1. Computer Networks

Foundations and Key Principles

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Summary

- Introduction
- Computer Network
- Usage of Computer Networks
- Computer Network Communication
- Computer Network Topology
- Client-Server and Peer-to-Peer (P2P) Models
- Types of Computer Networks

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Introduction/1

Evolution of Networking Devices:

- **Mainframes to Personal Computers:** Early reliance on large, centralized systems to modern-day ubiquitous personal computing devices.
- **Rise of Mobile Technology:** Transition from static desktops to mobile smartphones and tablets enabling anytime, anywhere connectivity.

EARLIER

TODAY

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Introduction/2

Proliferation of Internet Services:

- **Expansion of Streaming Services:** Impact of high-speed internet on entertainment; from traditional broadcasting to on-demand streaming platforms like Netflix and YouTube.
- **Social Media Networks:** Evolution from basic communication tools to complex platforms driving social interactions, business, and news dissemination.

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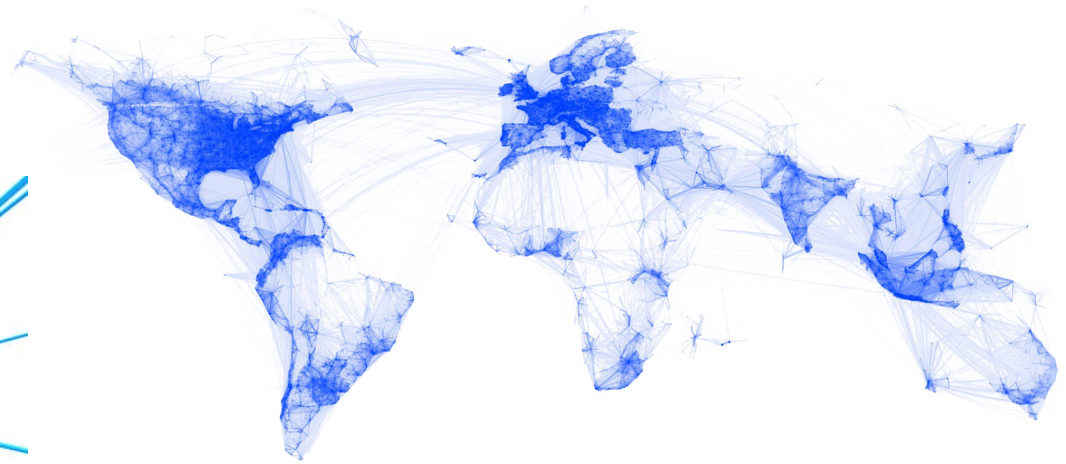
Introduction/3

Impact on Society:

- **Digital Inclusion and the Global Village:** The role of advanced networking in bridging geographical and socio-economic divides.
- **Challenges:** Addressing cybersecurity threats and privacy concerns in an increasingly interconnected world.



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Computer Network

A computer network is a group of interconnected computer systems and other computing devices that communicate with each other to share resources and information. It allows multiple users to exchange data, access shared applications, and utilize common hardware like printers and servers.

Networks can range from simple connections between two computers to vast global networks like the **Internet**. They typically use various technologies, protocols, and physical infrastructures to facilitate seamless communication and data transfer among connected devices.

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Usage of Computer Networks/1

Business Applications:

- **Resource Sharing:** Computer networks enable the shared use of essential devices across different computers within a network. This includes printers, scanners, and fax machines, allowing multiple users to utilize the same physical resources efficiently, reducing costs and improving productivity.
- **Information Sharing:** Networks facilitate the seamless exchange of information between individuals, organizations, and technologies. This capability is crucial for collaboration and decision-making, as it ensures that relevant data can be accessed and utilized from multiple locations and platforms.
- **Communication Medium:** Networks serve as vital communication channels. They support various communication tools such as email, video conferencing, and instant messaging, which are essential for modern business operations. These tools help in maintaining effective communication among employees, clients, and partners, regardless of their physical locations.
- **E-commerce:** Networks are fundamental to e-commerce activities. They enable transactions such as online payments, electronic fund transfers, and management of digital marketplaces. This digital infrastructure is key to conducting business in the global market, providing a platform for buying and selling products and services online.

