# Parallel & Distributed Computing

## Chapter # 1

### Introduction.

⇒ Over whelming pace of continuous change
- increasingly powerful computers
- high speed networks.
- smaller size

⇒ Increasing digitization of society
- how many computers are being used?
- mobile computers?

⇒ Distributed vs Decentralized systems

Types of Networked Computer Systems

i) Decentralized Systems
- processes and resources are necessarily spread across multiple computers.

ii) Distributed Systems
- Processes and resources are sufficiently spread across multiple computers.

⇒ Decentralization

- spreading implementation across multiple computers.
- is not end goal
- implementation decision that needs to be considered carefully.
- focus on sufficiently for spreading processes and resources.
- less spreading is generally preffered.

Examples of Decentralized Systems

1) Geographically Dispersed Systems

- monitoring physical locations like power plants.
- decentralization arises from spatial necessity of spreading processes and resources.

2) Distributed Ledger

Blockchain

- lack of mutual trust b/w pasticipants
- Uses publically verifiable transaction mechanism

- decentralization arises due to trust issues.

## Distributed Systems Example

1) Google Mail Services
   - access via web interface or mail clients
   - incoming and outgoing server
     imap.gmail.com
     smtp.gmail.com
   - estimated 10,000 mails per second are processed.

2) Network Attacked Storage (NAS)
   - smaller distributed system
   - typically 2-4 hard drives.
   - functions as file server.

## Challenges

- complexity
- Partial failures
- security

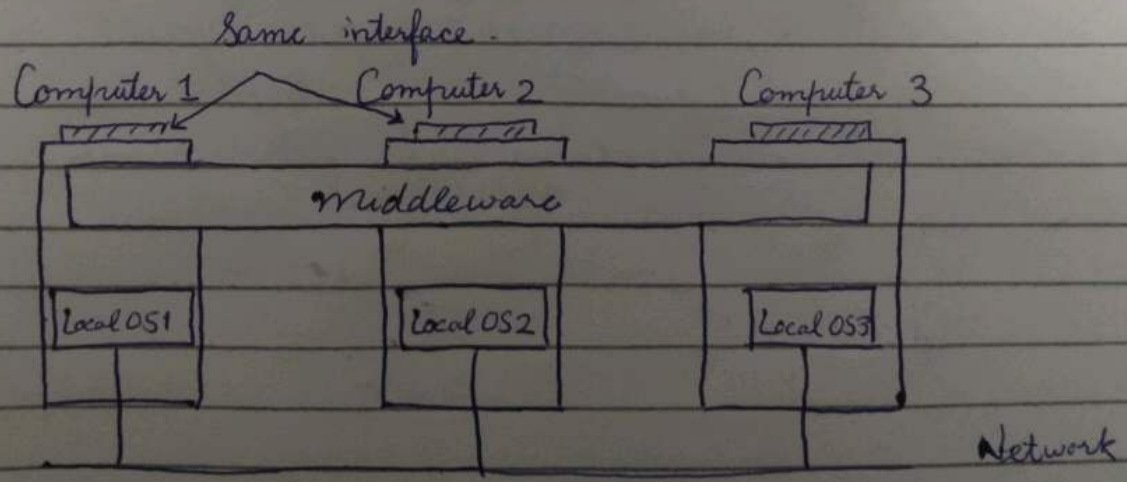
# Design Goals of Distributed Systems

## 1) Resource Sharing

- Make remote resources easily accessible
- economic benefits
- collaborative work.

## 2) Distribution Transparency

- Hiding complexity of resource distribution
- resources are invisible to end users and applications.
- achieved through middleware maintaining consistent interfaces while hiding the implementation details.



| Transparency | Discription |
| --- | --- |
| Access | hide diff in data representation and how it is accessed. |
| Location | hide where object is located |
| Relocation | hide that object may be moved to another location while in use. |
| Migration | hide that object may move to another location. |
| Replication | hide that object is replicated |
| Concurrancy | hide that object may be shared by seval users |
| Failure | hide failure & recovery of object. |

## Degree of Transparency

⇒ Aiming at full transparency can be too much.
- comm. latencies cannot be hidden
- completely hiding failures is impossible

⇒ Full transparency will cost performance
- keeping replicas upto-date will consume time.
- flushing of write operations

⇒ Exposing Distributive may be good
- location based services.

