Ch4.

4.1

4.1.1 Static channel allocation

- Static allocation
  - Poor fit to computer systems with extremely bursty data traffic.
  - Performance affected when peak traffic to mean traffic ratios are 1000:1
  - Most channels will be idle most of the time.
- Dynamic allocation tries to resolve static allocation problems.

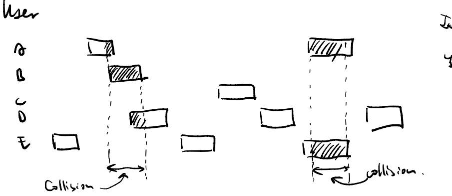
4.1.2 Dynamic Channel Allocation

- Independent traffic
- Single Channel
- Observable collisions
- Continuous or slotted time.
- Carrier sense or no carrier sense

4.2 Multiple access protocols.

4.2.1 ALOHA

Pure ALOHA: send the frame when ready, resend if the frame is destroyed.



在pure ALOHA中，发生任何时间传输
产生冲突就重传

pure ALOHA is free.

Slotted ALOHA add some limit.

like send frame at probability p.

Slotted ALOHA: required to wait to send a frame for the beginning of the next slot.

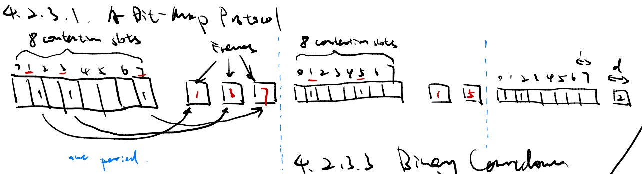
4.2.2 CSMA (Carrier Sense Multiple Access Protocols)

- Persistent and non-persistent CSMA.
  - 1-persistent CSMA: if the channel is idle, the stations send its data. Otherwise, the station just waits until it becomes idle.
  - Nonpersistent CSMA: if the channel is busy, the station does not continually sense it for the purpose of seizing it immediately.
  - P-persistent CSMA: if the channel is idle, it transmits with a probability p. With a probility, it defers until the next slot.
- CSMA with collision detection
  - Known as CSMA/CD (CSMA with Collision Detection)
  - Quickly detect the collision and abruptly stop transmitting.
  - Basis of the classic Ethernet LA.

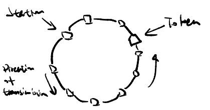
4.2.3 Collision-Free protocols.

- Bit-map protocol: - Basic bit-map method. - Reservation protocols.
- Token passing: Token bus.
- Binary countdown: As soon as a station sees that a high-order bit position that is 0 in its address has been overwritten with a 1, it give up.

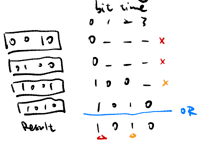
4.2.3.1. A Bit-Map Protocol



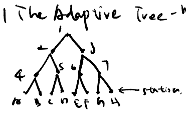
4.2.3.2. Token Passing



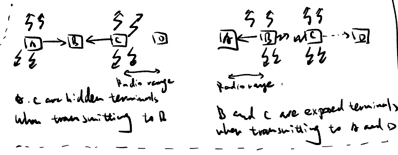
4.2.3.3 Binary Countdown

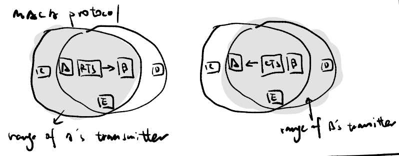


4.2.4.1 The Adaptive Tree-Walk Protocol



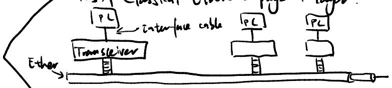
4.2.5 Wireless LAN Protocols

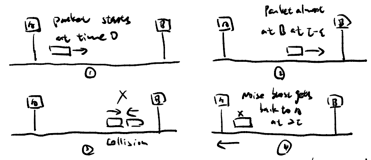




4.3 Ethernet

4.3.1 Classical Ethernet Physical layer.





∴ A give up, wait later resend.