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Usage of Computer Networks/2

Home Applications:

- **Remote Information Access:** Computer networks enable remote access to personal and professional information from virtually any location, including one's home. This flexibility allows individuals to work from anywhere, accessing work files, databases, and applications through secure connections like VPNs, enhancing productivity and work-life balance.
- **Person-to-Person Communication:** Networks are crucial in facilitating direct communication between individuals using various methods such as phone calls, text chats, and video calls. These tools help maintain personal relationships and professional collaborations across distances, reducing the need for physical travel and enabling more dynamic and immediate communication.
- **Interactive Entertainment:** Computer networks play a pivotal role in the realm of entertainment, connecting users with a wide array of interactive content. This includes social networking sites that allow for sharing and communication among users, online gaming platforms that enable multiplayer gaming experiences, and streaming services that provide real-time access to movies, music, and television shows. These platforms not only entertain but also create communities and bring people with similar interests together.

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Usage of Computer Networks/3

Mobile Applications:

- **M-commerce:** This form of commerce allows the buying and selling of goods and services through wireless handheld devices, such as smartphones and tablets. M-commerce utilizes mobile networks to provide convenient and fast transactions from anywhere, enabling consumers to shop, manage finances, and access service on-the-go. This includes mobile payments, banking, and shopping through dedicated apps and mobile-friendly websites, thereby enhancing user convenience and broadening market reach for businesses.
- **GPS Navigation System:** Navigation systems use network technology to provide location and time information under all weather conditions and anywhere. These systems offer turn-by-turn navigation instructions to help users reach their destinations efficiently. They are integrated into mobile devices and vehicles to assist with route planning, traffic monitoring, and location tracking, improving travel safety and convenience.
- **Instant Messaging:** Networks support a variety of instant messaging services that allow users to send and receive messages in real-time. These services extend beyond text messaging to include voice calls and the sharing of multimedia files, such as images and documents. Instant messaging has revolutionized communication, offering a quick, cost-effective, and versatile method of staying connected personally and professionally across the globe.

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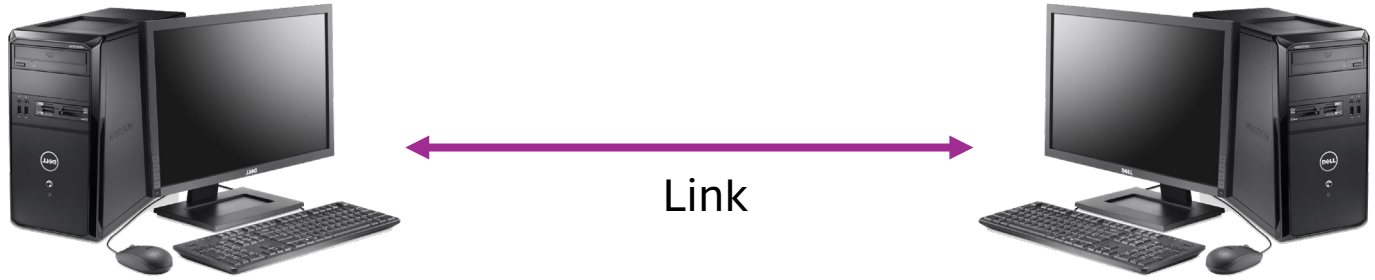
Computer Network Communication/1

- **Point-to-point:** a direct link between two devices.



- **Broadcast:** a link shared among multiple devices.

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Computer Network Communication/2

- **Point-to-Point:**

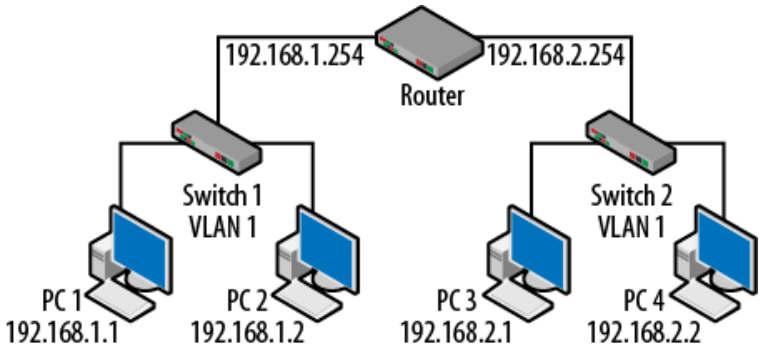
This network is structured through a series of links and nodes.

