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Networking concepts

Networking Fundamentals

Welcome to networking concepts!

What you will learn

At the core of the lesson

You will learn how to:

- Distinguish between different types of networks
- Describe common network topologies and network management models
- List different types of network protocols

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You will learn how to:

- Distinguish between different types of networks
- Describe common network management models and network topologies
- List different types of network protocols

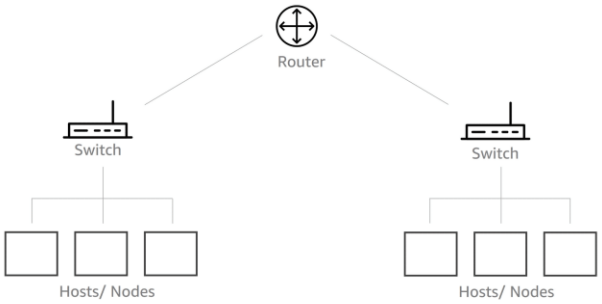
Types of computer networks

In this section, you will understand basic computer networks.

Local-area network (LAN)

From the standpoint of *geographical span*, two of the most common types of computer networks are *local area networks (LANs)* and *wide area networks (WANs).*

A LAN connects devices in a *limited geographical area*, such as a floor, building, or campus.



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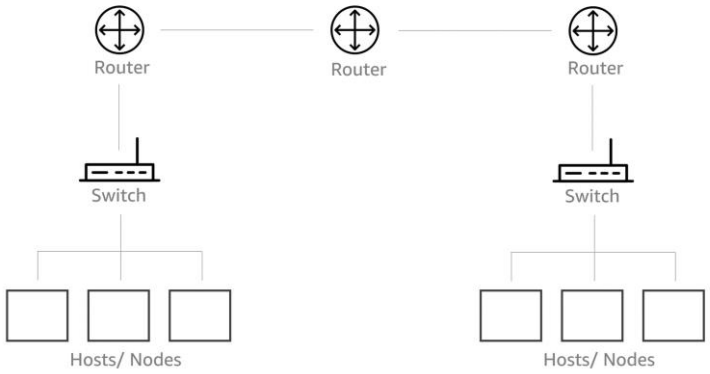
LAN:

- In the example above, a LAN with one router, two switches, and three nodes under each switch. Each switch or subnet, can represent an office floor or building within the same corporate office or school.
- LANs commonly use the *Ethernet* standard for connecting devices, and they usually have a high data-transfer rate.
- *Wireless technology* is also commonly used for a LAN.

Wide-area network (WAN)

- A WAN connects devices in a *large geographical area*, such as multiple cities or countries.
- WANs are *used to connect LANs.*



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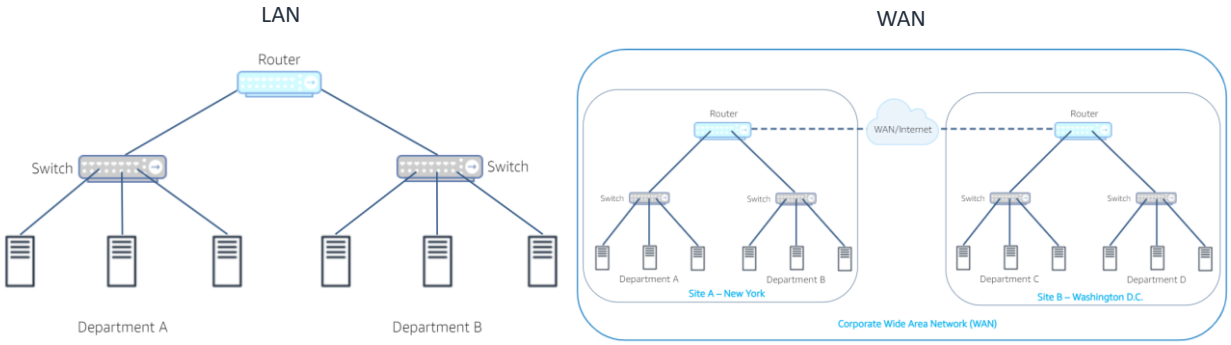
WAN:

- In the example above, a WAN with three routers, two switches and three nodes under each switch. Examples of WANs are two corporate offices located across the United States connected by a WAN (the internet).
- WANs use technologies such as fiber-optic cables and satellites to transmit data which are used to connect *LANs*.
- The *internet* is considered to be the largest WAN.

