EXTENDING LANS: REPEATERS, BRIDGES, AND SWITCHES

Distance Limitation and LAN Design

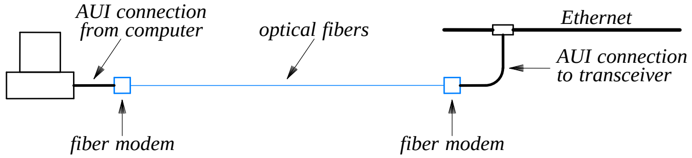
- Distance limitation is a fundamental part in the design of LAN networks
  - To ensure that delays do not become significant
  - To ensure that all stations attached to a LAN receive a sufficiently strong signal
- As a result, LAN technology work best to connect computers within a single building
- Unfortunately, people who interact electronically do not always occupy offices located within a few hundred meters
- Extending cables beyond the maximum bounds, or increasing the power of the signals generated by network interface hardware, will not solve this problem;
  In fact, it will violate the network design assumptions

Extension Techniques

- To overcome this distance limitation problem and to extend LAN connectivity so that it can run across longer distances, additional hardware components are needed; these components include
  - Fiber modems
  - Repeaters
  - Bridges
  - Switches

Fiber Modems

- The simplest LAN extension mechanism
- Uses an optical fiber cable and a pair of fiber modems
- The most common use of fiber modems involve connecting a computer in one building to a LAN in another building
- Since fiber has low delay and high bandwidth, such a mechanism can allow a computer to be connected to a several kilometers away network



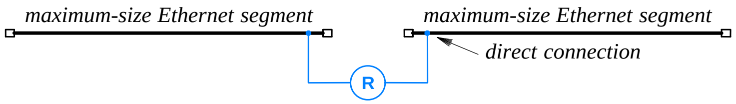
Fiber modems used to provide
A connection between a computer and a distance Ethernet

- *Which Ethernet is shown in the above figure?*

- A fiber modem
  - Accepts electrical signals from the network, or from the computer
  - Converts them to a digital form data
  - Generates pulses of light, equivalent to this digital data, which travel along the fiber
- A fiber modem also
  - Accepts pulses of light from the fiber
  - Converts them to a digital form data
  - Generates electrical signals, equivalent to this digital data, which go to the network or the computer

Repeaters

- A repeater is usually an analog electronic device that
  - Continuously monitors electrical signals on each cable
  - When it senses a signal on one cable, it transmits an amplified copy of this signal on the other cable
- A repeater can double the effective size of an Ethernet network, without violating the network design assumptions
- Repeaters do not understand frame formats, nor have physical addresses

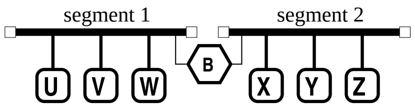


A repeater R connecting two Ethernet

- Any pair of computers on an extended LAN can communicate with each other
- Computers do not know whether a repeater separates them or not
- Although repeaters guarantee sufficient signal strength, they increase the delay; note that CSMA/CD scheme is designed for low delay, otherwise it fails
- IEEE 802.3 standard specifies that the network will not operate correctly if more than *four* repeaters separate any pair of stations
- Repeaters and Fiber modems can be combined together to connect two segments; known as Fiber Optic Intra-Repeater Link (FOIRL)
- A repeater does not distinguish between the signals that correspond to a valid frame and other signals; therefore, when a collision/noise occurs on one segment, a repeater recreates the signals on the other segment and cause the same problem to occur on all other segments

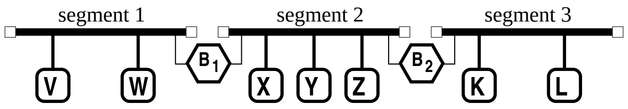
Bridges

- Like a repeater, a bridge connects two LAN segments
- Unlike a repeater, a bridge handles complete frames and uses the same network interface as a conventional computer
  - A bridge listens to the traffic on each segment
  - When it receives a frame from one segment, it verifies that the frame arrived undamaged
  - *If necessary*, it forwards a copy of the complete correct frame to the other segment (frame filtering)
    - ∗ Using the source address found in the frame's header, a bridge learns the location of each computer attached to the LANs it connects
    - ∗ If the destination physical address of the frame in hand belongs to a computer attached to the segment over which the frame arrived (using the knowledge which was built in the above step), the bridge discards the frame without forwarding a copy
    - ∗ If the destination does not lie on the segment over which the frame arrived, the bridge sends a copy of the frame on the other segment
    - ∗ If the destination address is a broadcast/multicast address, the bridge sends a copy of the frame on the other segment



Six computers connected to two-segment bridged LAN

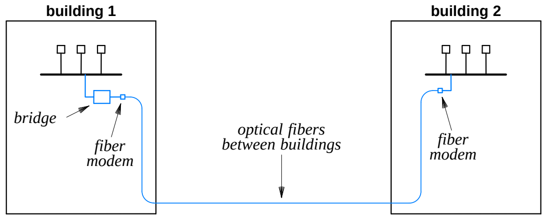
Event	List for segment 1	List for segment 2	Action
Bridge boots	-	-	
U sends to V	U	-	Propagation from segment 1 to segment 2
V sends to U	U,V	-	
Z broadcasts	U,V	Z	Propagation from segment 2 to segment 1
Y sends to V	U,V	Z,Y	Propagation from segment 2 to segment 1
Y sends to X	U,V	Z,Y	Propagation from segment 2 to segment 1
X sends to W	U,V	Z,Y,X	Propagation from segment 2 to segment 1
Y sends to X	U,V	Z,Y,X	
W sends to Z	U,V,W	Z,Y,X	Propagation from segment 1 to segment 2