3) Openess
- system components are easily usable and integrable.
- Standards of interoperability using standard rules, syntax, and semantics using Interface Definition Language (IDL).

4) Dependability
- Fault tolerance
- masks failures and ensure seamless recovery

⇒ fault classification
- temporary
- recovering

- permanent

Real work examples - harddrive.

Terms

Fault - cause of an error

Error - component that leads to failure

Failure - not working upto the specifications.

Fault Prevention

Fault Tolerance

Fault Removal

→ Fault Forecast

Metrices

• MTTF • MTTR (meantime to repair)

↓

(meantime to failure)

Mean Time between failures

MTBF = MTTF + MTTR

5) Security

- Crucial for dependability
- Authentication
  - verify identity
- Authorization
  - determine right to access certain resources.

- Cryptography
  - key technique for securing data.
- Secure Channels
  - HTTPS.

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## Design Goals

6. Scalability
   - Handling growth in users, resources, and geography such that system maintains its performance.

i) Size Scalability
   - ability to add more users without degrading performance.

ii) Geographical Scalability
   - maintains performance despite significant communication delays due to distances.

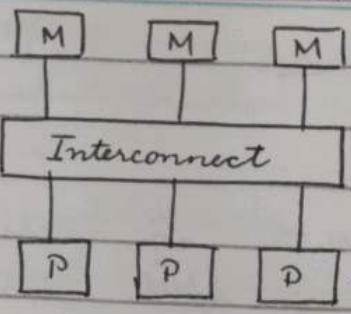
iii) Administrative Scalability
   - easy management across multiple independent administrative domains

# Classification of Distributed Systems.

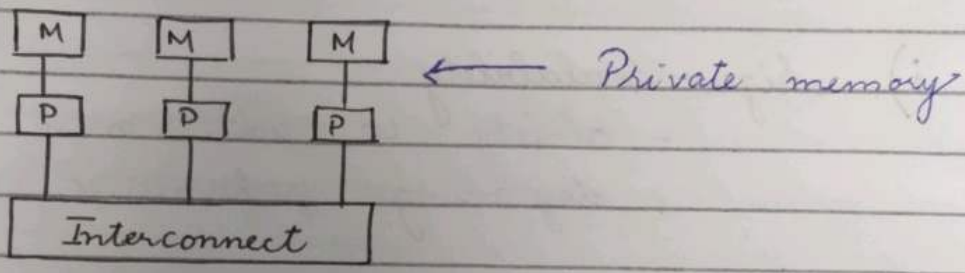
1) High Performance Distributed Computing.
   - High Performance computing (HPC)
   - Involves Parallel Processing
     i)- Multiprocessor machines.
     ii)- Multicomputer Systems.

Shared memory

i)




ii)




⇒ Cluster Computing

- group of high-end systems connected through high-speed interconnect (LAN).

- homogeneous → same OS & hardware

- tightly coupled managing nodes.

Examples

- weather forecasting
- Computation Fluid Dynamics.
- Gene sequencing
- Astro physics.

El-Capitan — top 500.10 m

- CA USA 2024
- $600 million USD
- 43808 AMD EPIC 24C @ 1.8 GHz
- Total memory of 5.43 PB
- 2746 PFLOPIs
- 30 MW

