Chapter 1: roadmap

1.1 What *is* the Internet?

1.2 Network edge

- end systems, access networks, links

1.3 Network core

- circuit switching, packet switching, network structure

1.4 Delay, loss and throughput in packet-switched networks

1.5 Protocol layers, service models
協定層級及服務模型

1.6 Networks under attack: security

1.7 History

Protocol "Layers" 協定層級

Networks are "complex"!

網路非常複雜

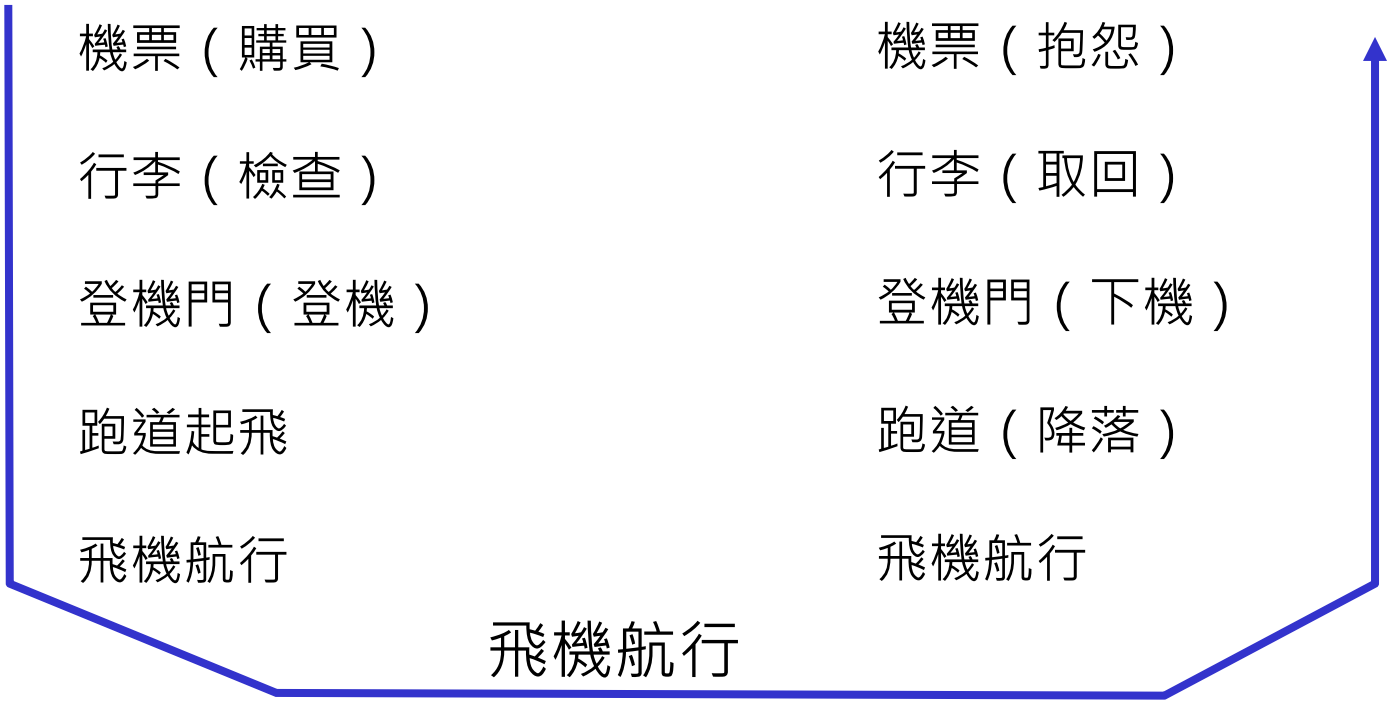
- many "pieces":
  - hosts
  - routers
  - links of various media
  - applications
  - protocols
  - hardware, software

Question:

Is there any hope of *organizing* structure of network?

