CSE 803

Introduction to Distributed Computing

3 Credit

Ashraful Haiday Sir

Term Test 3 টি (Best 1 count)

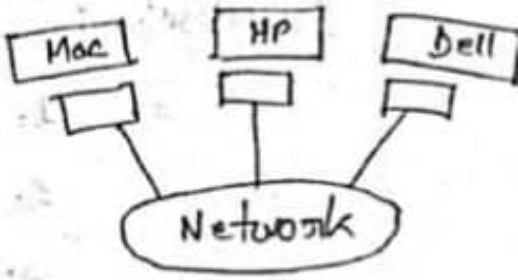
Class: 01
23 May 202

Introduction to Distributed Computing

Definition: A distributed system is a collection of autonomou on independent computer interconnected with network capable of collaborating on a task based on distributed softwa

Component:

1. Network
2. Software
3. Middleware



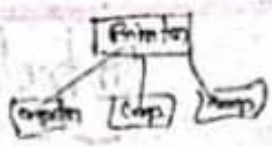
Features:

1. Heterogeinity
2. Increased performance
3. Concurrency
4. Access to remote data
5. Scalability
6. Openness
7. Fault tolerance

* No common physical clock enhanced reliability.
* Increased cost ratio
* Access to geographically remote data & resources.

Example: telephone, mobile computing
computer network such as internate
ATM machine

Advantage :



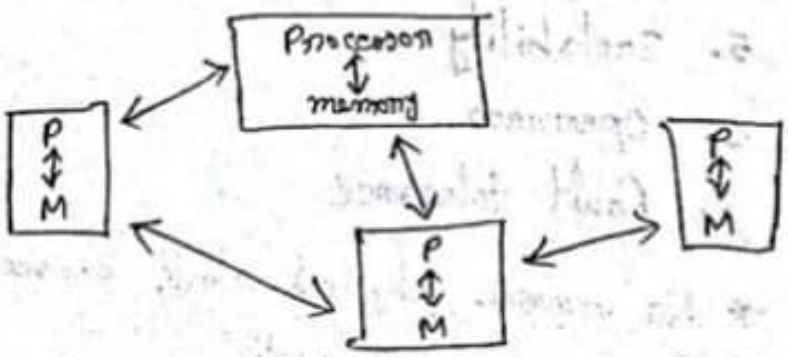
1. Information sharing
2. Resource sharing
3. Shorter response time
4. Higher output
5. Scalability
6. Transparency (স্বচ্ছতা)
7. Higher reliability
8. Better flexibility (৪) Better price & performance ratio

T.T. - 1

Drawbacks :

1. Developing distributed software
2. Networking problem
3. Security problem
4. Performance problem
5. Openness
6. ~~Scalability~~
7. Reliability and fault tolerance

Figure:



Question:

- What is Distributed System ? What is the advantage and disadvantage of it ? 2+4

* Distributed = ভাগ করা

* Computer network কি চারদিকে আকাশের network-এ ছড়িয়ে দেয়ার প্রক্রিয়াই হচ্ছে distributed computing.

* autonomous = independent

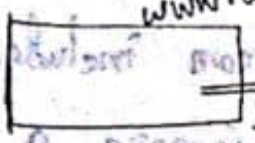
* Heterogeinity → network এর অন্তর্ভুক্ত computer গুলো same model এর থাকা বাধ্যতামূলক নয়।
Software & hardware same না হলেও চলে।

* Concurrency → একই সাথে অনেকগুলো কাজ করা সম্ভব।

* Scalability → মাপযোগ্যতা (ইচ্ছে করলে network এর সংখ্যা কিছুটি/বাড়াতে পারা।)

* Fault tolerance → কোন একটা network-এ fault হলে পরের বাকি network তা সহ্য করবে, কোন effect করবে না।

* Security problem → denial of service এর মাধ্যমে।



যদি hacker একসাথে 300 জন user তুলে একই website কাজ করে না, hold হয়ে যায় এটাই security problem। এটা হল denial of service এর মাধ্যমে।

* Scalability :→ অনেকগুলো network add দিয়ে procedure slow হয়ে যাবে।

Monday

(Another Part) :-

Parallel System: A ~~parallel~~ system is said to be a parallel system in which multiple processor have the direct access to a shared memory. This forms a common address space.

→ Generally used tightly coupled system.
→ Use more than two processor. (more)
→ Can process the data simultaneously.
→ Applications are running on multiple computers linked by communication bus.

(I.T-1)

→ Tightly coupled systems.
→ Low flexibility.
→ High dependency.

(Extra) • Parallel systems deal with the simultaneous use of multiple computer resources that can include a single computer with multiple processors, a number of computers connected by a network to form a parallel processing cluster or a combination of both.

Figure:

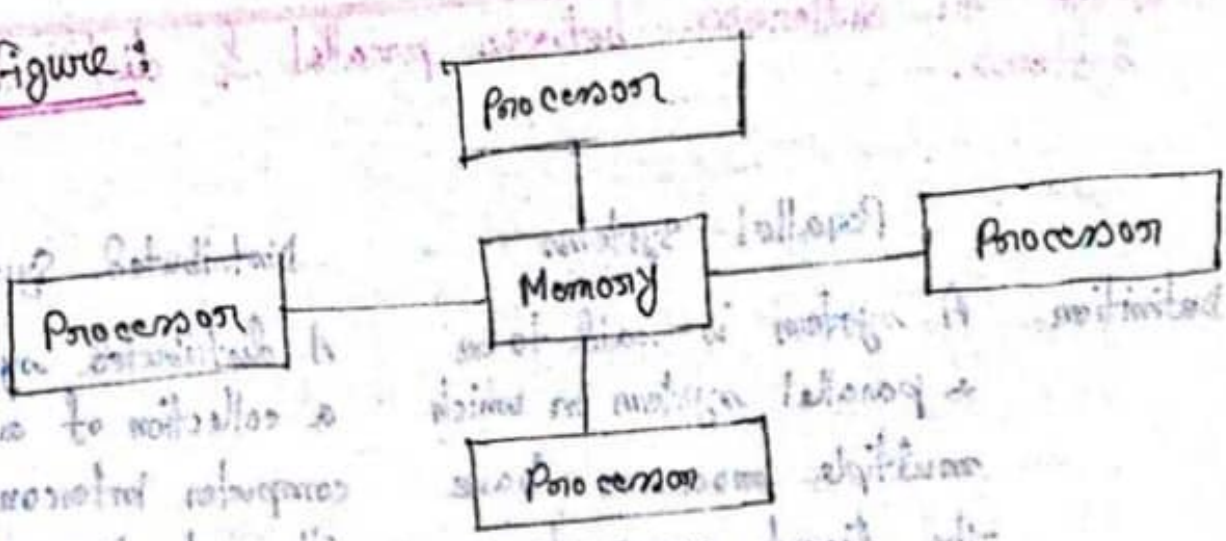


fig: Parallel system

Example:

1. Solving mathematical problem.
2. Super computer.
3. Terminals connected to single server.

** Advantage:

1. Provide concurrency
2. Memory constrain
3. Save time.
4. Can calculate complex things.
5. Taking advantage of non local resources
6. Cost saving
7. User friendly

* Disadvantages

① Lack of scalability between memory & CPU.
② Programmer responsibility for synchronization.
③ Difficult & expensive to design & produce shared memory.
④ Low flexibility.

T.T-1

* Write the difference between parallel & distributed systems. — 5

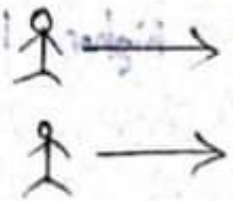
	Parallel Systems	Distributed Systems
Definition	A system is said to be a parallel system in which multiple processors have the direct access to a shared memory.	A distributed system is a collection of autonomous computer interconnected with network capable of collaborating on a task based on distributed software.
Memory	Tightly coupled system shared memory.	Loosly coupled system distributed memory.
Control	Global clock control	No global clock control.
Main focus	Performance Scientific computing.	Performance (cost and scalability) Reliability/ availability Information/ resource sharing.
	Homogeneous	Heterogeneous
	Parallel systems ~~supports~~ have various protocols for instance Gemini and Ethernet etc.	Distributed systems usually support to protocols like Ethernet.

	Parallel systems do not support fault tolerance.	Distributed systems are fault tolerant.
	Parallel systems supports both high level abstraction & low level abstraction but commonly they have low level abstraction.	Distributed systems has higher level of abstraction.
	Memory usage of parallel systems are lower.	Memory usage of distributed systems is higher.
	Occurs in a single computer.	Involves multiple computers.
	Multiple processors execute multiple tasks at the same time.	Multiple computers perform tasks at the same time.
	Processors communicate with each other using a bus.	Computers communicate with each other via the network.

Example

Parallel System:

- একসাথে একটি সমস্যার ভিন্ন ভিন্ন লোক একটি problem solve করে।



- Hardware & Software একসাথে tightly interconnected থাকে।
- Hardware & Software এর dependency বেশি থাকে।
- Scientific কাজে Parallel System (P.S) use করা হয়।
- Calculator, Super Computer-এ use করা হয়।
- Which one is more effective?

→ Between parallel & distributed system, distributed system is more effective.
(Advantages গুলো সামনে এর সিরিজে)

Parallel computing provides concurrency & saves time & money. In distributed, a single task is divided among different computer, where in parallel, multiple processor perform multiple task.

* What is Moore's law?

Moore's Law : Prediction by Gordon Moore that the number of transistors in an integrated circuit doubles approximately every 18 ~~year~~ month.

Commonly described as performance doubling every 18 months because of faster transistors & more transistors per chip. The good use of increasing number of transistor is to increase the width as : 4 bit > 8 bit > 16 > 32 > 64

(প্রতিবার computer / microprocessor এর component সংখ্যা double হয়ে যাচ্ছে)

~~12 month → Double~~

18 month → Double

2 bit < 4 bit < 8 bit < 16 bit

Fundamental limit of the speed of a processor —

- Power wall
- Latency

* microprocessor এর chip গুলোর scalability যদি সমান না হয়, তাহা Power wall.

Power wall:

- The "power wall" refers to the difficulty of scaling the performance of computing chips and systems at historical levels, because of fundamental constraints imposed by affordable power delivery & dissipation.

** Power wall & latency wall indicate the era of single thread performance improvement. more transistor on a chip are now applied to increase throughput system.

Latency:

- Latency is the time it takes for data to pass from one point on a network to another.

- Suppose server A in New York sends a data packet to server B in London. Server A sends the packet at 04:38:00.000 GMT and server B receives it at 04:38:00.145 GMT. The amount of latency on this path is the difference between these two times: 0.145 seconds or 145 milliseconds.

- Most often, latency is measured between a user's device (the "client" device) and a data center.

Model:

1. Architecture System model
   - Client server
   - Peer to peer (P2P)

2. Interconnection model
   - Synchronous
   - Asynchronous

3. Fault model

4. Security model.

27/06/2022

Hardware Models

Categories of Distributed Computing System Model :-

1. Minicomputer model.
2. Workstation model.
3. Workstation - server model.
4. Processor - pool model.
5. Hybrid model (merged model)

1 # Mini Computer Model :

- The minicomputer model is a simple extension of the centralized time-sharing system.
- This model consists of a few minicomputers interconnected by a communication network.
- Each minicomputer usually has multiple users simultaneously logged on to it.
- Each user is logged on to one specific minicomputer, with remote access to other minicomputers.
- Network allows a user to access remote resources.

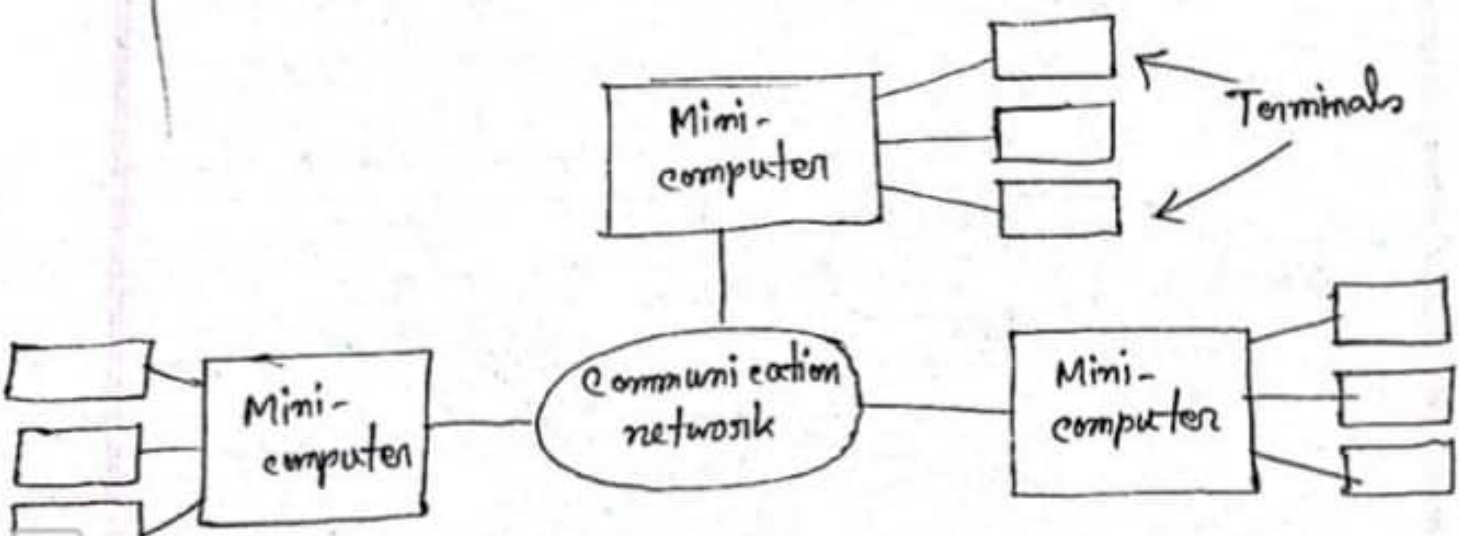


fig : Mini-computer model

- একটা communication network এর মাধ্যমে অনেকগুলো ছোট ছোট computer connected থাকলে।
- এই communication network এর নাম "Orpanet".
- Resource sharing এর কাজে এই model use হয়।

Workstation Vs Server:

Server: Servers are software & hardware that store data, manage network resources, & fulfill client requests.

Example: FTP, web, application, mail, proxy etc.

(Server হলো একটা hardware বা software যেটা data store করে রাখে। Client যখন request করে, server সেটা provide করে। i.e. - server থেকে movie download নেয়া।

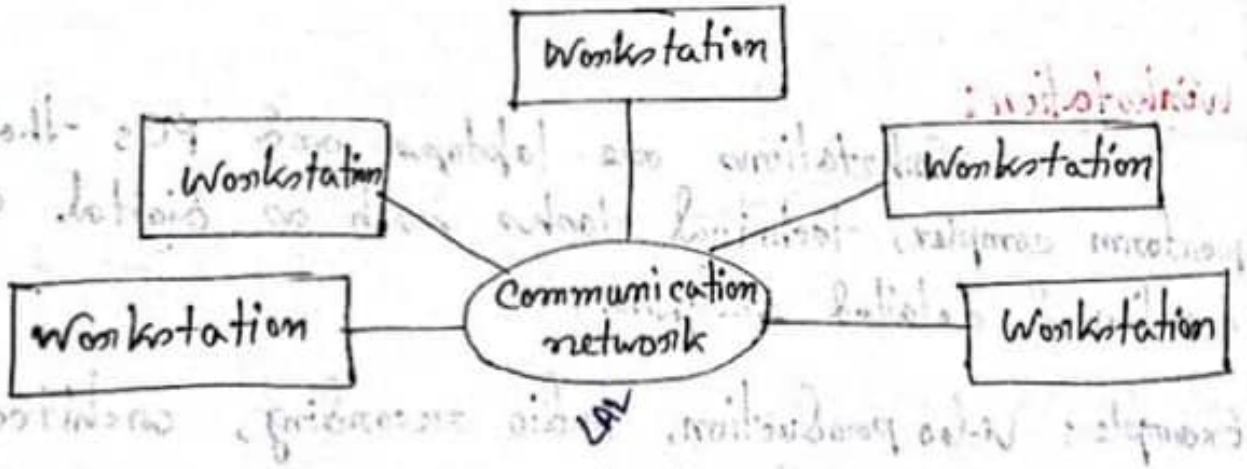
Workstation:

Workstations are laptops and PCs that quickly perform complex, technical tasks such as digital content creation & detailed analysis.

Example: Video production, audio recording, architecting, engineering, database management, etc.

2| Workstation Model:

- Consists of several workstations interconnected by a communication network.
- Each workstation is equipped with its own disk and serves as a single-user computer.
- Example: Diskful, Diskless.
- "IDEA" interconnect all these workstations by a high-speed LAN so that idle workstations may be used to process jobs of users who are logged onto other workstations and do not have sufficient processing power at their own workstation to get their jobs processed efficiently.



- একটা network এর সাথে অনেকগুলো Laptops/pc connect থাকে।
- এই laptop গুলোতে disk থাকতেও পারে, নাও থাকতে পারে।
- বর্তমানে diskless টা জনপ্রিয় বেশি। (Google drive, Amazon web server)

অবশ্যই PC-এর same configuration না!

* চারটা রুমে চারটা laptop নিয়ে চারটা workstation set করছি। এখন যদি ২ জন break নেয়, বাকি ২ জন কাজ করতেছে, তখন CPU টা use করে না। CPU time টা waste হয়। এটা এর drawbacks।

* একটা PC এর configuration high, একটার খুব low! low PC টা high range এর কাজ (Graphics related) করতে পারছে না। তাকে high range এর PC (থেকে সাহায্য) নিতে হবে। অর্থাৎ এটা complex জিনিস এবং time consuming। এই ধারণা থেকে workstation model এসেছে।

* এখানে প্রত্যেকটা workstation একটা communication network এর মাধ্যমে connected থাকবে। এই network কে বলে LAN (Local Area Network)।

* একটা PC থেকে অন্য PC তে কাজ করা যায়।
* File টা use হবে যেখানে main source সেখানে।
* এটা শুধু workstation related।

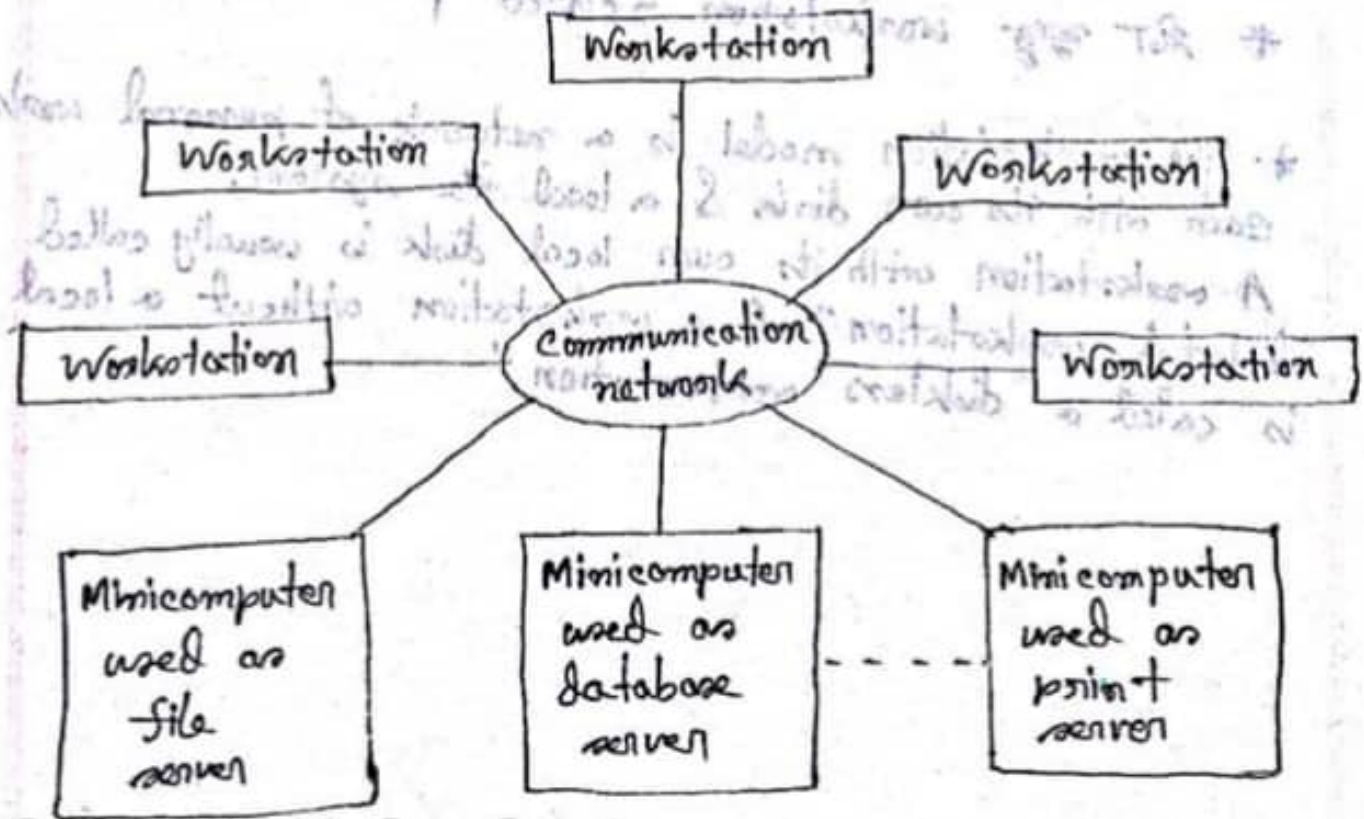
* The workstation model is a network of personal workstations, each with its own disk & a local file system.
A workstation with its own local disk is usually called a "diskful workstation" & a workstation without a local disk is called a "diskless workstation."

