Chapter 11
Extending LANs

The Problem

- the networks we have studied so far have been multiaccess networks
- multi-access networks do not scale well (i.e., cannot be used as wide area networks). Why?

Goal: Want to create networks with lots of hosts that span large geographic distances. Ideally, want one gigantic network? Or do we?

Repeater

- **Repeater** is a bidirectional, analog amplifier that retransmits analog signals

\[ \text{Strong Signal} \rightarrow \text{Weak Signal} \rightarrow \text{Strong Signal} \]

![Diagram: Repeater Connecting Two Ethernet Segments](image-url)
Obvious Drawbacks:

- Despite drawbacks, can more than double the length of a LAN segment

Repeater Characteristics:

- Simply copy signals between segments
- Any Ethernet segment is limited to meters
- One repeater doubles the length to meters
- How many repeaters can we add?
**Repeater Limits**

* Can’t extend Ethernet with repeaters indefinitely
  1. 
  2. 
  3. The limit is:

**Repeater Animation (Quicktime) (Shockwave)**
**Logically just one wire**

- repeaters are nice because they are easy to use/install
- essentially have a longer wire
- everything else stays the same

**Bridges**

- Like Repeaters, Bridges can be used to connect to LAN segments
  - Like Repeaters they retransmit packets from one segment on other segment(s)
- Unlike Repeaters,
  - Bridges have
  - Performs some processing on the frame
**Store-and-Forward**

- **Store-and-Forward** means
  1. Read in a complete frame (buffering all bits until the frame has been completely received)
  2. Check to make sure the frame is OK (e.g., check CRC)
  3. Transmit the frame out on all interfaces (except the incoming interface)
- NIC must operate in promiscuous mode so that it sees all packets
- Bridges are invisible to all other computers

**Bridges vs. Repeaters**

- Repeaters

- Bridges

Bridging Animation (Quicktime) (Shockwave)
Compared with:
Repeater Animation (Quicktime) (Shockwave)
**Dumb vs. Learning Bridges**

- **Dumb Bridges** forward every packet they receive on all interfaces except the incoming interface
- Disadvantages of Dumb Bridges

- **Learning Bridges**

**Learning Bridges**

- Know a (hopefully the best) route to the destination
- Only forward the packet on that interface, not on the other interfaces (sometimes called **Filtering**)  
- Advantages

- How does a learning Bridge know the route?
Learning the Routes

- How can a bridge “learn” the route to a machine?

Example

The Learning Algorithm

- The Algorithm

Essentially we end up with a smart network that can route the packet directly from the source to the destination.
Consider the following network topology:

```
  5  6
  7  8  9
```

**What’s the catch?**

- Consider the following network topology

  ![Network Topology Diagram]

**Eliminating Cycles**

- **Idea:** Arrange the bridges into a Spanning Tree (a graph theory idea)
- Spanning tree ensures all hosts are reachable, but there are no cycles
- **Problem:** How do bridges cooperate to form a spanning tree?
Problems with Bridges

- Bridges help extend LANs to WANs but are not the complete answer
- Cycles in Dumb Bridging mode are deadly!
- What about Broadcast traffic?

- What about Multicast traffic?

- Limited Scale

- Heterogeneity? What types of networks can be bridged together?
**Switched Ethernet Concept**

- Effectively one host per LAN segment
- All LAN segments are bridged together
- The Hub contains all LANs and bridges
With switching, multiple stations can transmit simultaneously
Provides much higher aggregate bandwidth
But, machine-to-machine bandwidth does not increase