional failure of a replica, the following 3 phases of the algo are executed repeatedly.

① Elect a replica to be the master/coordinator.

↳ When a master fails, several replicas may decide to assume the role of a master.

↳ To ensure that the result of the election is unique, each replica generates a sequence no. larger than any sequence no. it has seen & broadcasts it in a purpose message.

↳ The replicas that haven't seen a higher sequence no. broadcast a promise reply & declare that they will reject proposals from other candidate masters.

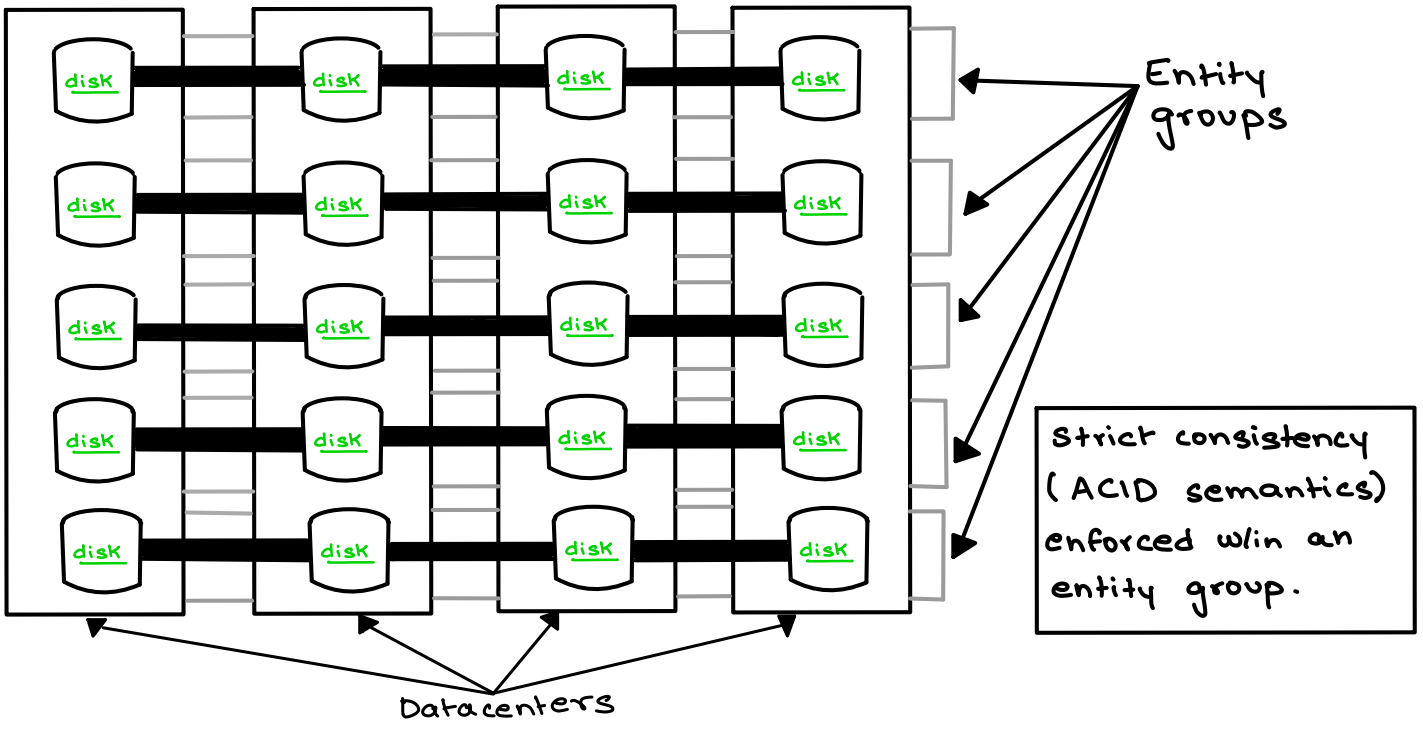
↳ If the no. of respondents represents a majority of replicas, the one that sent the purpose msg is elected master.

② The master broadcasts to all replicas an accept message, including the value it has selected, & waits for replies — acknowledge / reject.

③ Consensus is reached when the majority of the replicas send an acknowledge msg; then the master broadcasts the commit msg.

MEGASTORE

- It is scalabe storage for online services.
- The system, distributed over several data centers, has a very large capacity & it is highly available.
- The basic design philosophy of the system is to partition the data into entity groups & replicate each partition independently in data centers located in different geographic areas.
- Megastore supports only those traditional DB features that allow the system to scale well & that don't drastically affect the response time.
- It uses Paxos consensus algo to replicate primary user data, metadata, & system configuration info across data centers & for locking.
- The entity groups are app^n-specific & store together logically related data.
- The data model is declared in a schema consisting of a set of tables composed of entries, each entry being a collection of named & typed properties.
- A Megastore table can be a root or a child table.