Exam / Viva

3| The Workstation - Server Model :-

- Workstation - server model consists of a few minicomputers & several workstations interconnected by a communication network.
- One or more of the minicomputers are used for implementing the file system. Other minicomputers may be used for providing other types of services, such as database service & print service.
- Normal computation activities required by the user's processes are performed at the user's home workstation, but requests for services provided by special servers (such as a file server or a database server) are sent to a server providing that type of service that performs the user's requested activity & returns the result of the request processing to the user's workstation.

T.T.-1

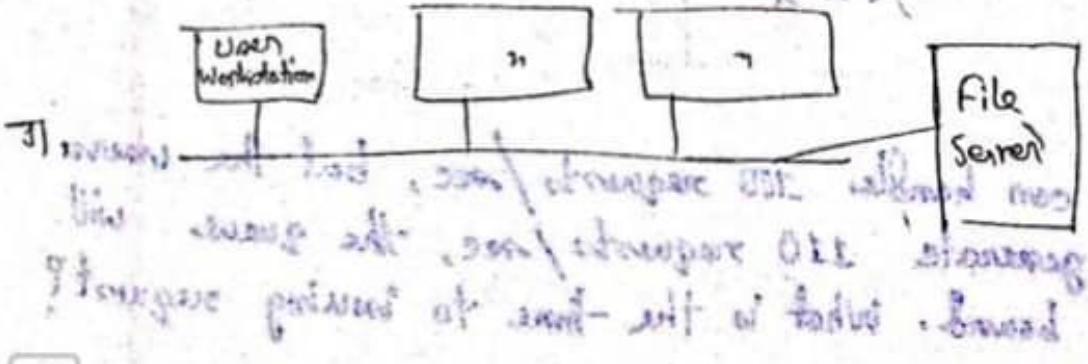


* Describe workstation-server model of a distributed system. — 15

Advantage :

1. Diskless workstations are cheap, quiet, & easy to maintain
2. High reliability & scalability.
3. Backup and Hardware maintenance are easier to perform
4. Newly released software is easily installed.
5. Facilitates user mobility.

- এই model-এ PC, hardware/software (store করার ক্ষমতা) এর পরিপ্রেক্ষিতে কিছু minicomputers এবং একটি communication network এর মাধ্যমে interconnected থাকে
- কিছু minicomputer use হয় file implement করার জন্য,
- বাকি " " service provide করার জন্য,
(i.e – database, print)
- Server থেকে কোন কিছু পেতে চাইলে তখন workstation server model বলে।
- এই server গুলো related।
- The wo



4. The Processor Pool Model :-

- The processor pool model consists of multiple processors and groups of workstations.
- It consists of large microcomputers & minicomputers attached to the network.
- The model is based on the observation that most of the time a user does not need any computing power, all processing is done by the processor bank.
- Each processor has its own memory to load & run.
- The main argument for the processor pool model comes from "queuing theory".

T.T.-1

- If the average number of requests per second to a system is λ and it can process μ requests per second then it can be proven that the mean time between issuing a request & getting a complete response, T, is related to λ and μ by the formula :-

$$T = \frac{1}{\mu - \lambda}$$

If the server can handle 100 requests/sec, but the users continuously generate 110 requests/sec, the queue will grow without bound. What is the time to issuing request?

Solution:- We know,

$$T = \frac{1}{\mu - \lambda}$$

$$= \frac{1}{110 - 100}$$

$$= \frac{1}{10}$$

$$= 0.1$$

Here,
μ = 110 requests/
λ = 100 requests/
T = ?

$T = \frac{1}{100 - 110}$

$= -0.1$

Queuing Theory :-

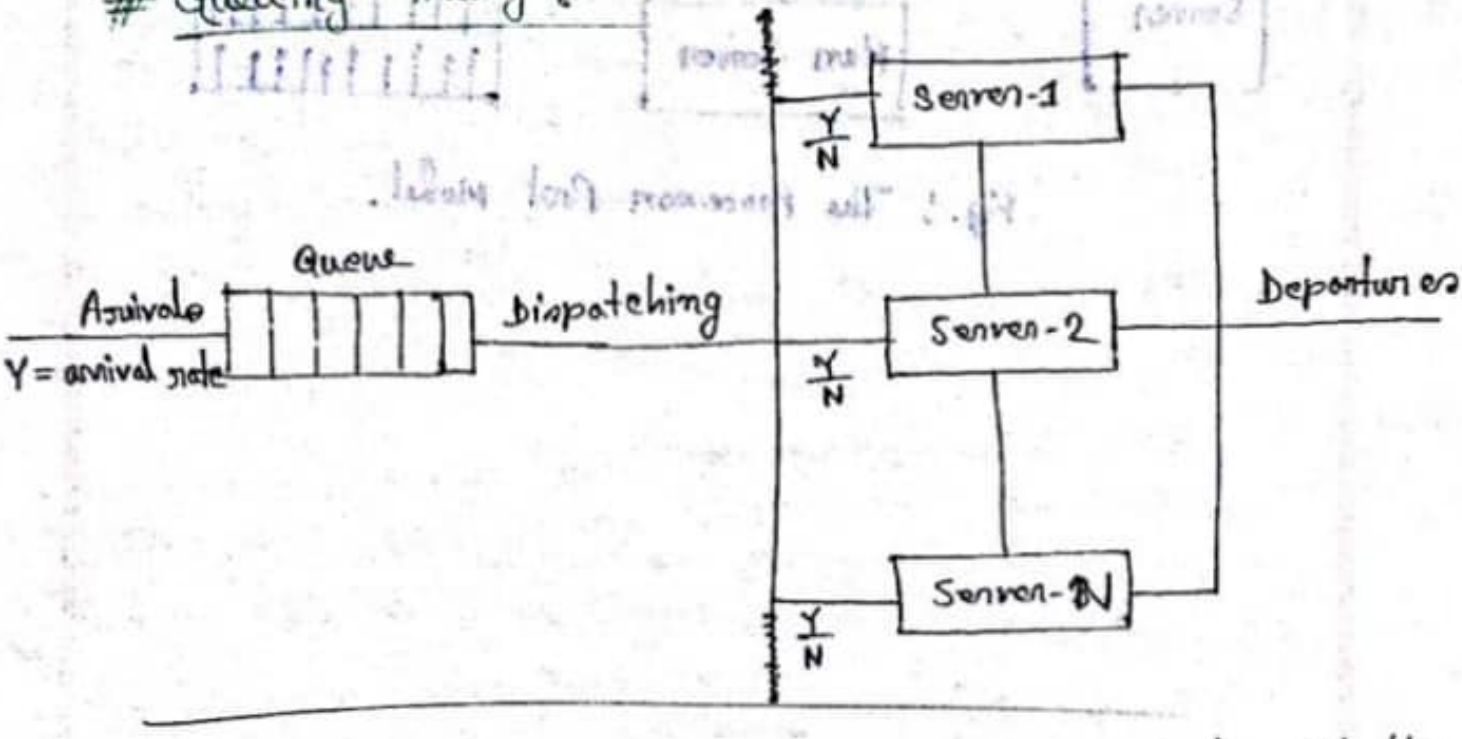


Fig. Queuing system.

A processor pool model consist of a bank of CPUs each with its own local memory of operating with shared memory. In this model all processing is done by the processing model.

It comes from the queuing theory.

λ = number of request/sec
μ = process request/sec
T = Time between request and process

Then, $T = \frac{1}{\mu - \lambda}$

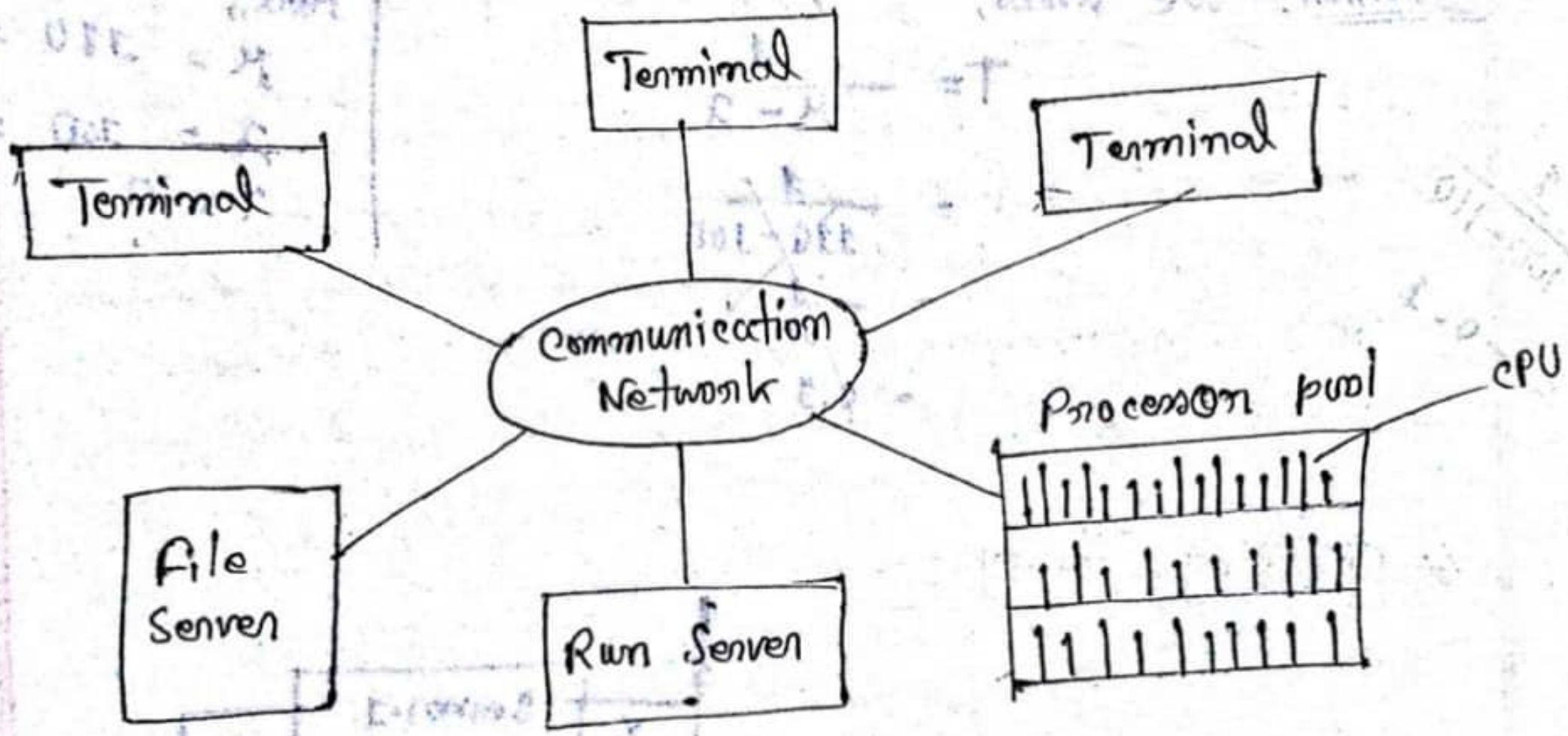


Fig.: The Processor Pool Model.

#Which model is Best?

→ The choice depends on the nature of the workload. If the primary use of the system is for resource sharing or supporting integrated personal productivity applications, or providing fault tolerance then the 'workstation model' is more suited.

→ We mostly used the 'workstation server model', a large number of computer users only perform simple interactive tasks such as editing jobs, sending electronic mails, and executing small programs.

→ But for high computation 'processor pool' is suitable.

The most widely used model for building distributed computing systems is a workstation - server model. The reason behind is that a large number of - - - - -

* Workstation-server model is more popular than the workstation model for building distributed computing systems.

* Depends on nature of workload. Algorithm with large amount of parallism such as simulations and then parallel. If the use of it for resource sharing then distributed. A hybride based on the both model may be suitable solutions.

29 June 2022

Lecture: 04

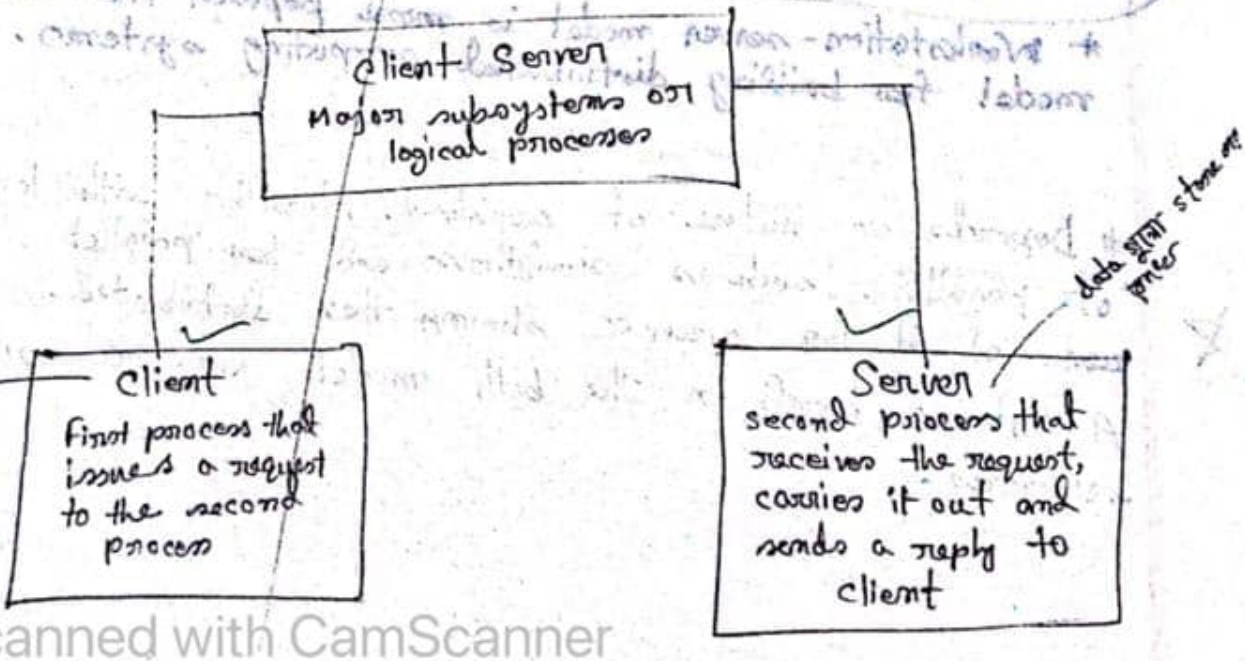
Parallel & Distributed Computing

Various software architectures exist that are usually used for distributed computing. At a lower level, it is necessary to interconnect multiple CPUs with some sort of network, and cables. At a higher level, it is necessary to interconnect processes running on these CPUs with some sort of communication system & execution environment.

Software Architecture :- Explain different type of architecture.

1| Client-Server Architecture :

- Most common distributed system architecture which decomposes the system into two major subsystems or logical processes.
- In this architecture, the application is modeled as a set of services that are provided by servers and a set of clients that use these services. The servers need not know about clients, but the clients must know the identity of the servers.



How works :- কীভাবে কাজ করে : — ৩ টি Portion এ কাজ করে, যেমন

Service

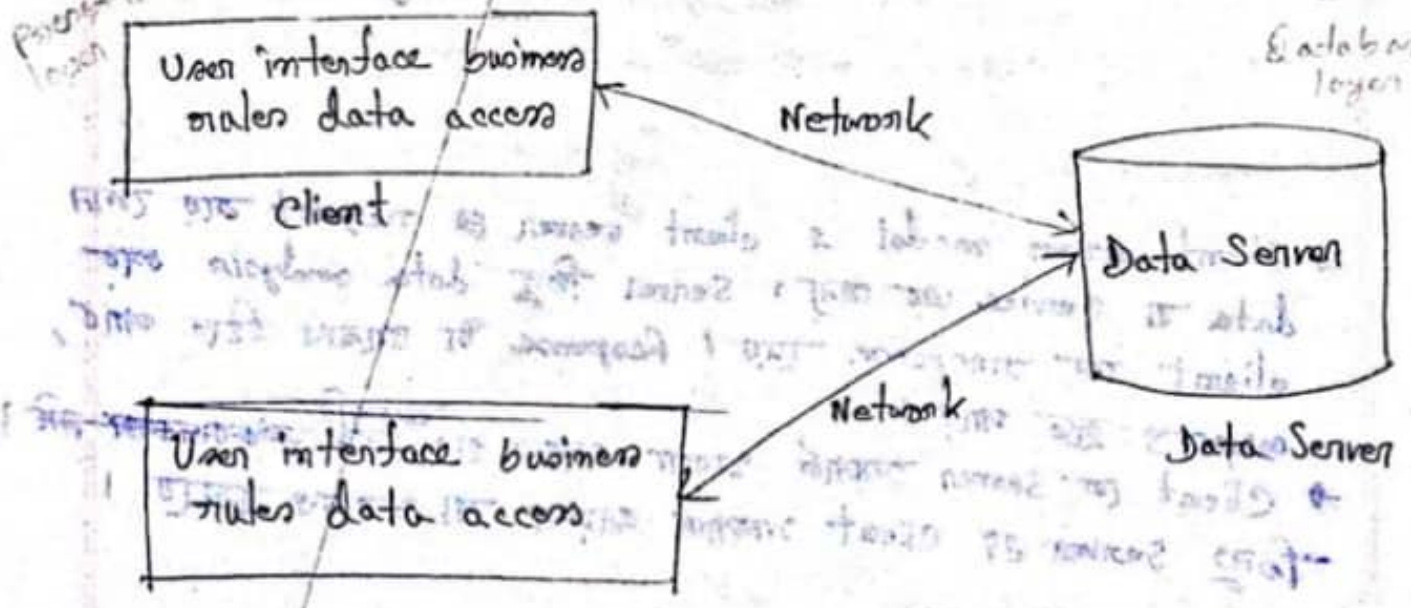
- Provides services through an interface.
- Forms queries by translating user input to server operation

Response

- Responds to requests by returning expected results to the client.
- Initiates communication with the server.

Mitigate:

- Performs data analysis on results and displays them to the user.
- Hides implementation & complexity of service functions



~~2-Tier~~

Fig.: 2-Tier client Server Architecture.

2-Tier = দুই level (client level & server level)

Merits & Demerits :-

Advantages :-

① Provides services through an 'interface'. Forms queries by translating user input to server operations.

② Simplifies the design & the development.

③ Easy to migrate or integrate existing applications.

Disadvantages :-

① Responds to requests by returning expected results to the client. Initiates communication with the server.

② Security complications.

③ Limited server availability & reliability.

* client-server model এ client server কে request করে কোন data বা service এর জন্য। Server তিনি data analysis করে client কে response দেয়। Response টা তখনই হবে যখন, client থেকে request আসে।

* client কে server সবসময় খোলা থাকতে হবে কিন্তু server এ client সবসময় খোলা না থাকলেও চলবে।

2] Multi-Tier Architecture :-

- Like client-server but function physically separated.
- Multi-tier architecture is a client-server architecture in which the functions such as presentation, application processing, and data management are physically separated.
- By separating an application into tiers, developers obtain the option of changing or adding a specific layer, instead of reworking the entire application.
- It provides a model by which developers can create flexible and reusable applications.
- The most general use of multi-tier architecture is the three-tier architecture. A three-tier architecture is typically composed of a presentation tier, an application tier, and a data storage tier and may execute on a separate processor.