4.3.2 Classical Ethernet MAC Sublayer Protocol.

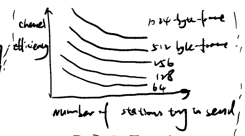
Ethernet (DIX) Frame formats

Byte	8	6	6	2	0-1500	0-46	4
	Preamble	Destination address	Source address	Type	Data	Pad	Checksum

IEEE 802.3

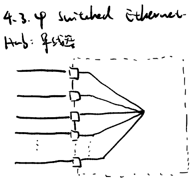
Preamble	SOF	Destination address	Source address	Length	Data	Pad	Checksum

4.3.3 Ethernet Performance.

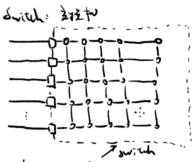


4.3.4 Switched Ethernet

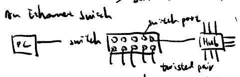
Hub: 集线器



Switch: 交换机



An Ethernet switch



Hub: all stations are in the same collision domain. They must use the CSMA/CD Algorithm to schedule their transmissions.

Switch: each port is its own independent collision domain. Collisions are now impossible, and CSMA/CD is not needed.
When a switch port receives an Ethernet frame from a station, the switch checks the Ethernet addresses to see which port the frame is destined for. The switch then forwards the frame over its high-speed backplane to the destination port.

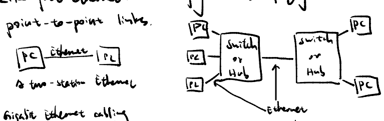
4.3.5 Fast Ethernet.

Name	Cable	Max. segment	Advantages
100 Base-T4	Twisted pair	100m	Uses category 3 UTP
100 Base-Tx	Twisted pair	100m	Full duplex at 100Mbps (Cat 5 UTP)
100 Base-FX	Fiber optics	2000m	Full duplex at 100Mbps; long runs

The basic idea behind fast Ethernet was simple: keep all the old frame formats, interfaces, and procedural rules, but reduce the bit time from 100 nsec to 10nsec.

4.3.6 Gigabit Ethernet

Like fast ethernet, all configurations of gigabit Ethernet use point-to-point links.



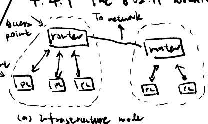
Gigabit Ethernet cabling

Name	Cable	Max. segment	Advantages
1000 Base-SX	Fiber optics	550m	Multimode fiber (50, 62.5 microns)
1000 Base-LX	Fiber optics	5000m	Single (10μ) or multimode (50, 62.5μ)
1000 Base-CX	2 Pairs of STP	25m	Shielded twisted pair
1000 Base-T	4 Pairs of UTP	100m	Standard category 5 UTP

4.3.7 10-Gigabit Ethernet.

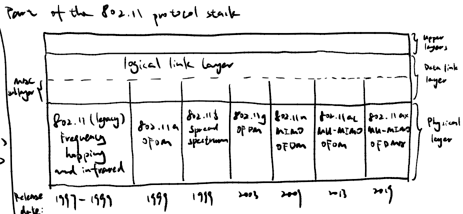
Name	Cable	Max. segment	Advantages
10GBase-SR	Fiber optics	Up to 300m	Multimode fiber (0.85μ)
10GBase-LR	Fiber optics	10km	Single-mode fiber (1.3μ)
10GBase-ER	Fiber optics	40km	Single-mode fiber (1.5μ)
10GBase-CX4	4 Pairs of twinax	15m	Twinaxial copper
10GBase-T	4 Pairs of UTP	100m	Category 6a UTP

4.4.1 The 802.11 Architecture and Protocol Stack.

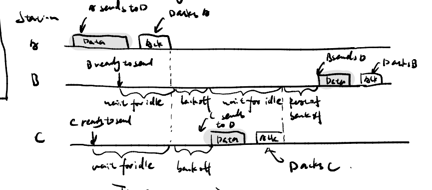


In infrastructure mode, each client is associated with an AP (access Point) that is in turn connected to the other network. The client sends and receives its packets via the AP. Several access points may be connected together, typically by a wired network called a distribution system.

