Ethernet, 802.11, Networking

CS158a
Chris Pollett
Mar 21, 2007.

Outline

- Ethernet Performance
- Other types of Ethernet
- 802.11
- Data Link Layer Switching

Ethernet Performance

- To rigorously analyze the exponential backoff algorithm is quite complicated.
- Metcalfe and Boggs (1976) give a simplified treatment where they assume k stations and a constant probability of retransmission in each slot.
- If each station transmits during a contention slot with probability p, the probability A that some station acquires the channel is $A=kp(1-p)^{k-1}$.
- Here k is for the number of choices for the single station that transmits, p come from that station station that transmits $(1-p)^{k-1}$ come from those that don't.
- A is maximized when p=1/k, and A approaches 1/e as k gets large.
- Now let's look at the number of contention slots. The probability this is exactly j is $A(1-A)^{j-1}$. So the mean number of slots per contentions is the sum of these terms to infinity which is equal to 1/A.
- So if each slot has a duration 2T, then the mean contention interval is 2T/A. If p is optimal, then this 2Te.

More On Ethernet Performance

- If the mean frame takes P seconds to transmit, when many stations have frames to send, the channel efficiency is:

  Channel Efficiency= P/(P+#num contention slots)

  =P/(P+2T/A)

- Notice that the longer the cable, the bigger 2T will be and the worse the efficiency.
- This equation can be reworked in terms of the frame length using P=F/B and T=L/c where B is the bandwidth, L is the cable length, c is the propagation speed, and e is the number of contentions/slot in the optimal case, one gets:

  Channel Efficiency= 1/(1+2BLe/cF)

  Increasing BL reduces the efficiency for a given frame size. So as bandwidth increases one needs to compensate by making the framelength longer or by reducing L.

Other Types of Ethernet

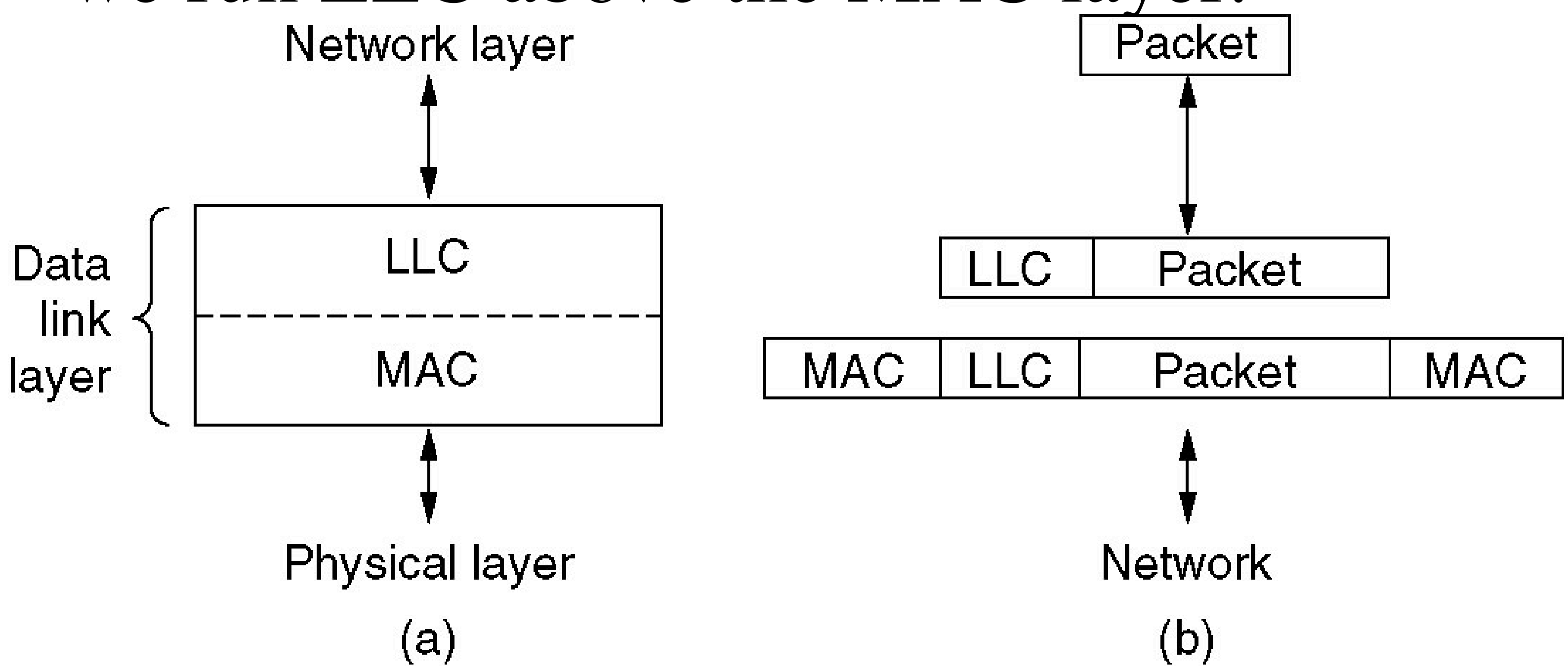
Switched Ethernet -- consists of a **switch** containing a high-speed backplane and room for 4-32 plug-in line cards. Machines output Ethernet frames to the switch. The switch checks frames to see if they are destined for a machine on same card or a different card. If for the same card, the frame is sent on the wire on same card, if no copied to different card. Each card acts as its own **collision domain**. So two machines on different cards can send within their cards at the same time. This increases the amount of traffic that can be handled before saturation. One can also buffer data.