LAN versus WAN



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LAN:
Within the same building or floor.
WAN:
Can be geographically different locations; however, they are connected by a corporate WAN.

Network topologies

In this section, you will understand basic network topologies (physical and logical).

Network topologies

What is a network topology?

- A topology is a *pattern* (or diagram*) that shows how nodes connect to each other*.
- Computer networks use different topologies to share information.
- The two topologies are:
  - **Physical topology** – Refers to the physical layout of wires in the network
  - **Logical topology** – Refers to how data moves through the network.

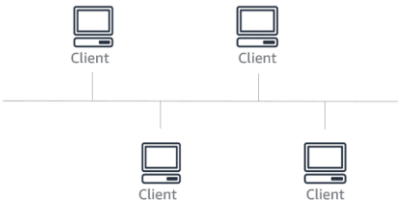
Its important to understand network management models because they define the roles and relationships of the devices in your network.

- Examples of network topologies include: **Bus, Star, Mesh**, and **Hybrid**.

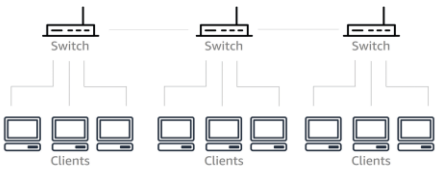
Physical topologies

Physical topology refers to how devices are connected within a network.

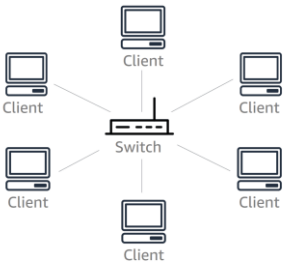
Bus topology – positions all the devices along a single cable.



Hybrid topology – combines two or more topology structures. This one is called a **star-bus topology**.



Star topology – every node in the network is directly connected to one central switch.



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- What is a physical topology?
    - Refers to how a network is connected.
- Examples of network topologies include: **Bus, Star, Mesh**, and **Hybrid**.
- **Bus** topology:
    - The physical topology *positions all the devices on a network along a single cable*. They run in a single direction from one end of the network to the other. A bus topology is also called a *line topology* or *backbone topology*.
    - This is simple to configure, however, it only allows one computer to send a signal at a time, which can cause network collisions that will bring down the network.
- **Star** topology:
    - The physical topology is set up so that *every node* in the network is directly *connected to one central switch* by using coaxial, twisted-pair, or fiber-optic cables.

- **Mesh** topology:
    - A *mesh* topology is a complex structure of connections that are similar to peer-to-peer, where the nodes are interconnected. Mesh networks can be full mesh or partial mesh.
    - In a *partial-mesh* topology, *all devices are connected to at least two other devices*.

    - In a *full-mesh* topology*, all nodes are interconnected*. A full-mesh topology provides full redundancy for the network. It is an expensive topology because it requires each node to have multiple network adapters and cables. You will most likely find a full-mesh topology in a WAN.
- **Hybrid** topology:
    - A hybrid topology *combines two or more different topology structures*. It is usually found in large organizations where separate departments have personalized network topologies to accommodate their network usage and other requirements.
    - Today, the *star-bus* topology is the most common hybrid topology.

Logical topologies

Logical topology refers to how data moves through a network.

Amazon **Virtual Private Cloud (VPC)** is an example of a logical topology:
- A VPC is a virtual network that allows you to launch AWS resources that you define. This VPC looks and works just like a normal network within a data center with the benefits of using AWS services for scalability.
- Bus, Star, Mesh, and Hybrid topologies all have logical portions as well.

