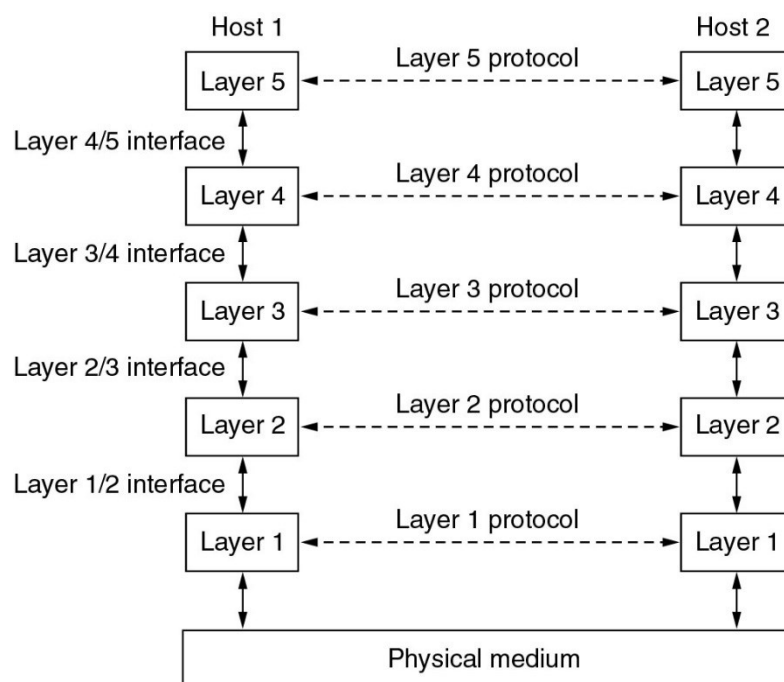# Review Outline on Computer Networks

——Translation ＆ Demonstration

Part 1 Introduction

1. Protocol Hierarchies 协议层次体系

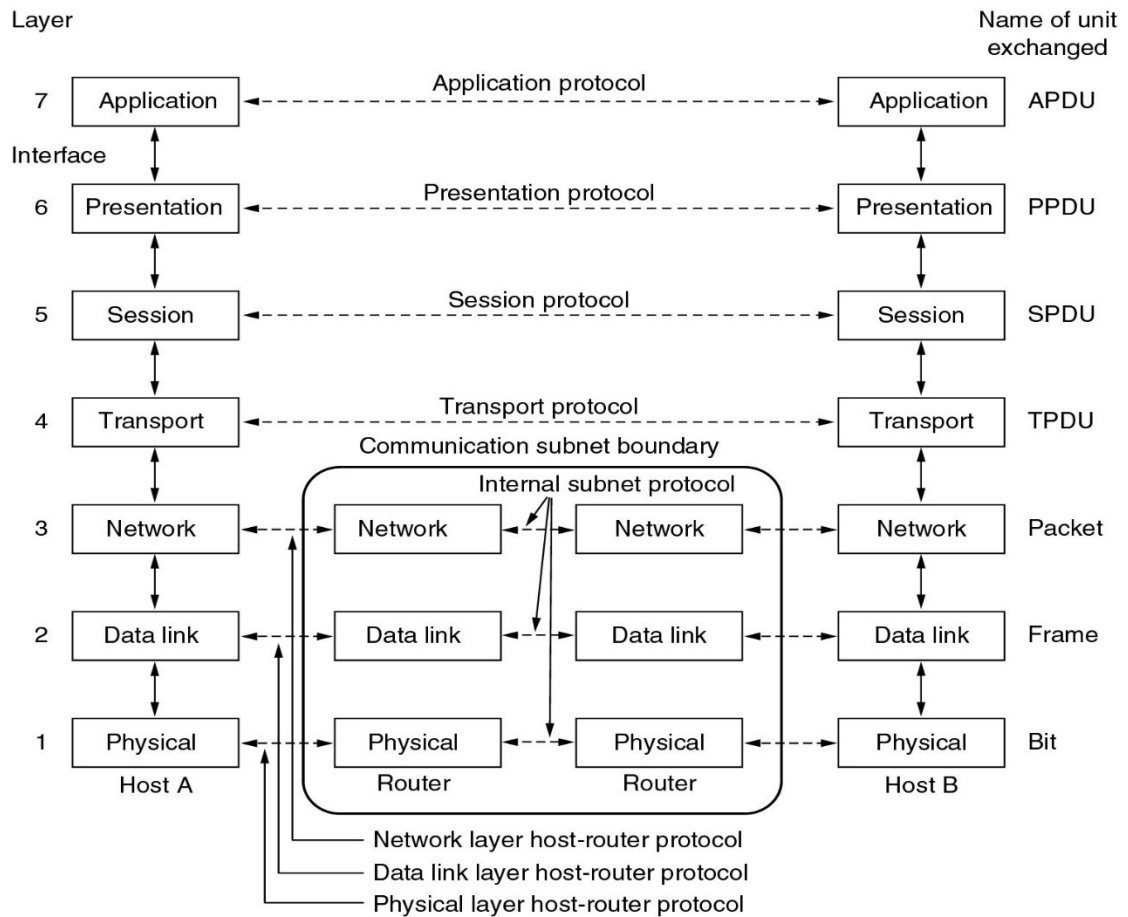   Layers, protocols, and interfaces. 层次、协议、接口