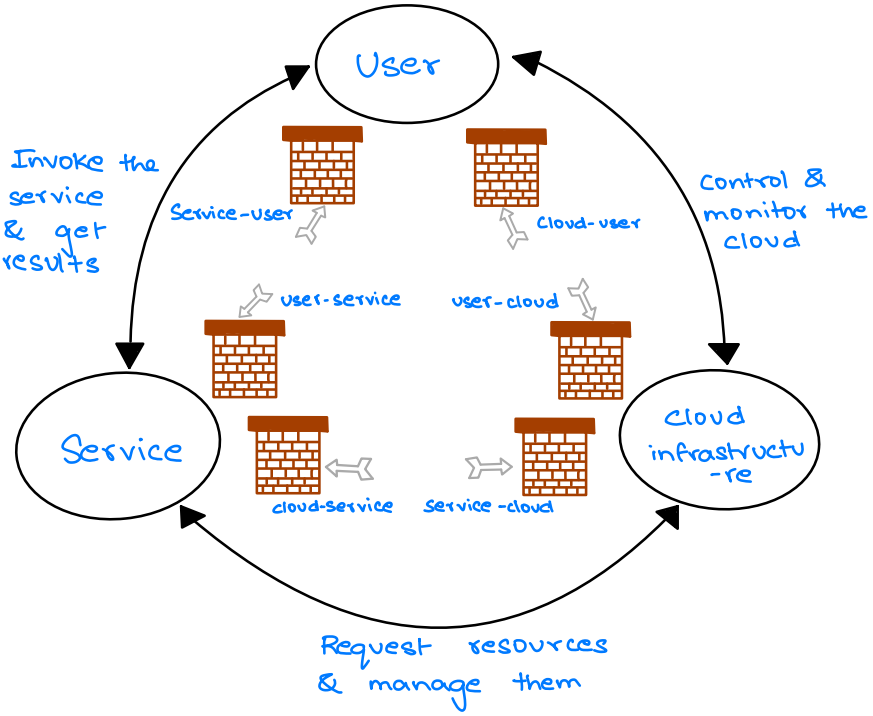


Strict consistency (ACID semantics) enforced w/in an entity group.

CLOUD SECURITY RISKS

- Classes of risk — traditional threats, threats related to system availability, & threats related to 3rd-party data control.
- **Traditional threats** begin at the user site. The user must protect the infrastructure used to connect to the cloud.
- The next threat is related to the authentication & authorization process.
- Moving to the cloud, there are many types of traditional attacks — DDoS, phishing, SQL injection.
- **Availability of cloud services** is another concern. System failures, power outages & other catastrophic events could shut down cloud services for long periods of time.
- **3rd-party control** generates concerns caused by the lack of transparency & limited user control.

SURFACE OF ATTACKS IN A CC ENVIRONMENT



- The 3 actors involved in the model considered are — the user, the service, & the cloud infrastructure.
- There are 6 types of attacks possible.
- The user can be attacked from 2 directions: from the service & from the cloud.
  - from the cloud: spoofs that originate from the cloud infrastructure
  - from the service: SSL certificate spoofing, attacks on browser caches, phishing
- The service can be attacked from the user & from the cloud.
  - from the user: Buffer overflow, SQL injection, privilege escalation
  - from the cloud: Limiting access to resources, privilege-related attacks, data distortion, injecting additional operations
- The cloud infrastructure can be attacked by a user who targets the cloud control system.
- The " " may also be targeted by a service requesting an excessive amount of resources & causing the exhaustion of resources.

SECURITY, PRIVACY & TRUST

① SECURITY

- Security is the top concern for cloud users, who are accustomed to having full control of all systems on which sensitive info is stored & processed.
- Major user concerns are unauthorized access to confidential info & data theft.
- Data is more vulnerable in storage than while it is being processed.
- Threats during processing can originate from flaws in the VMM, rogue VMs, or a VMBR.
- The next concerns regard user control over the life cycle of data. It is virtua-lly impossible for a user to determine whether data that should have been deleted is actually deleted.
- Lack of standardization is another concern. Today there are no interoperability standards.

② PRIVACY

- The term privacy refers to the right of an individual, a group of individuals, or an organization to keep info of a personal or proprietary nature from being disclosed to others.
- Our discussion targets primarily public clouds where data, often in an encrypted form, resides on servers owned by a CSP.
- The owner of the data cannot rely exclusively on the CSP to guarantee the privacy of data.
- The main aspects of privacy are — the lack of user control, potential unauthorized secondary use, data proliferation, & dynamic provisioning.
- A CSP may obtain revenues from unauthorized secondary usage of info, eg — for targeted marketing.

③ TRUST

- It means "assured reliance on the character, ability, strength, or truth of someone or something."
- 2 conditions must exist for trust to develop:
  - ↳ Risk — the perceived probability of loss.
  - ↳ Interdependence — the idea that the interests of 1 entity cannot be achieved without reliance on other entities.
- A trust relationship goes through 3 phases:
  (1) a building phase — trust is formed.
  (2) a stability " — when trust exists.
  (3) a dissolution " — " " declines
- The Internet offers individuals the ability to obscure or conceal their identities.
- The resulting anonymity reduces the cues normally used in judgements of trust.
- Policies & reputation are 2 ways of determining trust.

THREATS IDENTIFIED BY THE NIST PROJECT

VMM-Based threats:

① **Starvation of resources** & **denial of service** for some VMs.
Probable causes — badly configured resource limits, rogue VM w/ the capability to bypass resource limits set in the VMM.

② **VM side-channel attacks** by a rogue VM under the same VMM.
Probable causes — lack of proper isolation of inter-VM traffic due to misconfiguration, limitation of packet inspection devices, presence of VM instances built from insecure VM images.

③ **Buffer overflow attacks.**

VM-Based threats:

① **Deployment of rogue or insecure VM.**
Probable cause — improper config of access controls on VM admin tasks.

② **Presence of insecure & tampered VM images** in the **VM image repository**
Probable causes — lack of access control to the VM image repository, lack of mechanisms to verify the integrity of the images.