Switched Networks

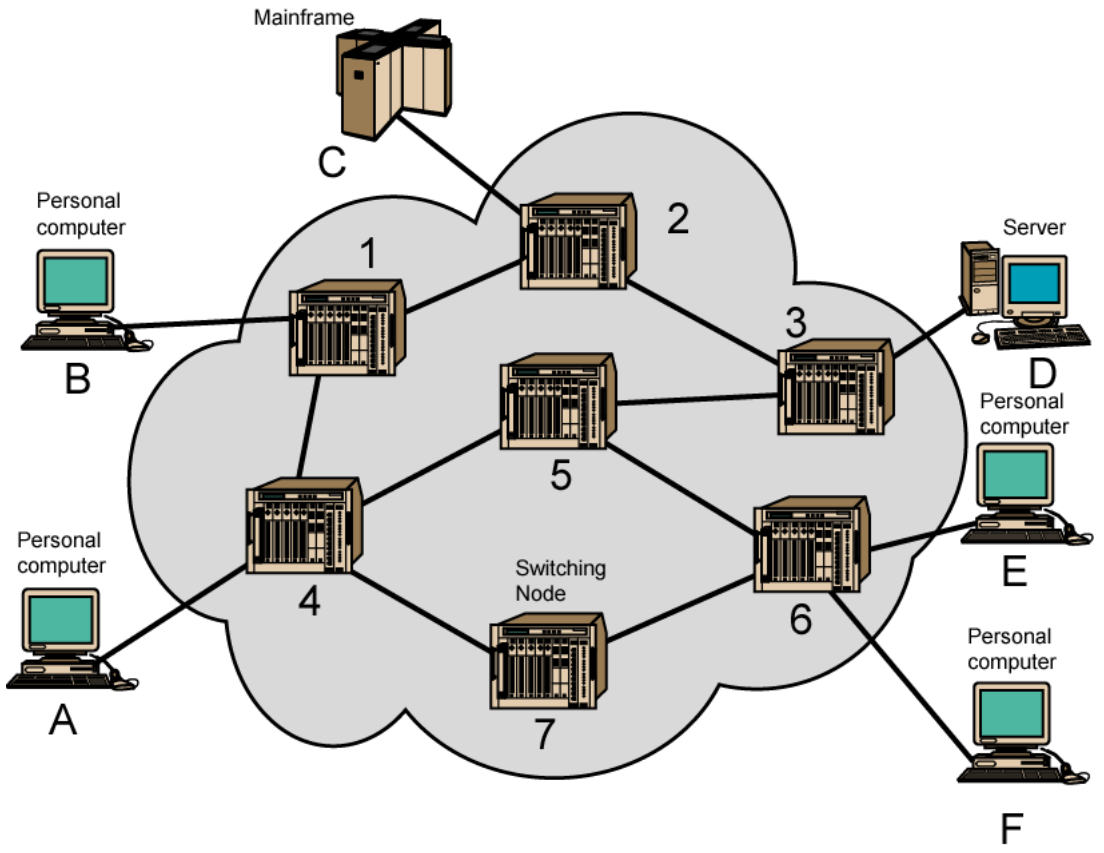
Faculty of Technology
University of Sri Jayewardenepura
2020

Growing Complexity of Networks

- Next-generation networks need to be secure, reliable, and highly available.
- They must support a globalized workforce.
- They must be able to integrate legacy devices.

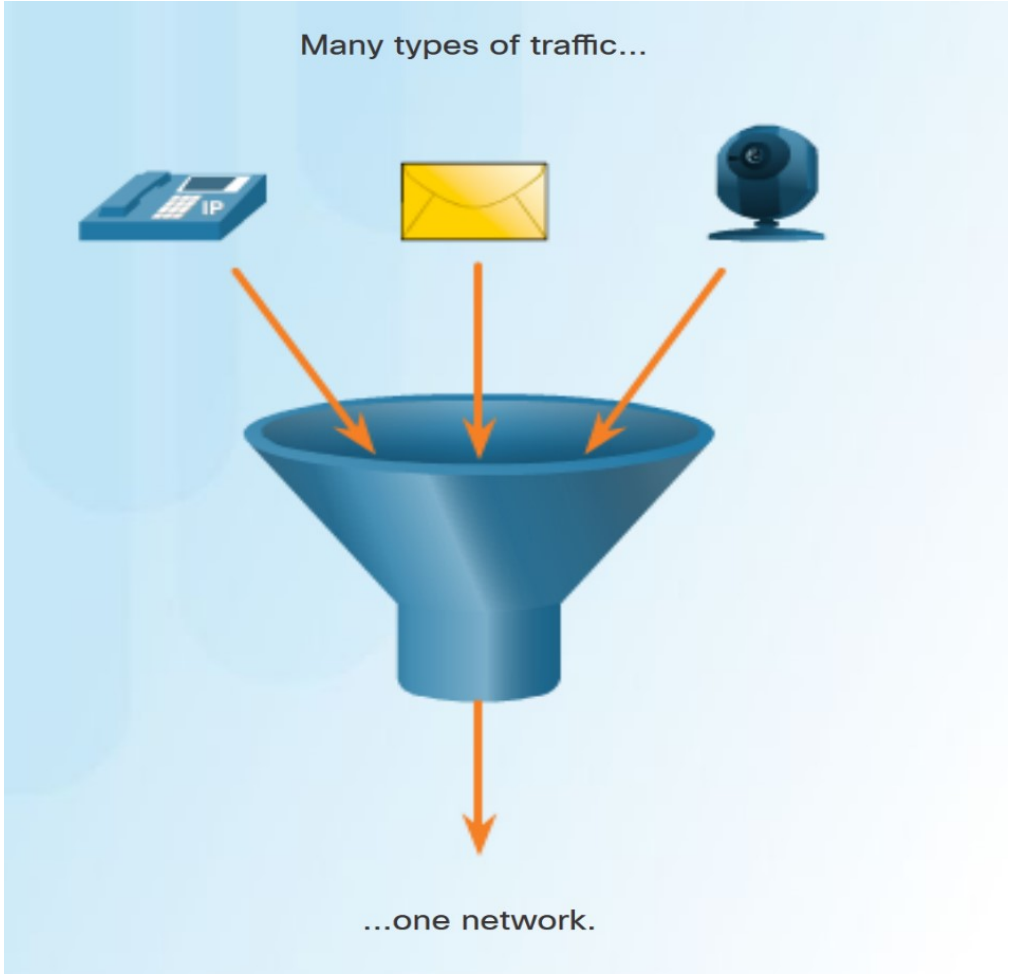
Switching Networks

- Long distance transmission between stations is typically done over a network of switching nodes.
- Switching nodes do not concern with content of data.
- Data entering the network from a station are routed to the destination by being switched from node to node.