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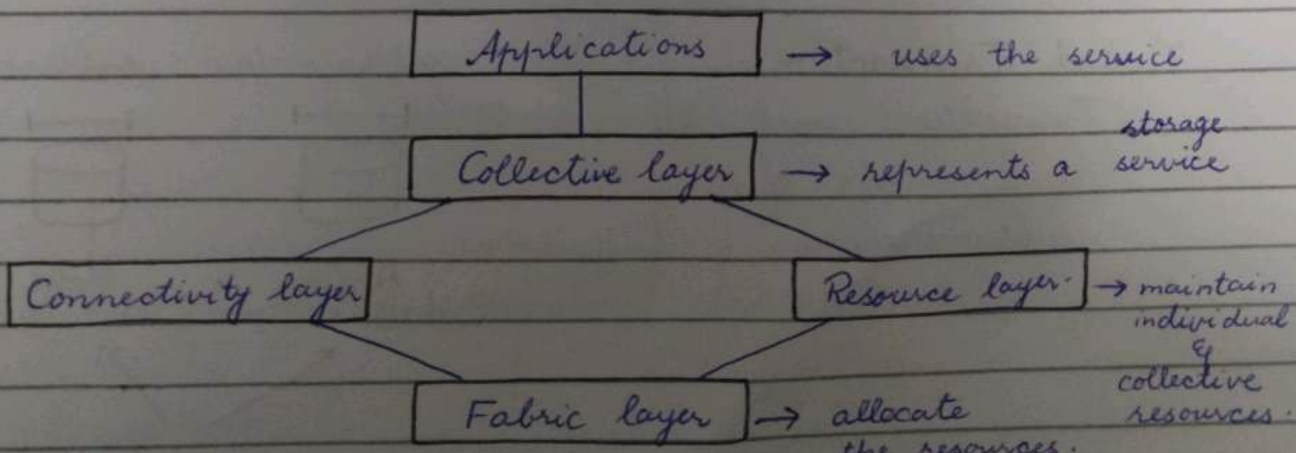
⇒ Grid Computing

- Heterogeneous federation of systems
- Dispersed across several organizations.
- Spans over a wide area network. (WAN)

Layered Architecture of Grid Computing.



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# Classification of Distributed Systems

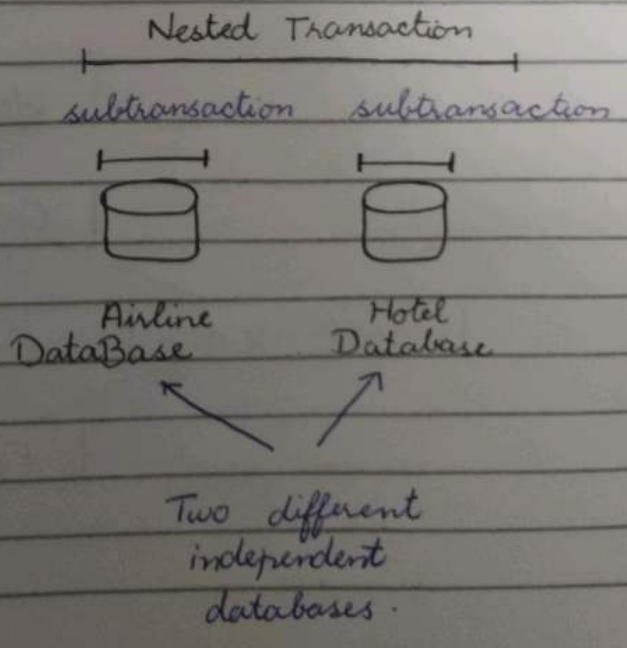
1) HPDC
2) Distributed Information Systems

- Integrate applications into an enterprise-wide information system using middleware solutions.

- Distributed Transaction Processing
  - → combining multiple requests into a single distributed transaction.
  - → ACID
    - ↳ atomic, consistent, Isolated, durable.
  - → all or nothing.

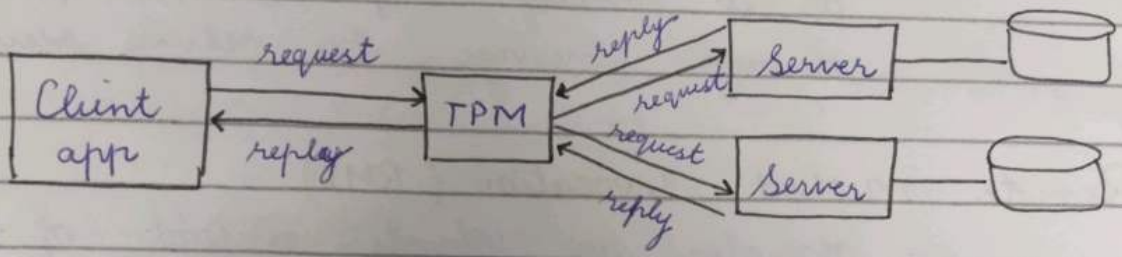
## Nested Transaction

- Transaction constructed as a number of subtransactions.



