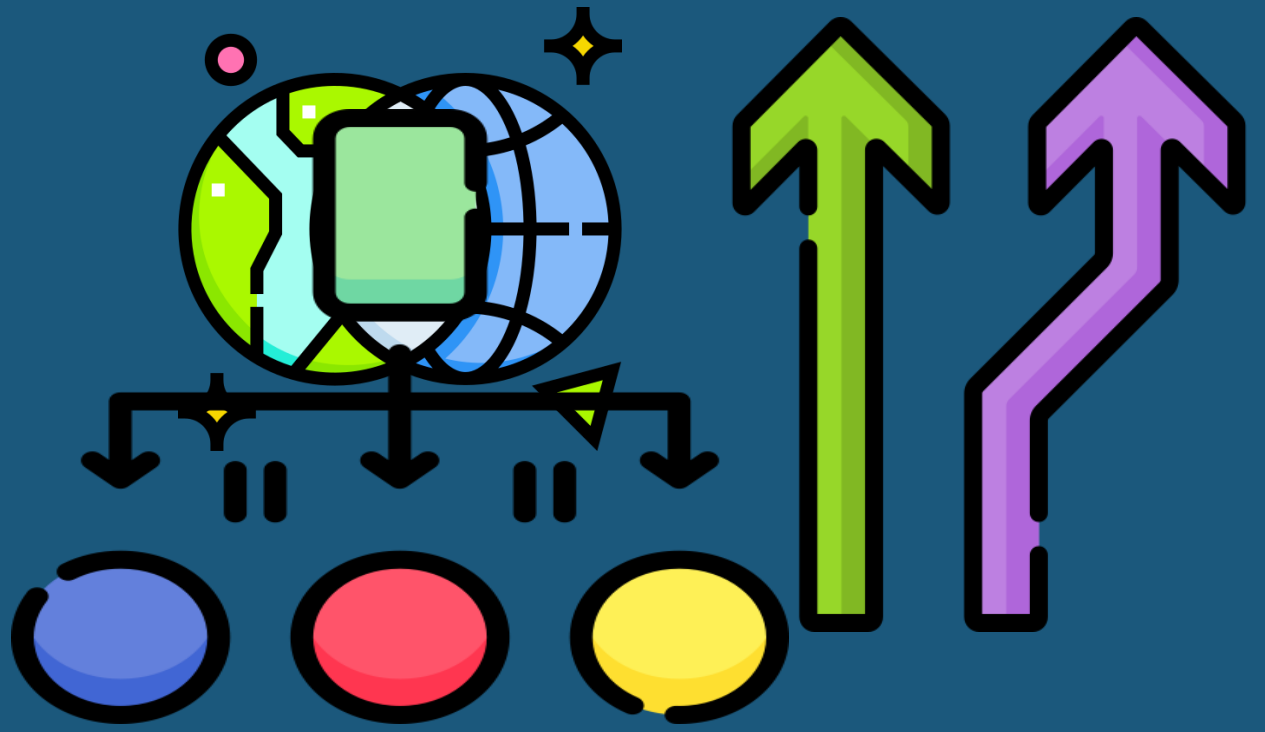

# Parallel and Distributed Computing


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# Lesson

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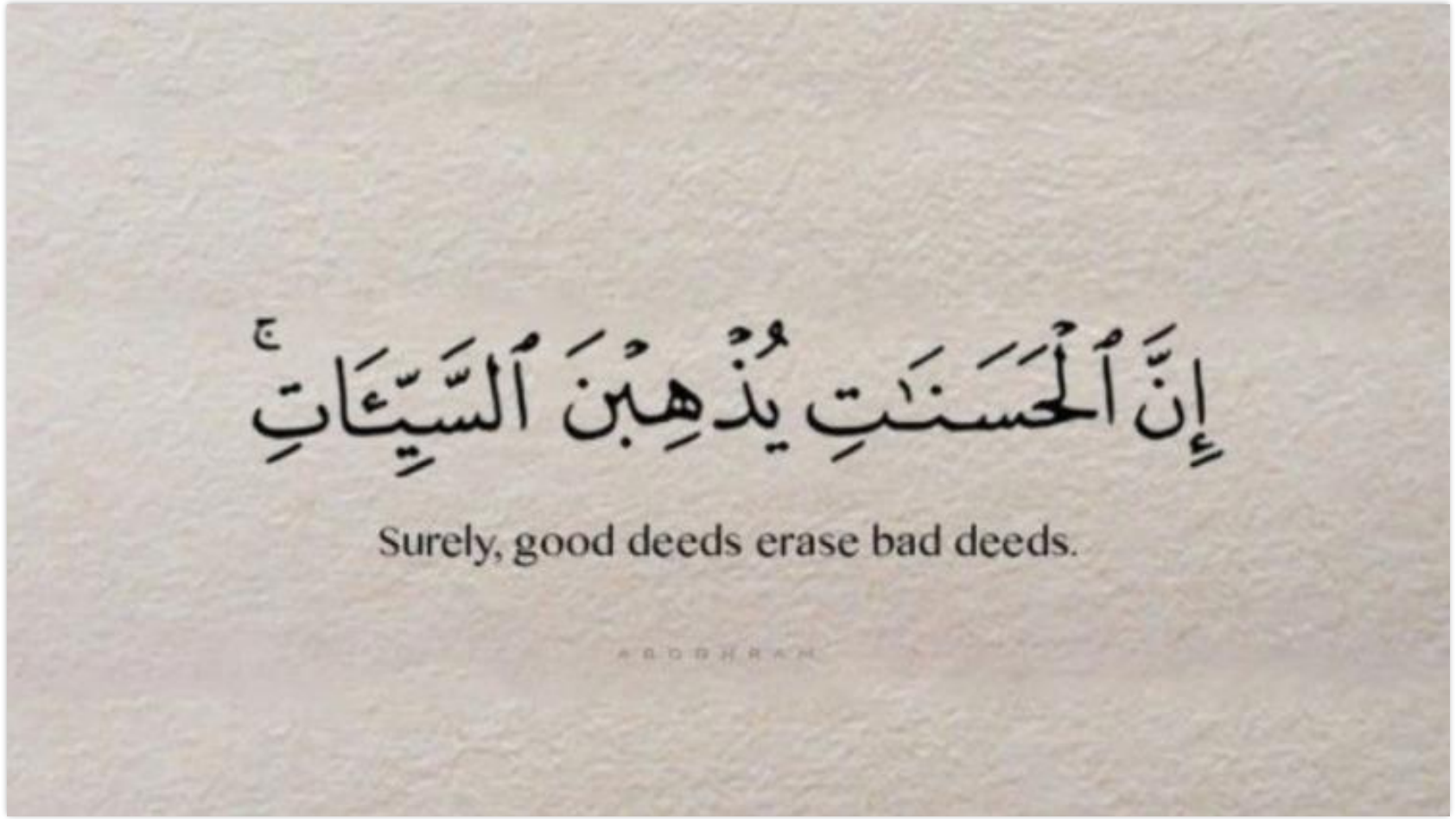

# Today' Lecture

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What is a Distributed System?

- Models of Distributed Systems