Part of the 802.11 protocol stack

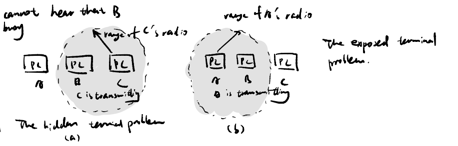


4.4.3 The 802.11 MAC Sublayer Protocol

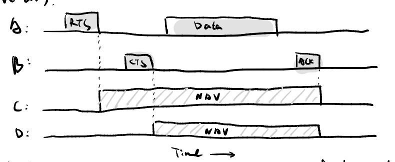


A wants to send B but cannot hear that B is busy

B wants to send to C but mistakenly thinks the transmission will fail



Solution①: With virtual sensing, each station keeps a logical record of when the channel is in use by tracking the NAV (Network Allocation Vector).

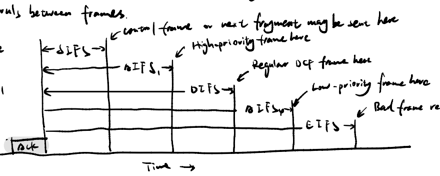


Virtual channel sensing using CSMA/CA.

However, while RTS/CTS sounds good in theory, it is one of those designs that has proved to be of little value in practice.

True solution: 802.11e. It works by extending CSMA/CA with carefully defined intervals between frames.

Interframe spacing in 802.11



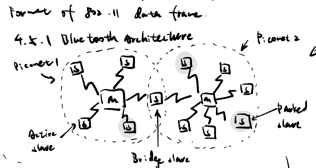
4.4.4 The 802.11 Frame Structure.

Bytes	2	2	6	6	6	2	0-2312	4
	Frame control	Duration	Address 1 recipient	Address 2 transmitter	Address 3	Sequence	Data	Check sequence

Bits	Version =00	Type =10	Subtype =0000	To DS	From DS	More frag.	Retry	Pwr. mgt.	More data	Protected	Order
	2	2	4	1	1	1	1	1	1	1	1

Format of 802.11 data frame.

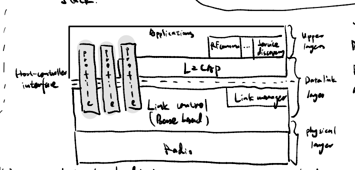
4.5.1 Bluetooth Architecture



Two piconets can be connected to form a scatternet.

The basic unit of a Bluetooth systems is a piconet, which consists of a controller node and up to seven active worker nodes within a distance of 10 meters. An interconnected collection of piconets is called a scatternet.

4.5.3 The Bluetooth Protocol Stack.



The Bluetooth protocol architecture

The link control (or base band) layer includes elements of the physical layer. It deals with how the controller controls time slots and how these slots are grouped into frames.

The link manager handles the establishment of logical channels between devices, including power management, pairing and encryption, and provides reliability if needed.

L2CAP (Logical Link Control Adaptation Protocol) frames variable-length messages and provides reliability if needed.

4.5.6 The Bluetooth frame structure

Bits	72	54	0-2744
	Access code	Header	Data (at 1X rate)

3	4	1	1	1	8	
Addr	Type	F	A	S	CRC	Repeated 3 times

72	54	16	0-8184	2
Access code	Header	Guard/Sync	Data (at 2X or 3X rate)	Trailer

(a) Basic rate data frame, top (b) Enhanced rate data frame, bottom.

It begins with an access code that usually identifies the controller so that workers within radio range of two controllers can tell which traffic is for them. Next comes a 54-bit header containing typical MAC sublayer fields. If the frame is sent at the basic rate, the data field comes next.

4.5.7 Bluetooth 5: Support for Internet of things device; Speed increased from 1Mbps to 2 Mbps; Message size has gone up from 31 bytes to 255 bytes; Range indoors has gone up from 10m to 40m; Power requirements have been reduced slightly. Slightly better security.