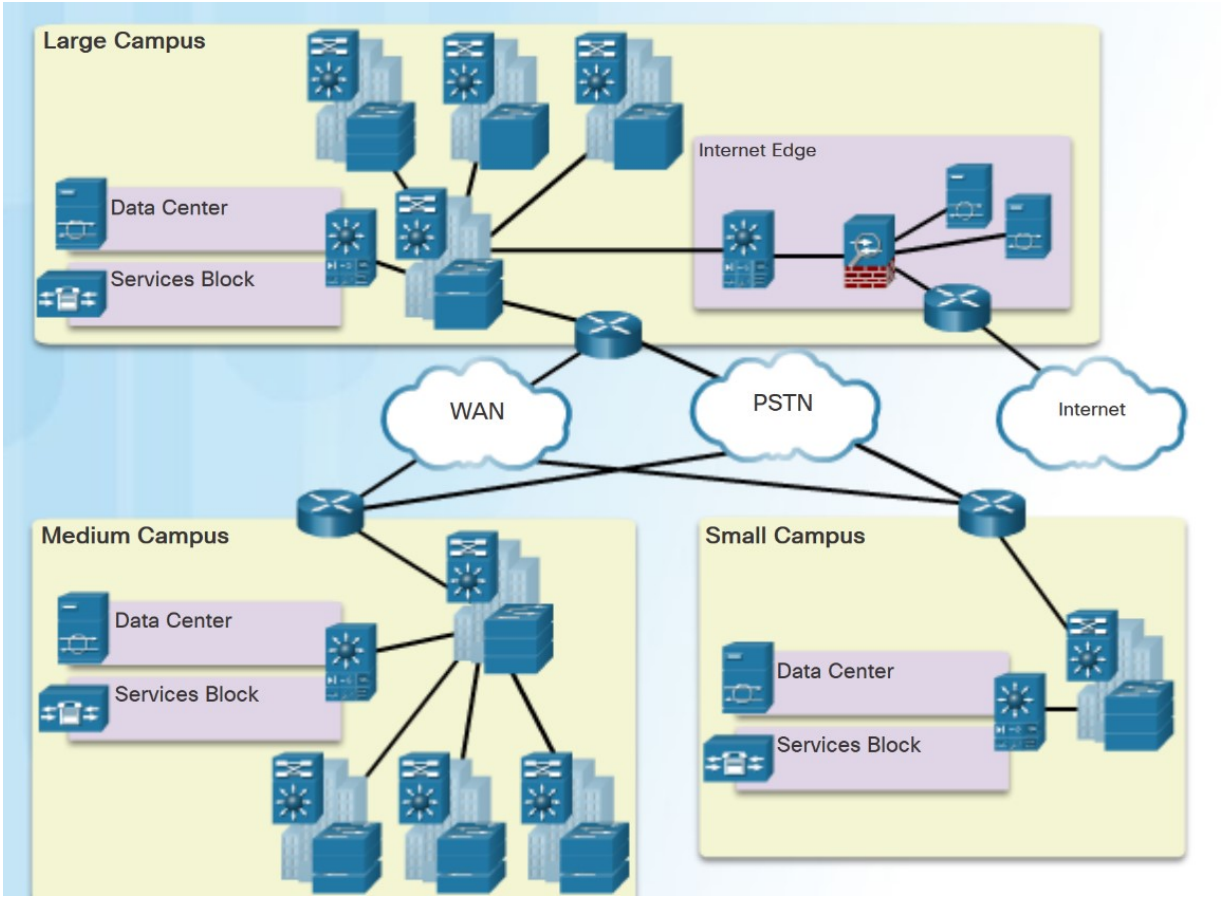
Elements of a Converged Network

- Converged network solutions integrate voice systems, IP phones, voice gateways, video support, and video conferencing.
- Primary benefit of the converged network - just one physical network to install and manage.



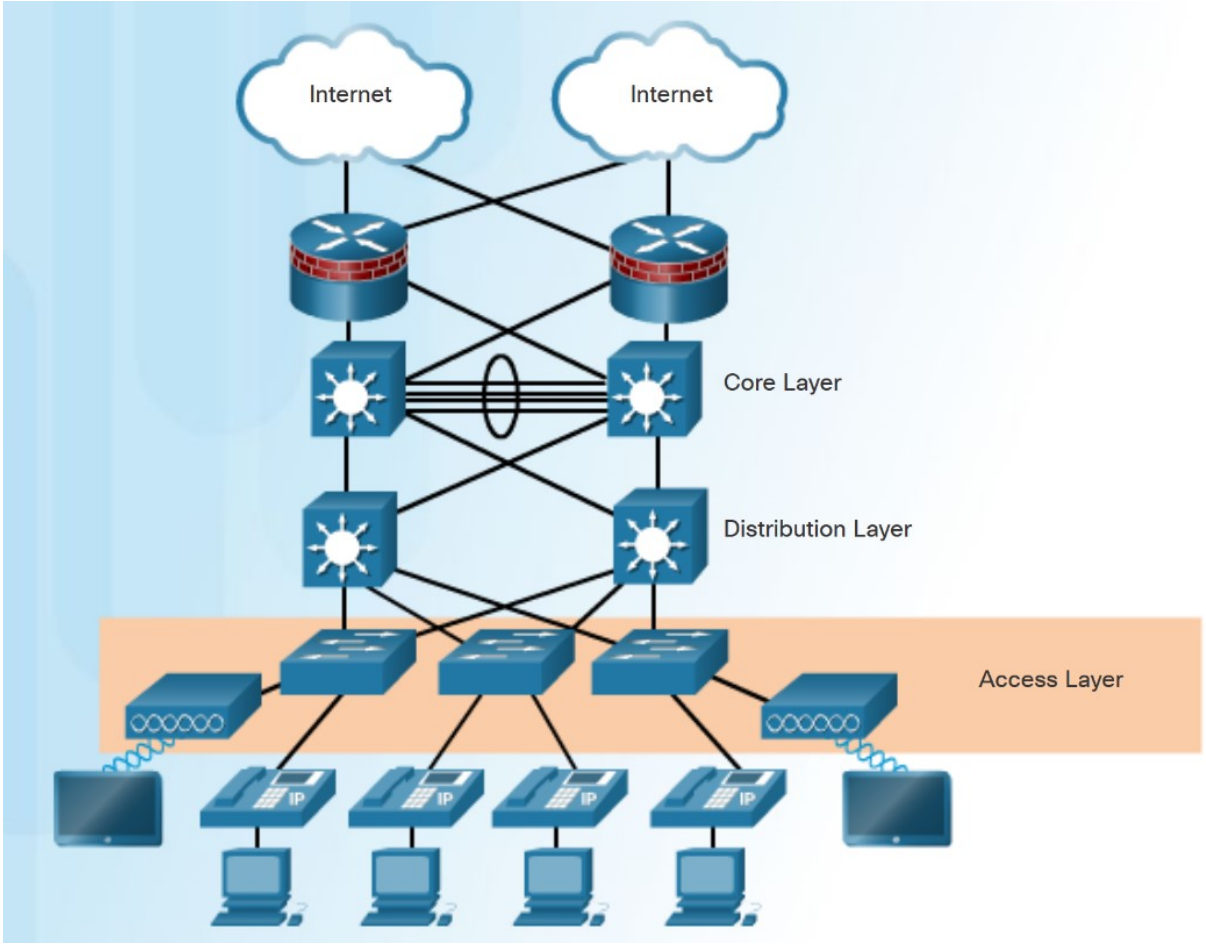
Cisco Borderless Networks

- Allows organizations to connect anyone, anywhere, anytime, on any device; securely, reliably, and seamlessly.
- Provides the framework to unify wired and wireless access, including policy, access control, and performance management across many different device types.
- Provides network services, and user and endpoint services that are all managed by an integrated management solution.