A node can be any device like a PC, a switch, or a router.

A switch serves to connect devices within the same network, whereas a router links different networks together.

Data packets are transmitted from a source to a designated destination, potentially traversing multiple nodes along the path.

Only the intended recipient, or destination node, processes the message.



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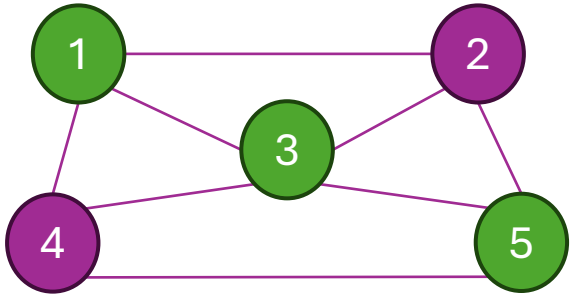
Computer Network Communication/3

- **Point-To-Point - Example:**

Let's consider a network consisting of 5 PCs:



- PC1 wants to send a message to PC5. Several paths are available, e.g., (1,4,5) or (1,2,5).
- The best path selection (i.e., the routing process) can be 'length-based' or 'traffic-based'.
  - If 'length-based', the shortest path is chosen.
  - If 'traffic-based', the less used path is chosen.
- Let's suppose the best path is (1,3,5), i.e., the green path.
  - PC1 sends the message to PC3, which then forwards it to PC5.
  - **What happens if PC3 is offline?** Another path is selected.

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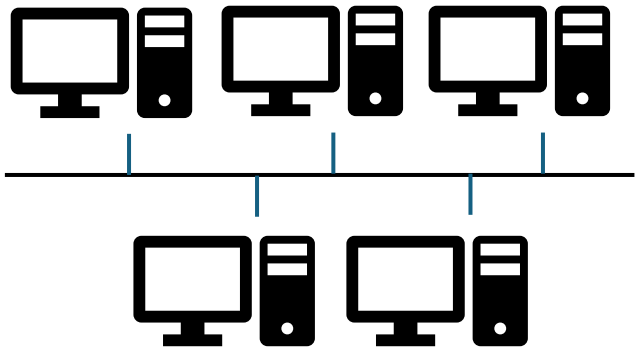
Computer Network Communication/4

- **Broadcast:**

A single communication channel is utilized by all computers on the network.

Generally, when any computer sends a message, it broadcasts it to all connected computers.



- **Broadcast:** The message is intended for all computers on the network.
- **Multicast:** The message is directed to a specific group of computers within the network.
- **Anycast:** The message can be received by any one of the computers in the network, typically the one nearest to the source.
- **Unicast:** The message is distributed to every computer, only the recipient specified in the message's address field processes it.

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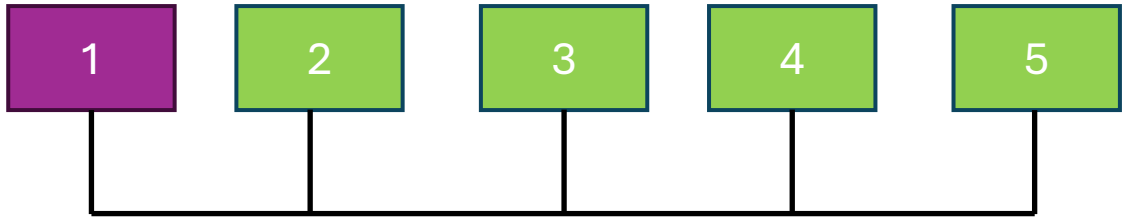
Computer Network Communication/5

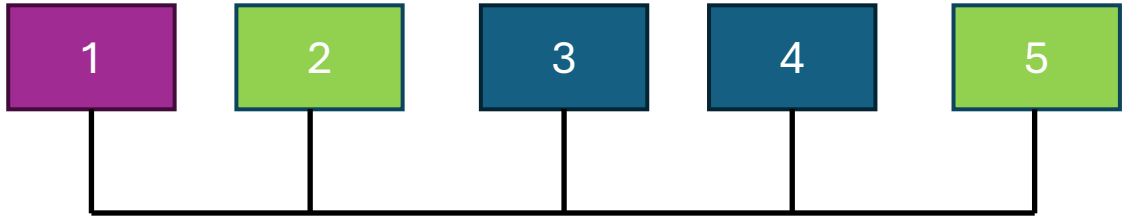
- **Broadcast - Example:**

PC1 sends a message that is received by all PCs.