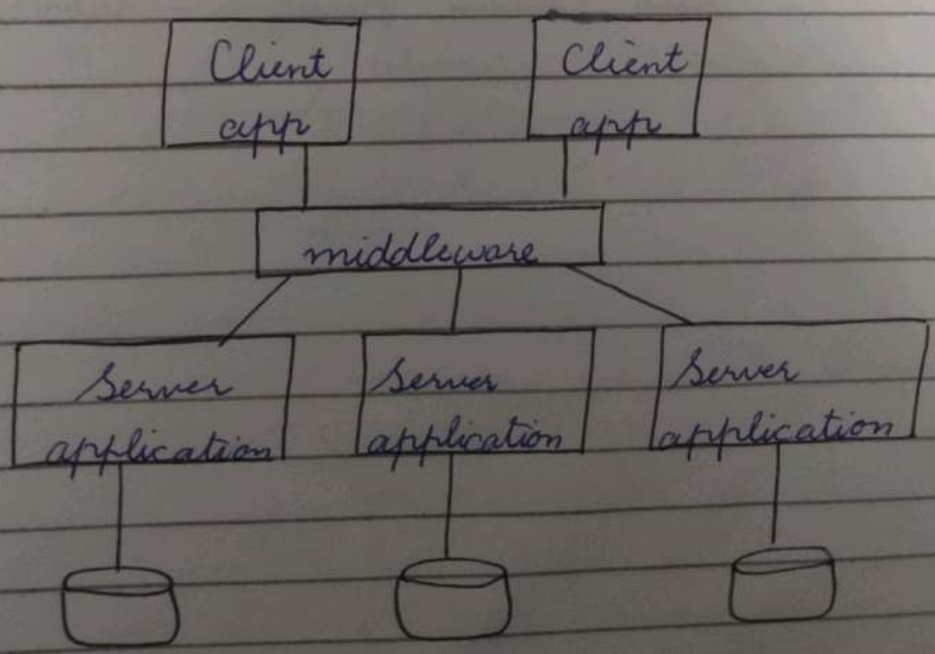
## Transaction Processing Monitor (T.P.M)

- coordinates the execution of a distributed transaction across several servers.




## Enterprise Application Integration (EAI)

- direct communication between independent components is essential leading towards EAI.
- middleware facilitates communication.



# Types of communication middleware

1) Remote Procedure Call (RPC)
   - requests are sent through a local procedure call, packaged as a message, processed, responded through message to return results.

2) Remote Method Invocation (RMI)
   - operates on objects instead of functions.

3) Message Oriented Middleware (MOM)
   - Messages are sent to logical contact points (published) and forwarded to subscribed applications.
   - Also called publish-subscribe systems.

# Classification of Distributed Systems.

1) HPDC
2) DIS
3) Pervasive Systems

- Evolution from Traditional to Emerging Distributed Systems

- HPDC & DIS
  - fixed nodes
- - high quality network.

- Pervasive Systems
  - mobility
  - embedded into usess environment

Types
1) Ubiquitous computing
2) Mobile computing
3) Sensor network.

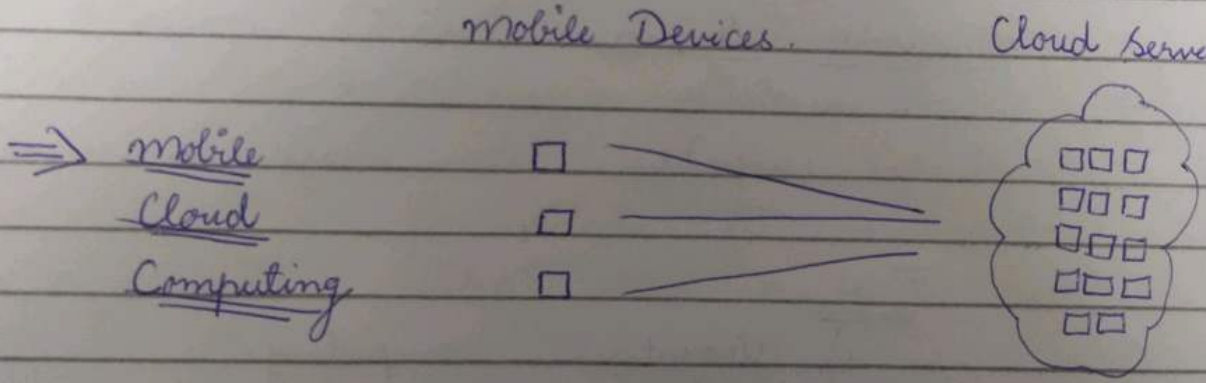
1) Ubiquitous Computing
   - Continuous presence & interaction.