2. The OSI reference model.
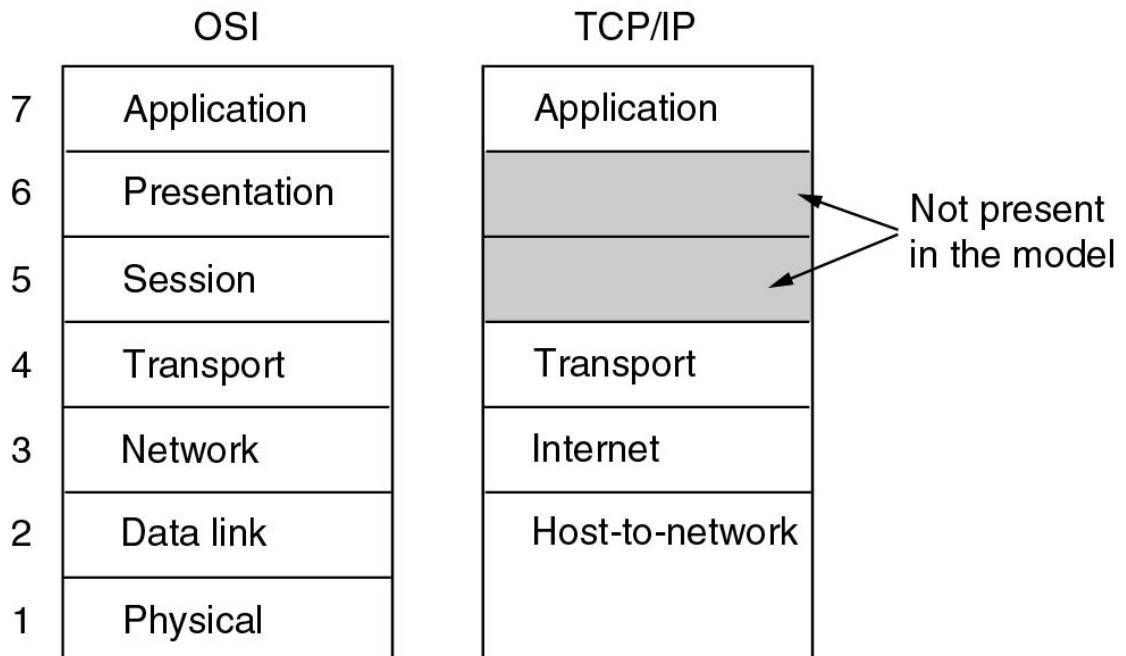
    Layer：（从上到下）应用层、表示层、会话层、传输层、网络层、数据链路层、物理层

    Name of unit exchanged：（从上到下）应用协议数据单元、表示协议数据单元、会话协议数据单元、传输协议数据单元、分组（包）、帧、比特位

    Protocol：（从上到下）应用层协议、表示层协议、网络层协议、会话层协议、传输层协议、总表述：传输子网边界、内部子网协议、分表述：网络层主机路由协议、数据链路层主机路由协议、物理层主机路由协议
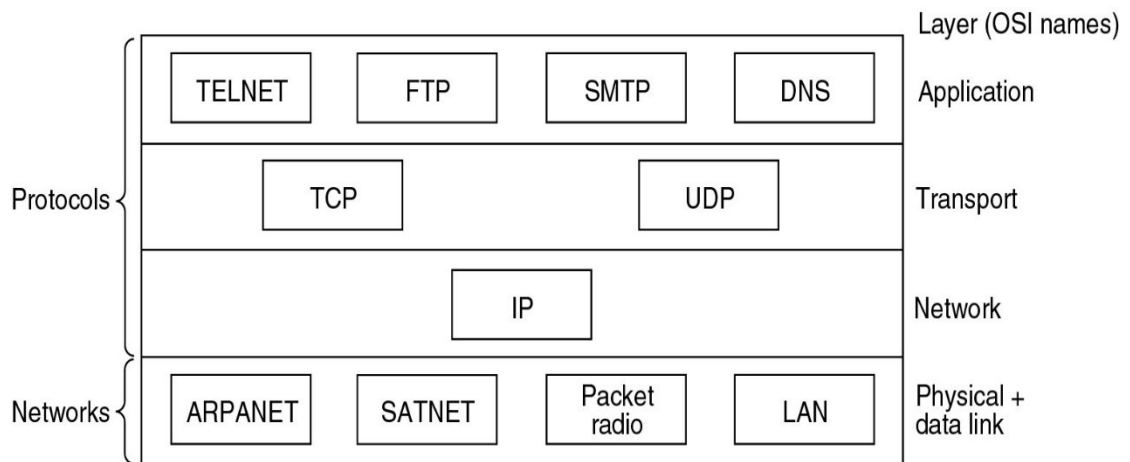
Layer ... Name of unit exchanged

7 Application — Application protocol — Application — APDU
Interface
6 Presentation — Presentation protocol — Presentation — PPDU
5 Session — Session protocol — Session — SPDU
4 Transport — Transport protocol — Transport — TPDU
Communication subnet boundary
Internal subnet protocol
3 Network — Network — Network — Network — Packet
2 Data link — Data link — Data link — Data link — Frame
1 Physical — Physical — Physical — Physical — Bit
Host A — Router — Router — Host B

Network layer host-router protocol
Data link layer host-router protocol
Physical layer host-router protocol

3. The TCP/IP Reference Model