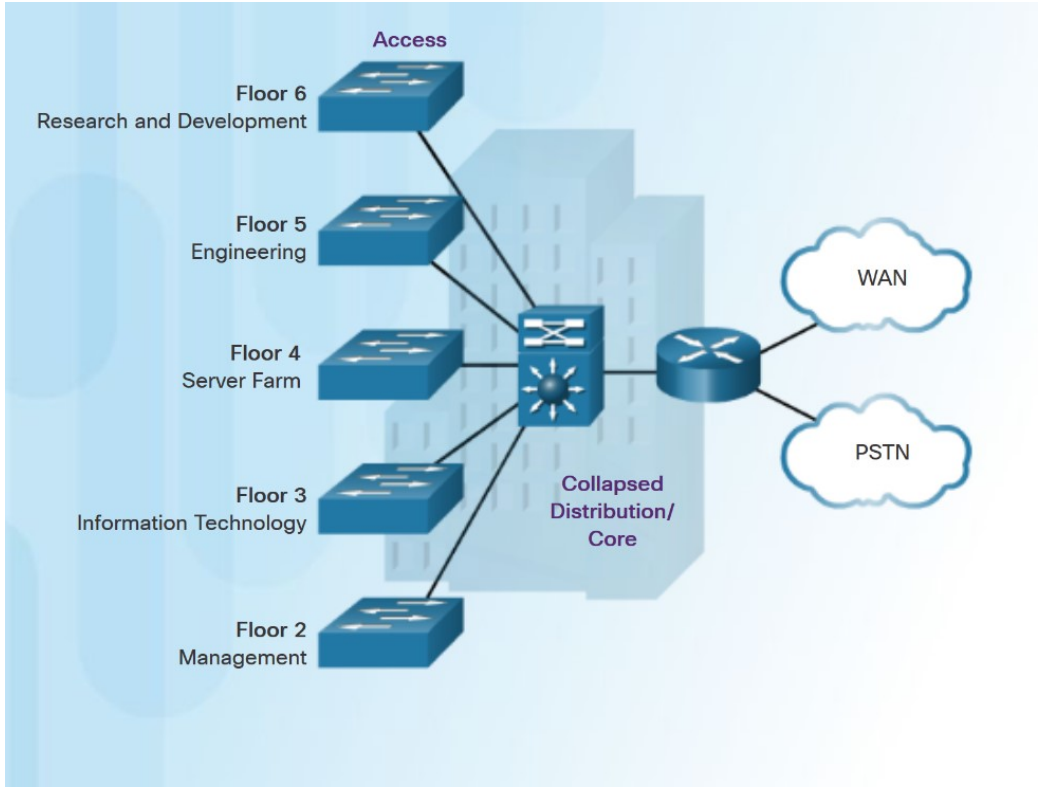
Hierarchy in the Borderless Switched Network

- Borderless switched network design guidelines are based on the following principles:
  - Hierarchical - Facilitates understanding the role of each device at every tier.
  - Modularity - Allows seamless network expansion and integrated services.
  - Resiliency – Provides an always available network.
  - Flexibility - Allows intelligent traffic load sharing.
- The three tiers of the hierarchical model are Access, Distribution and Core layers.



Access, Distribution, and Core Layers

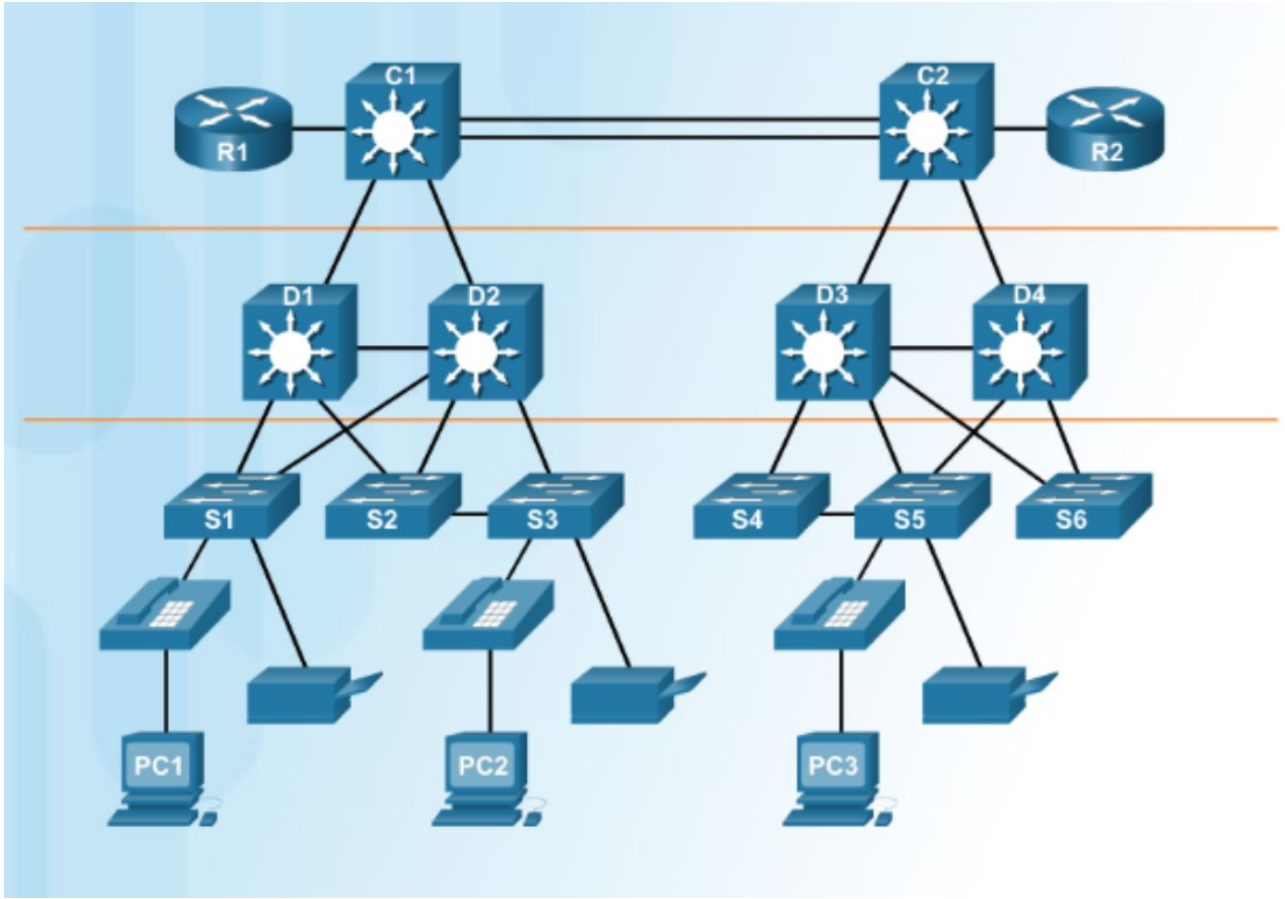
- Access Layer – provides network access to the user.
- Distribution Layer – interfaces between the access layer and the core layer. Provides functions such as:
  - aggregating Layer 2 broadcast domains and Layer 3 routing boundaries.
  - providing intelligent switching, routing, and network access policy functions to access the rest of the network.
- Core Layer – is the network backbone. It provides fault isolation and high-speed backbone connectivity.