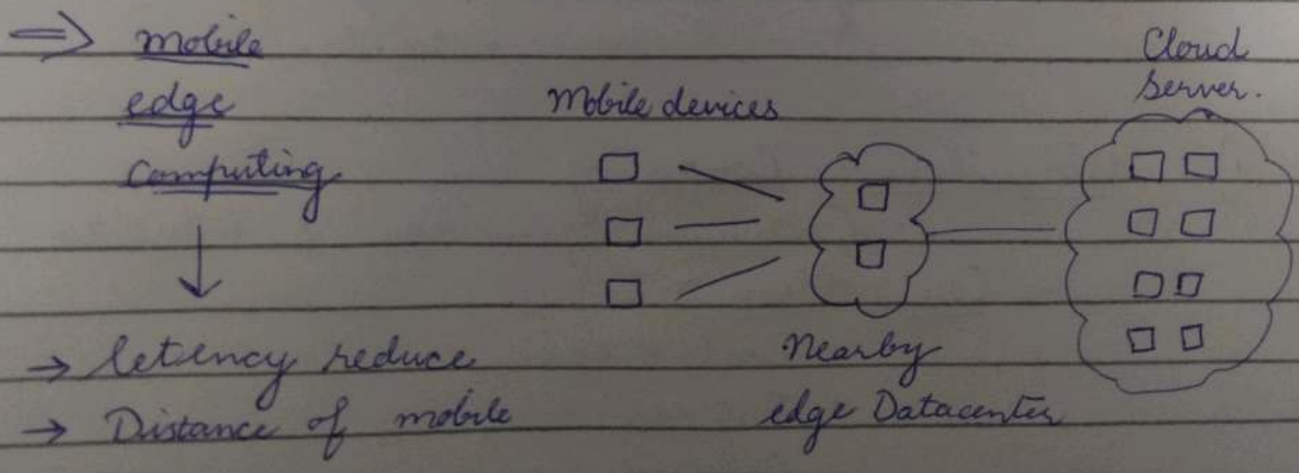
Core Elements
- Distribution
- Interaction
- Content awarness
- Autonomy
- Intelligence.

## Mobile Computing

- Diverse set of devices.
- Dynamic location & server discovery.
- Changing location.
- Reachability and server discovery.
- location awerness.

- Resource and Service sharing among mobile devices
  - not widely adopted.



## Sensor Networks

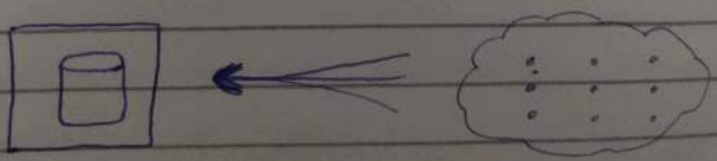
- sensor nodes collaborate to process sensed data efficiently in an application specific manner.

### Characteristics

- Many nodes equipped with one or more sensors.
- can act as actuators.
- Often battery powered.
- Use wireless communication
- Simple device with limited resources.
- Sensor networks organized as distributed databases.
- Two extremes:

i) Storing & processing data at operators site.

ii) Storing & processing data at sensors.