OSI   TCP/IP

7 Application   Application
6 Presentation
5 Session   Not present
                                         in the model
4 Transport   Transport
3 Network   Internet
2 Data link   Host-to-network
1 Physical

TCP/IP 协议的描述是：应用层、传输层、网络层、链路层（图中的最后两层在第五版中被更正为，物理层未展示、数据链路层对应为链路层即 link 层）

4. TCP/IP Protocols（传统协议中即记忆简拼，故不再分开阐述）

			Layer (OSI names)
TELNET	FTP	SMTP	DNS	Application

(Protocols) TELNET | FTP | SMTP | DNS — Application

TCP | UDP — Transport

IP — Network

ARPANET | SATNET | Packet radio | LAN — Physical + data link

(Networks)

Part 2 Sliding Window & Retransmission Strategy

1. Sliding Window 滑动窗口（协议）
   a) A One-Bit Sliding Window Protocol 一位滑动窗口协议
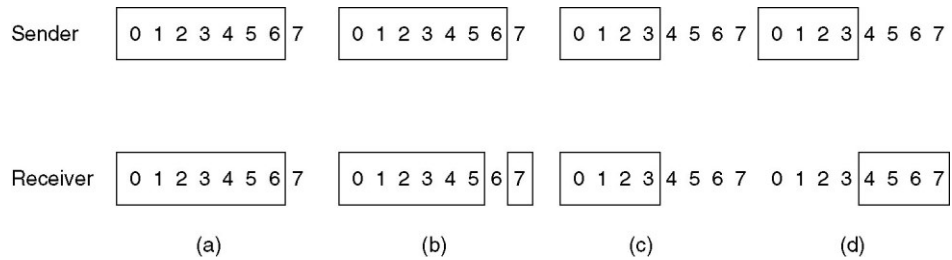   b) A Protocol Using Go Back N 回退 N 协议【发送端多窗口，接收端单/多窗口，timer 控制】
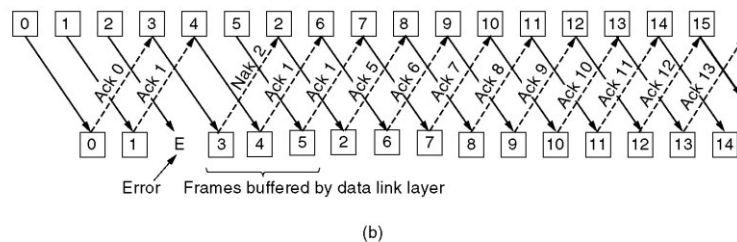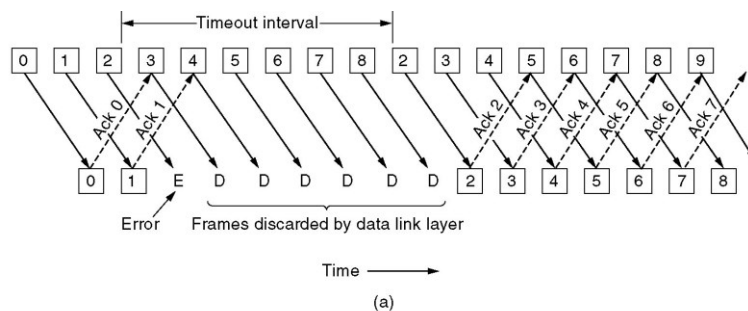
Pipelining and error recovery. Effect on an error when
(a) Receiver's window size is 1.
(b) Receiver's window size is large.