- Enabling Technologies for Distributed Systems
- Software Environments for Distributed Systems
- Performance in Distributed Systems
- Security in Distributed Systems
- Energy Efficiency in Distributed Systems

# Introduction to Distributed Systems

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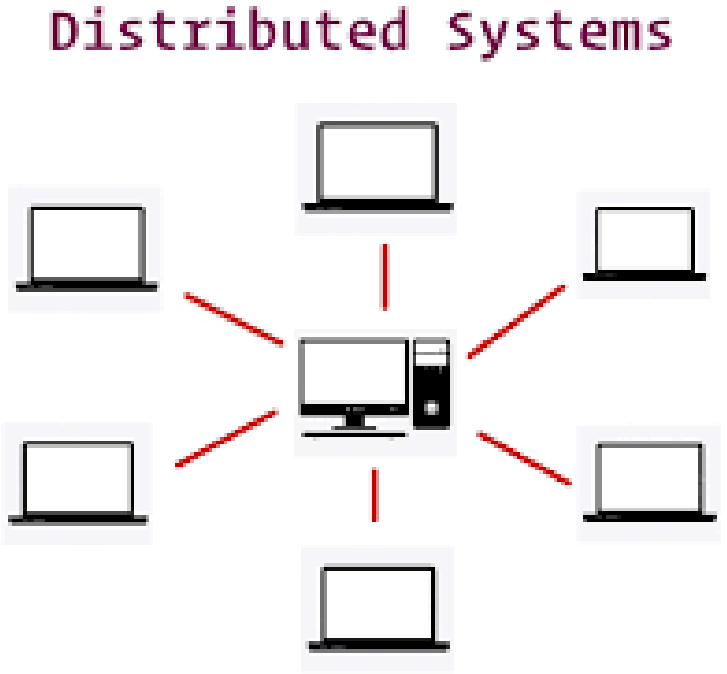
What is a Distributed System?