Smaller networks that do not need a separate distribution and core layer often use a two-tier campus or collapsed core network design.

Role of Switched Networks

- A hierarchical switched LAN allows more flexibility, traffic management, and additional features:
  - Quality of service
  - Additional security
  - Support for wireless networking and connectivity
  - Support for new technologies.



Switched Network Form Factors

- Considerations when selecting switches:
  - Cost
  - Port Density
  - Power
  - Reliability
  - Port Speed
  - Frame buffers
  - Scalability

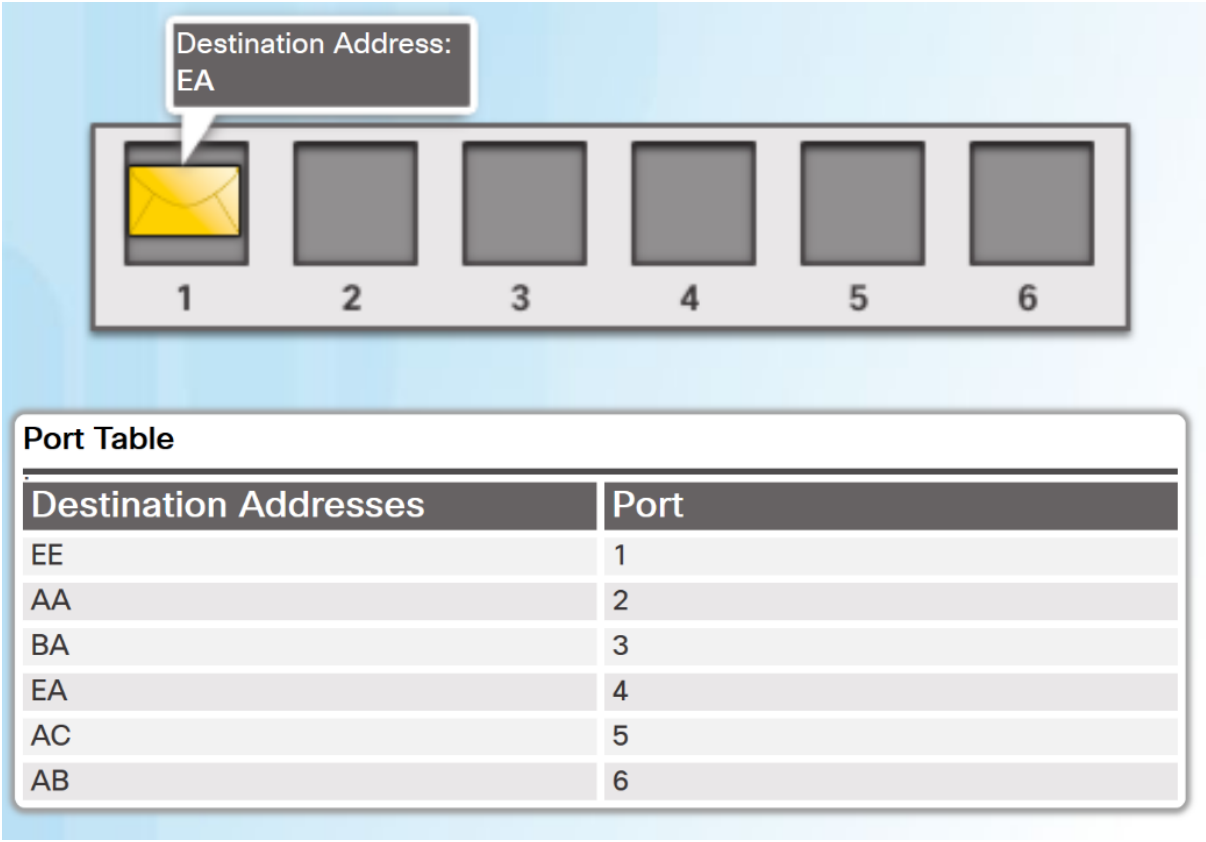
Modular Configuration

Fixed Configuration

Stackable Configuration

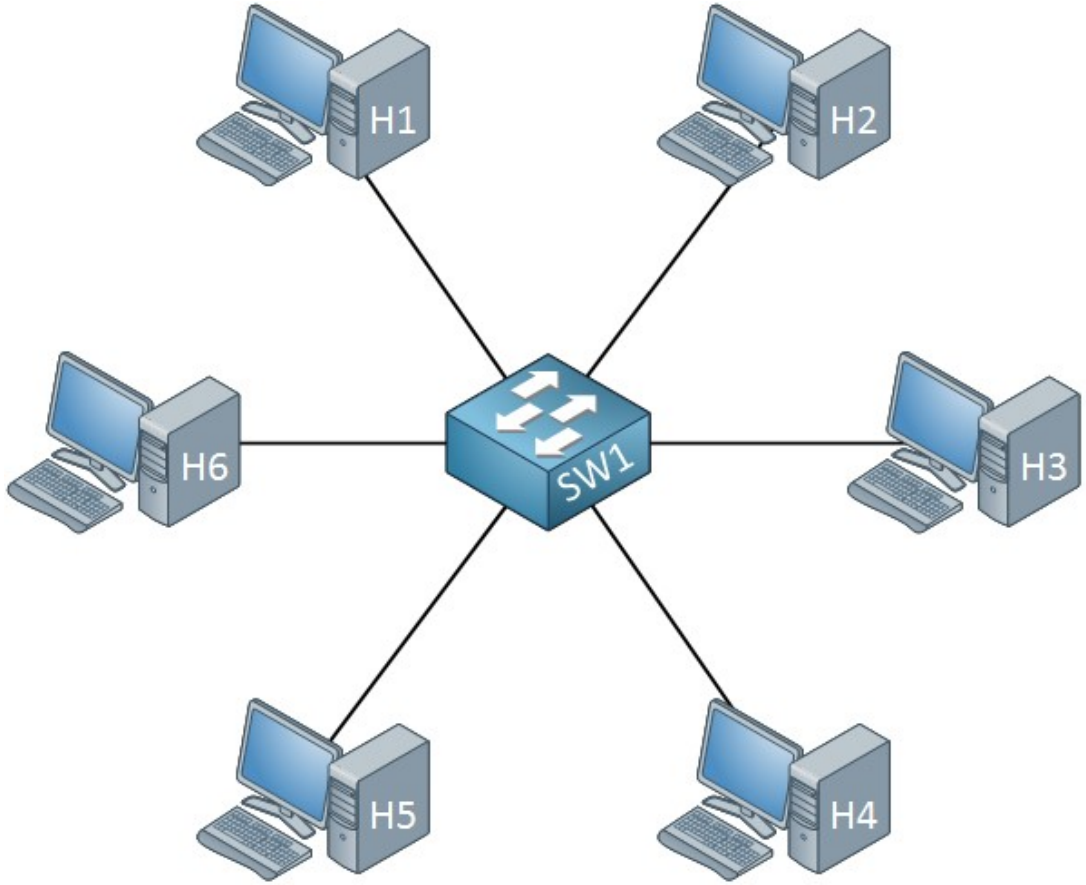
The Switched Environment

- A LAN switch makes decisions based on two criteria:
  - Ingress port - where a frame enters the device
  - Destination address
- A LAN switch maintains a table that it uses to determine how to forward traffic.
- In the diagram, If a message enters switch port 1 with a destination address of EA, then the switch forwards the traffic out port 4.
- Layer 2 Ethernet switches forward frames based on the destination MAC address.