   c) A Protocol Using Selective Repeat 选择重传协议【发送端接收端均为多窗口，仅坏帧重传，window size 不超过一半】

Sender 0 1 2 3 4 5 6 7   0 1 2 3 4 5 6 7   0 1 2 3 4 5 6 7   0 1 2 3 4 5 6 7

Receiver 0 1 2 3 4 5 6 7   0 1 2 3 4 5 6 7   0 1 2 3 4 5 6 7   0 1 2 3 4 5 6 7

(a)   (b)   (c)   (d)

(a) Initial situation with a window size seven.

(b) After seven frames sent and received, but not acknowledged.

(c) Initial situation with a window size of four.

(d) After four frames sent and received, but not acknowledged.

- d) 词汇们
    - i. stop-and-wait 停等协议
    - ii. RRT round-trip time 往返时间
    - iii. bandwidth-delay product 带宽延迟积
    - iv. piggybacked acknowledgement 捎带确认
    - v. pipelining 流水线
    - vi. utilization 利用率
2. TCP 重传（见 TCP 章节）

Part 3 MAC & Wireless

1. MAC（介质访问控制）
    - a) Multiple Access Protocols（多访问协议）
        - i. ALOHA(pure/slotted)【纯 ALOHA 和时槽 ALOHA】
        - ii. CSMA (Carrier Sense Multiple Access Protocols)【载波侦听多路访问】
            1) 1-persistent CSMA
            2) non-persistent CSMA
            3) p-persistent CSMA
            4) CSMA/CD (Carrier Sense Multiple Access Protocols with Collision Detection)【带冲突检测的 CSMA】
               先听后发，边发边听，冲突停发，随机延迟后重发
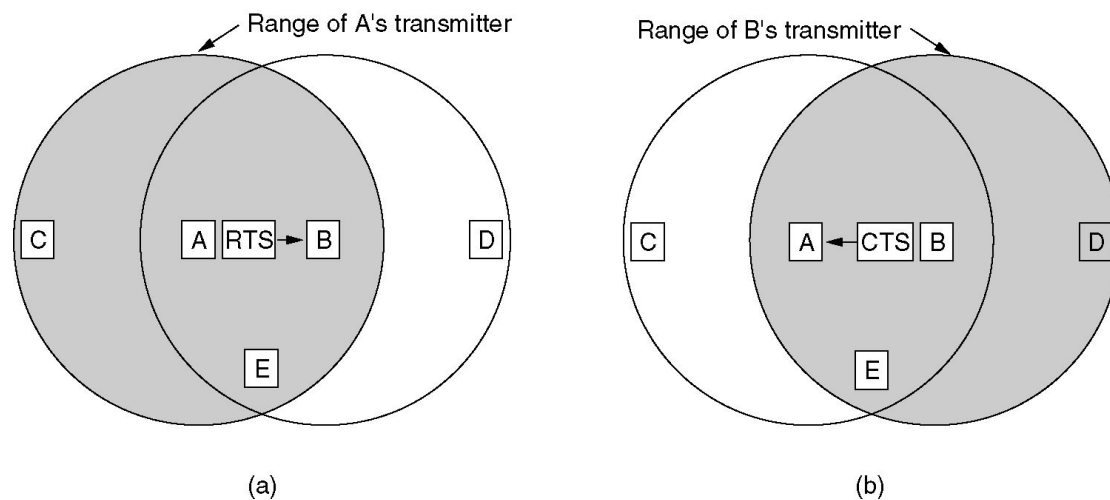   - iii. Collision-Free Protocol
    - b) 词汇们
        - i. contention system 竞争系统
        - ii. checksum 校验和
        - iii. collisions 冲突
        - iv. throughput 吞吐量
        - v. slot 时槽
        - vi. propagation delay 传输延时
        - vii. simultaneously 同时地
        - viii. idle 空闲的
        - ix. scenario 情形，方案
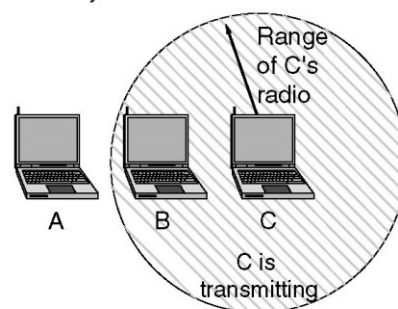   - x. token 令牌