- A collection of independent computers that appear as a single system.
- Aim to improve performance, fault tolerance, and scalability.
- Examples of Distributed Systems:
  - Cloud Computing (AWS, Google Cloud)
  - Distributed Databases (Cassandra, Hadoop)



# Models of Distributed Systems

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Client-Server Model:

- Clients send requests, servers respond w services.

- Widely used in web applications.

Peer-to-Peer (P2P) Model:

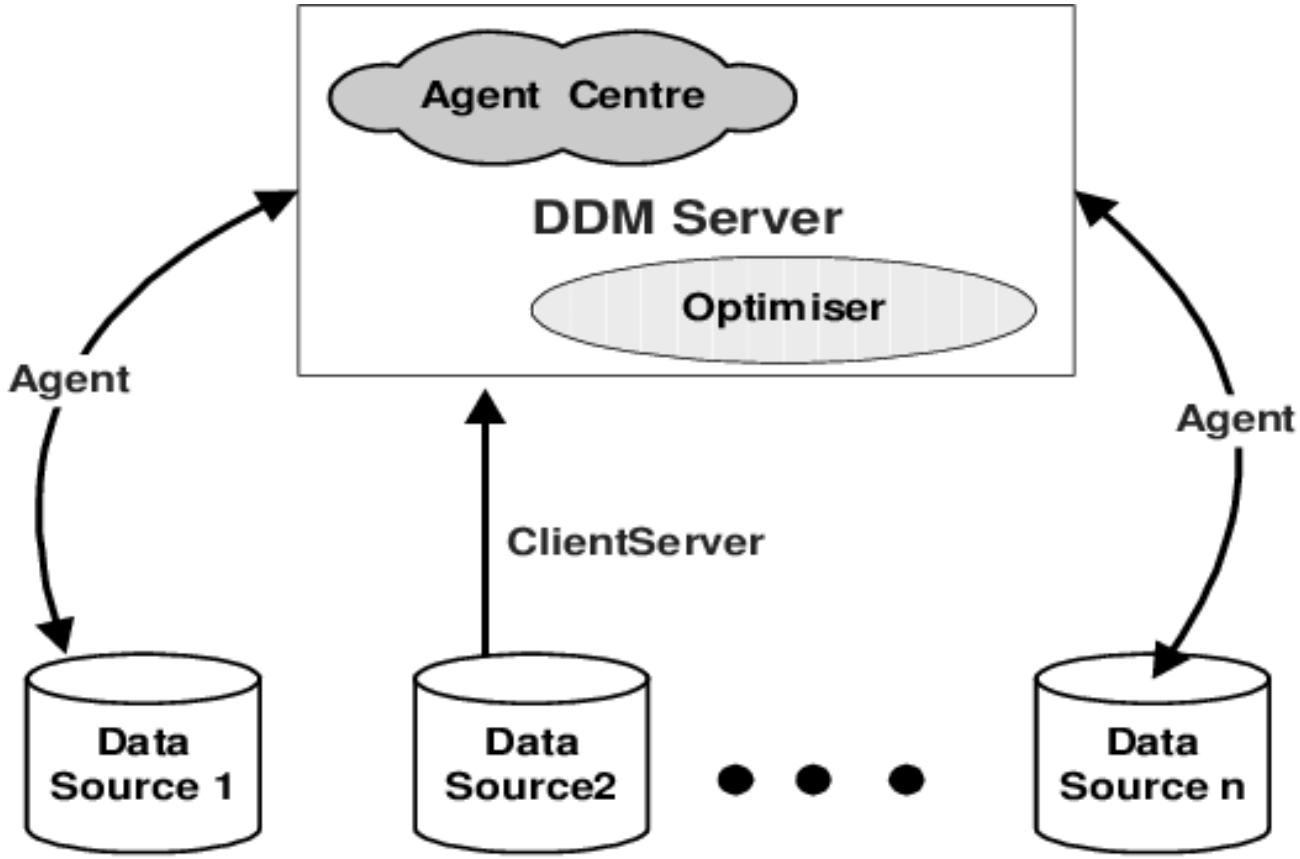
- Nodes communicate directly without a central server.