Switching Nodes

- Nodes may connect to other nodes, or to some stations.
- Network is usually partially connected.
  - However, some redundant connections are desirable for reliability
- Two different switching technologies
  - Circuit switching
  - Packet switching



Circuit Switching

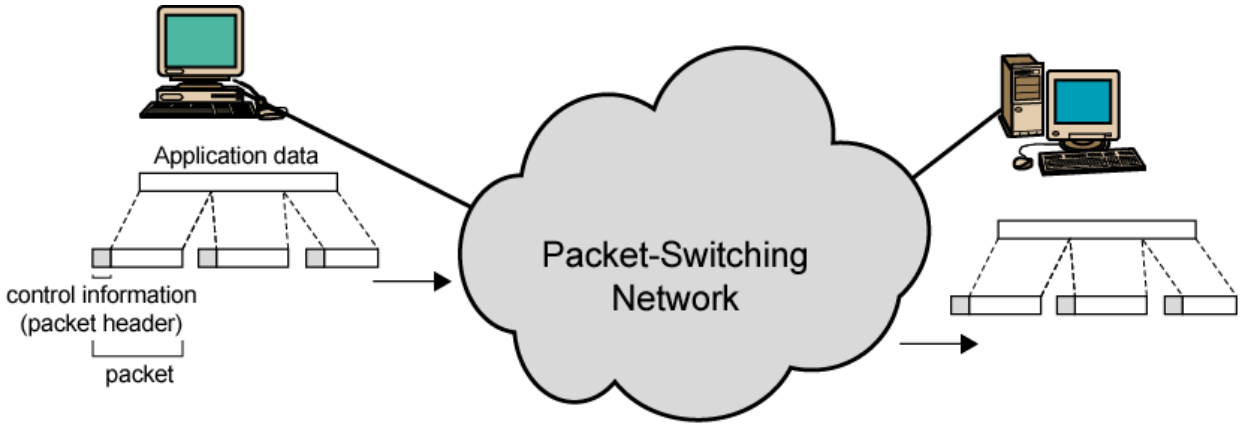
- Circuit switching:
  - There is a dedicated communication path between two stations (end-to-end)
  - The path is a connected sequence of links between network nodes. On each physical link, a logical channel is dedicated to the connection.
- Communication via circuit switching has three phases:
  - Circuit establishment (link by link) - Routing & resource allocation (FDM/TDM)
  - Data transfer
  - Circuit disconnect - Deallocate the dedicated resources
- The switches must know how to find the route to the destination and how to allocate bandwidth (channel) to establish a connection.

Circuit Switching Properties

- Inefficiency
  - Channel capacity is dedicated for the whole duration of a connection
  - If no data, capacity is wasted
- Delay
  - Long initial delay: circuit establishment takes time
  - Low data delay: after the circuit establishment, information is transmitted at a fixed data rate with no delay other than the propagation delay.
- Developed for voice traffic (public telephone network) but can also applied to data traffic.
  - For voice connections, the resulting circuit will enjoy a high percentage of utilization because most of the time one party or the other is talking.
  - But how about data connections?

Packet Switching Principles

- Problem of circuit switching
  - Designed for voice service
  - Resources dedicated to a particular call
  - For data transmission, much of the time the connection is idle (say, web browsing)
  - Data rate is fixed at both ends
- Packet switching is designed to address these problems.



Packet Switching Basic Operation

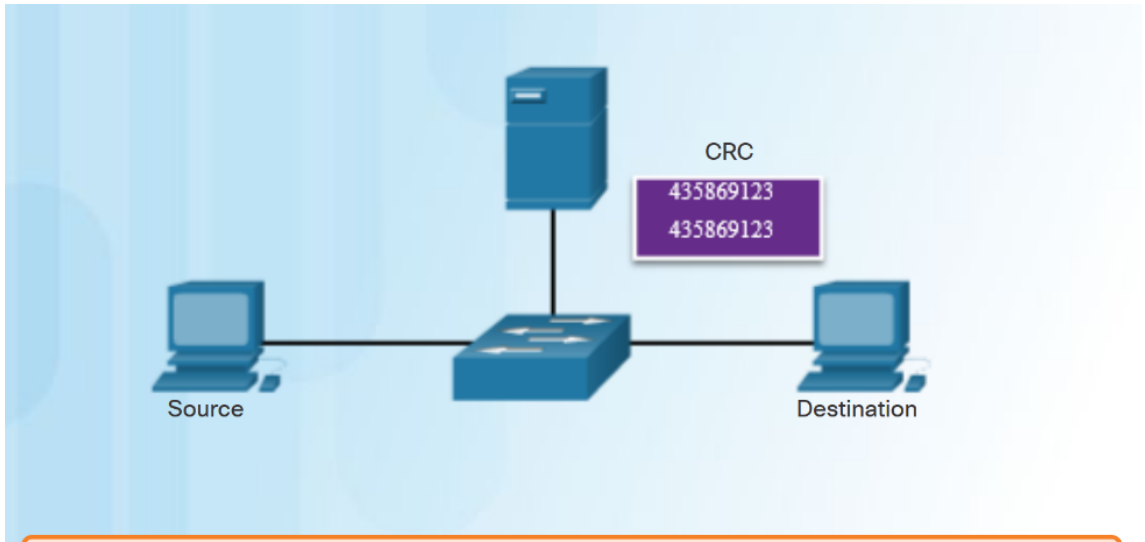
- Data are transmitted in short packets
  - Typically at the order of 1000 bytes
  - Longer messages are split into series of packets
  - Each packet contains a portion of user data plus some control info
- Control info contains at least
  - Routing (addressing) info, so as to be routed to the intended destination
  - Recall the content of an IP header!
- Store and forward
  - On each switching node, packets are received, stored briefly (buffered) and passed on to the next node.

Packet Switching Advantages

- Line efficiency
  - Single node-to-node link can be dynamically shared by many packets over time
  - Packets are queued up and transmitted as fast as possible
- Data rate conversion
  - Each station connects to the local node at its own speed
- In circuit-switching, a connection could be blocked if there lacks free resources. On a packet-switching network, even with heavy traffic, packets are still accepted, by delivery delay increases.
- Priorities can be used
  - On each node, packets with higher priority can be forwarded first. They will experience less delay than lower-priority packets.