2. Wireless
   a) RTS & CTS

Range of A's transmitter

Range of B's transmitter

(a)   (b)

The MACA protocol.   (a) A sending an RTS to B.   (b) B responding with a CTS to A.

Frame:
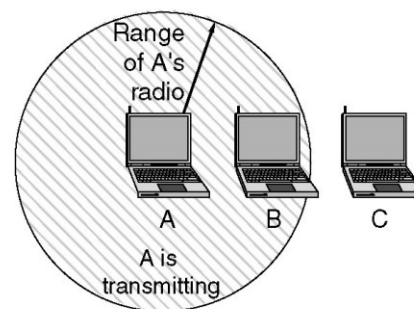   i. RTS (Request To Send) 【请求发送】
   ii. CTS (Clear To Send) 【允许发送】
   b) Problem

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

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

(a)   (b)

(a) The hidden station problem.   (b) The exposed station problem.

   i. Hidden Terminal Problem 【隐藏站问题】
   ii. Exposed Terminal Problem 【暴露站问题】
   c) Protocol
   i. MACA (Multiple Access With Collision Avoidance) 【避免冲突的多路访问】
   ii. MACAW(Multiple Access With Collision Avoidance for Wireless) 【无线的 MACA】
   iii. Explanation（Wikipedia 的解释）

   Multiple Access with Collision Avoidance (MACA) is a slotted media access control protocol used in wireless LAN data transmission to avoid collisions caused by the hidden station problem and to simplify exposed station problem.

   The basic idea of MACA is a wireless network node makes an announcement before it sends the data frame to inform other nodes to keep silent. When a node wants to transmit, it sends a signal called Request-To-Send (RTS) with the length of

the data frame to send. If the receiver allows the transmission, it replies the sender a signal called Clear-To-Send (CTS) with the length of the frame that is about to receive.

Meanwhile, a node that hears RTS should remain silent to avoid conflict with CTS; a node that hears CTS should keep silent until the data transmission is complete.

WLAN data transmission collisions may still occur, and the MACA for Wireless (MACAW) is introduced to extend the function of MACA. It requires nodes sending acknowledgements after each successful frame transmission, as well as the additional function of Carrier sense.

   d) 词汇们
      i. CSMA/CA 带冲突避免的 CSMA
      ii. exponential backoff 二进制指数回退
      iii. DCF 分散式协同功能
      iv. PCF 点式协同功能
      v. NAV 网络分配向量
      vi. SIFS 短帧间间隔
      vii. DIFS DCF 帧间间隔
      viii. EIFS 扩展帧间间隔

Part 4 Router & IP Protocol

1. Router Protocol
   a) Basis
      i. DVR (Distance Vector Routing) 【距离矢量路由】
         1) 即 Bellman-Ford 最短路径算法
         2) 用于 RIP 等
         3) 产生 count-to-infinity problem 【无穷计数问题】
      ii. LSR (Link State Routing) 【链路状态路由】
         1) 步骤：
            a) Discover its neighbors, learn their network address.
            b) Measure the delay or cost to each of its neighbors.
            c) Construct a packet telling all it has just learned.
            d) Send this packet to all other routers.
            e) Compute the shortest path to every other router.
         2) 衍生 IS-IS OSPF 等
   b) BGP (Border Gateway Routing Protocol) 【边界网关协议】
      i. 避免了无穷计数问题
      ii. 属于 interdomain protocol 【域间协议】
      iii. 实质 DVR
   c) 词汇们
      i. Autonomous System (AS) 自治系统
      ii. time-to-live (TTL) 生存时间值
      iii. routing-protocol convergence 路由协议收敛
      iv. congestion control 拥塞控制