- Diagram :

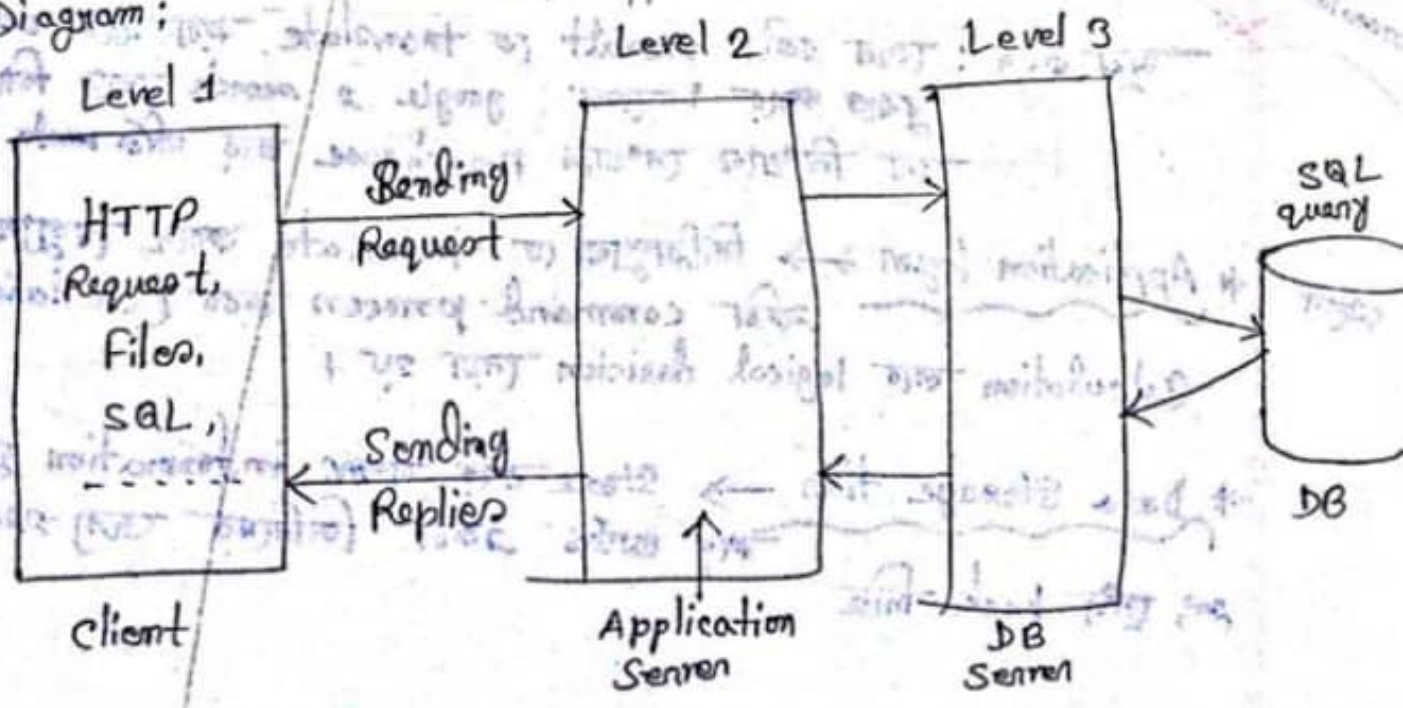


fig. : 3 Tier Architecture.

Advantages :-

- Better performance than client server.
- Enhances the reusability and scalability.
- Provides maintainability & flexibility.

Disadvantages :-

- Unsatisfactory Testability due to lack of testing tools.
- More critical server, limited server availability and reliability.

* layer গুলো separated থাকলে ঐ জিনিসটিকে reuse না করে নতুন করে change করে alter করতে পারবো।

* Presentation Tier → কোন একটা application এর সবচেয়ে উপরের অংশ যেটি user access করতে পারে।

translate

মূল কাজ : কোন একটা result কে translate করা যাতে user সহজে বুঝতে পারে। যেমন : google এ search করতে গিয়ে বানান ভুল লিখলে সেখানে paraphrase করে সঠিক words suggest করে।

* Application layer → জিনিসগুলো যে translate করে সেগুলো দ্বারা একটা command process করে (calculation করার জন্য) Calculation করে logical decision নেয়া হয়।

* Data Storage tier → store করে, এখানে information গুলো retrieve করে অর্থাৎ একটা জিনিসের জন্য request করলে, তখন back দিবে

Advantages :-

- Better performance than client server.
- Enhances the reusability and scalability.
- Provides maintainability & flexibility.

Disadvantages :-

- Unsatisfactory Testability due to lack of testing tools.
- More critical server, limited server availability and reliability.

* layer গুলো separated থাকলে ঐ জিনিসটিকে reuse না করে নতুন করে change করে alter করতে পারবো।

* Presentation Tier → কোন একটা application এর সবচেয়ে উপরের অংশ যেখানে user access করতে পারে।

translate

মূল কাজ : কোন একটা result কে translate করা যাতে user সহজে বুঝতে পারে। যেমন : google এ search করতে কিছু বানান ভুল লিখলে সেখানে paraphrase করে সঠিক words suggest করে।

প্রসেস

* Application layer → জিনিসগুলো যে translate করছে সেগুলো থেকে একটা command process করে (calculation করার জন্য) Calculation করে logical decision নেয়া হয়।

* Data Storage tier → Store করে রাখে information গুলো retrieve করে অর্থাৎ একটা জিনিসের জন্য request করা হলে, তখন back দিবে

Advantages:-

- Better performance than client server.
- Enhances the reusability and scalability.
- Provides maintainability & flexibility.

Disadvantages:-

- Unsatisfactory Testability due to lack of testing tools.
- More critical server, limited server availability and reliability.

* layer গুলো separated থাকলে ঐ জিনিসটিকে reuse না করে নতুন করে change করে alter করতে পারবো।

* Presentation Tier → কোন একটা application এর সবচেয়ে উপরের অংশ যেটি user access করতে পারে।

translate

মূল কাজ : কোন একটা result কে translate করা যাতে user সহজে বুঝতে পারে। যেমন : google এ search করতে গিয়ে বানান ভুল লিখলে সেখানে paraphrase করে সঠিক words suggest করে।

* Application layer → জিনিসগুলো যে translate করে সেগুলো ক্রমে একটা command process করে (calculation করার জন্য) Calculation করে logical decision নেয়া হয়।

* Data Storage tier → Store করে এবং information গুলো retrive করে অর্থাৎ একটা জিনিসের জন্য request আসলে, তখন back দিবে

(3) Cluster :-

- Group of loosely coupled computers.
- A group of machines that are virtually or geographically separated and that work together to provide the same service or application to clients.
- More precisely, a group of two or more computers, or nodes, that run in parallel to achieve a common goal.
- Clusters are commonly connected through fast local area networks. (LAN)
- Clusters are usually deployed to improve speed and/or reliability over that provided by a single computer.
- Figure :

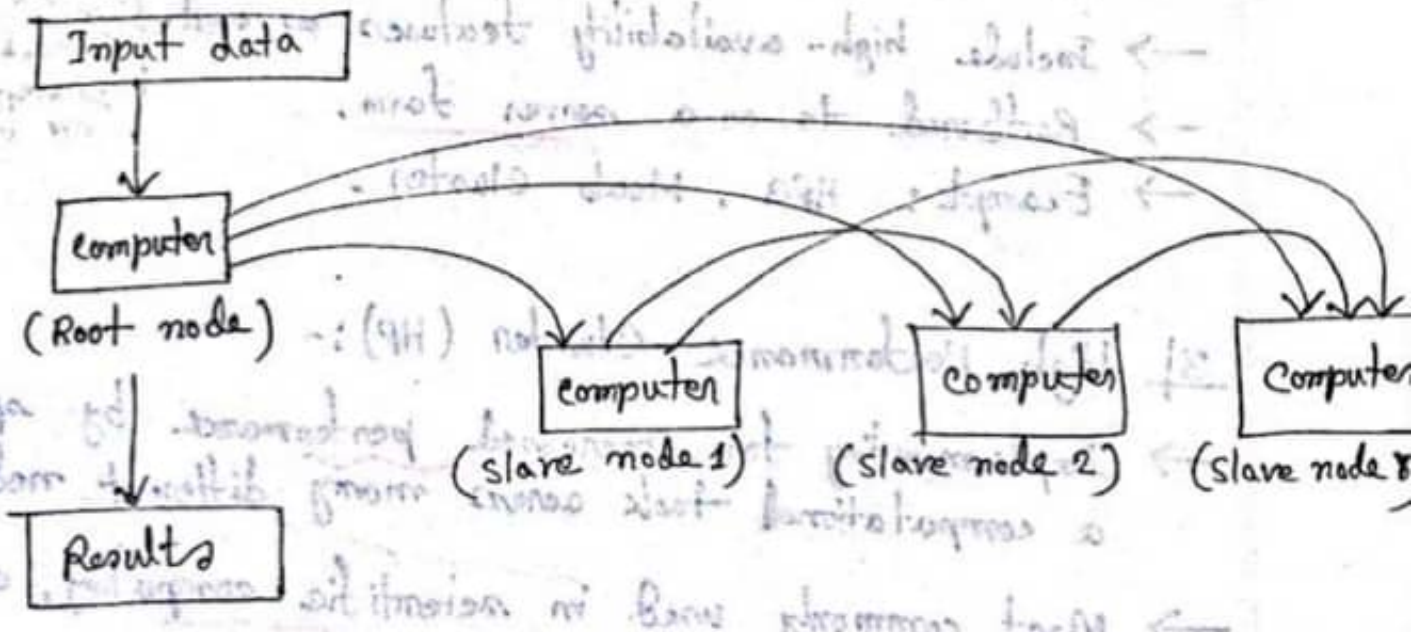


Fig. : Cluster

⁂ Types of Cluster :-

1| High Availability cluster (HA):

→ Implemented primarily for improving the services.
→ Operate by having redundant (extra) nodes, which are then used to provide service when system components fail.
→ Eliminate single points of failure.
→ Example: Linux-HA.

T.T.-1

2| Load Balancing cluster (LB):-

Balancing and sharing

→ Workload come through one or more load-balancing front ends, which then distribute it to a collection of back-end servers.
→ Include high-availability features as well.
→ Referred to as a server farm.
→ Example: HPC, Moab cluster.

frontend & backend पर workload balance करते हैं।

3| High Performance Cluster (HP):-

→ Implementing for increased performance by splitting a computational task across many different nodes.
→ Most commonly used in scientific computing, applications
→ commonly run custom programs.

* loosely coupled : কম্পিউটার কিছু hardware - software এর উপাদান বা component আছে, যেগুলো একে অপরের উপর খুব বেশি dependent না, তাই loosely coupled.

* Tightly coupled: hardware & software component গুলো strongly interconnected থাকে। তখন সেগুলো use করা বেশি flexible হয় না।

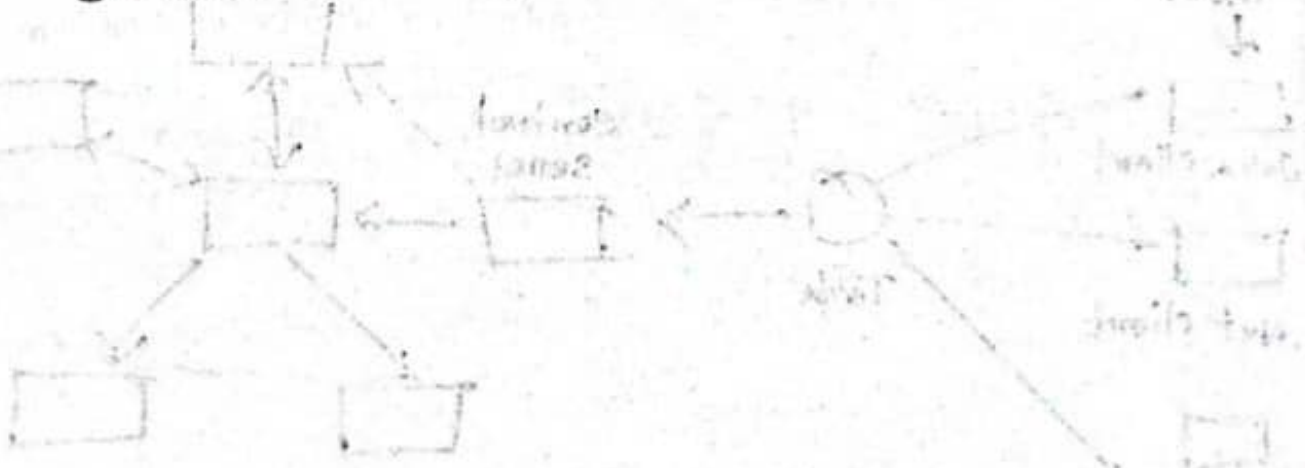
* Clustering হচ্ছে অনেকগুলো machine যেগুলো virtually separated থাকে কিন্তু একটি কাজ করার জন্য একসাথে কাজ করে।

* দুই বা ততোধিক computer যখন একই রকম কাজ করার জন্য একসাথে একই জায়গায় কাজ করে Ponallaly করে তাকে Clustering বলে।

* Clustering এ অনেক computer গুলো LAN এর মাধ্যমে connected থাকে।

* " তবে Grid কাছাকাছি।

* বিভিন্ন কাজের জন্য অনেক architecture আছে। তার overall নিচের কয়েক cluster & Grid আছে।

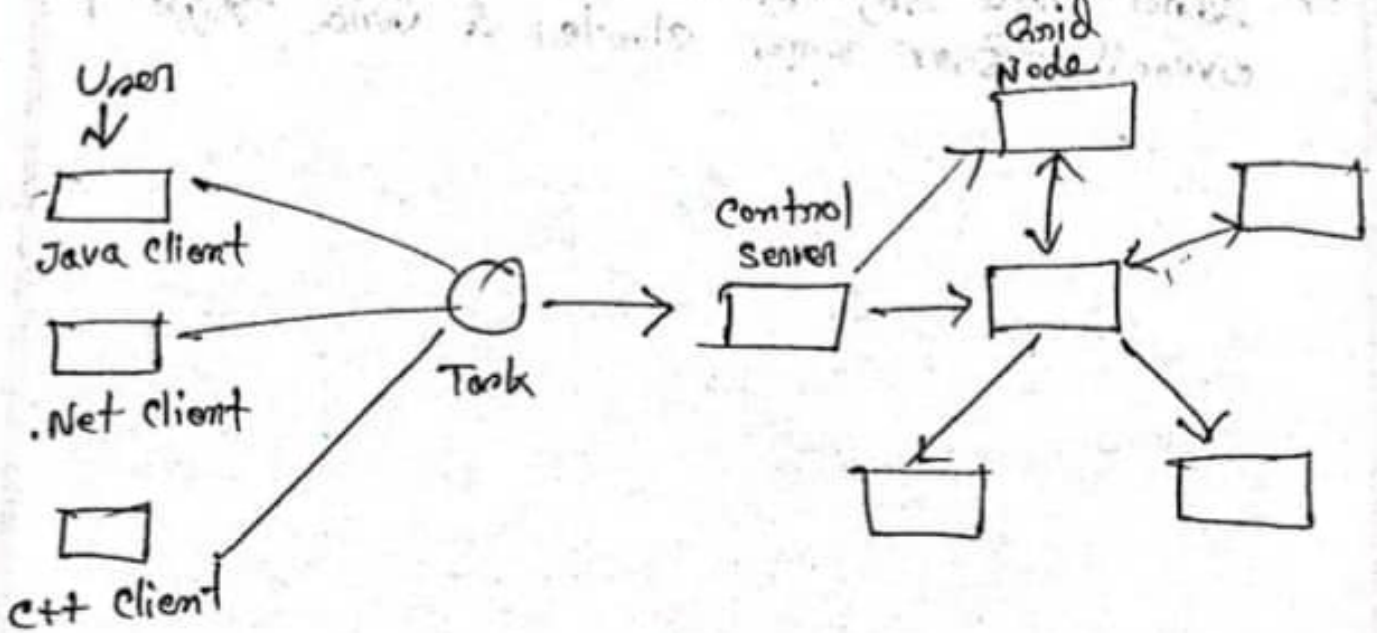


(4) Grid Architecture :/ cluster / computing

- Closely related to cluster where unique in Trust issue.
- In Grid, Multiple computers are connected by networks to accomplish a joint task.
- These tasks are computer-intensive & difficult for a single machine to handle. Several machines on a network collaborate under a common protocol & work as a single virtual supercomputer to get complex tasks done.
- This offers powerful visualization by creating a single system image that grants users & applications seamless access to IT capabilities.

* Clustering এর সাথে পার্থক্য হচ্ছে —
clustering এ একটা কাজ সবই জায়গা করে নেয়, কিন্তু Grid এ several কাজ several মানুষ জায়গা করে নেয়।

Diagram : How Grid computing works



(5) Peer to Peer :- (P2P)

- Relies on computing power & bandwidth of participants.
- ~~प्रकार~~ normal type ~~का~~ network architecture ~~में~~ ~~है~~ computer ~~को~~ communicate ~~करने~~ ~~के लिए~~ ~~आपस में~~ ~~सम्बन्ध~~ ~~साथ~~ ।
- Simple type of network where computers are able to communicate with one another & share what is on or attached to their computer with other users.
- It relies on the computing power & bandwidth of the participants.
- Such networks are useful for many purposes. Sharing content files containing audio, video, data or anything in digital format is very common, and real-time data, such as telephony traffic.
- A pure peer-to-peer network does not have the notion of clients or servers, & different from it.
- Important issue is 'Security'. Each computer on this type of network may allow or deny access to other computers, such as access to data & resources.
- ~~कुछ~~ resource ~~विशेष~~ ~~कंप्यूटर~~ ~~तक~~ ~~अन्य~~ ~~कंप्यूटर~~ ~~उपलब्ध~~ ~~नहीं~~ ~~होते~~ ।

T.1 2022

(6) Mobile Code :-

- Mobile code একটা program কে run করায়। এখন যদি Program টা migrate করতে চাই বা এক কম্পিউটার থেকে অন্য কম্পিউটারে স্থানান্তর করতে চাই, এক application থেকে অন্য application এ " " " object কে, সেই কাজটা করা হয় remotely mobile code এর মাধ্যমে।

- ~~Include sad~~
- Transfer করা হয় remote system এর মাধ্যমে। অর্থাৎ এক কম্পিউটারে বসে এক কম্পিউটারের data remotely অন্য কম্পিউটারে transfer করে, not physically.

T.T.-1

- Includes software from remote systems.
- Mobile code is the ability for running programs, code or objects to be migrated (or moved) from one machine or application to another.
- This is the process of moving mobile code across the nodes of a network as opposed to a distributed computation where the data is moved.
- Mobile code includes software obtained from remote systems, transferred across a network.
- Downloaded & executed on a local system without explicit installation or execution by the recipient.
- Example: Linux OS.

July 17, 2022

Contents:

1. Introduction to Erlang
2. Communication: Message passing & shared memory.
3. Middleware
4. Replication & Consistency
5. Communication — Synchronous, Asynchronous

1| Introduction to Erlang:

- The term is named after the Danish telephone engineer, A.K. Erlang, the originator of queueing theory.
- The erlang is a unit of traffic density in a telecommunication system. It is a functional programming language & runtime environment.
- It was built to have inherent support for concurrency, distribution, & fault tolerance.

(Why you will use Erlang)

- Usage sector:
  - → Previously was originally developed to be used in large telecommunication systems.
  - → Now e-commerce, computer telephony, and banking sectors as well.
- This makes it possible for one channel to carry numerous calls simultaneously by means of multiplexing.

Types of Erlang :-

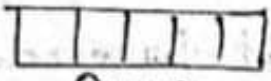
→ Erlang B
→ Erlang C

- Erlang B is a calculation for —
  → Busy Hour Traffic (BHT).
  → The percentage of calls that are blocked because not enough lines are available.

- Erlang C is a calculation for a given average duration of the call, and an acceptable level of delay in answering the call.

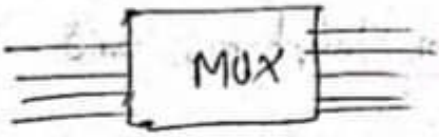
Lecture

- Erlang procedure ~~মূলত~~ telecommunication ~~এ~~ কাজে use হয়।



(16246) 1 2 3

- Traffic density measure ~~এ~~ কাজে use হয়।
- ~~যে~~ একটি functional programming language ~~যেটির~~ সাহায্যে ~~traffic density, traffic management~~ করা হয়।



একাধিক input নিয়ে
" output দেয়।

- Erlang B use হয়। Busy Traffic Hour (BTH) measure করার জন্য।
- " " Percentage of average time on call.
- Erlang C " " কতোক্ষণ queue ~~এ~~ wait করে হয়।

why you will use it.

Why Erlang ?

Erlang should be used to develop your application for —

- To handle a large number of concurrent activities.
- Easily distributable over a network of computers.
- ~~facility~~
- Facility to make the application fault-tolerant to both software & hardware errors.
- Easily upgradable & reconfigurable.

2| Communication in Distributed System:

- Performed by message passing through request and reply messages
- 2 types of models like Message passing & Shared memory.
- Communication between processes & objects in a distributed system is performed by message passing through request and reply messages. The system is structured as a group of processes (objects), called servers, that deliver services to clients.
- For Inter process there are 2 models. They are —
  1. Message Passing Process Communication Model.
  2. Shared Memory " " .