- What is a logical topology?
    - Refers to how data moves through a network.
- Examples of logical topologies include: **Bus, Star, Mesh**, **Hybrid, and VPC**.
- **Bus** topology:
    - The logical topology and *data flow* on the network also follows the route of the cable, it *moves in one direction*.
    - This is simple to configure; however, it only allows one computer to send a signal at a time, which can cause network collisions that will bring down the network.
- **Star** topology:
    - The logical topology works with the *central switch managing data transmission*. Data that is sent from any node on the network must pass through the central switch to reach its destination. The central switch can also function as a repeater to prevent data loss.
- **Mesh** topology:
    - A *mesh* topology is a complex structure of connections that are similar to peer-to-peer, where the nodes are interconnected. Mesh networks can be full mesh or partial mesh.
    - In a *partial-mesh* topology, *all devices are connected to at least two other devices*.
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- **Hybrid** topology:
    - A hybrid topology *combines two or more different topology structures*. It is usually found in large organizations where separate departments have personalized network topologies to accommodate their network usage and other requirements.
    - Today, the *star-bus* topology is the most common hybrid topology.
- **VPC** topology:
    - Is a virtual network that allows you to launch AWS resources that you define. It's a logical network.

Amazon Virtual Private Cloud (VPC)

What is a Amazon VPC?

- An Amazon VPC is a virtual network that allows you to launch AWS resources that you define. This VPC looks and works just like a normal network within a data center with the benefits of using AWS services for scalability.
- In the following table, you will see the similarities between AWS services and traditional network topologies at the most basic function:

Traditional topology	AWS service or capability
Isolated network	Amazon VPC
Network segment	Subnet
Firewall	Security Group and Network Access Control List (NACL)
Server	Elastic Compute Cloud (EC2) instance

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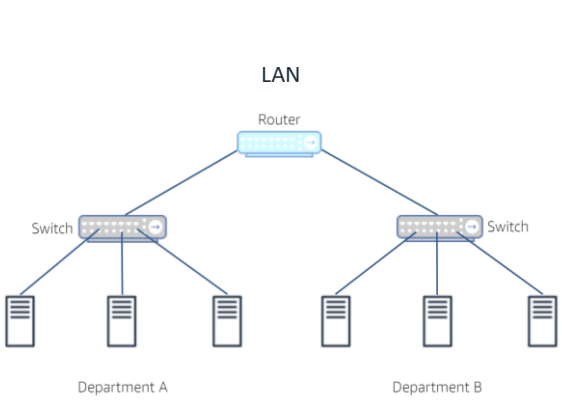
Please note that this is just a simple comparison of services between a traditional topology and AWS services.

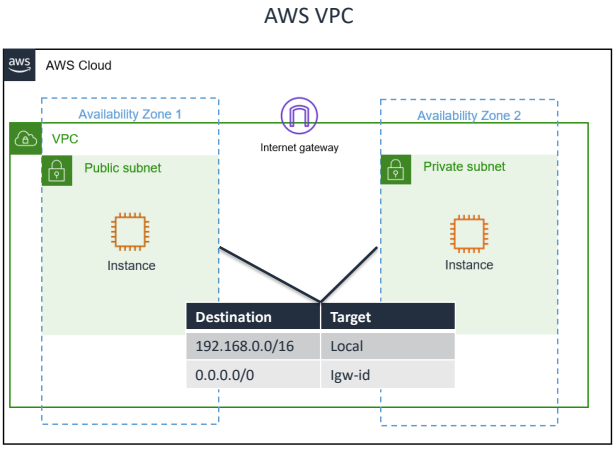
- An isolated network, most closely resembles the function of a VPC. Within an Amazon VPC, you can launch multiple AWS services and capabilities that are needed to create a working, scalable network. However, within an Amazon VPC, there is no maintenance required, and you can create an isolated architecture within minutes!
- A network segment acts as a subnet and separates a network between offices or buildings. AWS uses subnets in every architecture. Every node (EC2 instance) belongs in a subnet.
- Firewalls block traffic based on a set of rules. AWS has security groups that block traffic at the node (EC2 level) and NACLs that block traffic at the subnet level. These also block traffic based on a set of rules.
- Within a data center, there are servers. Within AWS, you can use an EC2 instance to launch an array of servers.