- **Multicast – Example:**

PC1 sends a message that is received by the specified group of PCs (i.e., PC2 and PC5).



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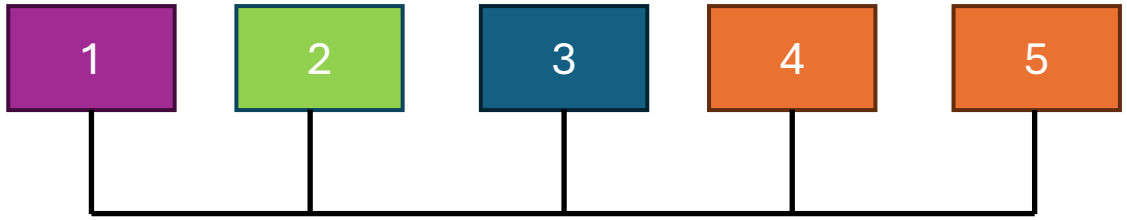
Computer Network Communication/6

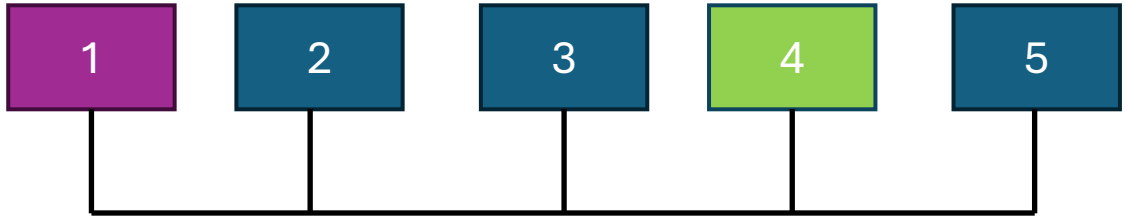
- **Anycast - Example:**

PC1 sends a message that is received by the nearest PC (i.e., PC2) out of a group of potential receivers (i.e., PC4 and PC5).



- **Unicast – Example:**

PC1 sends a message that is received by the specified PC (i,.e., PC4).



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Computer Network Topology/1

Computer network topology refers to the arrangement of elements (including nodes and connecting lines) within a computer network. It can be visualized as the physical or logical arrangement of how devices like computers, routers, and switches interconnect.

There are 5 different topologies:

- Bus;
- Ring;
- Star;
- Mesh;
- Tree.

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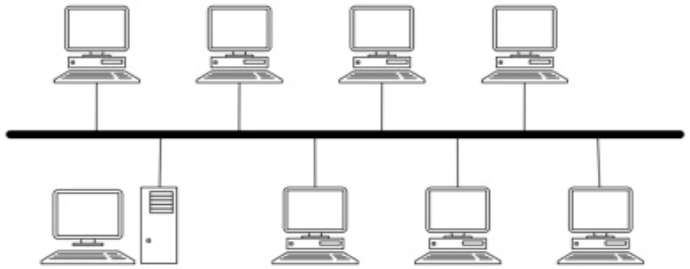
Computer Network Topology/2

Bus Topology: All devices share a single communication line or cable. Signals from the source travel in both directions to all machines connected on the network until they find the intended recipient.



Advantages:

- Cost-effective: Requires fewer cables compared to other topologies.
- Suitable for small networks.
- Straightforward to understand.
- Easily expandable by connecting additional cables.

Disadvantages:

- Single point of failure: If the main cable fails, the entire network goes down.
- Performance degradation: The network slows down as the number of nodes increases or under heavy traffic conditions.
- Limited cable length: The reach of the network is restricted by the cable length.

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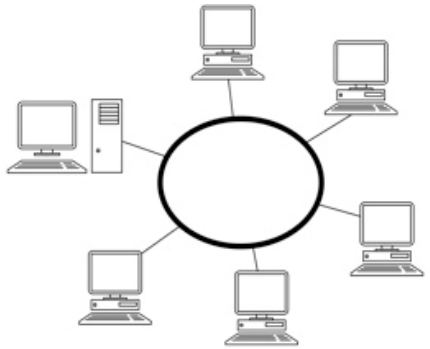
Computer Network Topology/3

Ring Topology: Devices are connected in a circular format, with each computer linked to two other computers. This setup forms a continuous pathway for signals through each device, with data traveling around the ring in one direction. Data transfer requires a token.