(i) Message Passing :-

- Message passing model allows multiple processes to read and write data to the message queue without being connected to each other.
- Messages are stored on the queue until their recipient retrieves them.
- Message queues are quite useful for inter process communication & are used by most operating systems.
- Example: Chat program with your friends, family, & Baby.
- Figure:

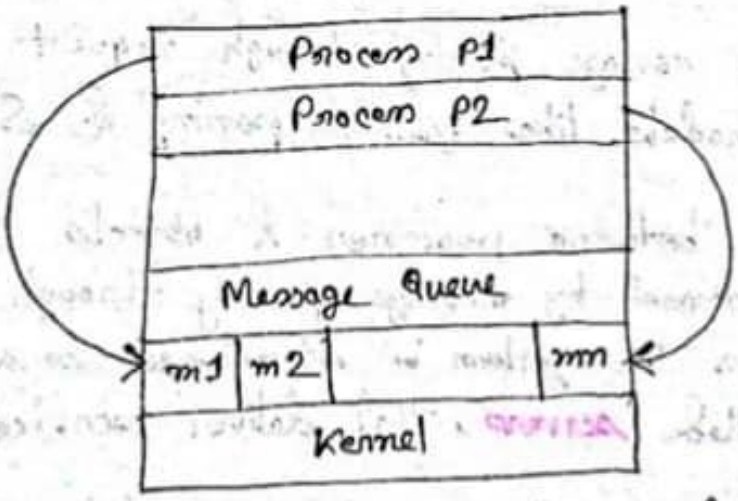


Fig.: Message Passing Model

- In the above diagram, both the processes P1 and P2 can access the message queue & store & retrieve data.

(इसमे Process एक दुसरे Process के साथ interconnected ना होकर message passing)

(ii) Shared Memory :-

- The shared memory in the shared memory model is the memory that can be simultaneously accessed by multiple processes.
- This is done so that the processes can communicate with each other.
- Faster as compared to the message-passing model.
- Example: All POSIX systems, as well as Windows operating system, use shared memory.

- Figure:

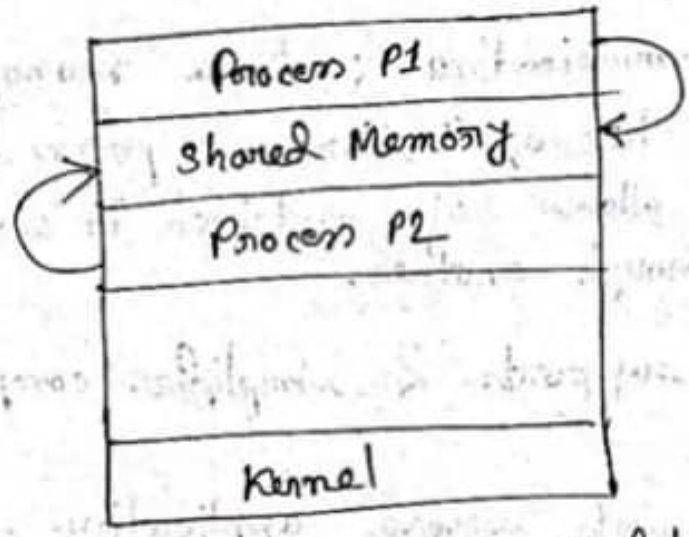


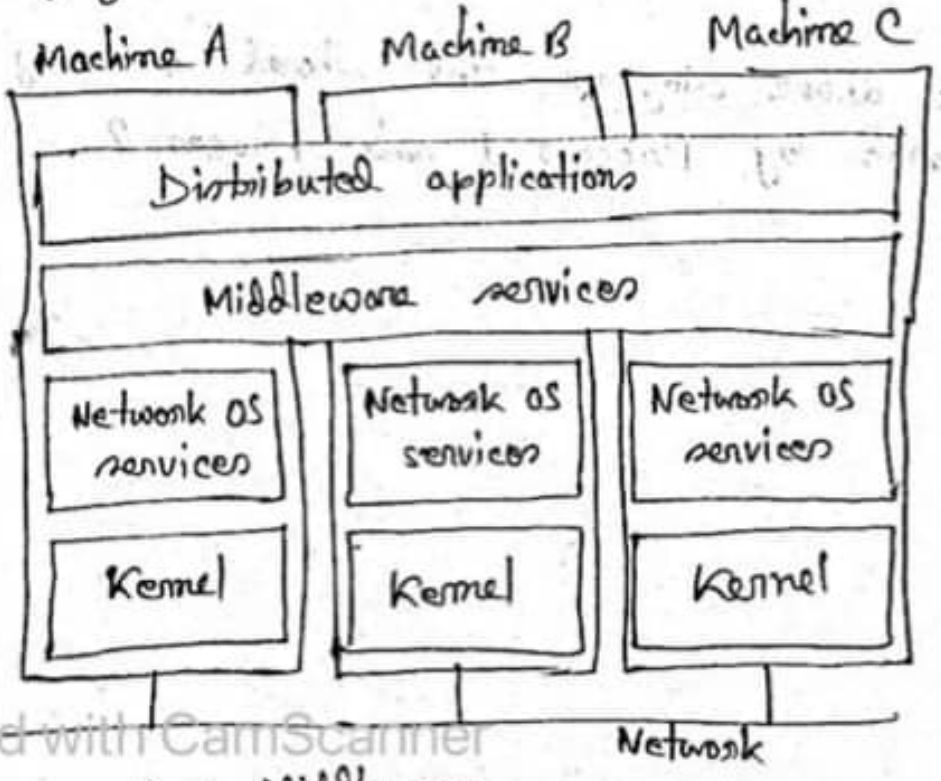
Fig.: Shared Memory Model

- In the above diagram, the shared memory can be accessed by Process 1 and Process 2.

(3) Middleware :-

- Glue together separate and already existing program.
- Middleware is the software that connects software components and it lies between the operating system and application on each side. Like web server.

- Middleware is software that provides services beyond those provided by the operating system to enable the various components of a distributed system to communicate and manage data.
- Enables communication & data management.
- It connects two applications & passes data between them. Middleware allows data contained in one database to be accessed through another.
- Middleware supports & simplifies complex distributed applications.
- It includes web servers, application servers, and messaging.



Eg: Middleware

Services :-

(i) Communication Services : producing calls, message queueing system, event notification services.

(ii) Information System Services : advance directory service (search engine), location service, data caching, and replication.

(iii) Control services : transaction processing, code migration.

(iv) Security Services : authentication & authorization, auditing service.

(4) Replication & Consistency :

- Replicated to enhance reliability or improve performance.

Reasons for Replication :

2020 5(d), 3(c)

a) ~~To increase the system's~~ reliability : If a file system has been replicated it may be possible to continue working after one replica crashes by simply switching to one of the other replicas. Also, by maintaining multiple copies, it becomes possible to provide better protection against corrupted data. For example, imagine there are 3 copies of a file, & every read & writes operation is performed on each copy. We can safeguard ourselves against a single, failing write operation, by considering the value that is returned by at least 2 copies as being the correct one.

b) Up large performance: the time to access the data decreases. As a consequence, the performance as perceived by that process increases.

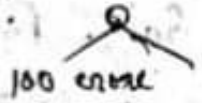
ISSUE:

- The problem is keeping replicas consistent (Transaction example). Informally, this means that when one copy is updated we need to ensure that the other copies are updated as well otherwise the replicas will no longer be the same.
- Cost of increased bandwidth for maintaining replication.

- Example:

To improve performance, Web browsers often locally store a copy of a previously fetched Web page (i.e., they cache a Web page). If a user requires that page again, the browser automatically returns the local copy. The access time as perceived by the user is excellent. The problem is that if the page has been modified in the meantime, modifications will not have been propagated to cached copies, making those copies out-of-date.

Consistency:



- Distributed algorithm design করা এবং একটা distributed system connected না।
- Software programming language; easily upgrade করা যায়।

(5) Communication :-

- 2 types : Synchronous & Asynchronous.

Synchronous Communication :

- Synchronous communication takes place in real-time between two or more people. All parties are online at the same time. When a message or request is sent, there's an immediate response.

- Synchronous communication is common in a "physical work location" where managers can walk up to a team member's office and ask for a document or question about a process. Work hours & break times are preset, & there's a ton of pressure to always be available.

- Examples: video conferencing,
  instant messaging,
  & telephone conversations.

- Used area;
  1. Brainstorming sessions
  2. Weekly team meetings
  3. Team building activities
  4. Project discussions.
  5. Interview sessions.

** instantly वा साथ साथ यदि communication हुन्छ (real time) i.e. — video conference.

Drawbacks: Synchronous ले exact solution instantly दिनुपर्छ भन्ने छैन।

instantly আসে!
আসে না!
Replies can be delayed.

Asynchronous Communication:

- Asynchronous communication means interaction without real-time conversation — replies can be delayed.

- A great example is an email. In this approach, people aren't scheduling meetings & responses are less time-sensitive.

- In this scenario, instead of asking your employees to be online at the same time, you give your teammates the flexibility to choose their working hours, irrespective of their location.

- Example: If you've sent an email requesting a document from a team member, rather than expecting an immediate response, you're patient & wait for them to respond later on.

Used Area:—

1. Messaging software: Messaging software like "Microsoft Teams and Slack." The recipient replies when they come online.

2. Email: There's no pressure to respond instantly to work emails. Employees can reply at a convenient time.

3. Video recording: Popular video recording tools include Zoom

4. Cloud collaboration: With tools like Google Workspace and Microsoft Teams, you can collaborate on documents with your teammates, make edits, & leave comments they can address at a convenient time.

5. Project management software: Project management tools are a great way to collaborate on projects, communicate deliverables and track project activity.

✱ Question :

Which one do you find more convenient that gives the precise solution to ameliorate the issues?

Answer:

Synchronous communication happens when messages can only be exchanged in real time. It requires that the transmitter & receiver are present in the same time. For instance, phone calls or video meetings.

On the other hand asynchronous communication happens when information can be exchanged independent of time. It doesn't require the recipient's immediate attention, allowing them to respond to the message at their convenience. For instance, emails, online forums, and collaborative documents.

Asynchronous communication is better for working with different time zones as it creates a permanent record of ideas, decisions, and discussions. In synchronous transmission, too much on real-time communication leads to burnout & depletes individual efficiency. By contrast, in asynchronous communication, it saves from unnecessary distractions

Difference between synchronous & asynchronous communication

Synchronous	Asynchronous
1. Takes place in real-time between two or more people.	1. Happens over a period of time.
2. Requires recipient's immediate attention.	2. Recipient can respond to the communication at their own pace.
3. Examples: • Face-to-face conversations, • Phone, video calls, • Meetings (physical, virtual), • Chat messaging — real time.	3. Examples: • E-mail. • Message boards (e.g. slack, MS Teams) • Dashboards (e.g. ERP, CRM, Jira, kanban boards) • Chat messaging — non-real time
4. Workers scheduled in for regular video meetings.	4. No scheduled video meetings for workers.
5. Quick responses to messages are expected.	5. Slower message responses are the norm.
6. Creates interruptions in a workday.	6. Eliminates interruptions.
7. The other party is actively waiting for replies.	7. Neither expecting nor waiting for an incoming message.
8. → Simple & easy to implement, → Contributes to reliability, → No backward error recovery needed.	8. → High concurrency. → More flexible than synchronous. → Lower deadlock risk than in synchronous communication

benefit:

and gives time to streamline activities on personal end. We can use this kind of communication when we do not need immediate response. It gives time to respond - leading to definite messages & shaping up the quality of conversations & meetings. To sum up, asynchronous communication provides a wealth of advantages for remote teams - reducing distractions, increasing focus time, & providing centralized, written documentation that helps keep everyone aligned.

But it shouldn't be presumed to be the sole or default mode of communication. Successful remote teams intentionally choose when, how, and why they communicate asynchronously & diverge from that when it's important for them to connect in real time.

Lecture : 06 — 20/01/2022

Network Security

Contents:
1. Network security
2. Security Model (নিচের model use করে, Security ensure করে ...)
3. Thread & Attack
4. Network Auditing
5. Cryptographic Algorithm
   → Synchronous
   → Asynchronous.

1) Network Security: In distributed computing, network security means

2020 3(b)

- Guarantee the privacy, integrity, and availability.
- Network security means a set of measures to guarantee the privacy, integrity and availability of resources.
- It involves the protection of objects and securing processes & communication channels.
- The policy is to specify who is authorized to access resources.

Strategies: (Security ভালো রাখতে strategy maintain করে)

Most important

To mitigate these risks there are a number of strategies that can be employed :—

1. Encryption algorithms that protect data. (Digital signature / Authentication)
2. Firewalls that limit access to specific ports / cables.
3. Intrusion detection systems that identify anomalous behavior among network services.
4. Intrusion prevention systems (IPS) respond by initiating defensive actions like blocking suspicious IP addresses.

---

* Data গুলো protect করে encryption algorithm
* Access limit করে দেয় firewall এর কাজ।
* Block the IP address access করে intrusion prevention (" ")

* Behavior change হলে detect করে তাকে intrusion detection system। (Identify anomalous behavior)

Security Requirements :-

↳ 3 requirements.

2020 2(b)

(1) Confidentiality : Requires that the data only be accessible by authorized parties.

(2) Integrity : Requires that only authorized parties can modify data.

(3) Availability : Requires that data are available to authorized parties.

#(2) Security Model :

2020 3(b)

- Securing the processes and the channels used for their interactions & protecting the objects that they encapsulate against unauthorized access. (Main area → object ka secure karna)

Server → Store (object) → access

Protecting Objects :-

- Server manages a collection of objects on behalf of some users. The users can request the server to perform operations on the objects. The server carries out the operation specified in each invocation & sends the result to the client.
- Objects are intended to be used in different ways by different users. For example, some objects may hold a user's private data, such as their mailbox, & other objects may hold shared data such as web pages. To support this, access rights specify who is allowed to perform the operations of an object — for example, who is allowed to read or to write its state.

(fig.)

P.T.O

Object : Intended for use by different clients via remote invocation.
Principal : Authority on whose behalf invocation is issued.

Figure :-

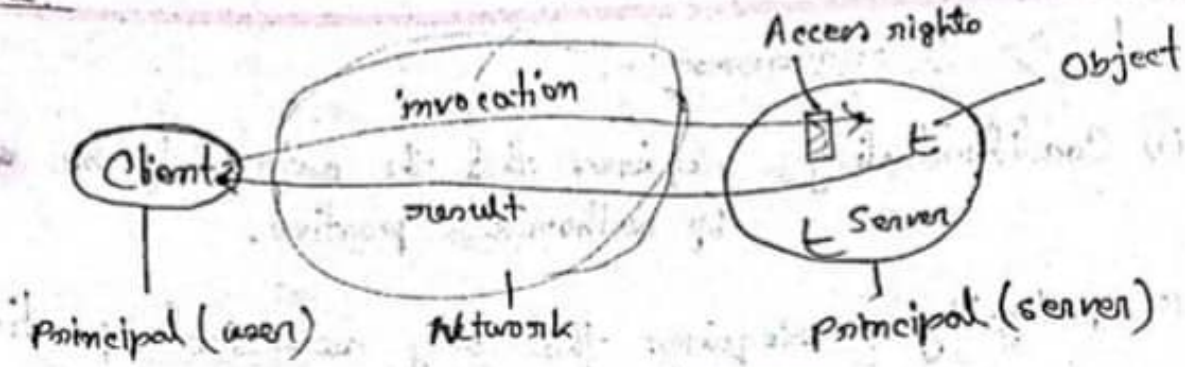


fig. : Security Model.

The Enemy :

- Processes interact by sending messages. The messages are exposed to attack because the network and the communication service that they use are open.

- Enemy that is capable of sending any message to any process & reading or copying any message sent between a pair of processes. Such attacks can be made simply by using a computer connected to a network, or a program that generates messages that make false requests to services.

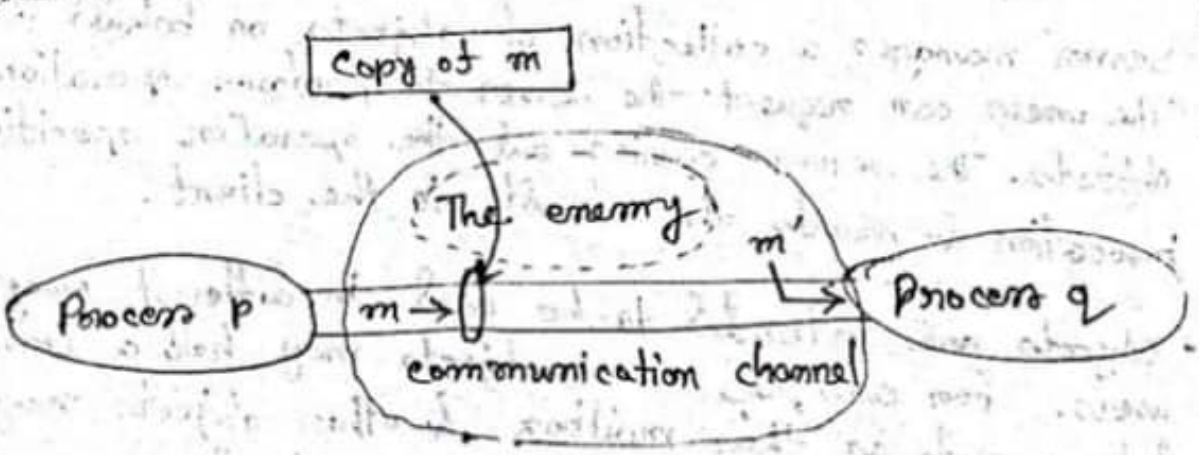


fig. : Enemy Attack.

এমন একটা process যেটা কোন message কে অবিকলভাবে copy করতে পারে।

2020; 2(a)

How to Ameliorate ? How can we defeat the enemy in a network system ?

→ Use cryptography.
→ Secure channel.
→ Identification (password protection).
→ Authentication.

(03) Threat & Attack :-

কোন ডিভাইস (data/resource) যখন access করতে গেলে তখন যে harm বা drawback আসতে পারে, সেটাই threat ।

~~• Give together separate & already existing program~~

• A Threat is a possible security risk that might exploit the vulnerability of a system or asset. Or that could break security and cause harm. The origin of the threat may be accidental or environmental, human negligence, or human failure.

* Types of Threats :-

1| Eavesdropping
→ Obtaining copies of messages without authority.
(কোন data copy করে যদি অন্য জায়গায় send করি without authority বা অনুমতি ছাড়া, তাকে eavesdropping, hacker steal & manipulate data

2| Masquerading
→ Sending / receiving messages using the identity of another principal without their authority.
(authority ছাড়া কোন message pass করলে)

3. Message tempering :

→ intercepting & altering messages.
(message কে change/alter করে দেওয়া এটা message tempering).

4. Denial of Service :

→ Flooding a channel with requests to deny access to others.
(কোন web site এ per sec এ লিমিটেড user access করতে পারে। কেউ hacking করে অতিরিক্ত রিকোয়েস্ট পাঠিয়ে site কাজ করতে দেয় না। এটা denial of service)

A denial-of-service (DoS) attack is an attack meant to shut down a machine or network, making it inaccessible to its intended users. DoS attacks accomplish this by flooding the target with traffic, or sending it information that triggers a crash.

A distributed denial-of service attack is a DoS attack that uses multiple computers or machines to flood a targeted resource.

5. Replaying : Intercepting, storing, replaying, message.

Where to use :-

(Threat মুক্ত যেখানে সেখানে use হয়) :-

1. Online shopping / banking
   - intercept credit card information (message tempering)
   - purchase goods using stolen credit card details.
   - replay bank transactions.

2. Online stock market information service
   - observe the frequency or timing of requests to deduce (অনুমান করা) useful information, e.g. the level of stock.

3. Website
   - Flooding with requests (denial of service)

4. My computer
   - receive / download malicious code (virus)

Attack:-

- An assault on the system security & devices from an intelligent threat to violate the security policy of a system.

Types of Attack:-

① Malware attack:

Malware refers to malicious software viruses including worms, spyware, ransomware, adware, and trojans. Ransomware blocks access to the networks key components, whereas spyware is software that steals all confidential data without your knowledge. Adware is a software that displays advertising content such as banners on a user's screen.

- How to prevent a malware attack:

(i) Use antivirus software.
(ii) Use firewalls. Firewalls filter the traffic that may enter your device. Example: Window Firewall.
(iii) Stay alert & avoid clicking on suspicious links.
(iv) Update OS and browsers regularly.

② Phishing Attack:

It is a type of cybersecurity attack during which malicious actors send messages pretending to be a trusted person or entity.

can be prevented by:-

(i) Scrutinize the emails we receive.
(ii) Make use of an anti-phishing toolbar.
(iii) Update passwords regularly.

3| Password attack: It is a form of attack wherein a hacker cracks our password with various programs and password cracking tools.
Example:- Keylogger attacks, brute force attacks.

How to prevent:
(i) Use strong alphanumeric passwords with special characters
(ii) Abstain from using the same password for multiple websites or accounts.
(iii) Update the passwords.
(iv) Do not have any password hints in the open.

4| Man-in-the-Middle attack: It is also known as eavesdropping attack. In this attack, an attacker comes in between a two-party communication, i.e the attacker hijacks the session between a client & host By doing so, hackers steal & manipulate data.

How to prevent:
(i) Be mindful of the security of the website ~~you~~ are using. Use encryption on ~~your~~ the devices.
(iii) Refrain from using public Wi-fi networks.