4.6 DOCSIS (Data over Cable Service Interface Specifications)

4.6.1 Overview

- MAC sublayer performs channel allocation, configuration of quality of service, unique forwarding model.
- Uses a standard MAC frame format.

4.6.2 Ranging

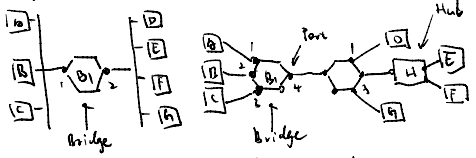
- Cable modem transmits a ranging request
- CMTS (headend) determines the network delay to the cable modem and performs necessary power adjustment

4.6.3 Channel bandwidth allocation

- Service flows
- Request-grant process and low-latency DOCSIS

4.7 Data link Layer Switching

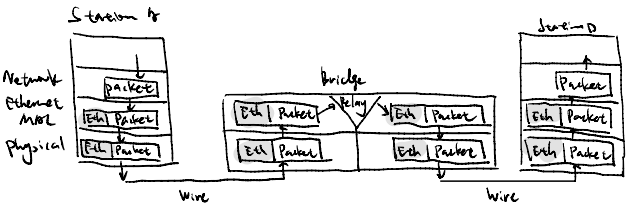
4.7.2 Learning Bridge



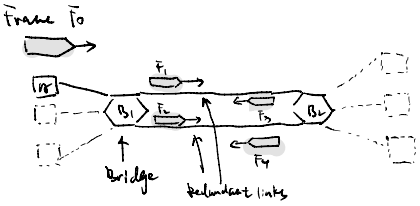
Bridge connecting two multidrop LANs

Bridges (and a hub) connecting seven point-to-point stations

Protocol processing at a bridge:



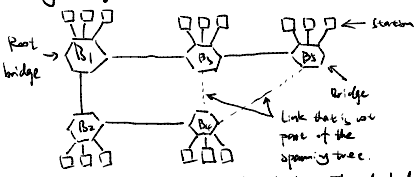
4.7.3 Spanning-Tree Bridges



Bridge with two parallel links.

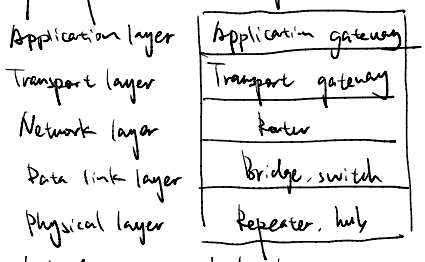
Problem: B2 does not know that they are copies of the same frame, rather than two different frames sent one after the other.

Solution: For the bridges to communicate with each other and overlay the actual topology with a spanning tree that reaches every bridge:

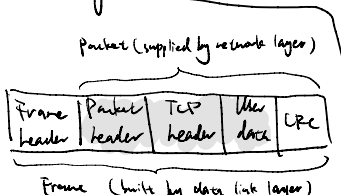


A spanning tree connecting five bridges. The dashed lines are links that are not part of the spanning tree.

4.7.4 Repeaters, Hubs, Bridges, Switches, Routers, Gateways

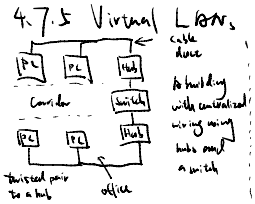


Which device is in which layer.

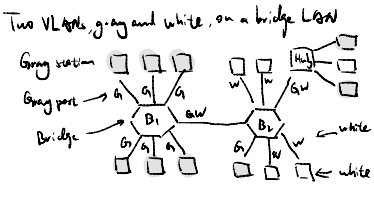


Frame, packets and headers.

