LAN Distance Limitations

• LAN technologies are designed with constraints of speed, distance, and cost.
• A typical LAN technology can span, at most, a few hundred meters. LANs are not designed for long distances.
• The need for fair access on shared media such as Ethernet and token ring limits the size of a LAN.
  - CSMA/CD doesn’t work satisfactorily when a network gets too big.
  - Neither does token passing.
LAN Distance Limitations

• Signal strength and noise become serious problems over long distances.

• How can a LAN be extended to cover larger distances such as the Gettysburg campus?

• Let’s see.
LAN Extensions

- Several techniques extend the effective size of a LAN medium.
- Most techniques use additional hardware.
- LAN signals are relayed between LAN segments.
- The resulting mixed technology stays within original engineering constraints while spanning greater distances.
Fiber Optic Extensions

• Fiber optic cable can be used to extend a connection to a computer on a LAN.
• On Ethernet, fiber optic cable and two fiber modems are inserted into the AUI cable.
• This technique does not involve changing the original LAN and works over distances of several kilometers.
Repeaters

- **repeater** - a bidirectional analog amplifier that amplifies and retransmits signals.
- A repeater can be used to extend the size of a LAN medium.
- One repeater can effectively double the length of a LAN segment.
  
  **Example:** An Ethernet repeater can double the maximum size of an Ethernet segment from 500 meters to 1000 meters.
- Ethernet can’t be extended indefinitely with repeaters. CSMA/CD requires low delay and won’t work on a long medium.
Repeaters

- The Ethernet standard includes a limit of 4 repeaters between any 2 stations.
Characteristics of Repeaters

• Repeaters are very easy to use. Just plug them in and they’re ready to go.

• Repeaters simply retransmit signals between segments.

• Repeaters don’t understand frame formats.

• Repeaters don’t have hardware addresses.

• Collisions affect the entire extended network.

• Noise propagates throughout the extended network.
Bridges

• **bridge** - a hardware device that connects two LAN segments and copies frames from one to the other.

• Like a repeater, a bridge connects two LAN segments.

• Unlike a repeater, a bridge understands and retransmits complete frames.
  - Uses a NIC like any other station.
  - Can perform additional frame processing.

• A bridge is invisible to other attached computers.
Characteristics of Bridges

• Bridges are relatively easy to use.
• Bridges isolate collisions and noise.
• Bridges perform frame filtering.
Frame Filtering

• In addition to not forwarding collisions and noise, bridges perform frame filtering. They forward frames only as necessary.

- A bridge knows the location of each computer.

- When it receives a frame, it checks the destination address.

- If the destination computer is on the same segment, the frame is not forwarded.

- If the destination computer is on the other segment, the frame is forwarded.

- Broadcast and multicast frames are always forwarded.
How Does a Bridge Learn?

• Most bridges learn which computers are attached to which segment.
• Initially, a bridge doesn’t know anything about the locations of attached computers and its forwarding table is empty.
• Once a computer sends a frame, a bridge reads the source address and learns the computer’s segment. The information is added to the bridge’s forwarding table.
• As more computers transmit, the bridge learns more computer locations.
How Does a Bridge Learn?

- Until a bridge knows a computer’s location, it has to forward any frames intended for that computer.
- Once a bridge knows a computer’s location, it forwards only as necessary.
- Initially, there’s a lot of forwarding. As a bridge learns, forwarding is done only as needed.
- If a power failure occurs, a bridge’s forwarding table is wiped out. When power is resumed, a burst of traffic can occur.
Designing a Bridged Network

• A filtering bridge allows concurrent use of different LAN segments provided the traffic is local.

• Designers identify patterns of local usage and isolate groups of frequently communicating computers with bridges.

• Bridges can also be used to connect two LAN segments in different buildings.

• Bridges can even be used with leased-line, microwave, laser, and satellite to connect two LAN segments.
Bridges and Cycles

• Several bridges can be used to connect many LAN segments.

• A station on segment c transmits to a station on segment g through bridges $B_2$, $B_1$, $B_3$, and $B_6$.

• Broadcast frames are forwarded by all bridges.

• **Question:** What happens if another bridge connects segments f and g?

• The result is a cycle. If all bridges are allowed to forward all frames, an increasing number of frame copies can loop indefinitely.
Bridges and Cycles

- To prevent infinite looping when a bridged network contains cycles, some bridges must not be allowed to forward all frames.
  - Easy for a small bridged network.
  - Hard for a large bridged network.
  - What if a bridge fails or a new bridge is added? How are things updated?
Bridges and Cycles

• The solution uses the notion of a spanning tree from graph theory.
  - Bridges communicate with each other to determine a spanning tree. There's actually a spanning tree protocol.
  - Once a spanning tree is determined, bridges disconnect appropriate interfaces.
  - With the interfaces disconnected, loops are removed and frames cannot cycle.
  - If a link fails or a new bridge is added, the bridges reconnect all interfaces and run the spanning tree algorithm again.
Switches

• **switch** - an electronic device that forms the center of a star topology network and uses the destination address in a frame to determine where to forward the frame.

• Physically, a switch resembles a hub.

• Unlike a hub which forwards what it receives to each computer, a switch forwards a frame only to the destination computer.

• A hub simulates a single segment shared by all computers. Only two computers can communicate at a time.
Switches

• A switch allows each computer to think it’s on a segment by itself.

• Thus, as many as half the computers can send at a time if they’re sending to the other half. Higher bandwidth.

• Essentially, switches are high-performance multi-interface bridges.

• The main difference between a bridge and a switch is that bridges usually have a small number of interfaces (2-4) whereas switches may have dozens of interfaces.
**Bridges vs Routers**

• **What’s the difference between a bridge and a router?**

• **router** - a hardware device that connects two or more networks and forwards packets according to information in its routing table.

• **bridge** - a hardware device that connects two LAN segments and copies frames from one to the other.

• Both routers and bridges are **store-and-forward** devices. Both receive entire packets, store them in a queue, and forward them.
Bridges vs Routers

- Both routers and bridges are candidates for interconnection devices, but there is a fundamental difference.

- A bridge forwards packets using hardware or physical addresses. That is, a bridge is a layer 2 packet switch.

- A router forwards packets using IP addresses. That is, a router is a layer 3 packet switch.