Fast Ethernet -- IEEE developed in 1992-1995 as 802.3u. The bit time is reduced from 100ns to 10ns but otherwise the protocol is essentially the same as Ethernet. Fast Ethernet uses twisted pair, hubs, and switches. Cables called 100Base-T4, 100Base-TX or 100Base-FX depending on whether CAT-3, CAT-5 or fiber optic cables used.

Gigabit Ethernet -- IEEE developed in 1998 as 802.3z. Uses point-to-point connections. Could be between just two machines, or more typically each machine connects to a hub or a switch. No CSMA/CD is needed if switch, since in this case frames would be buffered. In the case of a hub there is no buffering and so CSMA/CD is needed. Frames need to be padded to at least 512 bytes (**carrier extension**) because of the higher speed. The system also supports sending of concatenated sequences of frames. (**frame bursting).** Cables are 1000Base-SX, 1000Base-LX, (both of these are fiber) 1000BASE-CX (shielded twisted pair), 1000Base-T (CAT-5).

IEEE802.2: Logical Link Control

The MAC layer does not do error correction or flow control. If we want this on our LAN we run LLC above the MAC layer.



802.11 (Wireless LANs)

- We will now consider 802.11 standard for wireless LANs.
- These specs say both how the physical layer works, and how the data link layer works.
- All 802 specs (so both 802.3 and 802.11) need to be indistinguishable as far as the network layer is concerned.
- The physical layer of 802.11 supports transmission over infrared as well as two radio based techniques FHSS (Frequency Hopping Spread Spectrum), DSSS (Direct Sequence Spread Spectrum).
- In 2001 two further techniques were added: OFDM (orthogonal FDM) and HR (high rate)-DSSS operating at 54 and 11 Mbps.
- The data link layer of 802.11 is split into two layers a MAC layer and an LLC layer.