Comparing LAN/WAN and Amazon VPC

In this section, you will compare LAN and Amazon VPC and WAN and the Amazon VPC.

LAN and AWS VPC





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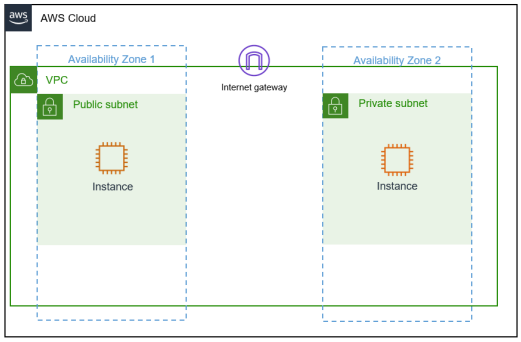
Above is an example of a LAN topology and an AWS VPC network. There are similarities between a LAN and an AWS VPC.

- Starting from the bottom of the LAN and center for the VPC, they both have nodes or instances.
- The next layer in the LAN is a switch or subnet, which is also depicted within the VPC as Public and Private subnets.
- Moving up one layer, there is a router in the LAN directing traffic. The table within the VPC that states the Destination and Target represents the routes that route traffic within and out of the VPC.

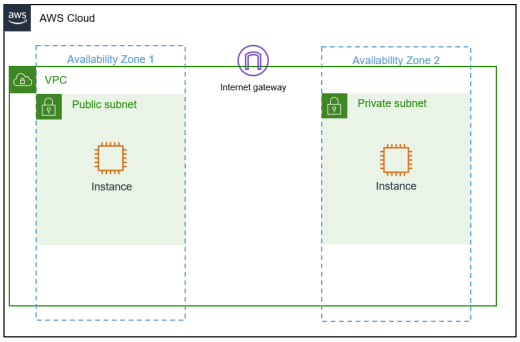
WAN and AWS VPC

AWS VPC
us-west-2 (Oregon)



VPC peering/
WAN

AWS VPC
us-east-1 (N. Virginia)



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An example of a WAN where a city on the West coast can communicate to a city on the East coast from the same company within AWS is called VPC peering. This is beyond the scope of this course; however, this is an example of how this is achieved.

- When a VPC is created, it is created in a region which is like a state, these are located across the United States for high availability and redundancy. There are multiple regions in the world, however, for this example, two of the four regions of the United States were used (Oregon and N. Virginia).
- In order for these two VPCs to communicate and share resources together, just like a corporate WAN, a connection is needed. This connection is called VPC peering, which enables traffic to be routed privately between the two VPCs.

Network management models

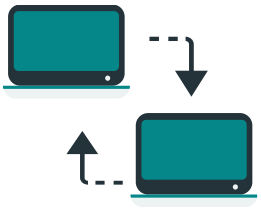
In this section, you will cover the different network management models.

Network management

What is network management?

- A network management model is a representation of *how data is managed*, and *how applications are hosted in a network*.
- The two most common models for LAN are:
  - **Client-server**
  - **Peer-to-peer**

Client-server model



Peer-to-peer model

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Why is it important?

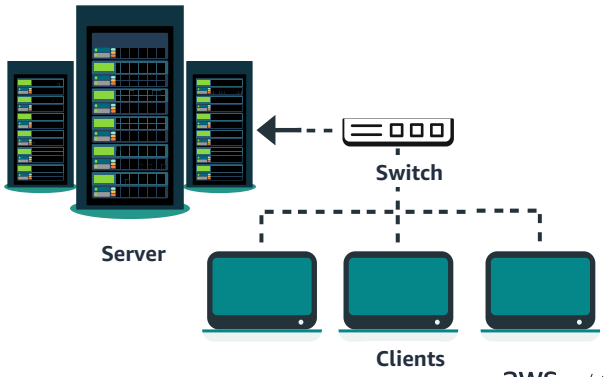
- Its important to understand network management models because they define the roles and relationships of the devices in your network.
- The two most common for LAN are:
  - Client-server
  - Peer-to-peer

Client-server model

What is a client-server model?