5] SQL Injection attack:

A Structured Query Language (SQL) injection attack occurs on a DB-driven website when the hacker manipulates a standard SQL query.

How to prevent:

(i) Use an Intrusion detection system, as they design it to detect unauthorized access to a network.

(ii) Carry out a validation of the user-supplied data. With a validation process, it keeps the user input in check

6] Denial-of-Service attack:

This attack is a significant threat to companies Here, attackers target systems, servers, or networks and flood them with traffic to exhaust their resources & bandwidt

When this happens, catering to the incoming requests beco overwhelming for the servers, resulting in the website it hosts either shut down or slow down. This leaves the legitimate services requests unattended.

How to prevent:

(i) Run a traffic analysis to identify malicious traffic.

(ii) Understand the warning signs & takes necessary steps without delay.

(iii) Formulates an incident response plan.

(iv) Outsource DDoS prevention to cloud-based service providers.

7. Insider Threat: It happen when an individual from within an organization attacks who knows everything about the organization.

How to prevent:

(i) Organizations should have a good culture of security awareness.

(ii) Companies must limit the IT resources staff can have access to depending on their job roles.

(iii) Organizations must train employees to spot insider threats.

8) Cryptojacking: closely related to cryptocurrency. It takes place when attackers access someone else's computer for mining cryptocurrency. The access is gained by infecting a website or manipulating the victim to click on a malicious link.

How to prevent;

(i) Update software & all the security apps as cryptojacking can infect the most unprotected systems.

(ii) Have cryptojacking awareness training for the employees.

(iii) Install an ad blocker.

(04) Network Auditing :- (পর্যালোচনা)

- Checking properly.
- Networking auditing is the collective measures done to analyze, study, & gather data about a network with the purpose of ascertaining (নির্ধারণ) its health in accordance with network / organization requirements.

- It works through a systematic process where a network is analyzed for:
  1. Security, Attack
  2. Availability,
  3. Management,
  4. Performance.
  5. Implementation.

- It uses both manual & automated techniques to gather data and review network posture. It reviews:
  - Network control & Security processes,
  - Network monitoring processes.

auto update or

Algorithm: TEA, DES
RSA

DSM (Distributed Share Memory)
একাধিক এর মধ্যে Share করা

1	0	1	0	1	1

21/09/2022

Part-2

Distributed Shared Memory

Lecture: 07

#Contents:

1. Introduction to Distributed Shared Memory
2. Shared Address Space
3. Implementation of DSM.
4. DSM Model
5. Application of DSM.

Introduction to Distributed Shared Memory :-

Distributed shared memory is the collection of shared memory & multicomputer.

$$DSM = SM + MC$$

- DSM is a mechanism for allowing user processes to access shared data without using interprocess communications.
- This provides a virtual address space that is shared among all computers.
- DSM consists of ~~two components~~:
  1. Shared address space. (যা virtually generate হয়)
  2. Replication & consistency of memory objects.

2019 3(a)

* Distributed share memory হচ্ছে shared ~~for~~ virtual address space এমন যা link এমন like opposite-এ ভিন্ন address generate হয়। ঐ link এ click করলে ঐ file টা access করতে পারি।

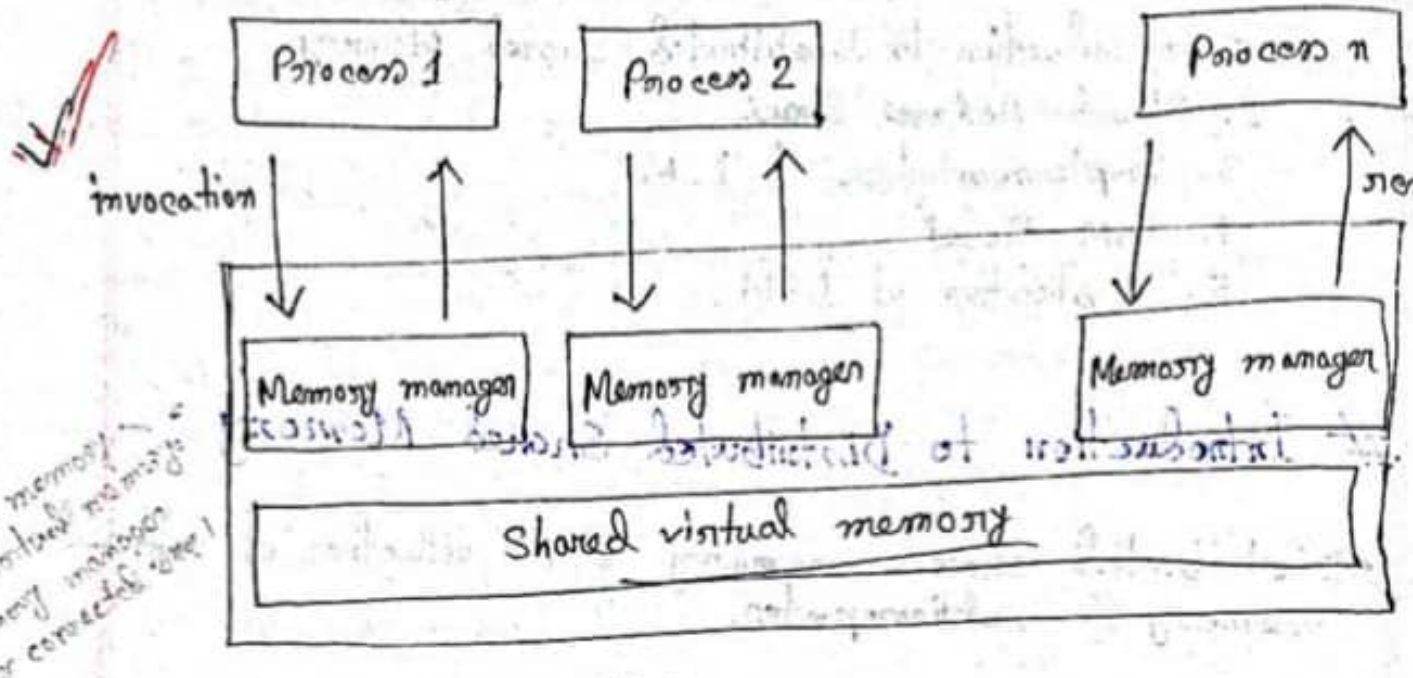


Fig. : DSM

DSM : shared memory + multicomputer.

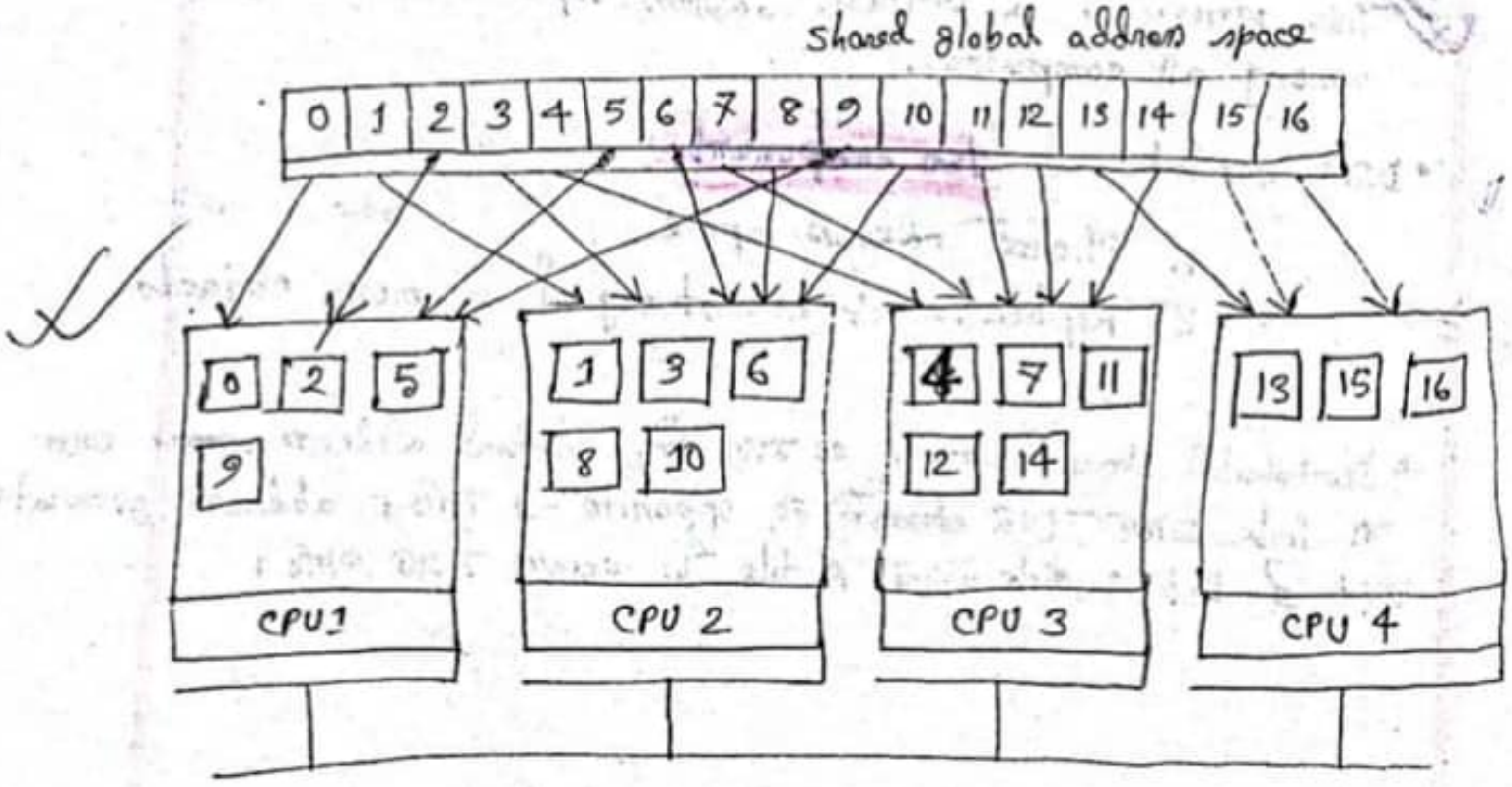
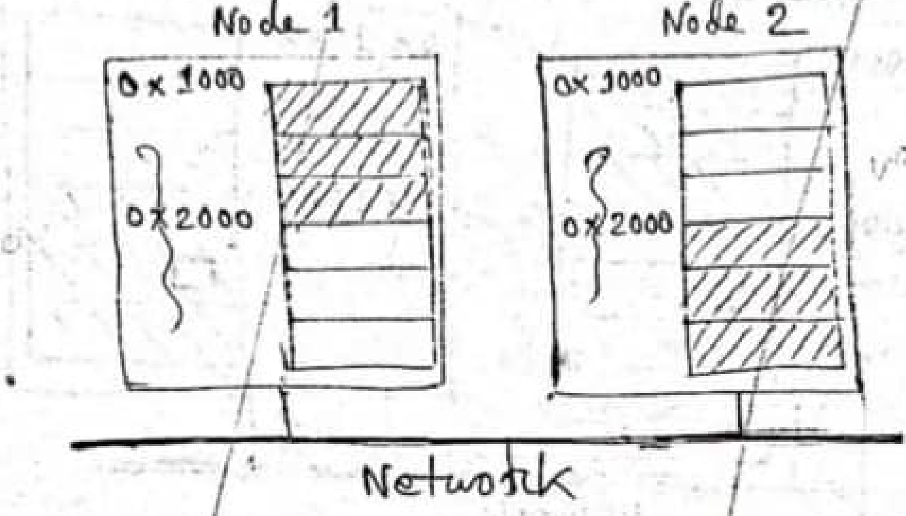


Fig. : DSM

(2) Shared Address Space :

- Allows multiple processing elements to share the same location in memory (that is to see each other read & write) without any other special directives.

- Shared addresses are valid in all processes.



* DSM এর মধ্যে এমন একটা Portion আছে, DSM মানে আমার যে memory টা আছে ওটা একটা replica তৈরী করবে, আর ঐ replica access করতে পারব Shared address এর মাধ্যমে। ওই address টাকে বলা হয় element যেটা memory এর location টাকে share করে।

এই link এর মাধ্যমে বিভিন্ন address generate হয়। এই address কোথায় আছে, সেই location টা generate করে Shared address space

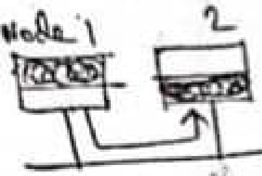
* যে location টার মাধ্যমে যে যে user আছে তারা read, write করতে পারে, without any problem or directives। আমি যে file টাকে use করব, যে share করছে তার Permission আর এখন দরকার নেই। আমি link এ click করলেই direct access করতে পারব।

এটাই shared address space.

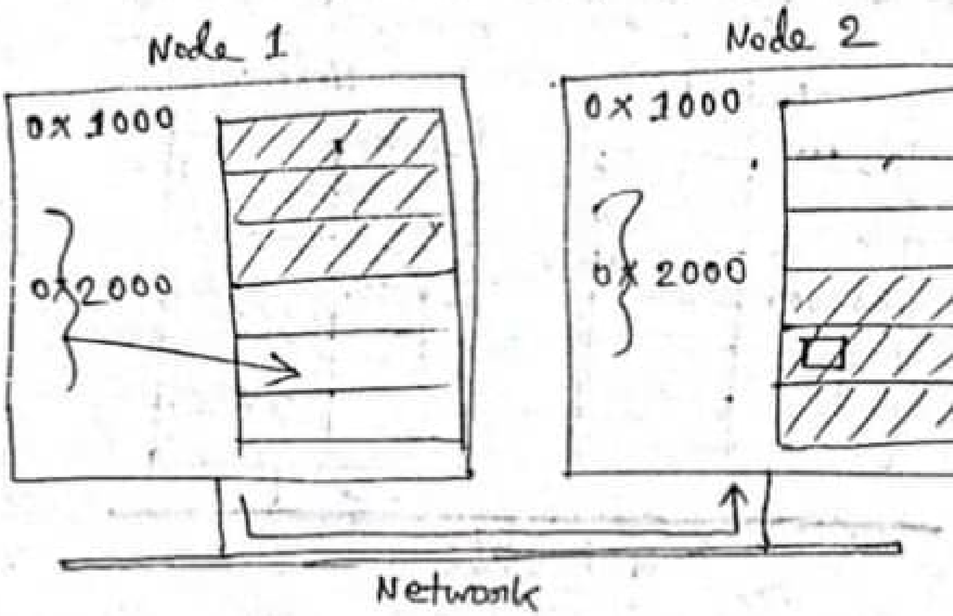
* DSM এটার maximum কাজই হয় Transparent remote access এর মাধ্যমে।

Transparent remote access

- Remote access is expensive compared to local memory access.
- Individual operations can have very low overhead.
- Threads can distinguish between local & remote access.



Google Doc এ সব user একসাথে change করতে পারছে।



যে memory টা share হয়েছে,
এমন একটি software, hardware বা network এর মাধ্যমে দূর থেকে access করা (যে file টা share হয়েছে), control করা, change করা

* Transparent remote access যে করছে, তার যে local memory আছে, local memory থেকে অনেক সময় expensive হতে পারে। কারণ network use করতে হয়, PC লাগবে, local memory বা hard-drive লাগবে, Internet লাগবে।

Drawbacks:

- Threads in network.
- Hamper privacy.
- Local memory (or primary memory) এবং remote memory এর মধ্যে পার্থক্য হচ্ছে thread এর attack।
- Local memory থেকে বেশি affected হওয়ার সম্ভাবনা থাকে DSM.

Advantages :

1. Ease of programming (shared memory model).
2. No bottlenecks in data access.
3. Pointer handling.
4. Shared pointers refer to shared memory.
5. Share complex data (lists, etc.)
6. No marshalling.
7. Simpler abstraction.
8. Better performance.
9. Flexible communication environment.

* **Pointer Handling :** Pointer মান যেটা কোন কিছু নির্দেশ করে। DSM এ মান্য যে shared address টা আছে, যেটা কোন ডাটাস্ট্রাকচার store করা আছে, সেটা handle করতে পারে। এই মিনিমাম হচ্ছে Pointer handling।

* **Marshalling :** Data collect করা হয়, network এ সহজে transfer করা কোন ধরনের change ছাড়াই যেটা Marshalling।

- Marshalling is the process of gathering data & transforming it into a standard format before it is transmitted over a network so that the data can transcend network boundaries.

* Why DSM ?

→ Shared memory model ; easiest to program.
→ Physically shared memory not possible on multicomputer.
→ DSM emulates shared memory.

(3) DSM Implementation :-

(a) Hardware :
- Multiprocessor (Example : MIT Alewife, DASH)

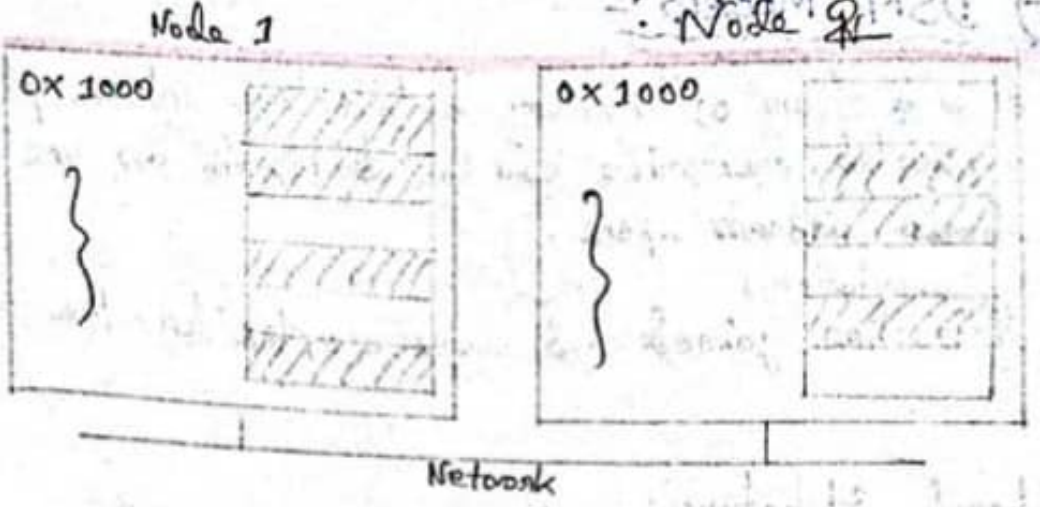
(b) OS with hardware support :
- SCI network cards.
- SCI maps extended physical address space to remote nodes.
- OS maps shared virtual address space to SCI range.

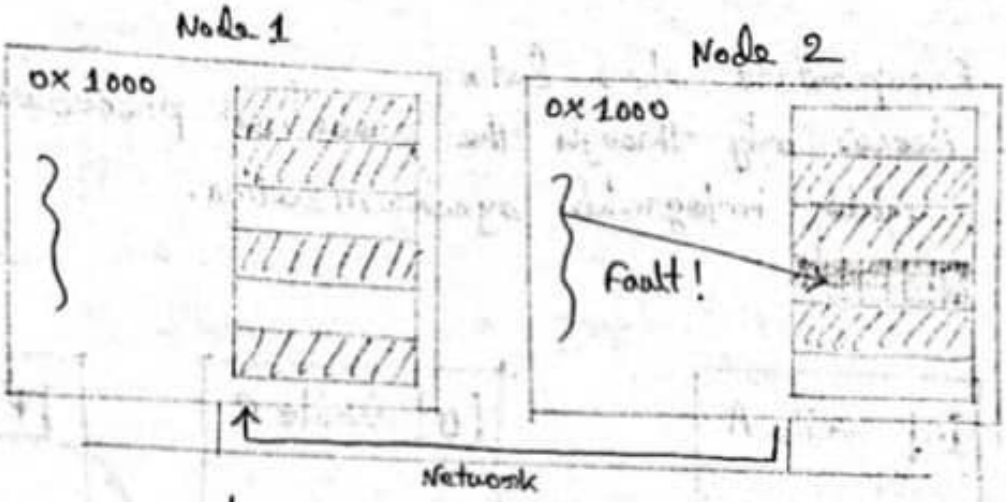
(c) OS and Virtual Memory :
- Virtual memory.
- Local address space.