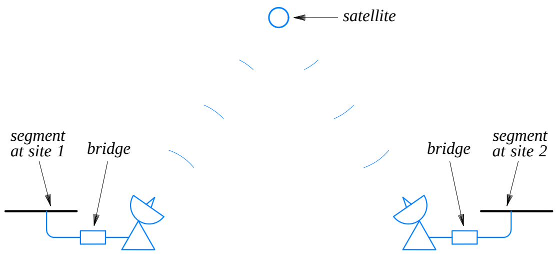
Seven computers connected to three-segment bridged LAN

Event	Bridge B_1		Bridge B_2		Action
	List for segment 1	List for segment 2&3	List for segment 1&2	List for segment 3	
B_1 & B_2 boot	-	-	-	-	
Y sends to K	-	Y	Y		segment 2 to segment 1 segment 2 to segment 3
L sends to Y	-	Y,L	Y	L	segment 3 to segment 2
W sends to V	W	Y,L	Y,W	L	segment 1 to segment 2 segment 2 to segment 3
V sends to W	W,V	Y,L	Y,W	L	
Z sends to V	W,V	Y,L,Z	Y,W,Z	L	segment 2 to segment 1 segment 2 to segment 3
B_1 reboot	-	-	Y,W,Z	L	
W sends to V	W	-	Y,W,Z	L	segment 1 to segment 2 segment 2 to segment 3

- A typical bridge consists of a CPU, RAM, ROM, and two network interfaces
- Bridges do not propagate noise signals or collided frames
- Bridges hardware are engineered to permit communications on separate segments at the same time (parallelism);
  Compare a bridged LAN with a single segment LAN, from the parallelism point of view
- Like repeaters, bridges and fiber modems can be combined together to connect two segments
- Moreover, bridges can be combined with leased serial line or even leased satellite, but in this case two special bridges are needed;
  Why repeaters can not do that?
- Bridges became more popular than repeaters because they help in isolating problems;



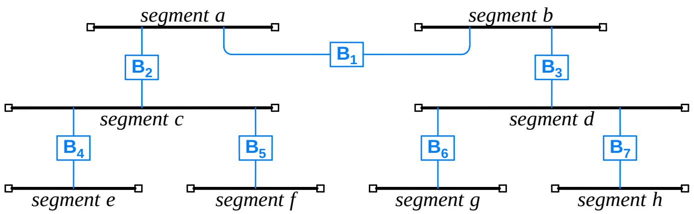
A combination of a bridge and fiber modems to connect two LAN segments



A combination of a bridge and satellites to connect two LAN segments

Complex Bridge Connections

- Because a bridge sends and receives frames, a bridged network can span many segments

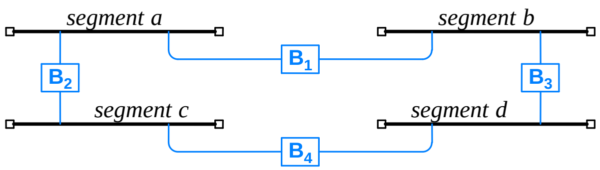


A bridged network

- Note that, adding one more bridge unintentional will introduce a cycle

A Cycle of Bridges

- When a network has a cycle of bridges:
  - Unless some bridges are prevented from forwarding broadcasts, copies continue to flow around the cycle forever, with computers on all segments receiving an infinite number of copies
  - If computer sent a frame with an invalid destination address, this frame will continue to flow around the cycle forever, even if bridge broadcasts are prevented

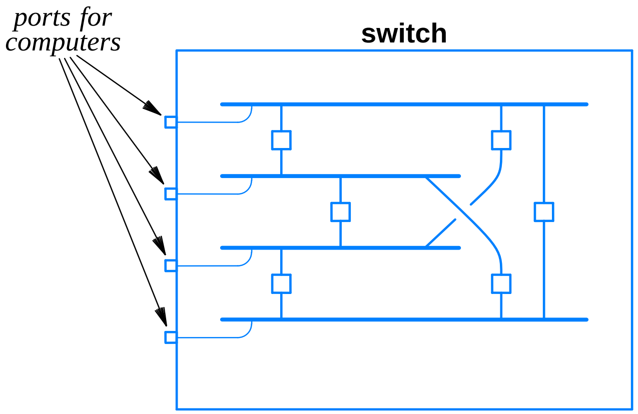


An example of bridges connected in a cycle

- Sometime, extra bridges are placed in a network to make it more immune to failure; in this case, when a bridge first boots,
  - ∗ It communicates with other bridges on segments to which it is connected, using a special multicast address
  - ∗ The bridges perform a computation known as the Distributed Spanning Tree (DST) algorithm to decide which bridges will not forward frames

LAN Switches

- Physically, similar to a hub
- Logically, similar to a bridge
  - Operates on frames
  - Understands physical addresses
  - Only forwards when it is necessary
- Conceptual operation
  - One LAN segment per host
  - A bridge interconnects each pair of segments
- Permits separate pairs of computer to communicate at the same time (parallelism)



The concept underlying a switched LAN (not an actual implementation)