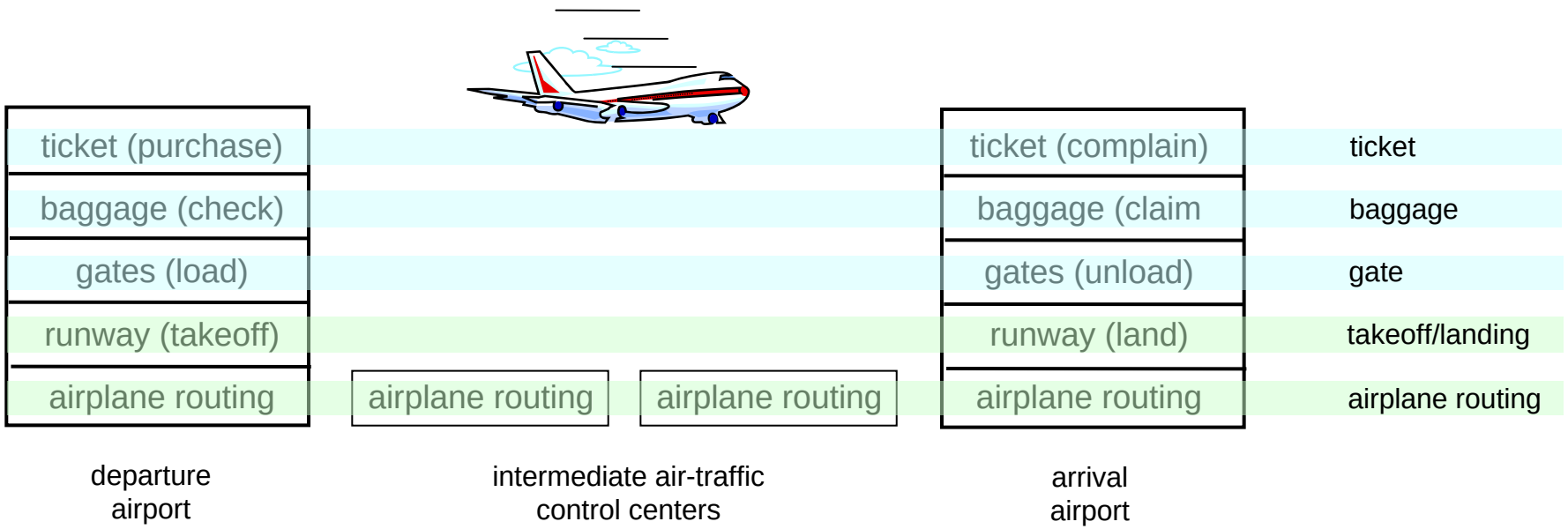
Or at least our discussion of networks?

Organization of air travel
航空公司系統



- a series of steps 一連串的步驟

Layering of airline functionality



Layers: each layer implements a service
每個層級提供一種服務

- via its own internal-layer actions
在該層內執行某些動作（例如登機、下機）
- relying on services provided by layer below
使用其正下方層級提供的服務

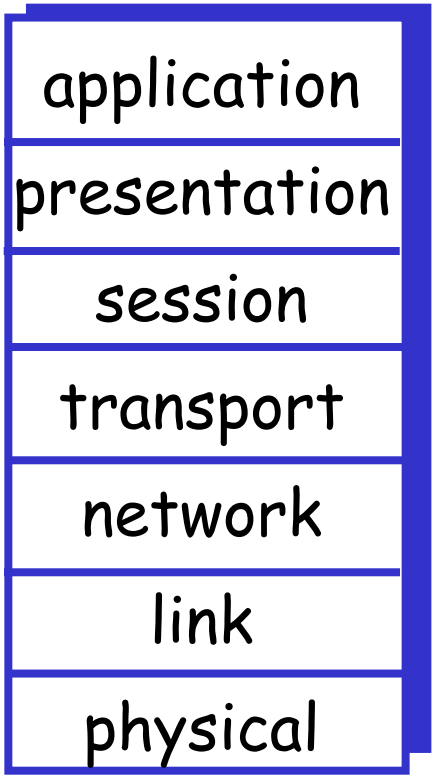
Why layering? 為什麼要分級？

Dealing with complex systems:

- explicit structure allows identification, relationship of complex system’ s pieces 簡化系統
  - layered reference model for discussion
- modularization eases maintenance, updating of system 易於維持及更新系統
  - change of implementation of layer’ s service transparent to rest of system 只需更動需要更動的層級
  - e.g., change in gate procedure doesn’ t affect rest of system
- layering considered harmful? 分級是否有壞處？
  - 考量不同，目的也不同