Switch Forwarding Methods

Store-and-forward switch



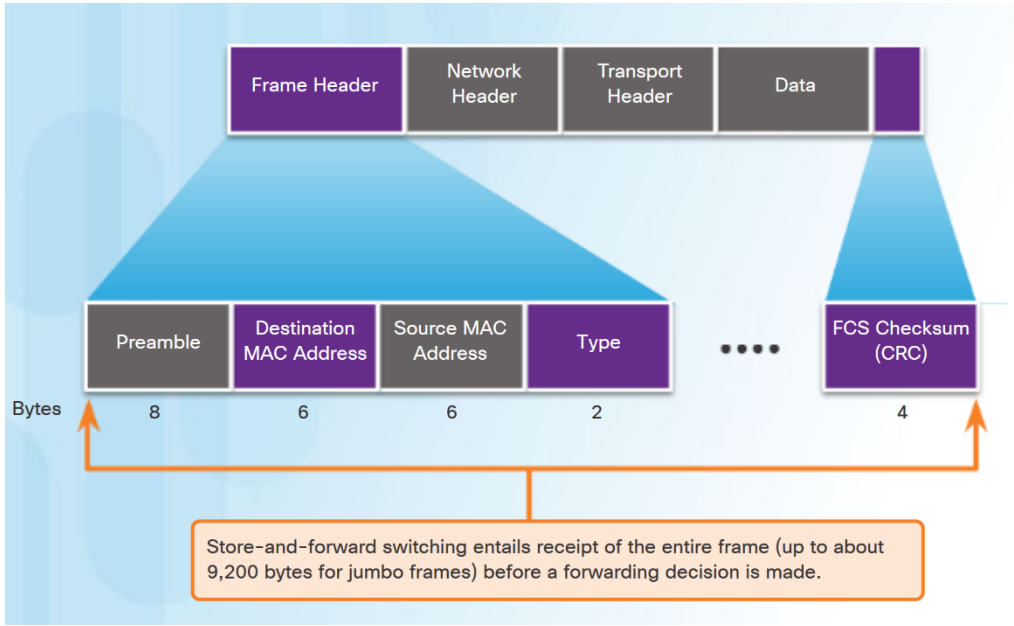
A store-and-forward switch receives the entire frame, and computes the CRC. If the CRC is valid, the switch looks up the destination address, which determines the outgoing interface. The frame is then forwarded out the correct port.

Cut-through switch

A cut-through switch forwards the frame before it is entirely received. At a minimum, the destination address of the frame must be read before the frame can be forwarded.

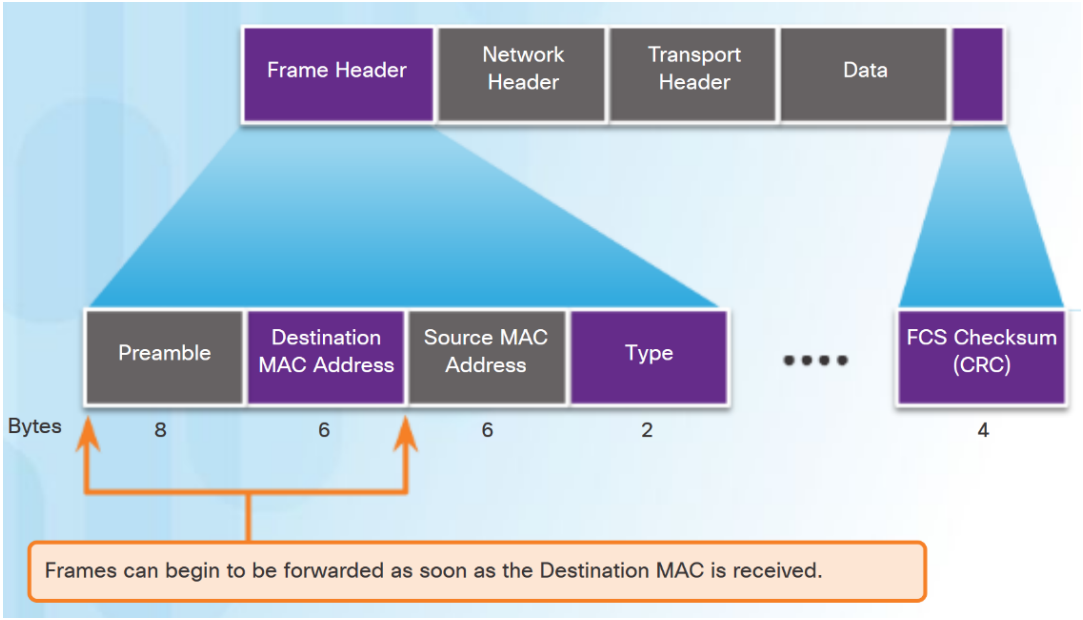
Store-and-Forward Switching

- Features of Store-and-Forward Switching:
  - Error Checking– After receiving the entire frame, the switch compares the frame-check-sequence (FCS) value in the last field against its own FCS calculations. Only error-free frames are forwarded
  - Automatic Buffering– ingress port buffering provides the flexibility to support any mix of Ethernet speeds.
- Store-and-Forward is Cisco's primary LAN switching method.



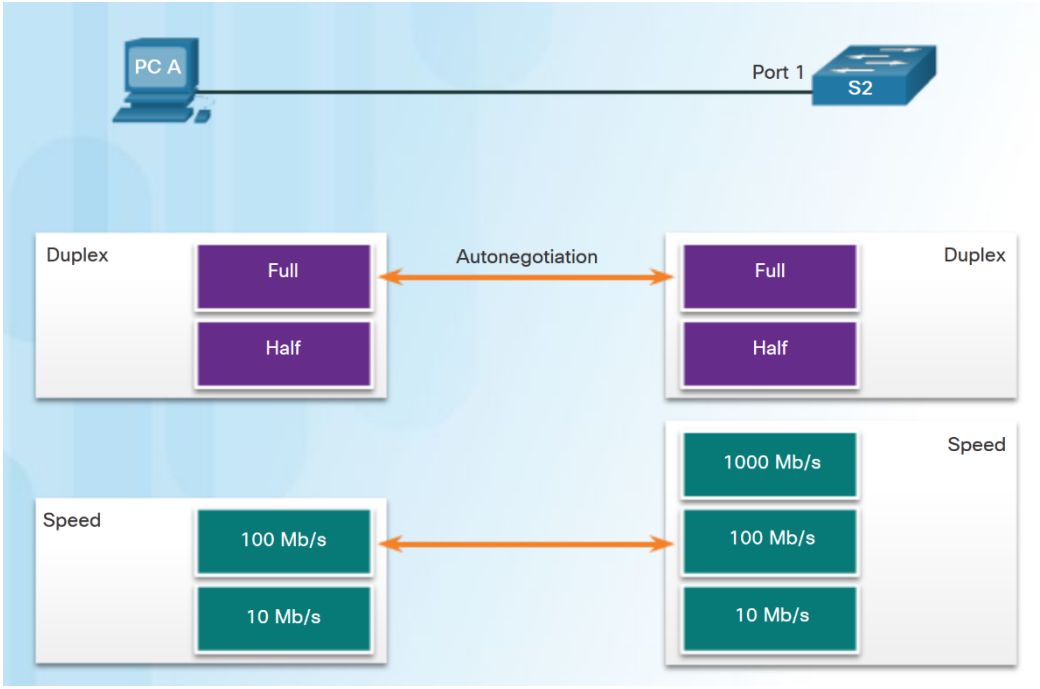
Cut-Through Switching

- Rapid Frame Forwarding -
  - The switch can make a forwarding decision as soon as it has looked up the destination MAC address.
  - Frames with errors are forwarded.
- Fragment Free –
  - modified form of cut-through switching. The switch waits for the collision window (64 bytes) to pass before forwarding the frame.
  - Provides better error checking than cut-through, with practically no increase in latency.