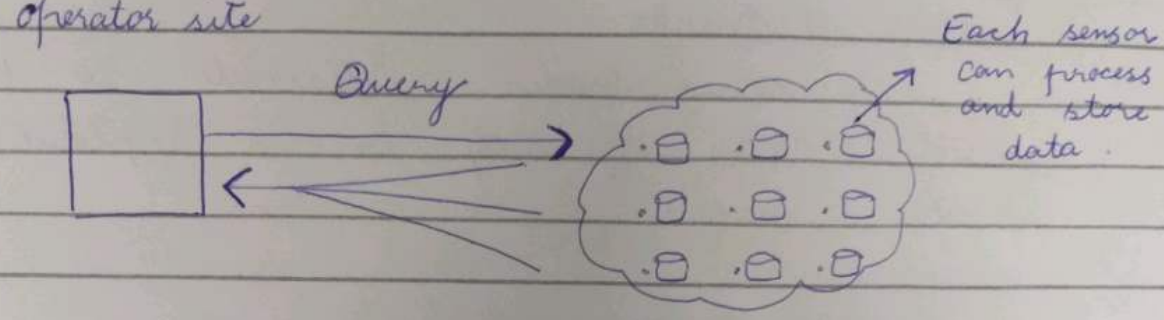


Operator's site

Sensor Network.

Use ⇒ forward data continuously.

→ Resource wastage more.




⇒ When we send query then sensors send data to operator site but in first approach sensors send data on operator site whether we ask or not.

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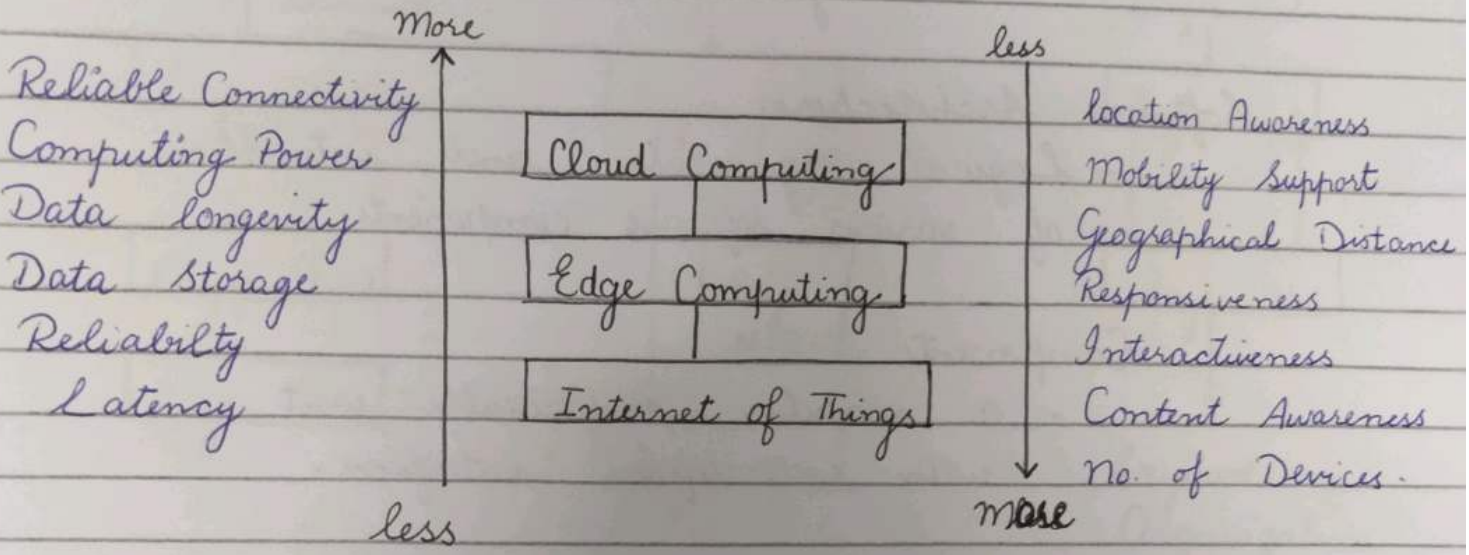
## Hierarchical view from clouds to devices.




## Developing Distribute systems : Pitfalls.

- False assumptions often made when developing a distributed application.

  - network is reliable
  - network is secure
  - network is homogeneous.

  - Topology does not change
  - Latency is zero.
  - Bandwidth is in infinite
  - Transport cost is cost.
  - There is one administrator.