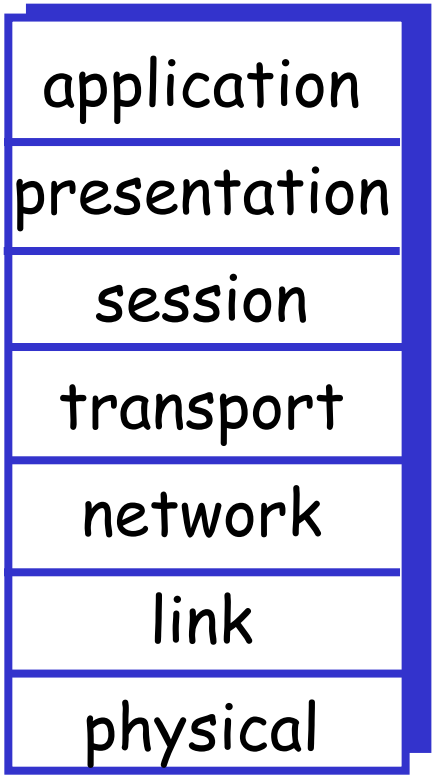
ISO/OSI reference model
ISO/OSI 參考模型

- ISO - International Organization for Standardization
- OSI - Open System Interconnection
- Application 應用層: supporting network applications
  - FTP, SMTP, HTTP
- Presentation展現層: allow applications to interpret meaning of data, e.g., encryption, compression, machine-specific conventions
- Session 會議層: synchronization, checkpointing, recovery of data exchange