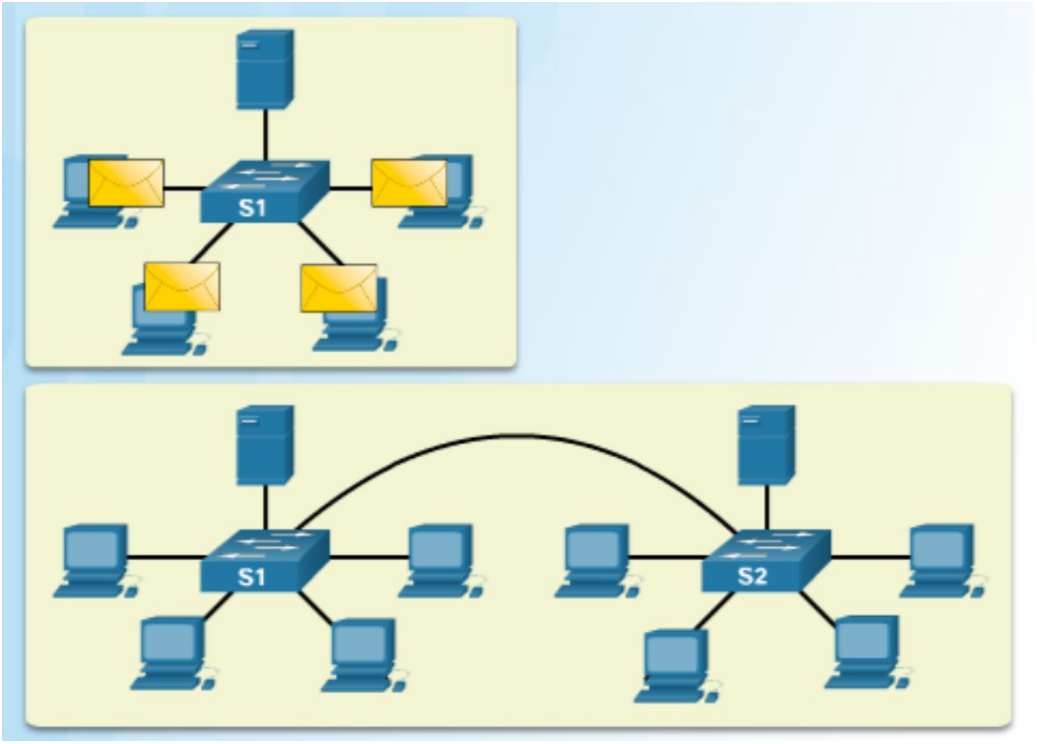
Switching Domains: Collision Domains

- In hub-based Ethernet segments, network devices compete for the medium, therefore collisions will occur.
- Ethernet switch ports operating in full duplex mode to eliminate collisions.
- Ethernet switch ports will autonegotiate full-duplex if connected to full-duplex device.
- If connected to a half-duplex device then the switch port will operate in half duplex and be part of a collision domain.



Switching Domains: Broadcast Domains

- One switch or multiple interconnected switches form a single broadcast domain.
- When a switch receives a broadcast frame, it forwards the frame out each of its ports, except the ingress port where the broadcast frame was received.
- When two switches or more switches are connected together, the broadcast domain is increased because the broadcast is propagated from switch to switch.
- Too many broadcasts can cause network congestion.



Alleviating Network Congestion

- The following characteristics of switches help alleviate congestion:
  - Establishing full-duplex links, therefore eliminating collisions.
  - High port density
  - Large frame buffers
  - Port speed
  - Fast internal switching
  - Low per-port cost

Packet Switching Technique

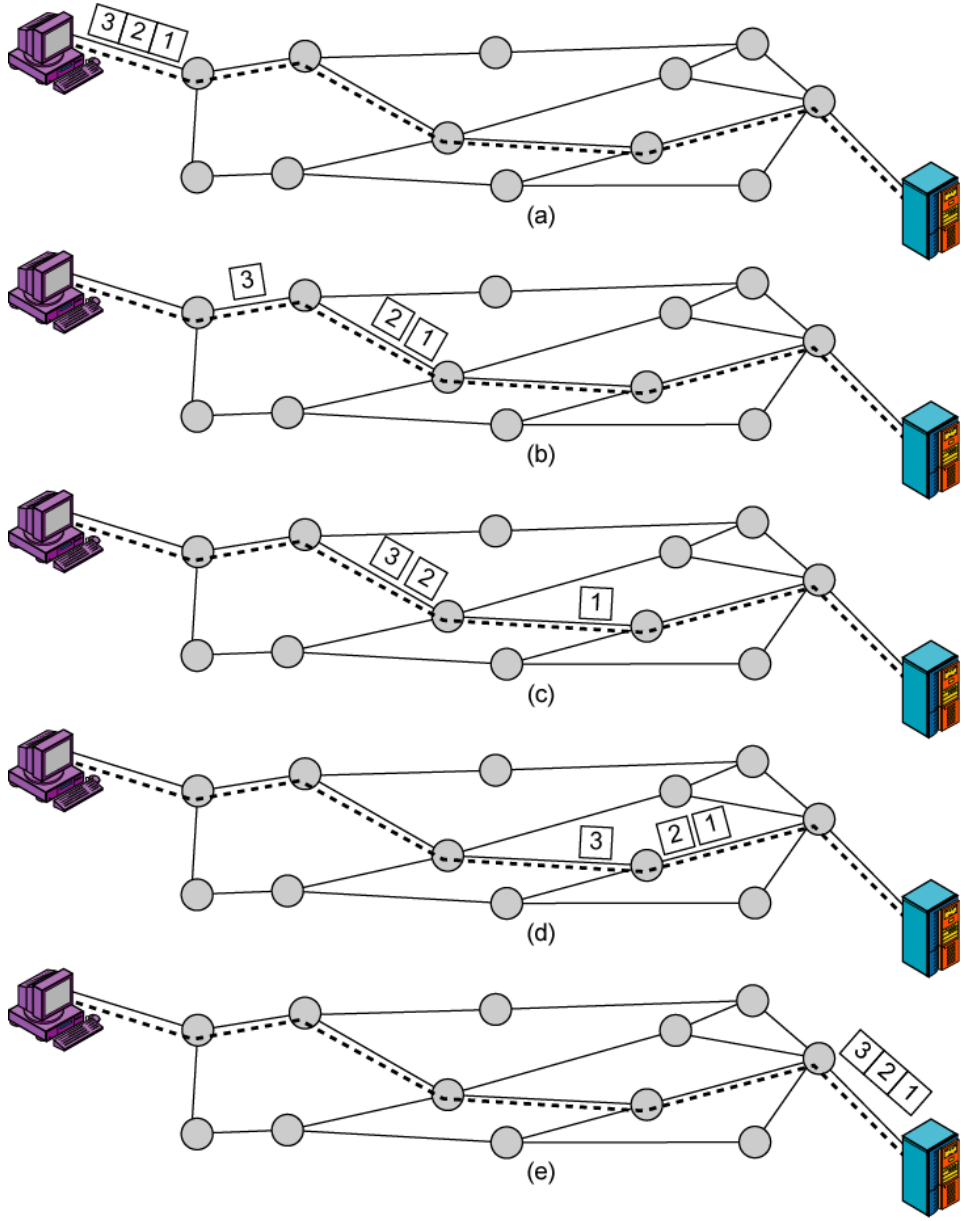
- A station breaks long message into packets
- Packets are sent out to the network sequentially, one at a time
- How will the network handle this stream of packets as it attempts to route them through the network and deliver them to the intended destination?
  - Two approaches
    - Virtual circuit approach
    - Datagram approach