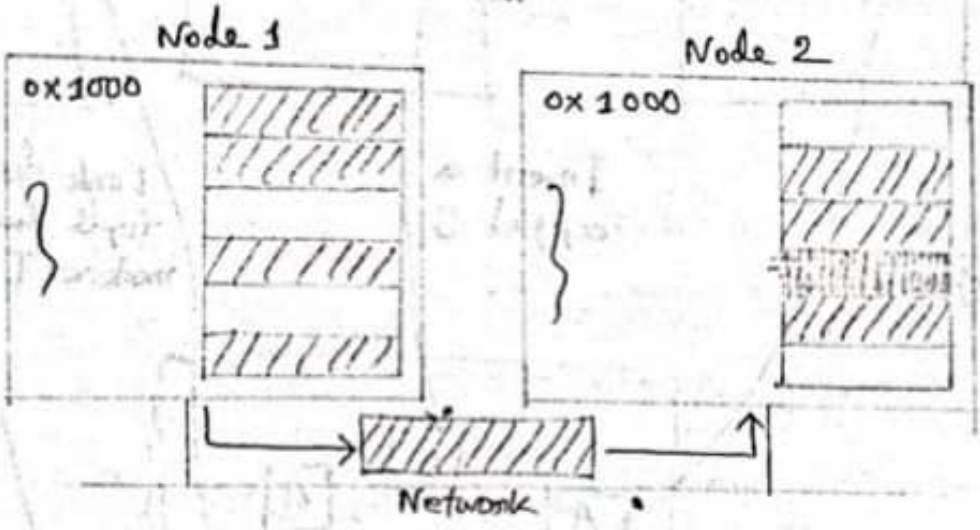
* fault tolerance

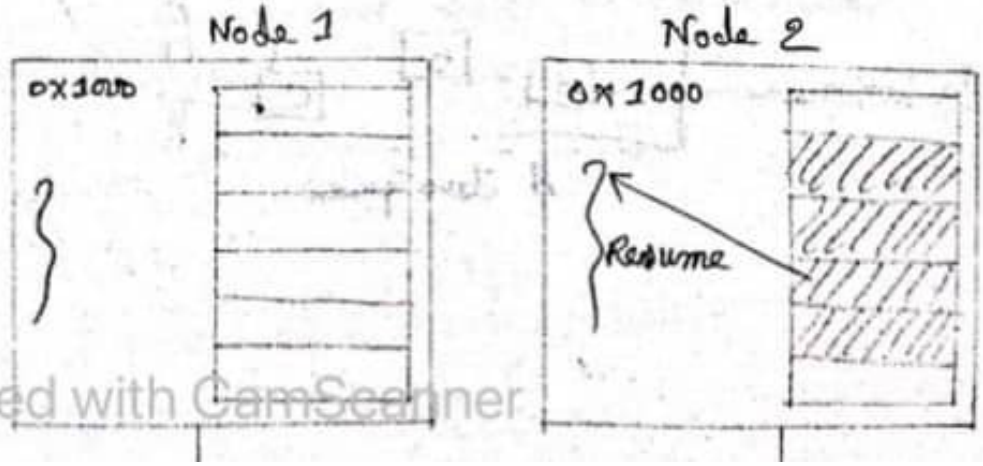
Figure explain

Figure:







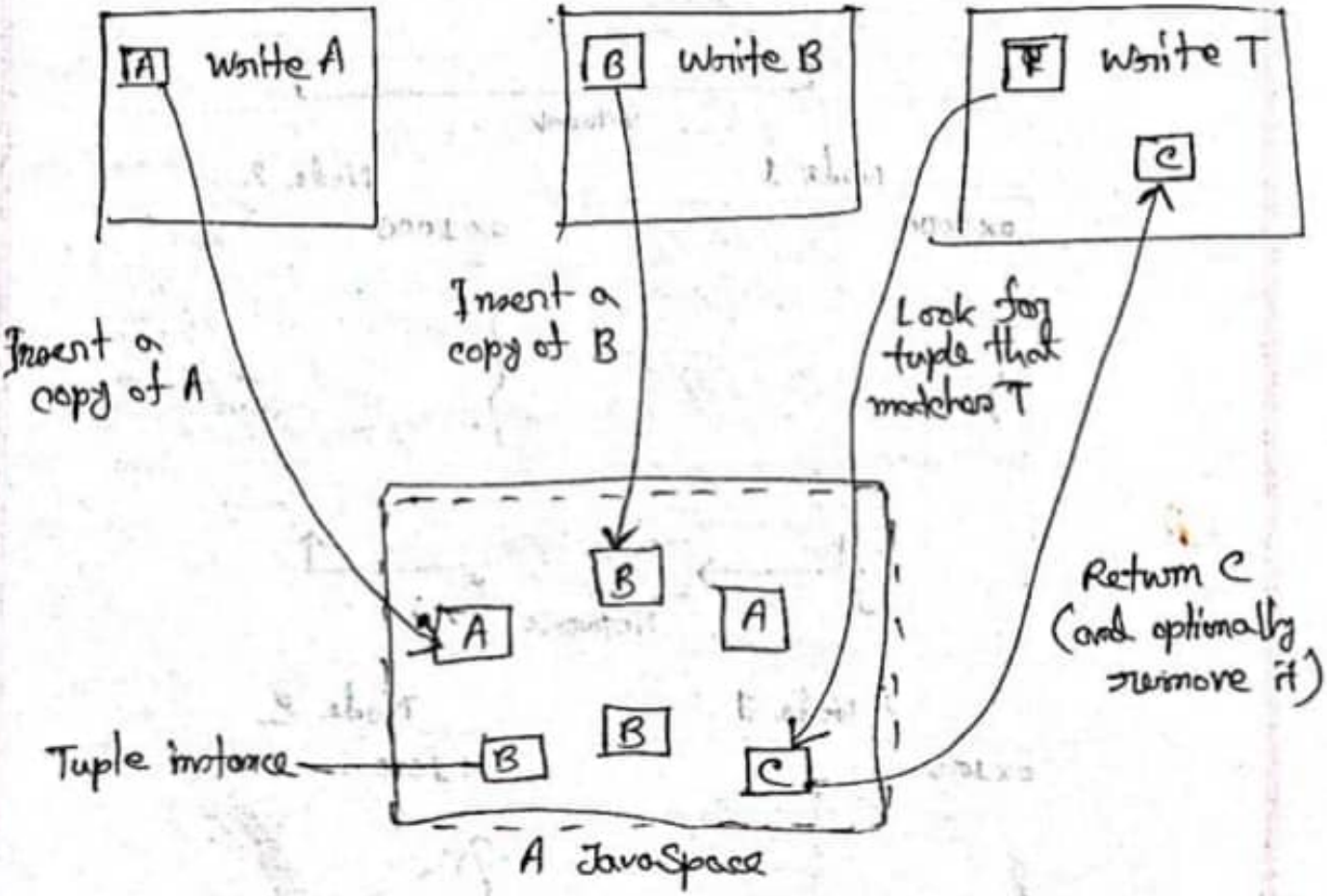


(4) DSM Models :-

- DSM is a form of memory architecture where physically separated memories can be addressed as one logically shared address space.
- annotation
- DSM is fine grained and more complex for the user.

Shared Structure:

1. Encapsulate shore data.
2. Access only through the predefined procedure.
3. Tightly integrated synchronization.



(5) Application

Application of DSM :-

1. Scientific Parallel Computing (i.e. - Bioinformatics simulation)
2. Graphics.
3. Data server.
4. Data storage.
5. Multiprocessor.
6. Multicomputer. (i.e. - Super computer, Cluster)

Requirements of DSM :-

1] Transparency :
- Location, migration, replication, concurrency.

2] Reliability :
- computations depend on the availability of data.

3] Performance :
- Important in high-performance computing
- Important for transparency

4] Scalability :
- Important in wide-area
- " for large computations.
- Access to DSM should be consistent
- According to a consistency model.

5] Programmability :
- Easy to program.
- Communication transparency.

2020 2(b) 1+2.

* What is network auditing?
To design a secure system what criteria should follow?

Answer:

Network Auditing: Network auditing refers to the process of gathering, analyzing, & studying network data, with the purpose of ~~assessing~~ measuring the network's health. Network security audit is a crucial part of the organization as they are the first step to identifying potential threats & vulnerabilities. In a typical network security audit, we will analyze all network devices and infrastructure and the management of the network.

Criteria for designing a secure system:-

Requirements

A system is considered secure when it fulfills the requirements regarding —

CIA

- Confidentiality,
- Integrity, &
- ~~Accessibility~~ Availability.

(1) Confidentiality: Requires that the data only be accessible for reading by authorized parties. It protects the user's private information to prevent unauthorized access. Confidentiality is the protection of information in the system so that an unauthorized person cannot access it.

(2) Integrity: Requires that only authorized parties can modify data. Integrity is the assurance that the information is trustworthy and accurate.

(3) Availability: Requires that data are available to authorized parties. Availability is a guarantee of reliable access to the information by authorized people.

04/11/2022
Last class

8 নং, 9 নং Cryptographic algo 2-3 marks 2q asked

Naming : A name in a distributed system is a structure of bit or character that is used to refer an entity.

Good naming system : (characteristics)

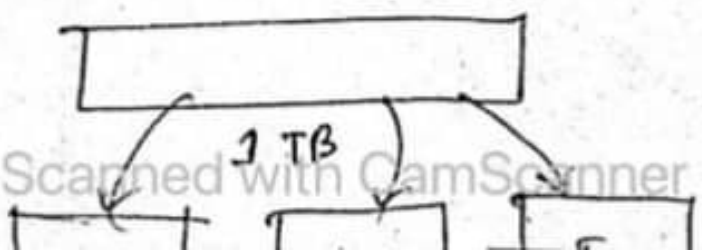
(1) Location transparency
(2) Location independency
(3) Multiple user define name on same object
(4) Replication transparency :

Difference bet 2 types of naming system : —

- Machine / System Oriented
- Human Oriented

Machine	Human
1. Auto generated	Predefined.
2. Structured or unstructured	Unstructured
3. Hard to remember	Easy
4. Example : mode	URL

Partitioning :



structure : • According to graph structure
• Improve look up performance
• Rigid structure
• Flexible

DFS : Distributed File System (DFS) is a method of storing & accessing file based in a server or client architecture. In DFS, one or more central servers store files that can be accessed, with proper authorization rights by any number of remote clients in the network.

Lecture : 06

Distributed File Systems

Content :
1. Introduction
2. NFS (Network File System)
3. AFS (Andrew File System) & Coda
4. GFS (Google File System)

Introduction :-

- Distributed File System Paradigm :- (ex - Google Classroom, Google doc file)
  - → File system that is shared by many distributed clients.
  - → Communication through shared files.
  - → Shared data remains available for long time.
  - → Basic layer for many distributed systems & applications.

Clients and Servers :

- → Clients access files and directories.
- → Servers provide files . " .
- → Servers allow clients to perform operations on the files and directories.
- → Operations : add / remove , read / write
- → Servers may provide different views to different clients.

* Distributed file system হচ্ছে এমন method যা file কে store করে, access করতে সাহায্য করে থাকে।
* client file গুলো server থেকে access করতে পারে।
* server client কে যেই file গুলো access করতে অনুমোদন দেয়।
* " host কে file modification করতে অনুমতি দেয়।
* Server হচ্ছে এমন mechanism যেটা functions কে handle করে যে, data কে

Requirements :-

1. Transparency (স্বচ্ছতা) ——
2. Flexibility ——
3. Concurrency ——
4. Replication ——
5. Fault Tolerance ——
6. Consistency ——
7. Security ——
8. Efficiency ——

Challanges of DFS :-

① Transparency :

→ Location : a client cannot tell where a file is located.
→ Migration : a file can transparently move to another server.
→ Replication : multiple copies of a file may exist.
→ Concurrency : clients access the same file.

② Flexibility :

→ Servers may be added or replaced
→ Support for multiple file system types.

③ Dependability :

→ Consistency : conflicts with replication & concurrency.
→ Security : users may have different access rights on clients sharing files & network transmission.
→ Fault tolerance : server crash, availability of files.

④ Scalability : Handle increasing number of files.

#Challenges :-

→ Requests may be distributed across servers.
→ Multiple servers allow the higher storage capacity.
→ Growth over geographic & administrative areas.
→ Growth of storage space.
→ No central naming service.
→ No centralized locking.
→ Network problem on server down.

The Clients perspective : File Service

Ideally, the client would perceive remote files like local ones.

* File Service Interface :-

কোন file যখন open করি, suppose download করব, ঐটার properties-এ দেখাবে না যা দেখতে পারব —

→ File: uninterpreted sequence of bytes.
→ Attributes: owner, size, creation date, permission, etc.
→ Protection: access control lists or capabilities.
→ Immutable files: simplifies caching & replication.

* **Stateless Server:** অনেক server আছে যেগুলো আমাদের কোন track করতে পারে না, আমি কী করতে যাচ্ছি, কী করছি না এই জিনিসগুলো track বা monitor করতে পারে না।

Bangla

* **Stateful Server :** আমি কী করছি, কোন অবস্থায় কী দেখছি, আমার API track করতে পারে।

* আমি যে file টা access করব, file টাকে access করার জন্য, প্রত্যেকবার request যাবে না যে আমি file টা open করতে যাচ্ছি, close করতে যাচ্ছি অর্থাৎ কোন limits নাই- Stateless-এ।

* Stateful-server-এ movie নামাতে 50 request করতে হয় প্রত্যেকবার, ফলে প্রত্যেকবার একটা wait time হয়, যখন জিনিসটা granted হয় then নামাতে পারি।

* Stateless vs Stateful Servers :-

Stateless Servers:

As the name suggests, the stateless server has no state with regard to the user's information. It means when the user access any web resource, the server does not keep a track of the user's identity or actions performed on the page. So every time, the user has to prove the identity to gain access.

In the case of stateless information servers this means that they do not keep track of which clients are accessing them. In other words, between one access & the next, the server & protocol are constructed in such a way that they do not care who, why, how, when or where the next access comes from.

Example: The Internet's basic protocol, HTTP, DNS
The Internet Protocol (IP).

Advantages of Stateless servers:

1. Fault tolerance.
2. No OPEN / CLOSE calls needed.
3. No limits on number of open files.
4. No problems if server crashes.
5. No problems if client crashes.
6. As the server does not need to manage any session, deploying the services to any number of servers is possible, & so scalability will never be a problem.
7. Server does not hold requests information.
8. Different servers can different information at once.

Stateful Servers:

In stateful server, the server is required keep information about the current state and session. In this, the server and the client are tightly bound. Client-server system is stateful if server tracks its clients, takes actions to keep their cached states "current". Client can trust its cached data.

Example: FTTP, Telnet etc.

Advantages of Stateful Servers:-

1. Shorter request messages.
2. Better performance.
3. Read ahead easier.
4. File locking possible.
5. Better performance (info in memory until close).
6. Quick turn-around (no overhead for follow-up requests).
7. Easy to cache information at server side.
8. Can implement transaction semantics easily.

Server-এ req. আসলে সবার API monitor হয়, কে কী নামাতে চাচ্ছে কিনা req. authorized হয়ে আসতে পারছি। এতে অনেক authorization delay হয়ে যাচ্ছে। Delay হলে তাতে download speed কমে যায়, এতে performance কমে যায়।

Caching :-

High-Speed data storage layer that store file temporarily and improve access time.

Virtually data store করে হার্ডের সুবিধা সমাধান করা।

We can cache in 3 locations: —

1. Main memory of the server
2. Disk of the client
3. Main memory of the client
   (process local, Kernel, or dedicated cache process).

Replication :-

Multiple copies of files on different servers.
An act on process of copying on duplication.

In a distributed computing, data is stored in over different computers in a network. Therefore, we need to make sure that data is readily availability for the users. Availability of the data is an important factor often accomplished by data replication. Replication is the practice of keeping several copies of data in different places.

Advantages :

1. Prevent data loss.
2. Increase availability of data.
3. Reliability of data.
4. Protect the system ~~design~~ against downtime of a single server
5. High performance.
6. Distribute workload.

Three designs:

① **Explicit replication:** The client explicitly writes files to multiple servers.

② **Lazy file replication:** Server automatically copies files to other servers after file is written.

③ **Group file replication:** WRITEs simultaneously go to a group of servers.

Case Studies:

(1) Network File System (NFS).
(2) Andrew File System (AFS) & Coda.
(3) Google File System (GFS).

Network File System (NFS):-

Properties:-

- Introduced by Sun microsystem 1984. (American Company)
- Multiple clients & servers.
- Stateless servers.
- File locking through a separate server.
- No replication. (drawback)
- Fits nicely UNIX idea of mount point.

The Network File System (NFS) is a mechanism for storing files on a network. It is a distributed file system that allows users to access files and directories located on remote computers & treat those files and directories as if they were local.

Exam.- NFS ... diagram ...

Advantages :

1. Enable multi computers to use the same file.
2. Everyone on the computer can access the same data.
3. Reduce storage cost.
4. Consistant.

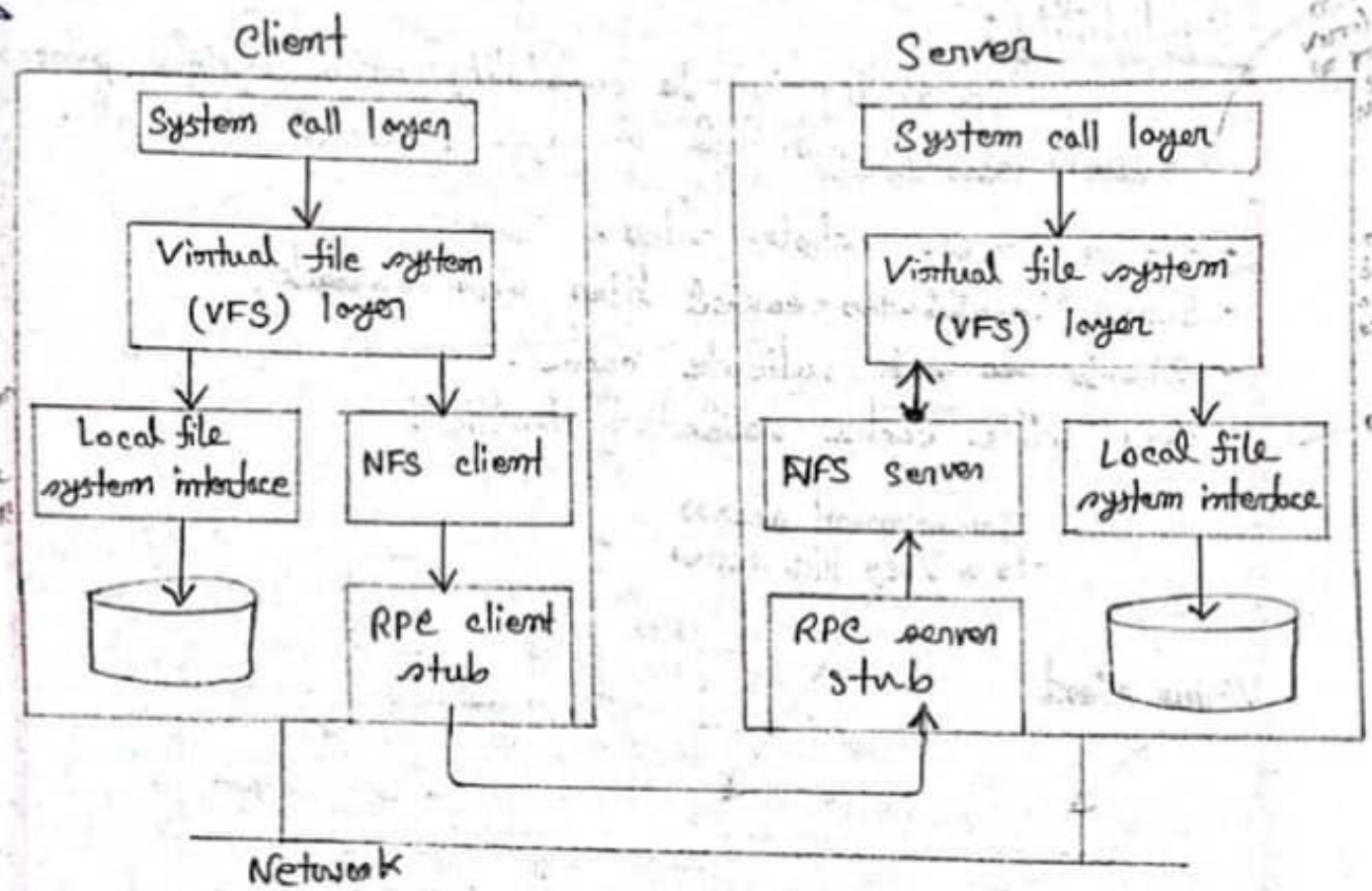


Fig. : NFS.

UNIX : ... operating system - multiple user ... multitasking ... UNIX ... multitasking ... multiuser ...

Maunt point : is a term that describes the location of a file.

Remote Produce Call : a powerful technique ... client-server based applica...

② Andrew File System (AFS) & Coda :-

Properties :

1. Developed as campus-wide file system.
2. Scalability.
3. Global name space for file system.
4. API same as for UNIX.
5. Cache on local disk.

Scalability :

Scalability is the capability of a system process, or a network to grow and manage increased demand.

- Server serves whole files.
- Server invalidates cached files with callback
- Clients do not validate cache.
- Very little cache validation traffic.