- The **data management** and **application hosting are centralized at the server** and distributed to the clients.

All clients on the network must use the **designated server to access shared files** and information that are stored on the serving computer.



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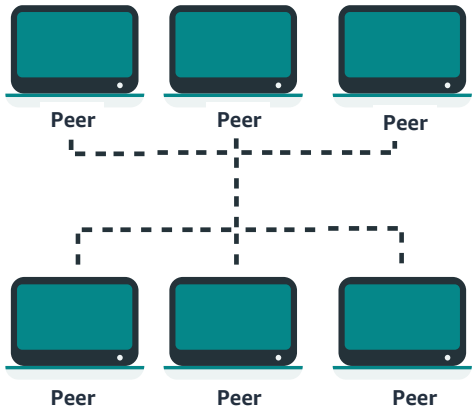
- In a client-server network model, the data management and application hosting are centralized at the server, and distributed to the clients.
- If the server goes down, no client can access the network until the server is restored.
- Examples of client-server models are:
    - File server and desktop clients
    - Print server and desktop clients

Peer-to-peer model

What is a peer-to-peer model?

- In this model, *each node has its own data and applications* and is responsible for its own management and security.

The **peer-to-peer model** is a distributed architecture that **shares tasks** or workloads among peers.



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- In a peer-to-peer model, each node has its own data and applications and is responsible for its own management and security.
- Peers are equally privileged participants in the architecture.
- For example, files can be shared directly between systems on the network without a central server.
- This model might be considered under the following conditions:
    - Users are responsible for backing up each node.
    - Security requirements are not restrictive.
    - A limited number of peers are used.

Network protocols

In this section, you will identify the basic networking protocols.

Network protocols

What is a network protocol?

- A network protocol defines the rules for formatting and transmitting data between devices on a network.
- It typically operates at layer 3 (Network) and layer 4 (Transport) of the OSI model.
- It falls into two categories:

Connection-oriented protocol

Connectionless protocol

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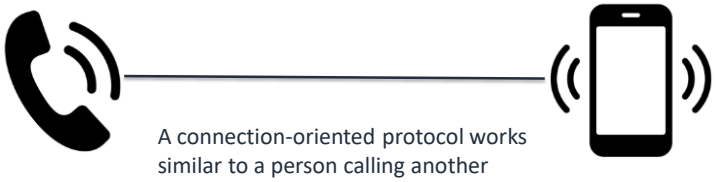
- An example of a connection-oriented protocol is a phone call between two people. One person calls and the other answers and therefore a connection is established.
- An example of a connectionless protocol is sending a package through the mail to another person. Once it leaves your hands, the package can get to its destination or it can get lost. It doesn't require a connection to be established.

Connection-oriented protocol

What is a connection-oriented protocol?

- It is a protocol that establishes a connection.
- It waits for a response.
- It creates a *session* between the sender and the receiver.
- It uses *synchronous* communication.



A connection-oriented protocol works similar to a person calling another person and they answer. The connection is then established.

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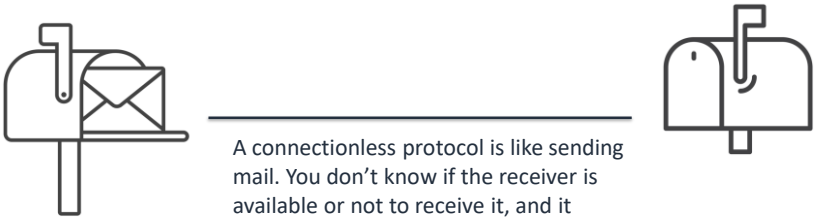
- With a connection-oriented protocol, there is typically a larger overhead because it ensures that a connection is established.
- It checks if the message was received or not received. If the message was received, a session is then established. If an error occurs or the message is not received, it sends the message again.
- It uses synchronous communication which means it happens in real time. For example, it requires two parties to establish a connection like a phone call between two people.