- Example: BitTorrent.

Message-Passing Model:

- Components communicate by passing messages over a network.

- Examples: MPI, RabbitMQ.



# Enabling Technologies for Distributed Systems

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- Networking Technologies:

  - High-speed networks (Ethernet, InfiniBand).

  - Network Protocols (TCP/IP, UDP, HTTP).

- Middleware:
  - Provides communication, data management, and services (CORBA, Java RMI).

- Cloud and Edge Computing:
  - Offloading computation to the cloud.
  - Edge computing brings processing closer to the data source.

# Software Environments for Distributed Systems

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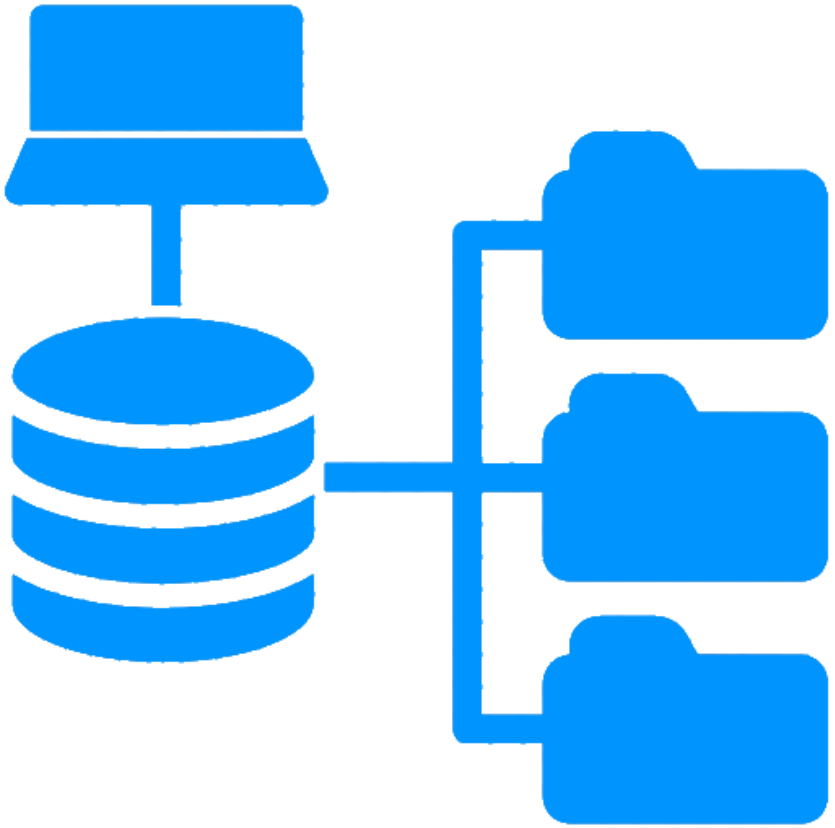
- Operating Systems:

  - Distributed OS manage resources across machines (e.g., Linux).

- Distributed File Systems:
  - Manage files over a network, ensuring consistency (e.g., HDFS, NFS).

- Programming Environments:
  - Hadoop, Spark, MPI, OpenMP for building distributed systems.