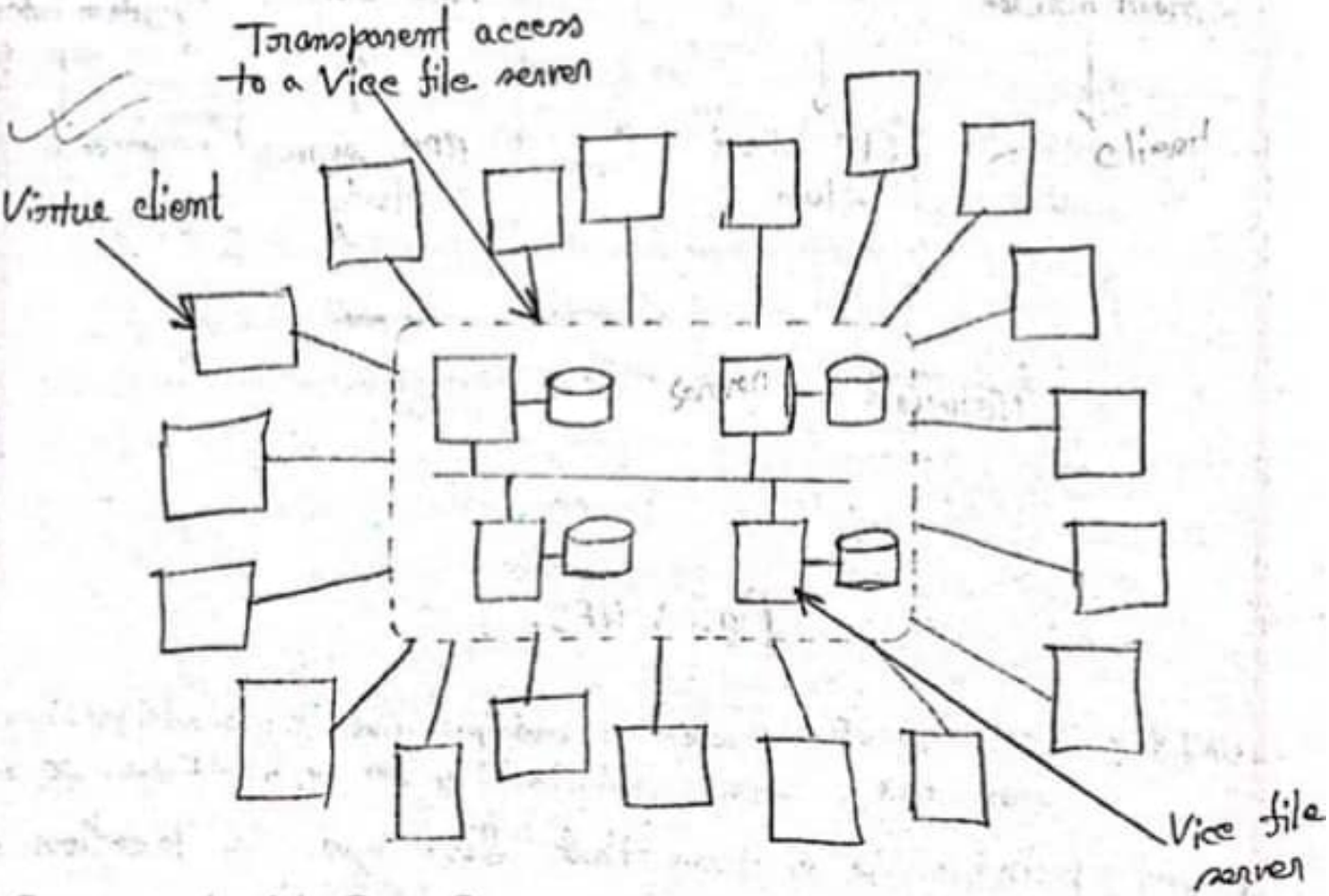


Fig.: AFS.

Coda:- Constant Data Availability.

→ Successor of the Andrew File System (AFS). (AFS is updated version)
→ Supports disconnected, mobile operation of clients.
→ Supports replication.

Google File System:-

Google file system is a distributed file system develop by google to provide efficient access to data using large cluster of hardware.

It provides fault tolerance, scalability, availability, and performance to large network and connected nodes.

Motivation:

- 10+ clusters.
- 1000+ nodes per cluster.
- Pools of 1000+ clients.

Properties:

① Files split in fixed-size of chunks of 64 MB.
② Chunk store on chunk server.
③ Chunk replicate on multi chunks.
④ Chunk replicate on chunk.
⑤ Provide efficiency.
⑥ No explicit caching. ⑦ Client interact with the chunk.

Chubby:

- Chubby is a lock service for loosely coupled distributed system.

- Lock service
- Simple FS
- Name service
- Synchronization / consensus service.

Lecture: 09

Fault Tolerance (☆)

(২টা ques আসবেই)

Content:
1. Failure
2. Reliable communication
3. Process Resilience
4. Recovery

Fault tolerance হচ্ছে কোন একটা system যদি কোন কারণে নষ্ট হয়ে যায় কোন system affect করবে না, আমার computer থেকে নষ্ট হয়ে গেল নির্দিষ্ট কাজে backup আছে। এই Procedure টাই fault tolerance

- Fault tolerance is the availability of system to continue operating without any interruption when one or two more components fail.

- Fault tolerance dependability নিশ্চিত করে।

Dependability (নির্ভরশীলতা):

Availability: system is ready to be used immediately.

Reliability: system can run continuously without failure.

Safety: when a system (temporarily) fails to operate correctly, nothing ~~catastrophic~~ serious happens.

Maintainability: how easily a failed system can be repaired.

Building a dependable system comes down to controlling figure & faults.

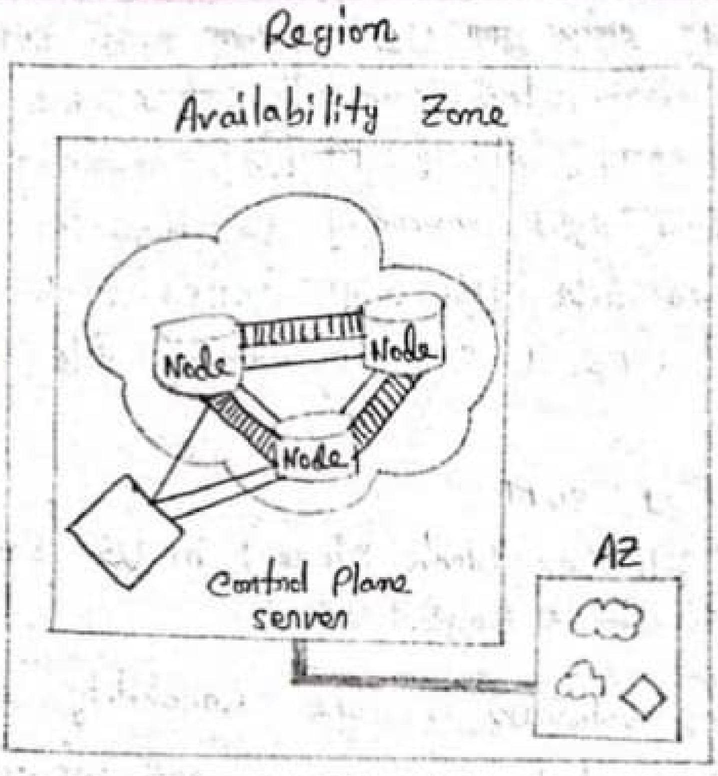
Case Study: AWS Failure 2011 :

(2011 সালের এপ্রিল মাসে US অঞ্চলের সবগুলো server down হয়ে গিয়েছিল। 2 দিন distributed connection ছিল না। এর কারণ ছিল — Server এর memory full হয়ে গিয়েছিল, memory upgrade করে পুরাতন সবগুলো file গুলো নতুন memory তে transfer করতে চাচ্ছিল। এই AWS Server-এর file গুলো অন্য server-এ transfer করার সময় দুই link এ চলে যেত। এ কারণে missing file এর জন্য AWS Error দিচ্ছে)

- April 21, 2011.
- EBS (Elastic Block Store) in US East region unavailable for about 2 days.
- 13% of volumes in one availability zone got stuck.
- Led to control API errors and outage in whole region.
- " " problems with EC2 instances and RDS in most popular region.
- due to reconfig error and re-mirroring storm.

Ques:- AWS Failure 2011 গুরুত্বপূর্ণ কেন? কীভাবে হইছে? Disadvantage গুলো কী কী?

(3 নং ques-এ must আসবে)



AWS EBS overview

Region → Availability Zones.
Clusters → Nodes → Volumes
Volume : replicated in cluster
Control Plane Services: API for volumes for whole region.
Networks : primary, secondary

What happened ?

1. Network config problem.
2. re-mirroring storm.
3. CP API thread starvation.
4. node race condition.
5. CP election overload.

(৩ নং, ৪ এর ২ কারণে — কী কী prob. হয়েছিল)

Failure: A system fails when it does not meet its promises or cannot provide its services in the specified manner.
(काम बंद हो जाना)

Error: Part of the system state that leads to failure (i.e., it differs from its intended value).
(Failure होने का कारण बनने वाला सिस्टम का कोई हिस्सा)

Fault: The cause of an error (results from design errors, manufacturing faults, deterioration, or external disturbance)
(इस गलती का कारण क्या है जैसे Procedure का fault।)

#Recursive: (Back जाना / Retrieve करते जाना)

(i) → Failure can be a fault
(ii) → Manufacturing fault leads to disk failure
(iii) → Disk failure is a fault that leads to database failure.
(iv) → Database failure is a fault that leads to email service failure.

Manufacturing fault
↓
Disk failure
↓
Database failure
↓
Email service failure

Ques: (2 marks का आएगा)
Failure, error, fault क्या है?

Total vs Partial failure:-

Imp. Qus:- (Failure কী? কয় প্রকার ব্যাখ্যা কর।)

Failure is of 2 types :-

★★★

(1) Total Failure: All components in a system fail. Typical in nondistributed system.

(2) Partial Failure: One or more (but not all) components in a distributed system fail.

In partial failure,

- some components affected.
- other " completely unaffected.
- Considered as fault for the whole system.

Types of Faults: (3 types)

★★★

① Transient fault: occurs once then disappear. (একবার হয়ে চলে যায়)

~~② Intermediate~~

② Intermittent fault: occurs, vanishes, reoccurs, vanishes, etc. (বিদ্যুতের lighting এর মতো)

③ Permanent fault: persists until faulty component is replaced.

(battery কোন হয়ে গেলে যতক্ষণ replace না করা পর্যন্ত solve হবে না)

Types of Partial Failure:-

① Process Failure: process proceeds incorrectly or not at all.

② Storage Failure: "stable" secondary storage is inaccessible.

③ Communication Failure: communication link or node failure.

④ Crash Failure: a server halts, but works correctly until it halts.

→ Fail-Stop: server will stop in a way that clients can tell that it has halted.

→ Fail-Resume: server will stop, then resume execution at a later time.

→ Fail-Silent: clients do not know server has halted.

⑤ Omission Failure: a server fails to respond to incoming requests.

→ Receive Omission: fails to receive incoming messages.

→ Send Omission: fails to send messages.

⑥ Value Failure: The value of the response is wrong.

⑦ Timing Failure: a server's response lies outside the specified time interval.

Detecting Failure :-

failure detection is a computer application on a subsystem that is responsible for the detection of node failure.

Synchronous systems : Has a clear time bound for each event that occurs in the system.

→ Timeout.
→ Failure detector sends probes to detect crash failures.

Asynchronous systems : Do not depend on the strict arrival time for reliable operation.

→ x timeout gives no guarantees.
→ Failure detector can track suspected failures.
→ Combine results from multiple detectors.

* **Fault Tolerance :** Fault tolerance is the ~~ability~~ availabili of a system to continue operating without interruption when one or more of its componen goes fail.

Goal :

① Automatically recover from partial failure.
② Without seriously effecting overall performance.

Imp V.I. Qus :-

* Write down the techniques of Fault tolerance.

~~Tech~~ Techniques :

① Prevention : prevent or reduce the occurrence of faults.

② Prediction : predict the faults that can occur and deal with them.

③ Masking : hide the occurrence of the fault from other process

④ Recovery : restore an ~~erroneous~~ faulty state to an error-free state.

① **Failure Prevention :** Make sure faults don't happen :

→ Quality hardware.
→ Hardened hardware.
→ Quality software.

② **Failure Prediction :** Deal with expected faults :

→ Test for error conditions.
→ Error handling code.
→ Error correcting codes.
• checksums
• erasure codes.

(3) **Failure Masking :** Try to hide occurrence of failures from other processes.

Mask :
(i) Communication failure.
(ii) Process failure

একটি file এ বানান ভুল share করেছি কিন্তু ২ বানান টাও problem দেখে ফিরে বা delete হয়ে গেছে। এই notification টা অন্যরা পায় না। এটাই masking করে fault hide করে।

Most Imp.

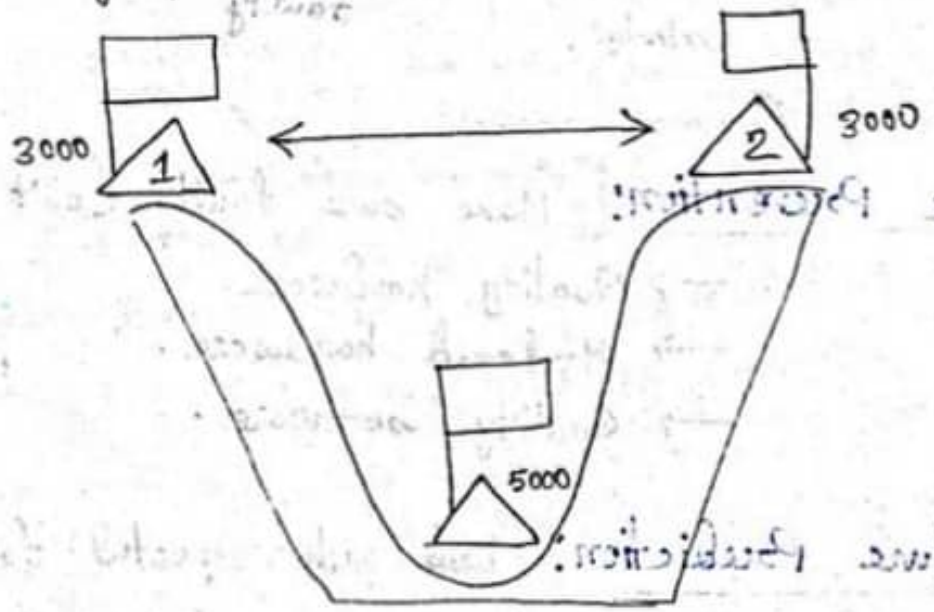
* Reliable Communication :-

Reliable group communication means at least one member of the group receives the message and replies to it.

- Focus on masking crash.
- Lost message failure.

* Two - Army Problem :-

Non-faulty processes but lossy communication.



→ 1 → 2 attack!
→ 2 → 1 ack
→ 2: did 1 get my ack?
→ 1 → 2 ack ack
→ 1: did 2 get my ack ack?
→ etc.

ack = acknowledge

* Consensus with lossy communication is impossible.
* Hence unsolvable (It has future scope)

Reliable Point-to-Point communication :-

Possible failures:

1. Client cannot locate server.
2. Request message to server is lost.
3. Server crashes after receiving a request.
4. Reply message from the server is lost.
5. Client crashes after sending a request.

(4) Failure Recovery: Restoring an erroneous (faulty) state to an error free state.

Issues:

(i) Reclamation of resources: locks, buffers held on other nodes.

(ii) Consistency: Undo partially completed operations prior to restart.

(iii) Efficiency: Avoid restarting whole system from start of computation.

Failure Recover
↓ 2 types

Forward Recovery

- Correct state without moving back to previous state.
- Error must be known in advance

Backward Recovery

- By moving to a back to previous state correct.
- High overhead.
- Recovery
- Impossible to roll back.

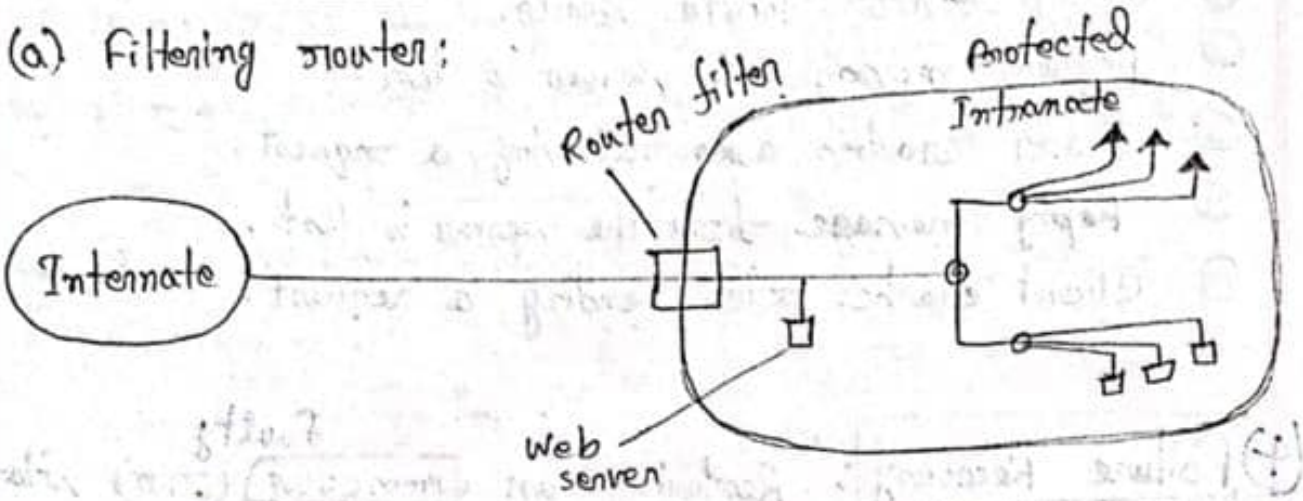
Last class

~~04/11/2022~~

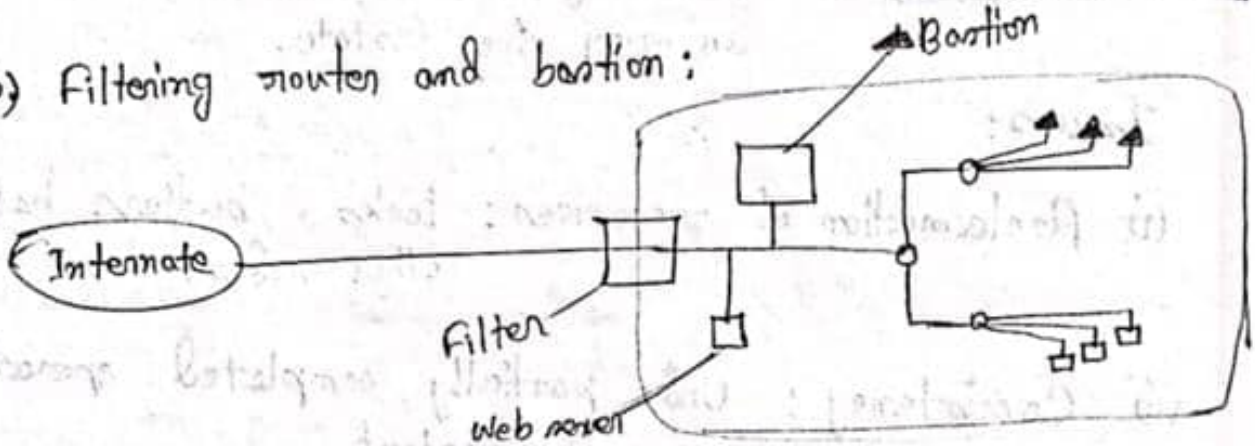
How we configure firewalls?

Configure firewall:

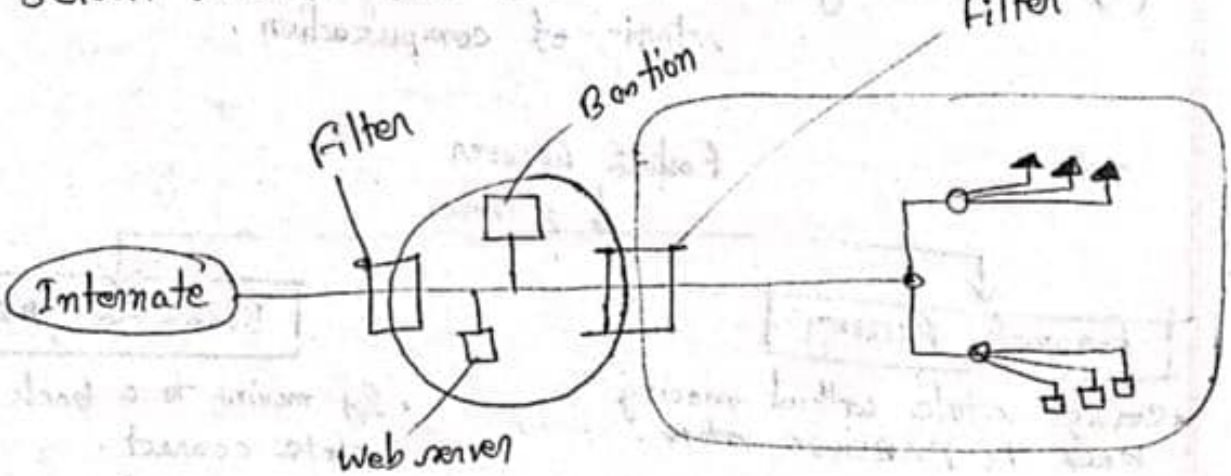
(a) Filtering router:



(b) Filtering router and bastion:



(c) Screen subnet for bastion:



* Compare among different symetric cryptographic algorithm.