Connectionless protocol

What is a connectionless protocol?

- It sends a message from one endpoint to the other, without ensuring that the destination is available and ready to receive the data.
- It *does not require a session* between the sender and receiver.
- It uses *asynchronous* communication.



A connectionless protocol is like sending mail. You don't know if the receiver is available or not to receive it, and it happens asynchronously.

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- With a connectionless protocol, there is typically little overhead because it doesn't care if there is a session established.
- This is faster then a connection-oriented protocol and uses asynchronous communication which means that one of the parties does not have to be available for data to be sent.
- As far as connectionless protocol is concerned, it just sends the data and it doesn't care if the receiving end gets the data or not.
- An example of this is like sending mail. You mail a letter or package and once it leave your mailbox or post office it is asynchronous between the sender and receiver. The party isn't readily available to receive the package and you won't know exactly when they will be, you just sent the mail hoping they will get it.

Examples of network protocols

Internet Protocol (IP)
- IP establishes the rules for relaying and routing data in the internet.

Transmission control protocol (TCP)
- TCP provides a reliable, connection-oriented, and ordered delivery of bitstreams over an IP network.

TCP/IP
- When TCP and IP are combined they form the TCP/IP protocol suite. TCP/IP implements the set of protocols that the internet runs on.

User Datagram Protocol (UDP)
- UDP uses a simple connectionless communication model to deliver data over an IP network. It is unreliable because it does not guarantee the delivery or ordering of data. It has lower overhead and is faster than TCP.

- **TCP/IP** is a *connection-oriented* protocol. It defines how to establish and maintain network communication in which application programs can exchange data. Data sent via this protocol is broken down into smaller chunks called packets. The goal of TCP/IP was to support an interconnection of networks (internet).
- **TCP** is great for transferring important files since there is a guarantee of connection, even though there is a larger overhead (time).
- With TCP, there is something called the **TCP handshake**. This handshake is comprised of three messages:
    - Synchronize (**SYN**)
    - Synchronize/Acknowledge (**SYN/ACK**)
    - Acknowledge (**ACK**)
- During this handshake, the protocol establishes parameters that support the data transfer between two hosts. For example:
    - Host A sends a SYN packet to Host B.
    - Host B sends the SYN with an ACK attached to acknowledge that they received it with the message back to Host A.
    - Host A sends the last message with ACK to Host B letting them know they received the SYN/ACK message.
- **UDP** uses *connectionless* communication and there is no guarantee of the delivery or ordering of data. The best example and use case of UDP is media. When streaming services such as a movie, UDP is used because it is fast, however, there are times when you might see buffering and things may seem off or out of order

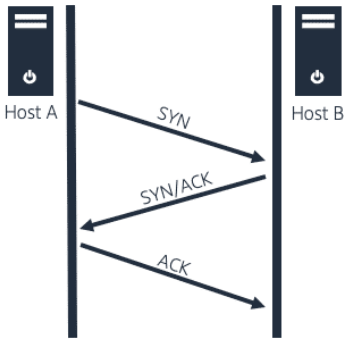
like the words do not match up to the picture. That is UDP delivering the data and the streaming service trying to order the data as UDP doesn't guarantee the order or delivery.

Transmission control protocol (TCP) handshake

TCP

- Is connection oriented
- TCP handshake comprises of three messages between sender and receiver:
  - Synchronize (SYN)
  - Synchronize/Acknowledge (SYN/ACK)
  - Acknowledge (ACK)

During the 3-step handshake, the protocol establishes parameters that support the data transfer.



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Why is this all important?