     v.   congestion collapse 拥挤崩塌

    vi.   traffic-aware routing 流量感知路由

   vii.   admission control 接入控制

  viii.   leaky bucket 漏桶（算法）

    ix.   token bucket 令牌桶（算法）

     x.   traffic throttling 交通节流

    xi.   load shedding 削减负荷

   xii.   RED (Random Early Detection) 随机早期检测算法

  xiii.   RSVP (Resource reSerVation Protocol) 资源预留协议

  xiv.   QoS (Quality of Service) 服务质量

   xv.   differentiated services 差异化服务

  xvi.   Path MTU (Maximum Transmission Unit) 路径最大传输单元

  xvii.   Packet Fragmentation 数据包拆分

 xviii.   jitter control 抖动控制

2. IP Protocol

   a)   IPv4

The IPv4 (Internet Protocol) header.

   b)   IP Addresses

IP address formats.

   c)   CIDR (Classless Interdomain Routing) 【无类别域间路由】

University	First address	Last address	How many	Written as
Cambridge	194.24.0.0	194.24.7.255	2048	194.24.0.0/21
Edinburgh	194.24.8.0	194.24.11.255	1024	194.24.8.0/22
(Available)	194.24.12.0	194.24.15.255	1024	194.24.12/22
Oxford	194.24.16.0	194.24.31.255	4096	194.24.16.0/20

   i. 指定任意长度的前缀的可变长子网掩码技术

   ii. 表示：遵从 CIDR 规则的地址有一个后缀说明前缀的位数，例如 192.168.0.0/16

   iii. 实现前缀路由聚合

  d) ARP & DHCP

   i. ARP（Address Resolution Protocol）【地址解析协议】，其基本功能为通过目标设备的 IP 地址，查询目标设备的 MAC 地址，以保证通信的顺利进行
另外在每台安装有 TCP/IP 协议的电脑或路由器里都有一个 ARP 缓存表，表里的 IP 地址与 MAC 地址是一对应的

   ii. DHCP（Dynamic Host Configuration Protocol）【动态主机设置协议】是一个局域网的网络协议，使用 UDP 协议工作，主要有两个用途：

    1) 给内部网络或网络服务供应商自动分配 IP 地址给用户

    2) 给内部网络管理员作为对所有计算机作中央管理的手段

  e) 词汇们

   i. IHL (Internet Header Length) 报头长度

   ii. fragment offset 分段偏移

   iii. prefix 前缀

   iv. dotted decimal notation 加点十进制表示

   v. subnet mask 子网掩码

   vi. classful addressing 分级寻址

   vii. NAT (Network Address Translation) 网络地址转换

   viii. source port 源端口

   ix. destination port 目标端口

   x. FTP (File Transfer Protocol) 文件传输协议

   xi. ICMP (Internet Control Message Protocol) 控制报文协议

   xii. leasing 延期（DHCP 中）

   xiii. intradomain routing 域内路由选择

   xiv. interior/exterior gateway protocol 内部/外部网关协议

Part 5 TCP

1. TCP Service Model

 a) port

Port	Protocol	Use
21	FTP	File transfer
23	Telnet	Remote login
25	SMTP	E-mail
69	TFTP	Trivial File Transfer Protocol
79	Finger	Lookup info about a user
80	HTTP	World Wide Web
110	POP-3	Remote e-mail access
119	NNTP	USENET news