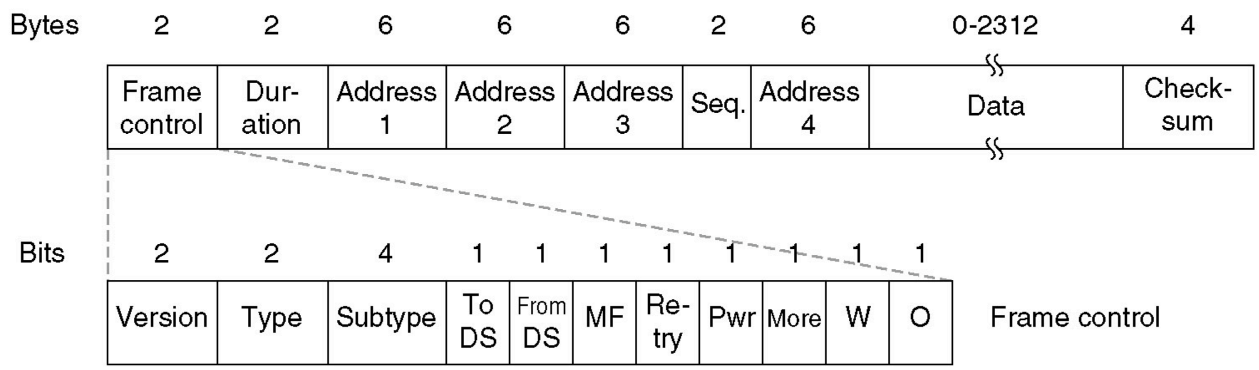
802.11 MAC Layer

- Has two modes: **Distributed Coordination Function** (DCF -- this is with a base station) and Point Coordination Function (PCF--without a base station)
- Uses a scheme like MACA called CSMA/CA (for collision avoidance)
- After an RTS or a CTS, other machines can estimate how long until it is possible for them to send. This is called a **network allocation vector** (NAV).
- Wireless networks are noisy, if p is the bit-error rate then $(1-p)^n$ is the probability an n bit frame arrives. For $p=10^{-6}$ over 1% of frames might still be destroyed.
- Thus, the sending station, once a channel has been acquired, rather then send the whole frame, instead gives a sequence of fragment bursts.
- Each of these is acknowledged by the receiver.

PCF mode

- The preceding discussion was for DCF mode.
- In PCF mode there is a base station and the base station polls each other station to see if they have frames to send.
- It periodically broadcasts a **beacon frame** to do this. This frame contains system parameters such as hopping sequences and dwell times, as well as clock synchronization etc.
- There is a protocol to use both PCF mode and DCF mode at the same time based on a scheme for splitting up the interframe time interval.

The 802.11 Frame Structure



- Version allows things like 802.11b and a to operate within the same cell at the same time.
- Type is either data, control or management
- Subtype is RTS or CTS.
- To DS and From DS indicate what kind of intercell distribution system the frame is going to or from (say Ethernet).
- Power management can be used to put receiver into/out of sleep
- W indicates WEP data.
- Two addresses are for source and destinations, the pair of addresses to deal with intercell traffic
- Seq indicates frame burst sequence number

802.11 Services

•802.11 LANs must provide the following services:

- Association
- Disassociation
- Reassociation
- Distribution
- Integration

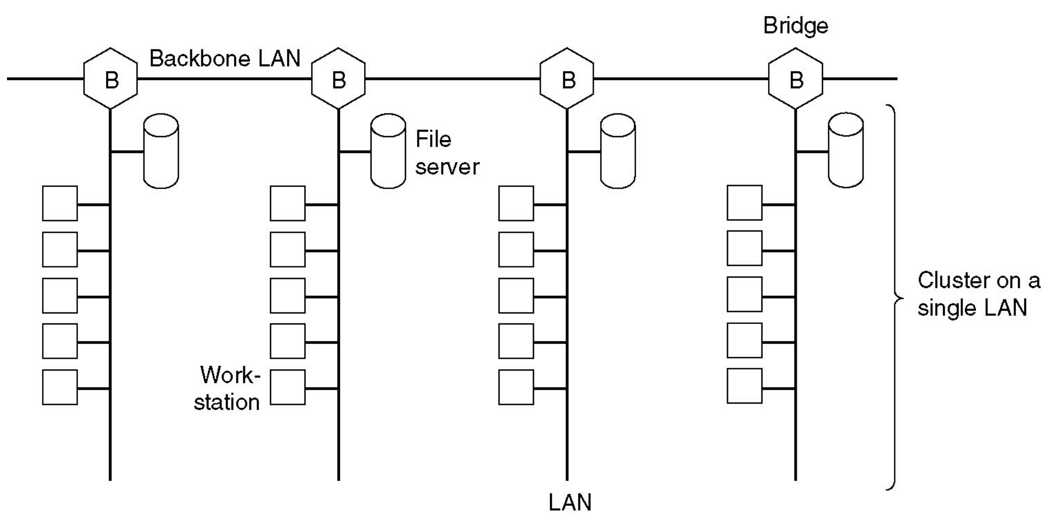
802.11 Services (cont'd)

The last four of these are intracell:

- Authentication
- Deauthentication
- Privacy
- Data Delivery

Data Link Layer Switching

- Multiple LANs can be connected by devices called **bridges**.
- These only examine the data link layer address in determining where to send data.
- A **router** is a device which operate one layer up and may look at network layer header info.