Advantages:

- Consistent performance: Maintains efficiency under high traffic or with many nodes, as nodes transmit data only when they possess the token.
- Cost-effective: Inexpensive to set up and expand.

Disadvantages:

- Complex troubleshooting: Diagnosing issues within this topology can be challenging.
- Disruptive maintenance: Adding or removing computers can interrupt network activity.
- Dependent stability: The failure of a single computer can impact the entire network.

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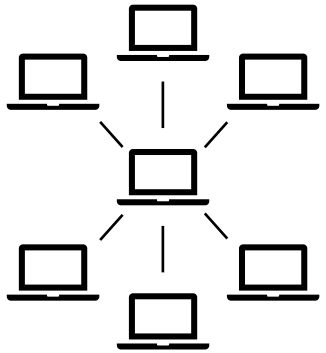
Computer Network Topology/4

Star Topology: Devices are connected to a central hub. Data on a star network passes through the hub before continuing to its destination. The hub acts as a signal repeater.



Advantages:

- Scalability: The network can be expanded with ease.
- Simple troubleshooting: Faults can be diagnosed quickly.
- Resilience of non-central nodes: The failure of individual non-central nodes does not disrupt the entire network.

Disadvantages:

- Vulnerability of the central node: The entire network is compromised if the central node fails.
- High load on central node: All network traffic must pass through the central node, which can become a bottleneck.

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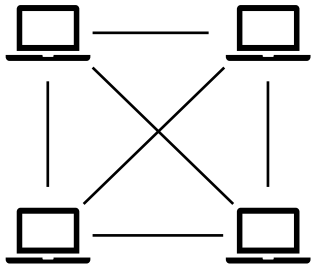
Computer Network Topology/5

Mesh Topology: Devices are interconnected with many redundant interconnections between network nodes. In a full mesh topology, every computer connects directly to every other computer. In a partial mesh topology, some computers connect indirectly through others.

FULL:



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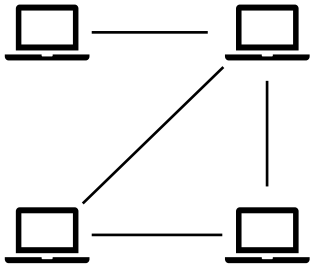

Advantages:

- Independent data paths: Each connection can independently handle its own data traffic.
- High fault tolerance: The network remains operational despite the failure of individual connections.
- Easy fault identification: Problems within the network can be diagnosed swiftly.

Disadvantages:

- Complex setup: Installation and configuration are challenging.
- High cabling costs: Significant expense due to the amount of cabling required.
- Extensive wiring: A large volume of wiring is necessary to connect each node independently.

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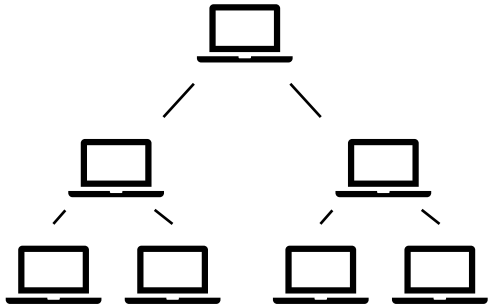
Computer Network Topology/6

Tree Topology: A variation of the star network setup that branches off other stars. It integrates multiple star topologies together onto a bus, combining the characteristics of both.



Advantages:

- Hybrid structure: Combines elements of bus and star topologies.
- Scalability: Adding new nodes is feasible and straightforward.
- Manageability: The network is easy to oversee and maintain.
- Effective error detection: Issues within the network can be identified promptly.

Disadvantages:

- Extensive cabling: Requires a lot of wiring.
- Elevated cost: The setup and maintenance can be expensive.
- Dependence on root node: The entire network is compromised if the root node fails.
- Maintenance complexity: Managing the network becomes more challenging as more nodes are added.