    b)   segment

        i.   fixed 20-byte header

        ii.   MTU 1500 bytes

2.   TCP Segment Header

   a)   TCP Header
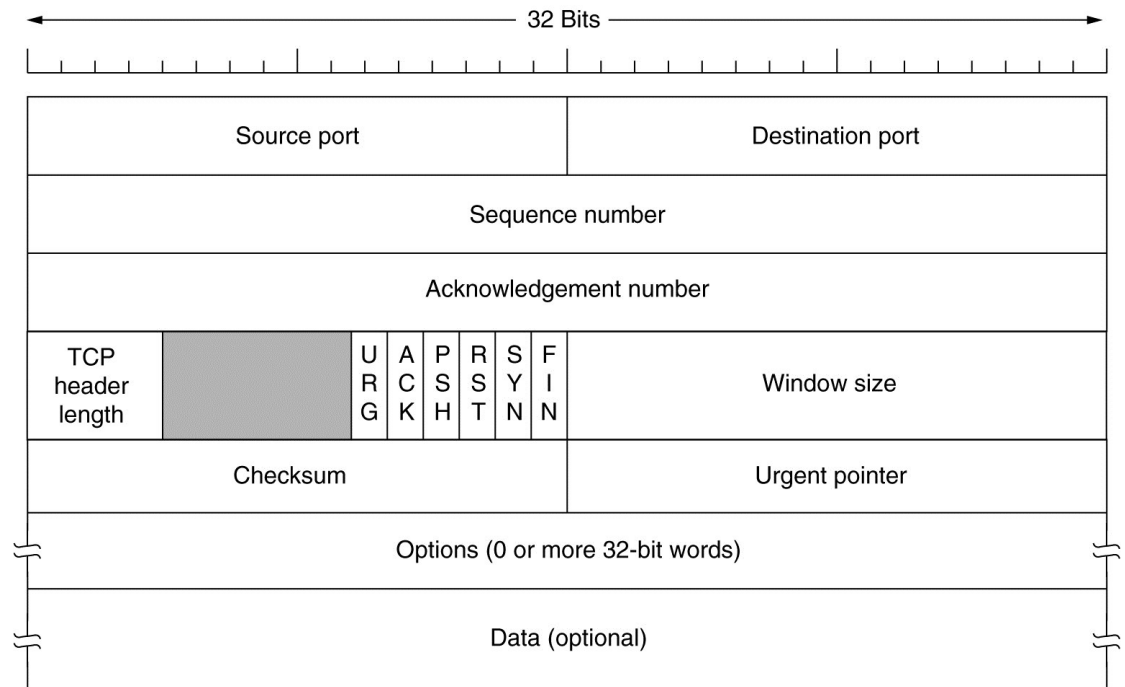
    b)   tips:

        i.   SEQ ACK 出现在 header 中 并为 32 位

        ii.   URG 表示 Urgent Pointer 字段有意义：

        iii.   ACK 表示 Acknowledgment Number 字段有意义

        iv.   PSH 表示 Push 功能，RST 表示复位 TCP 连接

        v.   SYN 表示 SYN 报文（在建立 TCP 连接的时候使用）

        vi.   FIN 表示没有数据需要发送了（在关闭 TCP 连接的时候使用）

        vii.   Window 表示接收缓冲区的空闲空间，16 位，用来告诉 TCP 连接对端自己能够接收的最大数据长度。

        viii.   Checksum 是校验和，16 位。

        ix.   Urgent Pointers 是紧急指针，16 位，只有 URG 标志位被设置时该字段才有意义，表示紧急数据相对序列号（Sequence Number 字段的值）的偏移。