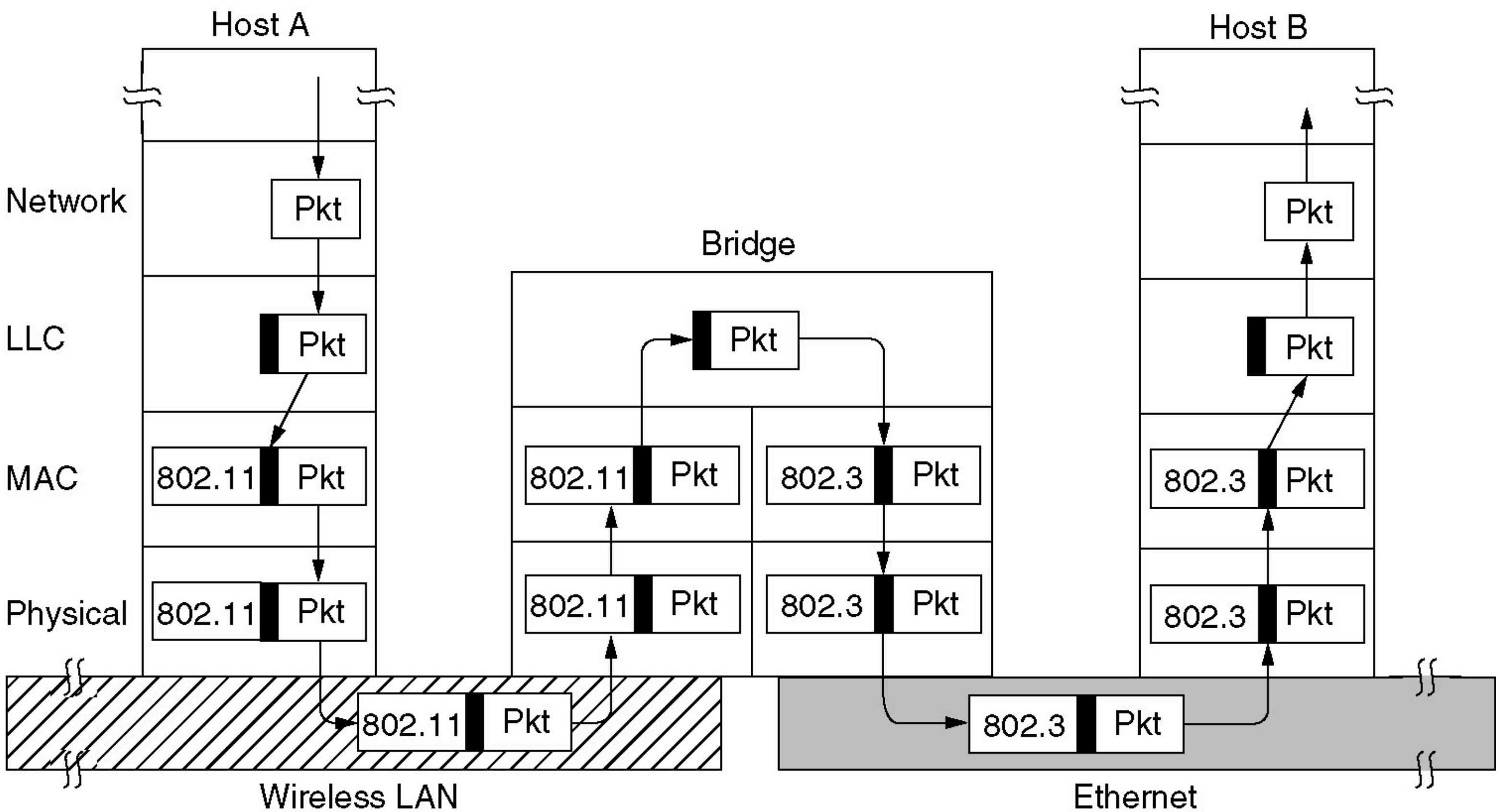


Uses of Bridges

- To allow traffic to flow between devices on 802.x and 802.y LANs.
- For organizations spread over several buildings might have several LANs connected by a backbone LAN
- To do load balancing because of how many nodes one has on a LAN.
- To handle longer distances
- Using hubs can enhance security by isolating who sees what data.