# Performance in Distributed Systems

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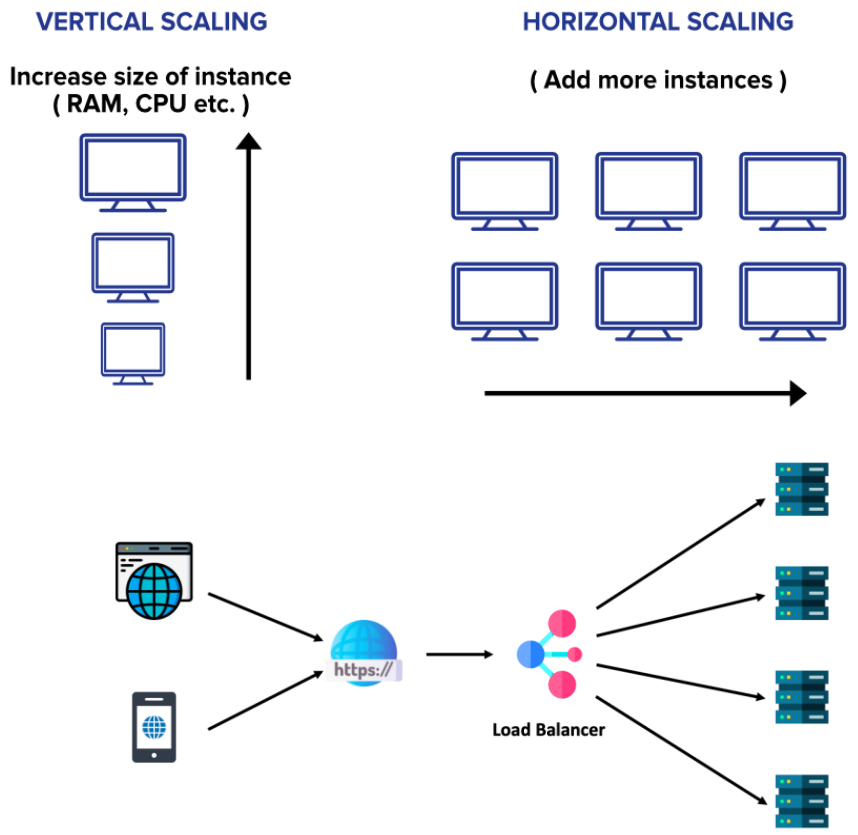
- Scalability:
- - Horizontal vs. Vertical scaling.
- Load Balancing:
  - Distributing workload across servers or nodes.
- Latency and Bandwidth:
  - Influences communication speed between nodes.
- Performance Metrics:
  - Throughput, response time, fault tolerance, availability.



# Security in Distributed Systems

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- Authentication and Authorization:

  - Ensuring legitimate access (OAuth, Kerberos).

- Data Encryption:
  - Protecting data using TLS/SSL, AES.

- Fault Tolerance and Redundancy:
  - Using replication to avoid data loss.

- DDoS Mitigation:
  - Traffic filtering, rate-limiting, DDoS protection.

# Energy Efficiency in Distributed Systems

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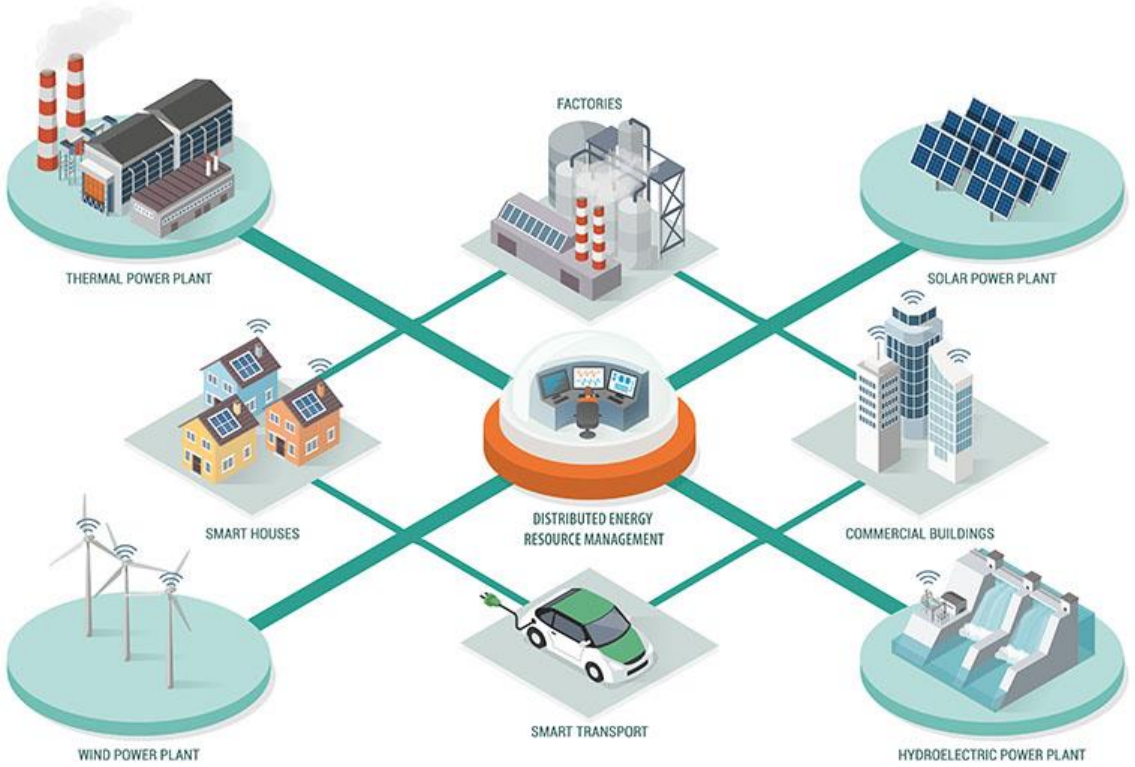
- Energy-Efficient Algorithms:
- - Optimizing tasks to reduce power consumption.
- Dynamic Power Management:
  - Scaling CPU frequencies or turning off idle components.
- Virtualization:
  - Efficient resource allocation through virtualization (VMware, Docker).
- Green Data Centers:
  - Optimizing cooling, power usage, hardware efficiency.