3.   TCP Transmission Policy (Sliding Window)

        Window management in TCP.
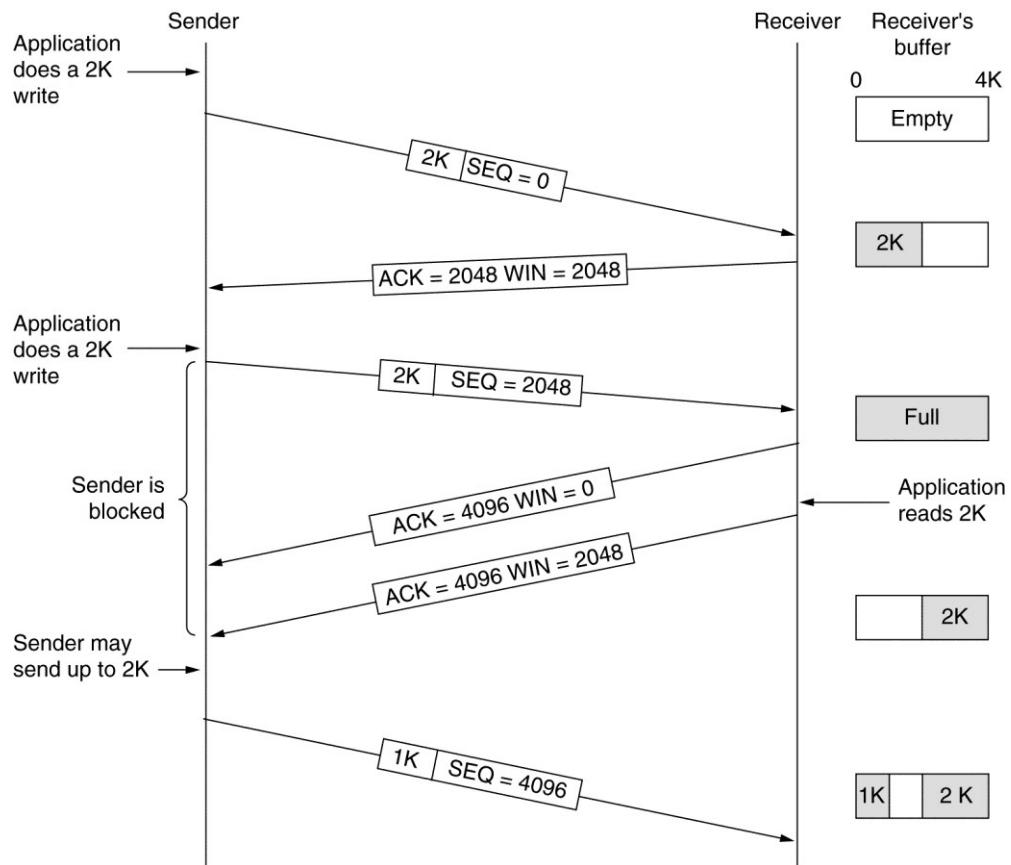
4. TCP Congestion Control
   a) slow start【慢启动】
      i. chart
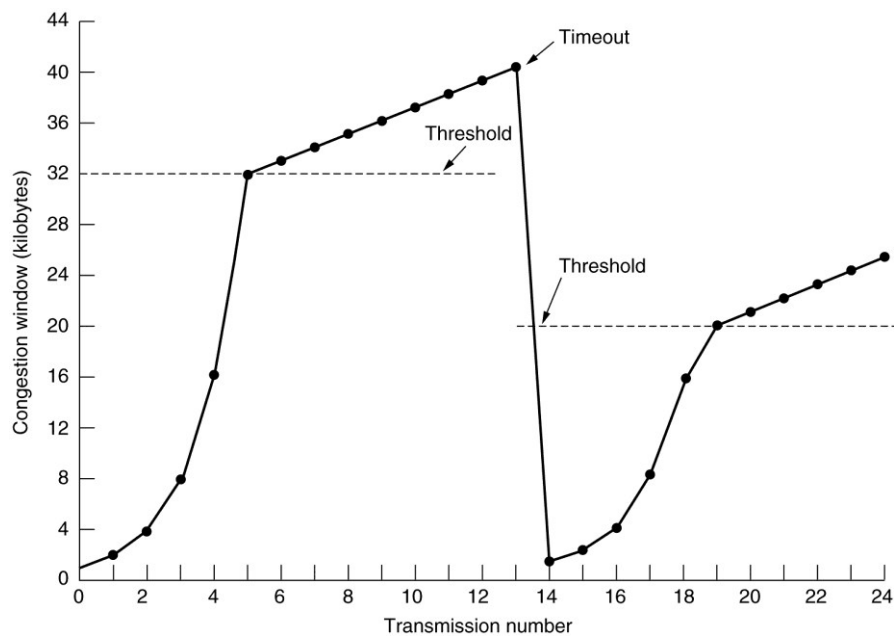
      ii. slow start threshold【慢启动阈值】
         1) 最大段长 1KB
         2) 初始拥塞窗口 64KB
         3) 指数增长至阈值开始慢启动

4) 遭遇丢包折半阈值，并回退到最小包 1KB

    b) fast recovery 【快速恢复】

        基于慢启动，但是丢包时回退到折半阈值处直接开始慢启动

5. 词汇们

    i. TPDU (Transport Protocol Data Unit) 传输协议数据单元

    ii. TSAP/NSAP (Transport/Network Service Access Point) 传输/网络服务访问点

    iii. three-way handshake 三次握手

    iv. end-host 主机

    v. ARQ (Automatic Repeat-request) 自动重传请求

    vi. well-known ports 周知端口（一般小于 1000）

    vii. MTU (Maximum Transmission Unit) 最大传输单元

    viii. cumulative acknowledgement 累积确认

    ix. MSS (Maximum Segment Size) 最大段长度

    x. window probe 窗口探查

    xi. delayed acknowledgement 延迟确认

    xii. RTO (Retransmission Timeout) 超时重传机制

    xiii. duplicate acknowledgement 重复应答

    xiv. sawtooth 锯齿

    xv. SACK (Selective Acknowledgment) 选择性确认