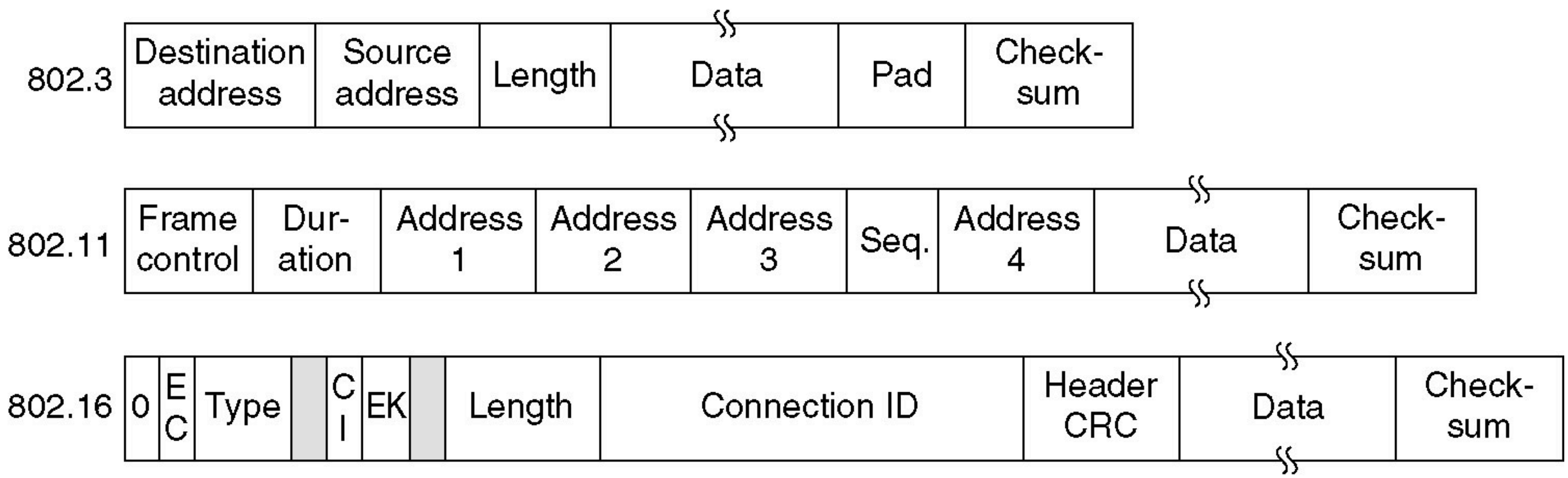
Bridges from 802.x to 802.y

Operation of a LAN bridge from 802.11 to 802.3.



Bridges from 802.x to 802.y (2)

The IEEE 802 frame formats. The drawing is not to scale.