4.7.5 Virtual LANs

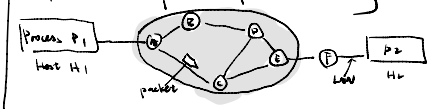


Two VLANs, gray and white, on a bridge LAN



Chp 5.1 Network Layer Design Issues

5.1.1 Store-and-forward packet switching

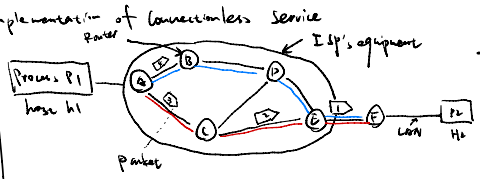


- A host with a packet to send transmits it to the nearest router; The packet is stored there until it has fully arrived, and the link has finished its processing by verifying the checksum; Then it is forwarded to the next router along the path until it reaches the destination host, where it is delivered. This mechanism is store-and-forward packet switching

5.1.2 Services Provided to the Transport Layer

- Services independent of router technology
- Transport layer shielded from number, type, topology of routers.
- Network addresses available to transport layer use uniform numbering plans – even across LANs and WANs

5.1.3 Implementation of Connectionless Service



Routing within a datagram network

A's table (initially)

A	-
B	B
C	C
D	B
E	C
F	C

Dest. Line

A's table (later)

A	-
B	B
C	C
D	B
E	C
F	B

C's table

A	B
B	B
C	-
D	E
E	E
F	E

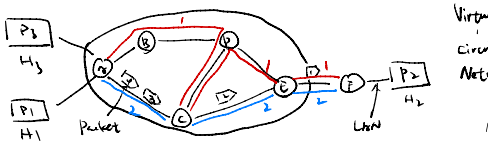
E's table

A	C
B	D
C	C
D	D
E	-
F	F

A decide to send packet 4 via a different route than of the first three packets. Perhaps it has learned of a traffic jam somewhere along the A-E path and updated its routing table.

- Note that a sink

5.1.4 Implementation of Connection-Oriented Service



A's table

In	Out
H1	1
H3	1

C's table

In	Out
1	1
2	2

E's table

In	Out
1	1
2	2

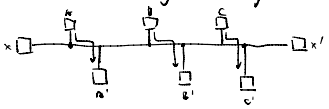
5.1.5 Comparison of Virtual-Circuit and Datagram Networks

Issue	Datagram network	Virtual-circuit network
Circuit setup	Not needed	Required
Addressing	Each packet contains the full source and destination address	Each packet contains a short VC number
State information	Routers do not hold state information about connections	Each VC requires router table space per connection
Routing	Each packet is routed independently	Route chosen when VC is set up; all packets follow it
Effect of router failure	None, except for packets lost during the crash	All VCs that passed through the failed router are terminated
Quality of service	Difficult	Easy if enough resources can be allocated in advance for each VC
Congestion control	Difficult	Easy if enough resources can be allocated in advance for each VC

5.2 Routing Algorithms in a Single Network

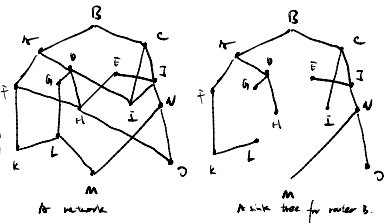
Optimality principle; shortest path algorithm; Distance vector routing; Link state routing; Optimality principle; Shortest path algorithm; Distance vector routing; Link state routing.

- The routing algorithm is that part of the network layer software responsible for deciding which output line an incoming packet should be transmitted on.
- Properties are desirable in a routing algorithm: correctness, simplicity, robustness, stability, fairness, and efficiency
- Nonadaptive algorithms do not base their routing decisions on any measurements or estimates of the current topology and traffic. Known as Static Routing.
- Adaptive algorithms, in contrast, change their routing decisions to reflect changes in the topology, and sometimes changes in the traffic as well. Known as Dynamic Routing.



Network with a conflict between fairness and efficiency.

5.2.1 The Optimality Principle



- One can make a general statement about optimality principle
- As a direct consequence of the optimality, the optimality principle, the set of optimal routes from all sources to a given destination form a tree rooted at the destination. Such a tree is called a sink tree