Virtual Circuit

- In virtual circuit, a preplanned route is established before any packets are sent, then all packets follow the same route.
- Each packet contains a virtual circuit identifier instead of destination address, and each node on the preestablished route knows where to forward such packets.
  - The node need not make a routing decision for each packet.
- Example:
  - X.25, Frame Relay, ATM

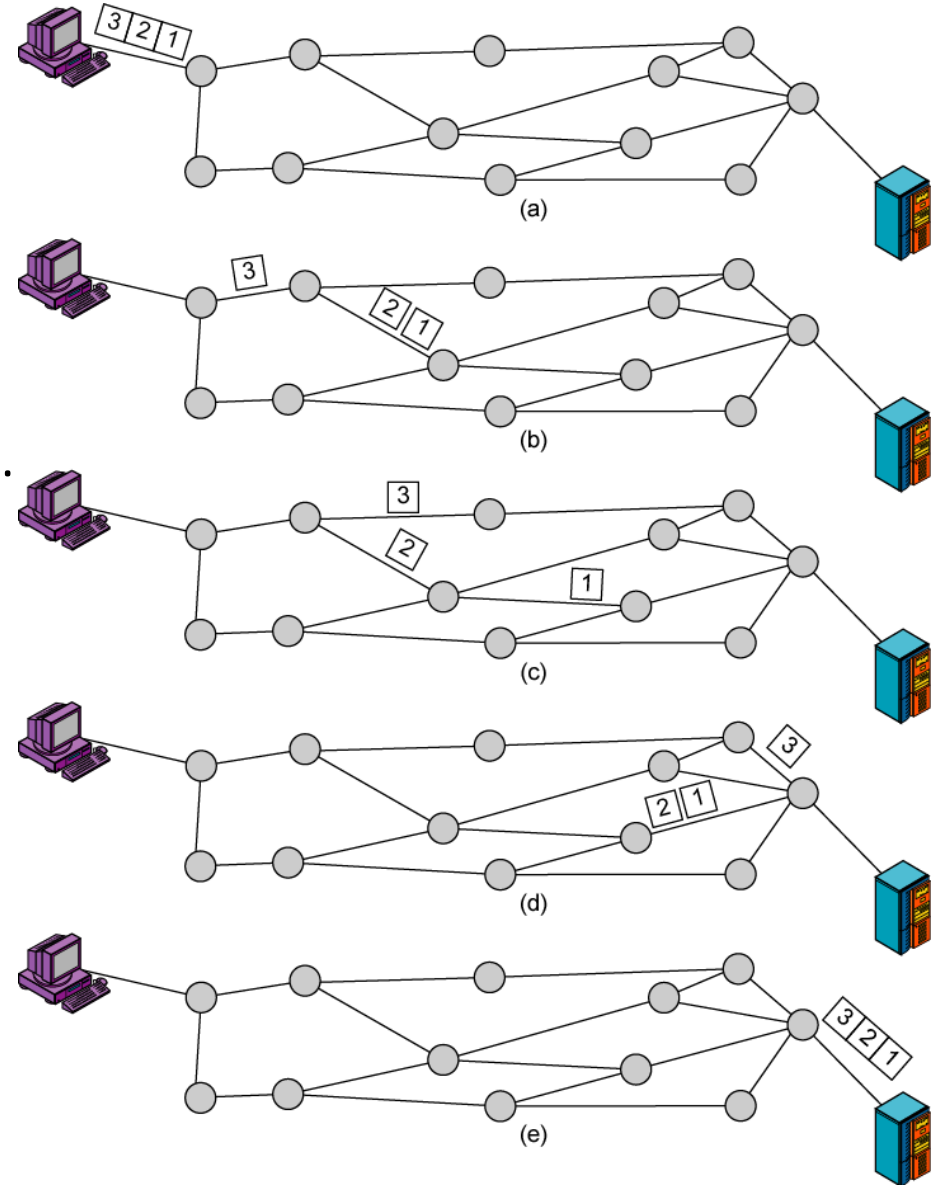
Virtual Circuit

- A route between stations is set up prior to data transfer.
- All the data packets then follow the same route.
- But there is no dedicated resources reserved for the virtual circuit! Packets need to be stored-and-forwarded.



Datagram

- Each packet is treated independently, with no reference to packets that have gone before.
  - Each node chooses the next node on a packet's path.
- Packets can take any possible route.
- Packets may arrive at the receiver out of order.
- Packets may go missing.
- It is up to the receiver to re-order packets and recover from missing packets.
- Example: Internet



Virtual Circuits vs. Datagram

- Virtual circuits
  - Network can provide,
    - sequencing (packets arrive at the same order) and
    - error control (retransmission between two nodes).
  - Packets are forwarded more quickly
    - Based on the virtual circuit identifier
    - No routing decisions to make
  - Less reliable
    - If a node fails, all virtual circuits that pass through that node fail.
- Datagram
  - No call setup phase
    - Good for burst type data, such as Web applications
  - More flexible
    - If a node fails, packets may find an alternate route
    - Routing can be used to avoid congested parts of the network

Comparison of communication switching techniques

Circuit Switching	Datagram Packet Switching	Virtual Circuit Packet Switching
Dedicated transmission path	No dedicated path	No dedicated path
Continuous transmission of data	Transmission of packets	Transmission of packets
Fast enough for interactive	Fast enough for interactive	Fast enough for interactive
Messages are not stored	Packets may be stored until delivered	Packets stored until delivered
The path is established for entire conversation	Route established for each packet	Route established for entire conversation
Call setup delay; negligible transmission delay	Packet transmission delay	Call setup delay; packet transmission delay
Busy signal if called party busy	Sender may be notified if packet not delivered	Sender notified of connection denial
Overload may block call setup; no delay for established calls	Overload increases packet delay	Overload may block call setup; increases packet delay
Electromechanical or computerized switching nodes	Small switching nodes	Small switching nodes
User responsible for message loss protection	Network may be responsible for individual packets	Network may be responsible for packet sequences
Usually no speed or code conversion	Speed and code conversion	Speed and code conversion
Fixed bandwidth	Dynamic use of bandwidth	Dynamic use of bandwidth
No overhead bits after call setup	Overhead bits in each packet	Overhead bits in each packet

Summary

- The trend in networks is towards convergence using a single set of wires and devices to handle voice, video, and data transmission.
- There has been a dramatic shift in the way businesses operate.
- There are no physical offices or geographic boundaries constraints. Resources must now be seamlessly available anytime and anywhere.
- The Cisco Borderless Network architecture enables different elements, from access switches to wireless access points, to work together and allow users to access resources from any place, at any time.

Summary

- The traditional, three-layer hierarchical design model divides the network into core, distribution, and access layers, and allows each portion of the network to be optimized for specific functionality.
- It provides modularity, resiliency, and flexibility, which provides a foundation that allows network designers to overlay security, mobility, and unified communication features.
- Switches use either store-and-forward or cut-through switching.
- Every port on a switch forms a separate collision domain allowing for extremely high-speed, full-duplex communication.
- Switch ports do not block broadcasts and connecting switches can extend the size of the broadcast domain, often resulting in degraded network performance.