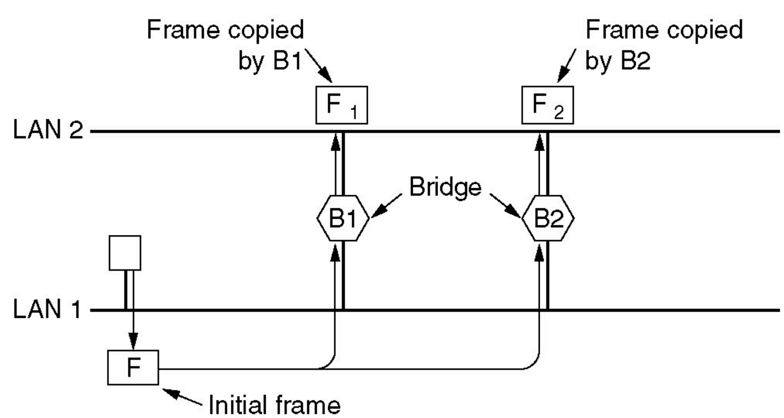


Local Internetworking

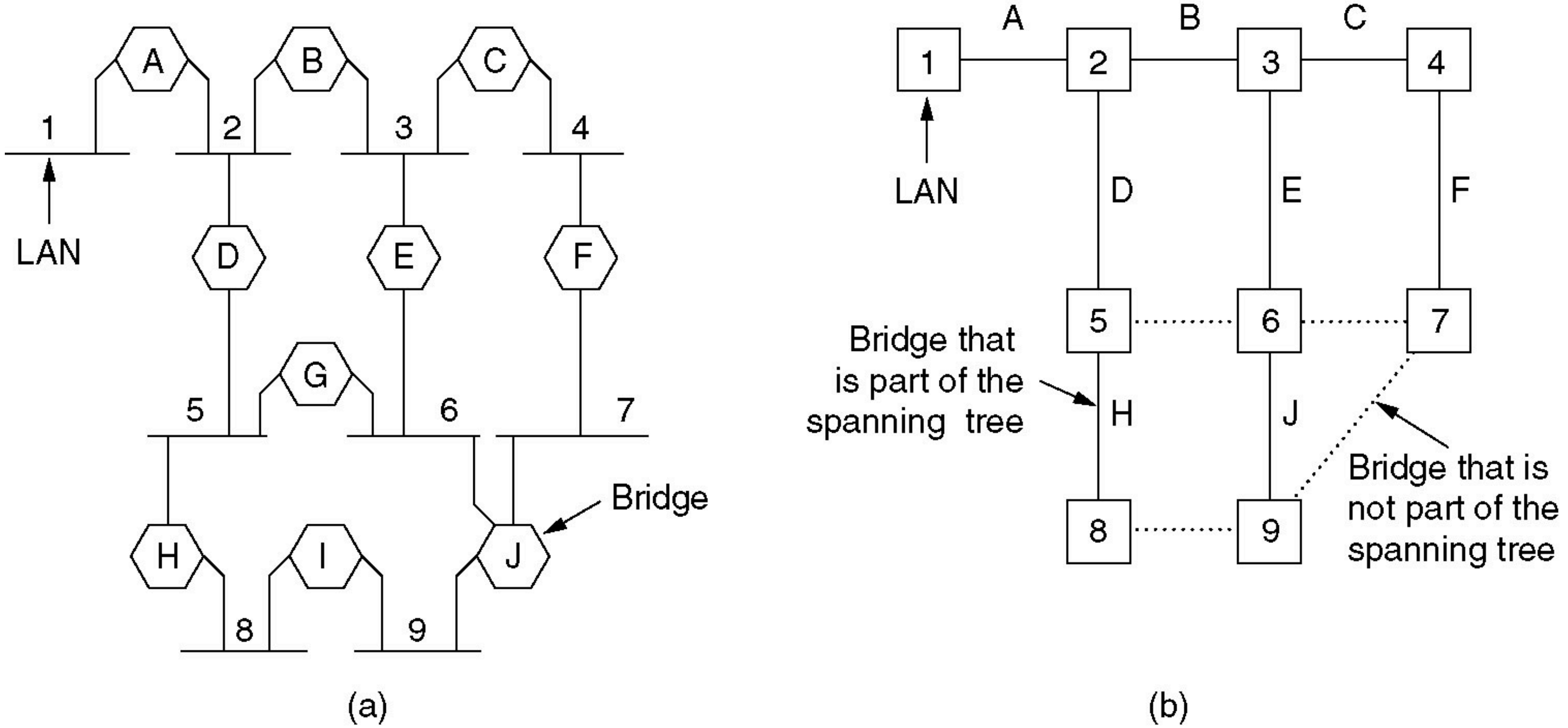
- Several LANs may be connected by bridges.
- In order to know where to send frames that live on different LANs, bridges use a **backward learning algorithm**.
- A bridge maintains a hash table consisting of (LAN station, LAN) pairs. Really, it would have (h(LAN station), LAN), but I am ignoring the hash function and focusing on the table aspect which is more important.
- A pair (a,5) stored in a bridges table, indicates that to send a frame to host a, send on LAN 5.
- This table is purged every few minutes in case machines go down, up etc. so that stale entries do not cause problems.
- Initially, all bridges have empty tables.
- When a frame from *a* destined to *b* enters a bridge from LAN *i*, the bridge checks if there is a table entry for *b* and makes an entry (a,i) into its table. If b is in its table it sends according to that entry. Otherwise, it floods each of the other LANs it is on with the frame destined for b.
- Thereafter, if a frame comes in destined for *a*, the bridge uses the table entry (a,i) and sends the frame onto LAN *i*.
- This table is implemented in hardware so is very fast.

Spanning Tree Bridges

- A local network might have multiple paths to the same destination.
- This can be done to enhance reliability
- However, loops can cause problems for the forwarding algorithm.
- To handle this, then bridges agree on a spanning tree and only forward along this.
- To agree on a spanning tree, each bridge broadcasts its serial number and the one with the lowest number becomes the root.
- Thereafter, by sending frames each bridge backwards learns the edges on a minimal spanning tree to this root.



Spanning Tree Bridges (2)



(a) Interconnected LANs. (b) A spanning tree covering the LANs. The dotted lines are not part of the spanning tree.