- When troubleshooting, you can use tools like **wireshark** or **tcpdump** on a linux machine to understand where your packets are getting lost in communication. By understanding the flags, and where they stand in each process, this will allow you to troubleshoot the issue of where the issue may lie.
- **TCP** is great for transferring important files since there is a guarantee of connection, even though there is a larger overhead (time).
- It is connection oriented.
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  - Host A sends the last message with ACK to Host B letting them know they received the SYN/ACK message.
- There is also a process where it gracefully closes the communication between sender and receiver (similar to saying good-bye to someone) with three messages:

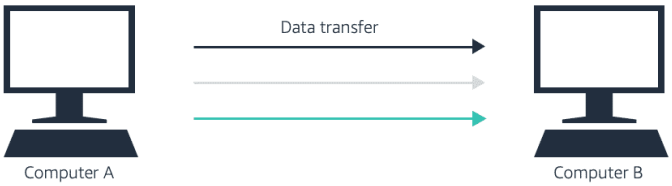
    - Finish (**FIN**)
    - Finish/Acknowledge (**FIN/ACK**)
    - Acknowledge (**ACK**)
- There are also something called reset (**RST**) flags when a connection closes abruptly and causes and error.

User Datagram Protocol (UDP)

User Datagram Protocol (UDP)

- It has lower overhead and is faster than TCP.
- Its connectionless.
- There is no guarantee all your data will get there, or in order.

UDP data flows from one computer to another, there is no SYN or ACK. It cares about speed more than ensuring data gets to computer B.



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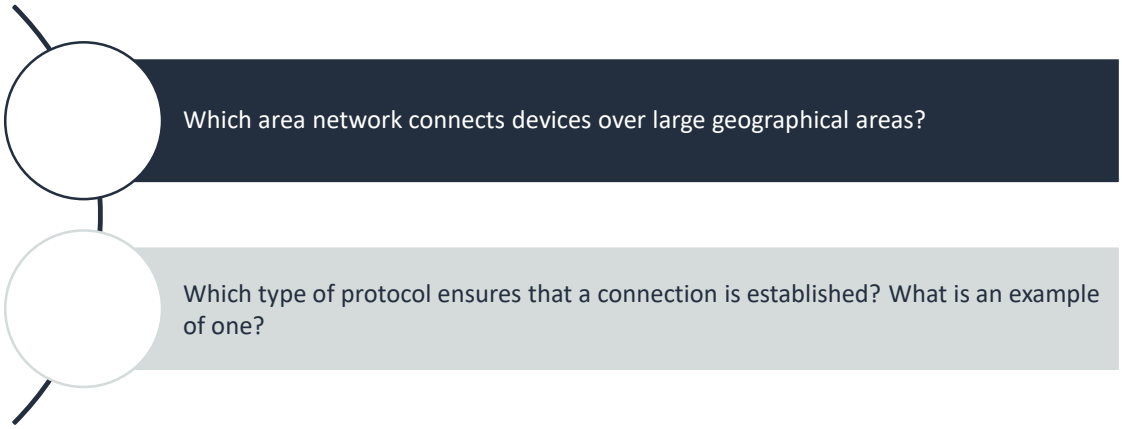
- It is about speed and doesn't provide a three way handshake to ensure data is delivered.
- It has minimum set of functions and is considered unreliable compared to TCP.

Checkpoint questions



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Q1:

Q2: Which type of protocol ensures that a connection is established? What is an example of one?

- **Connection-oriented protocol**
- **TCP**

Key takeaways

- A local-area network (LAN) connects devices in a limited geographical area, and a wide-area network (WAN) connects devices in a large geographical area.
- A network management model defines how data is managed, and how applications are hosted in a network. Client-server and peer-to-peer are two common network management models for a LAN.
- A network topology shows how nodes connect to each other. Star and hybrid are example patterns of a network typology.
- A VPC is a virtual network that allows you to launch AWS resources that you define. A VPC looks and works just like a normal network within a data center with the benefits of using AWS services for scalability.
- A network protocol defines the rules for formatting and transmitting data between devices on a network.

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- A network topology shows how nodes connect to each other. Star and hybrid are example patterns of a network typology.
- A VPC is a virtual network that allows you to launch AWS resources that you define. A VPC looks and works just like a normal network within a data center with the benefits of using AWS services for scalability.
- A network protocol defines the rules for formatting and transmitting data between devices on a network.

Thank you

aws re/start

Thank you.