# Case Study: HPC in Distributed Systems

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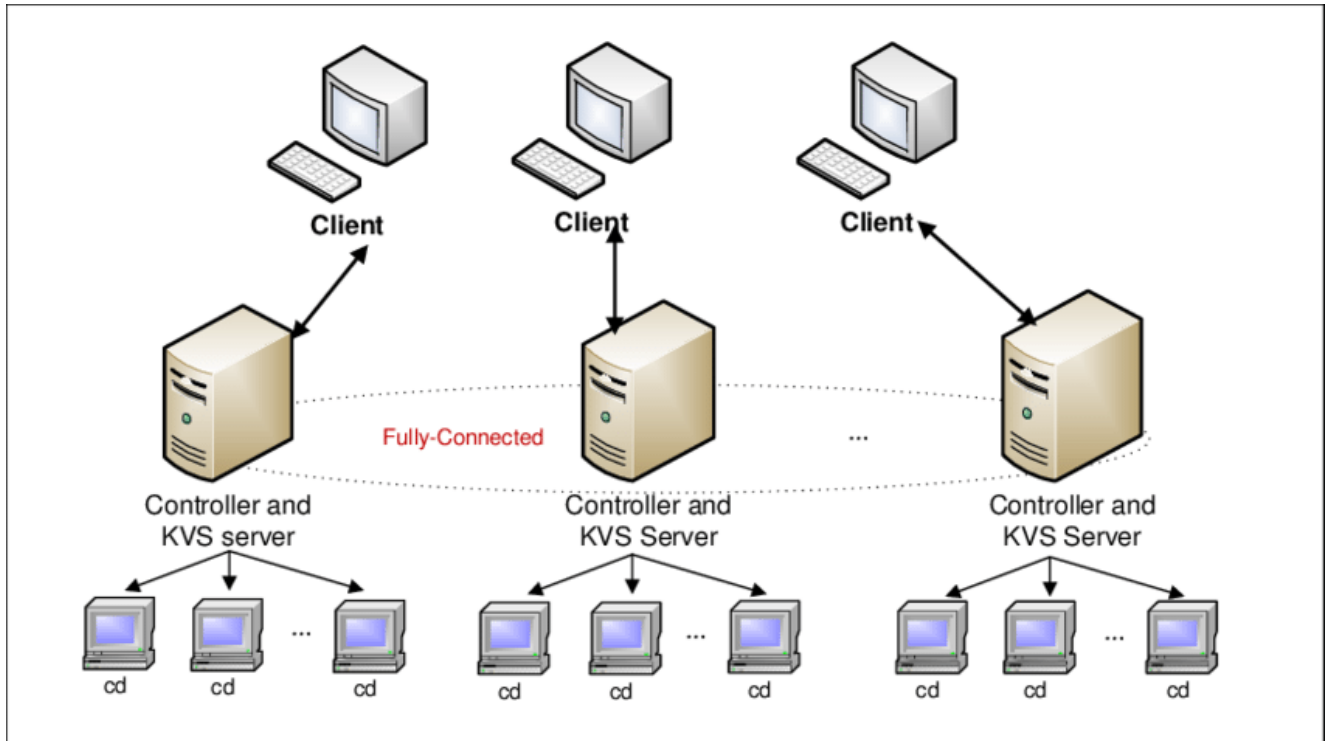
- HPC Clusters:

  - Solving complex computations using distributed systems.

- Parallel Computing with MPI and OpenMP:
  - Distributing tasks across multiple nodes.

- Applications:
  - Weather simulations, scientific research, big data analysis.



# Conclusion

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- Key Takeaways:
- - Distributed systems improve scalability, reliability, and performance.
- Future Trends:
  - Edge computing, quantum computing, AI integration.