TEA: TEA stands for tiny encryption algorithm.

1. Simple & concise (~~32 rounds~~).
2. Secure & reasonably fast.
3. Simple, symmetric algorithm.
4. Written Inc.
5. Key 128 bits.

DES: DES stands for Data Encryption Standard.

1. US standard for business applications.
2. 64 bits key.
3. Cracked in 1997.
4. Secure but poor performance.

RSA: RSA stands for (Rivest-Shamir-Adleman) three scientist name.

1. Pair of keys, one public and one private.
2. Encryption with public key.
3. Decryption possible only if private key known.
4. Factorizing large number.

AES: AES stands for Advance encryption standard.

1. Invitation for proposal 1997.
2. In progress.
3. Key size 128, 192 and 256 bits.

AWS Failure 2011 :-

Amazon Web Services (AWS) fails in April 21, 2011
It was unavailable in the US East region for 2 days.

Disadvantages :

① 13% of volumes in one availability zone got stuck.
② Led to control API errors and outage in whole region
③ Re-config error and re-mirroring storm.
④ Network config problem.
⑤ CP election overload.
⑥ CP API thread starvation.
⑦ Node race condition.

How a fault tolerance assured in a system?

⇒ Fault and failure are limited in a part. It needed to provide 3 main feature to distributed system.

(i) Reliability.
(ii) Availability.
(iii) Security.

04/11/2022
Last Class

Naming :

A name in a distributed system is a string of bits or character that is used to refer to an entity. System manages a wide collection of entities in different kinds. They are — files, processors, user, hosts.

* Entity, i.e. Address or Identifier definition — less imp.

→ * Good Naming System : (characteristics)

① Location transparency.
② Location independency.
③ Multiple user define name as same object.
④ Replication transparency.

→ * 2 types of Naming System :-

(1) Machine / System Oriented.
(2) Human oriented.

System Oriented Name	Human Oriented Name
1. Represent in machine readable form.	1. Variable length, character strings.
2. Structured or unstructured.	2. Usually structured.
3. Easy to store, manipulate and compare.	3. Easy to remember and compare.
4. Hard for remember and human to use.	4. Hard for machine to process.
5. Example: 'ncode.	5. Example: URL.
6. Auto generated	6. Predefined.

* Partitioning : Split (विभाजन) name space over multiple server.

2 types : —

(1) Structure :
- According to graph structure
- Improve look up performance
- Rigid structure.

(2) Structure free :
- Flexible
- Decrease look up performance.

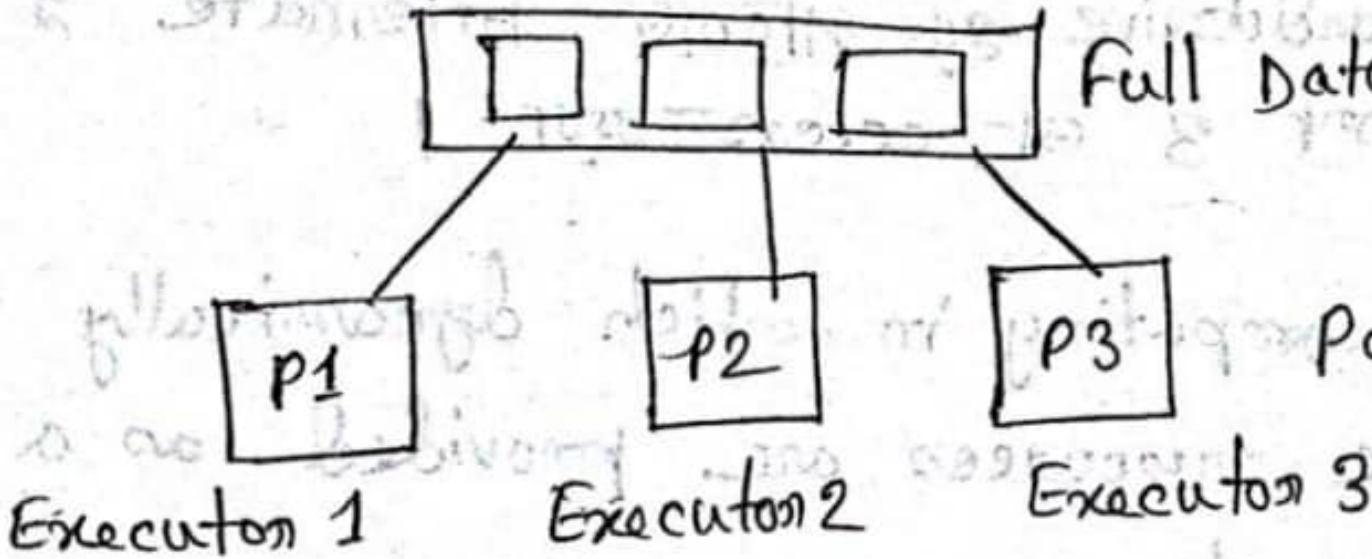


Fig.: Partitioning.

Cloud computing :-

~~কম্পিউটার~~ harddrive ~~এ~~ ~~থাকা~~ internate ~~এ~~ ~~কোন~~ 3 program ~~ব্যবহার~~ 3 ~~এ~~ access ~~করা~~ ।

A style of computing in which dynamically scalable and virtualize ~~রিসোর্স~~ resources are provided as a service over the internate.

It is a term refered to storing and accessing data over internate, doesn't store data in H.W, access data from remote server.

Key Characteristics :-

1. On demand and self-service. ~~Broad~~.
2. Broad network access -
3. Automated as needed.
4. Pooled ~~রিসোর্স~~ resources.
5. Elasticity — scalability
6. Measured service
7. Security.
8. Multi-tenancy.

Types of cloud computing : 3 types.

① Public: open service available to everyone.

② Private: Owned, operated & available to specific organization.

③ Hybrid: System use some private & some public cloud services.

Advantages of cloud computing :

① Cost savings : helps to save substantial capital cost as it does not need any physical hardware.

② Strategic edge : It helps to access the latest applications any time without spending time & money on installations.

③ High speed : cloud computing allows to deploy service quickly in fewer clicks. We can get the resources within fewer minutes.

④ Back-up and restore data : Once the data is stored in a cloud, it is easier to get the back-up & recovery of that.

⑤ Reliability : Reliability is one of the biggest benefits of cloud hosting. We can always get instantly updated about the changes.

⑥ Mobility : Employees who are at a remote locations can easily access all the cloud services. All they need is an internet connection.

⑦ Ultimate storage capacity : The cloud offers almost limitless storage capacity.

⑧ Collaboration: The cloud computing platform helps employees who are located in different geographies to collaborate in a highly convenient & secure manner.

⑨ Quick deployment: Cloud computing gives us the advantage of rapid deployment.

⑩ Automatic Software Integration: In the cloud, software integration is something that occurs automatically.

⑪ Flexibility.

Disadvantages of cloud computing:

① Data loss on theft.
② Data leakage, security risk.
③ Account or service hijacking.
④ Insecure interfaces & APIs.
⑤ Denial of service attack.
⑥ Technology vulnerabilities, especially on shared environments.
⑦ Lower bandwidth.
⑧ Need an internet connection: To use the cloud, we need to be connected to the internet.
⑨ There are additional costs for uploading & downloading files from the cloud.
⑩ Technical issues.
⑪ Lack of support.

Election Algorithm

Many algorithms used in distributed system require a coordinator that performs functions needed by other processes in the system. Election algorithms are designed to choose a coordinator. It is a technique to pick unique coordinator. Election algorithms choose a process from group of processors to act as a coordinator.

There are 2 election algorithms for 2 different configuration of distributed system.

1. Bully
2. Ring

Bully Election algorithm:

① This algorithm applies to system where every process can send a message to every other process in the system.

② Each process has a unique ID.

③ Process knows the ID and address.

④ communication reliable.

⑤ Select process with highest id.

⑥ If coordinate fail then election initiates.

⑦ Order of message required with n process.

⑧ a method for dynamically electing a coordinator or leader from a group of distributed computer process.

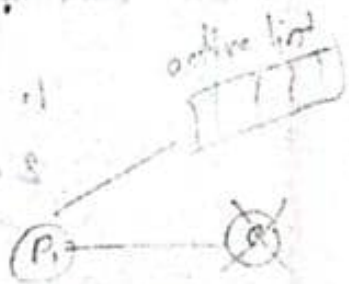
Ring Election algorithm :-

1. This algorithm applies to systems organized as a ring (logically or physically).

2. In this algorithm we assume that the link between the process are unidirectional and every process can message to the process on its right only.

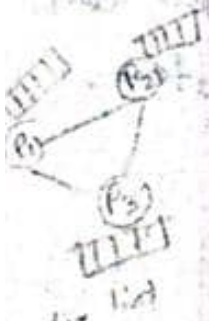
③ Data structure that this algorithm uses is 'active list', a list that has priority number of all active processes in the system.

④ ~~The goal of an~~



Algorithm :

① If process P_1 detects a coordinator failure, it creates a new active list which is empty initially. It sends election message to its neighbour on right and adds number 1 to its active list.



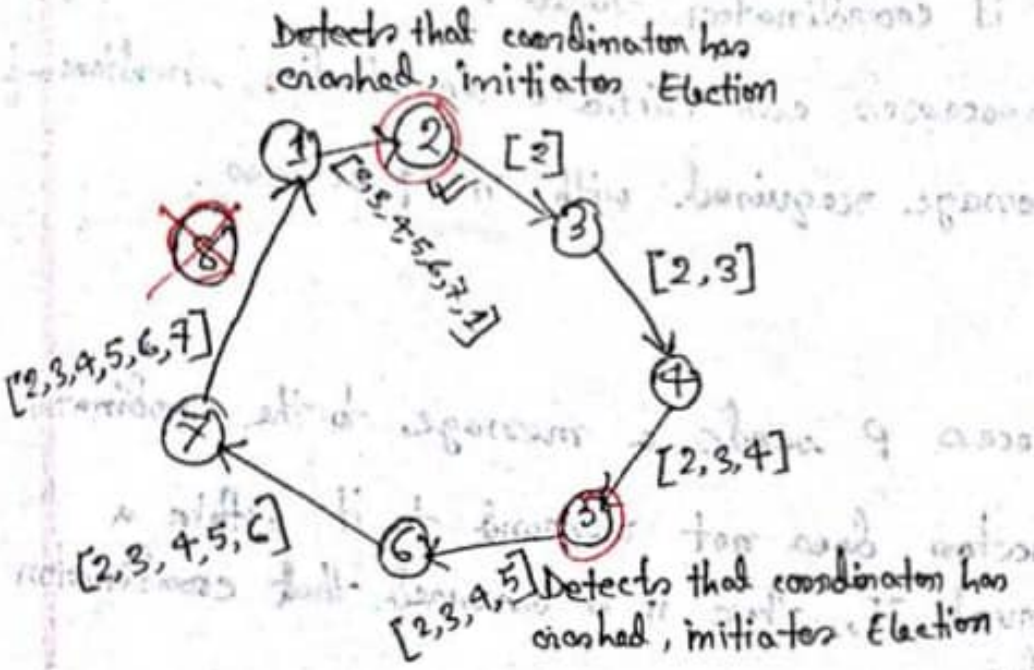
② If process P_2 receives message elect from processes on left, it responds in 3 ways.

(i) If message received does not contain 1 in active list then P_1 adds 2 to its active list & forward the message.

(ii) If this is the first election message it has received or sent, P_1 creates new active list with numbers 1 & 2. It then sends election message 1 followed by 2.

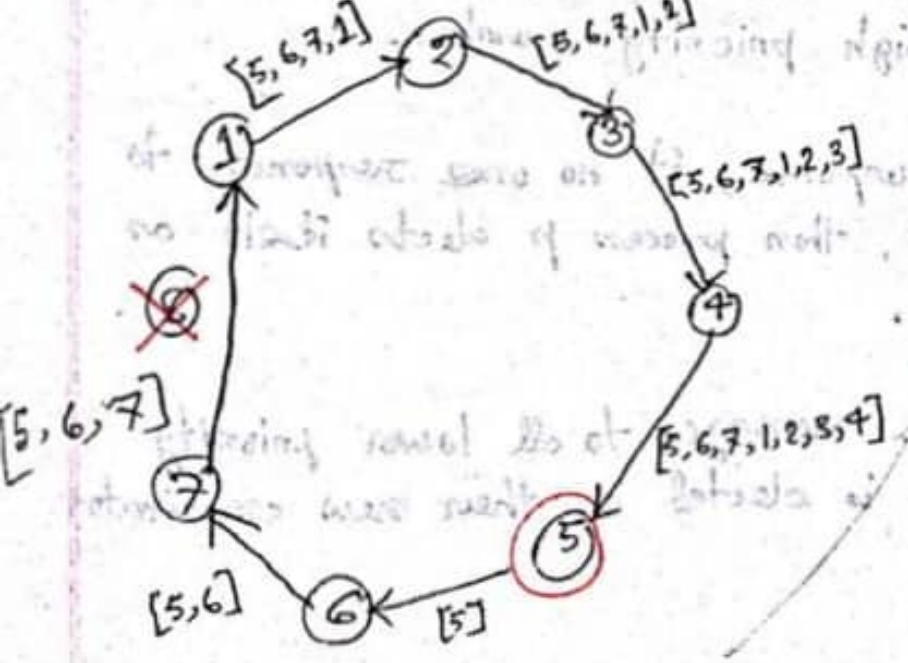
(iii) If process P_i receives its own election message 1 then active list for P_i now contains numbers of all the active processes in the system. Now process P_i detects highest priority number from list & elects it as the new coordination.

Example: Let, 2 and 5 start election message independently.

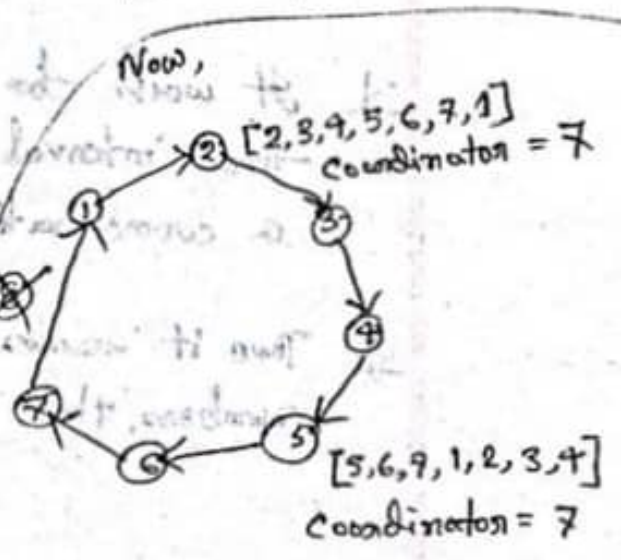


Here 2 is the initiator

So 7 is the coordinator selected by 2



Here 5 is the initiator



2 and 5 will convert Election messages to coordinator messages. All processes recognize highest numbered process as new coordinator.

Bully Election Algorithm:-

① Each process has a unique numerical ID.
② Process know the ID's and address of every other process.
③ Communication is assumed reliable.
④ Key idea: Select process with highest ID.
⑤ Process initiates election if it just recovered from failure & if coordinator failed.
⑥ Several processes can initiate an election simultaneously
⑦ $O(n^2)$ message required with n processes.

Algorithm:

⑧ Suppose process P sends a message to the coordinator.

1] If coordinator does not respond to it within a time interval T, then it is assumed that coordinator has failed.

2] Now process P sends election message to every process with high priority number.

3] If waits for response, if no one responds to time interval T, then process p elects itself as a coordinator.

4] Then it sends a message to all lower priority numbers, then it is elected as their new coordinator.

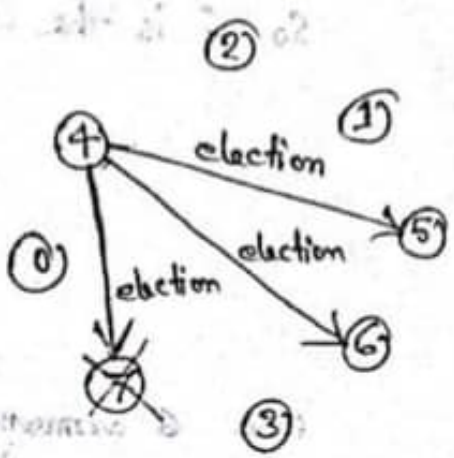
5] However, if an answer is received within time T from any other process Q,

→ Process P again wait for time interval T to receive another message from Q that it has been elected as coordinator.

→ If Q doesn't respond within time interval T, then it is assumed to have failed & algorithm is restarted

Example:

(i)

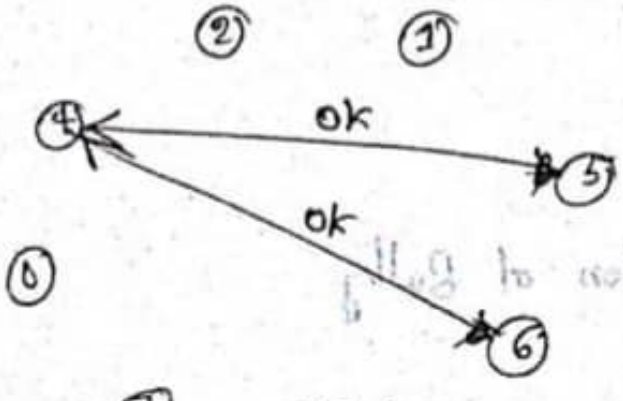


Let assume process 7 is the coordinator. But it has just crashed. Let process 4 sends msg to 7 & it is not responding & sends msg to 5, 6. (election)

process 7 has the highest number So it is the coordinator.

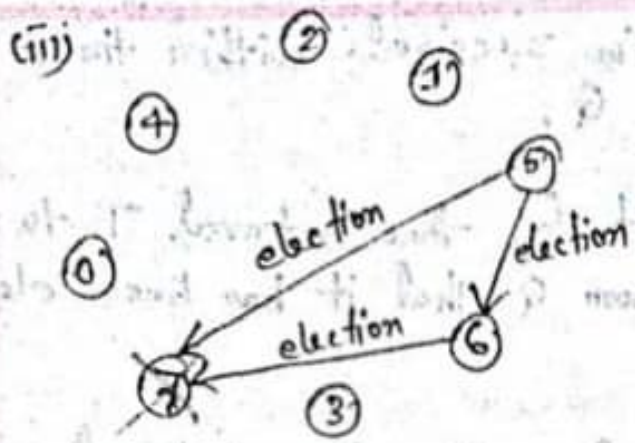
Process 4 sends election mes to all processes higher than it

(ii)



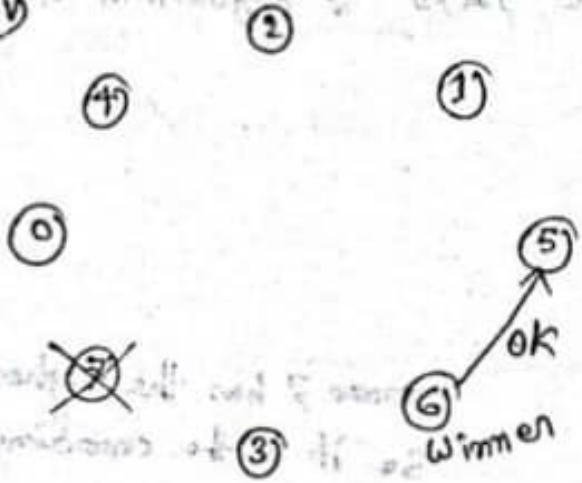
Now process 5 and 6 responds with 'OK' messag Process 4 job is over be it know 5 or 6 will bec the coordinator.

(iii)



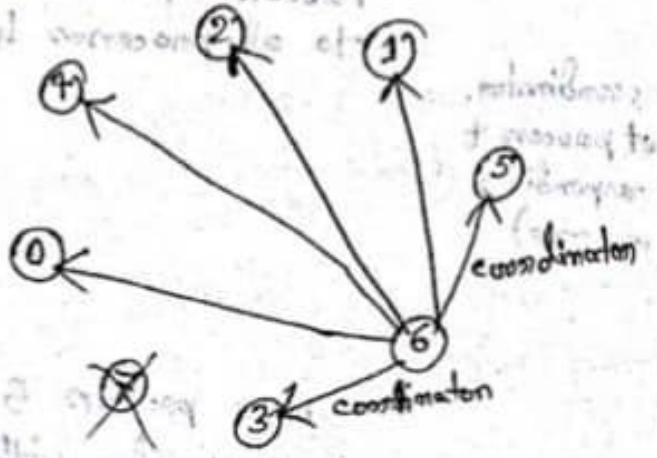
Now 5 sends election msg to 6 and 7. and process 6 will send msg to 7 because it has the higher priority.

(iv)



as 7 is discarded as 6 is the highest number and sends a OK message So 6 is the winner.

(v)



Now 6 announcing the, sending coordinating message to all other running processes.

implementation of Bully