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Client-Server Model

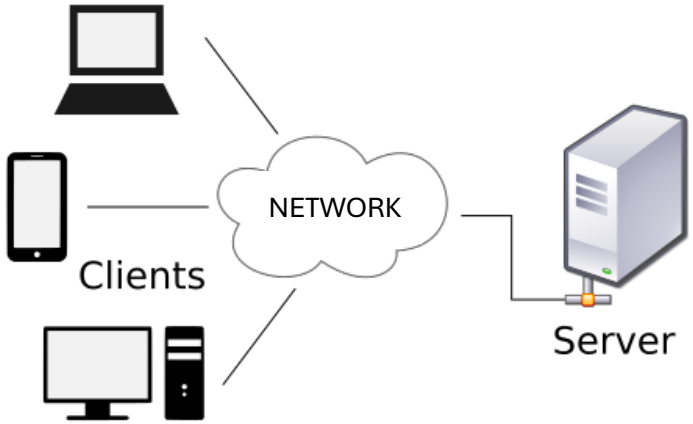
A computing architecture where multiple clients (devices or software) request and receive services from a centralized server. This model centralizes core functions and resources, offering efficiency and scalability by allocating tasks between providers (servers) and requesters (clients).

Client:

- Requests services or resources.

Server:

- Provides resources and services.
- Manages all processes and data storage.
- Sends output back to the client.



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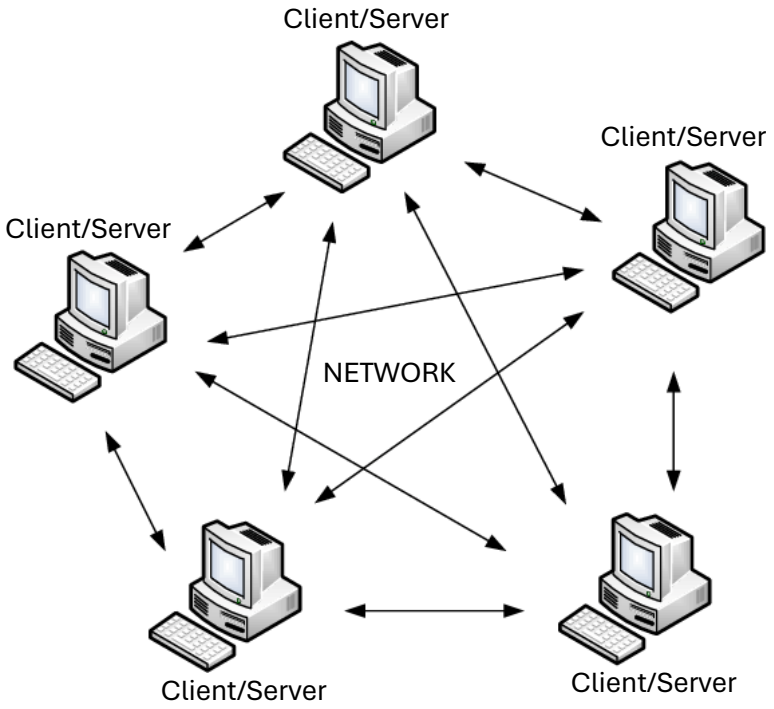
Peer-to-Peer (P2P) Model

A decentralized network architecture where each node, or "peer“, has equivalent capabilities and responsibilities. This model enables direct sharing of resources among peers without the need for centralized coordination, often used for file sharing, communications, and collaborative tasks.

Each peer can be server or client:

- Requests services or resources.
- Provides resources and services.
- Manages processes and data storage.
- Sends output back to the others.



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Types of Computer Networks

Networks can be categorized based on their geographic distribution and the distance between connected devices. This classification helps in understanding the scope and the technical requirements of different network setups. From personal devices interacting over mere meters to global communications spanning thousands of kilometers, each network type serves distinct purposes and fulfills specific connectivity needs. There are various network classifications based on their scale: Personal Area Networks (PANs), Local Area Networks (LANs), Metropolitan Area Networks (MANs), Wide Area Networks (WANs), and the global scale of the Internet.

Interprocessor distance	Processors located in same	Example
1 m	Square meter	Personal area network
10 m	Room	Local area network
100 m	Building	
1 km	Campus	
10 km	City	Metropolitan area network
100 km	Country	Wide area network
1000 km	Continent	
10,000 km	Planet	The Internet

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