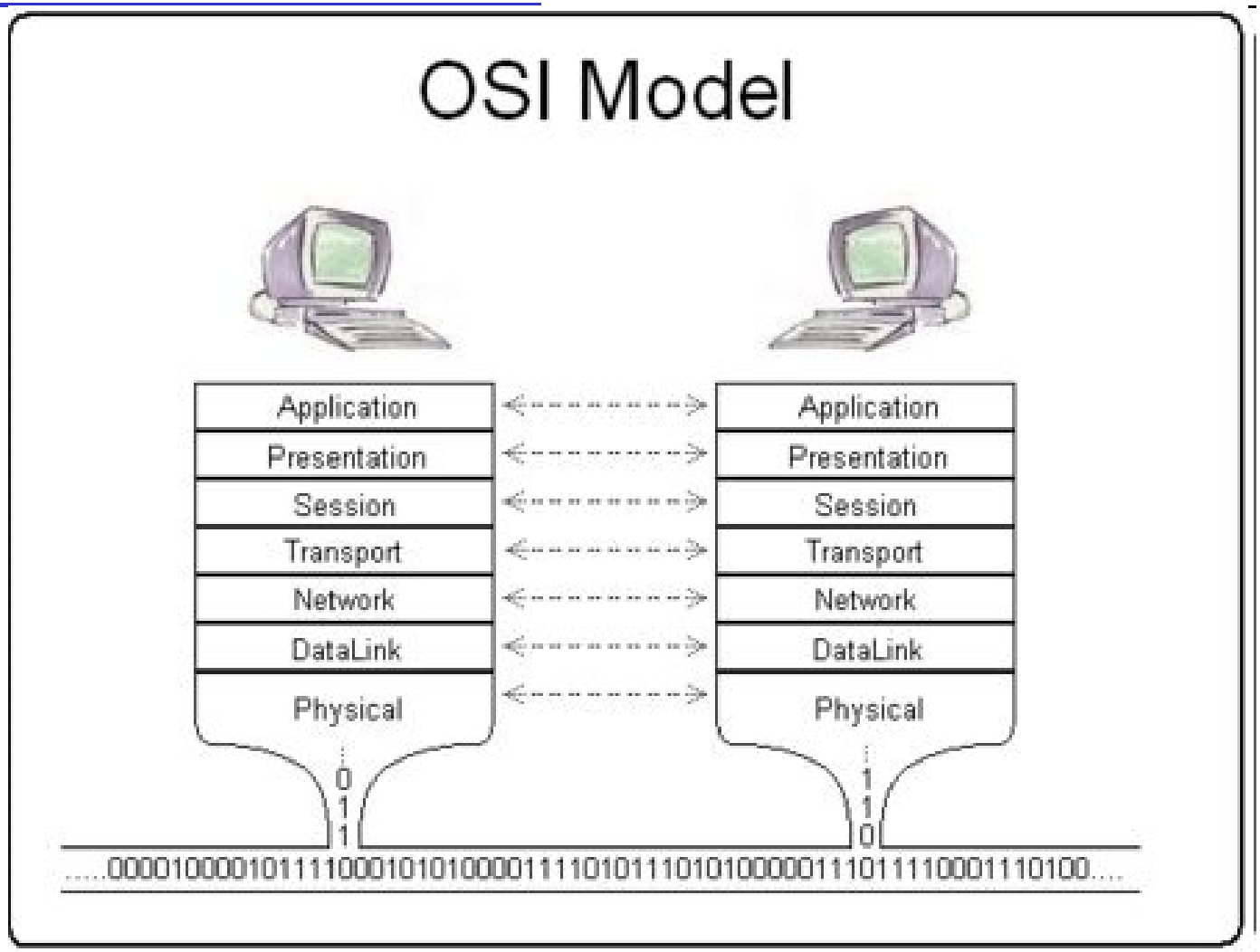


ISO/OSI reference model
ISO/OSI 參考模型

- Transport 傳輸層: process-process data transfer
  - TCP, UDP
- Network 網路層: routing of datagrams from source to destination
  - IP, routing protocols
- Link 鏈結層: data transfer between neighboring network elements
  - PPP, Ethernet
- Physical 實體層: bits "on the wire"

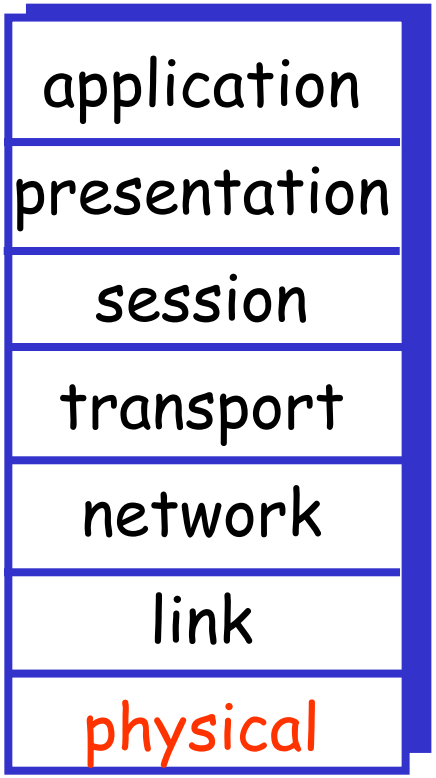


ISO/OSI reference model
ISO/OSI 參考模型



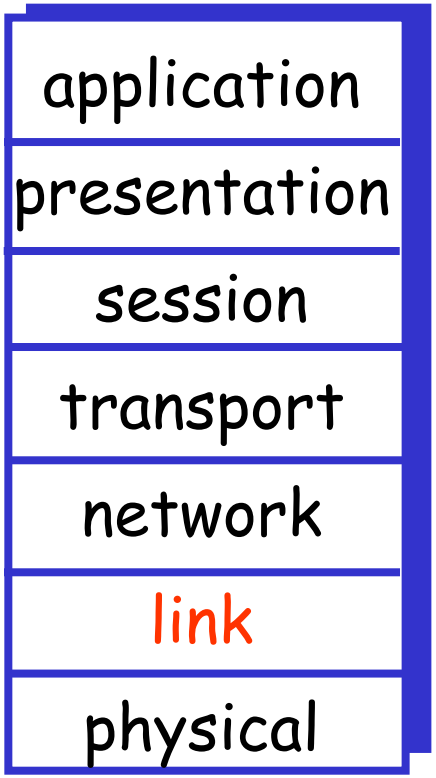
ISO/OSI reference model
Physical Layer 實體層

- Unit of transmission: bit
- Concerned with transmitting raw bits over a communication channel
  負責把一個bit正確傳輸
- Deal with
  - Mechanical
  - Electrical
  - Procedural interface
  - Physical transmission medium



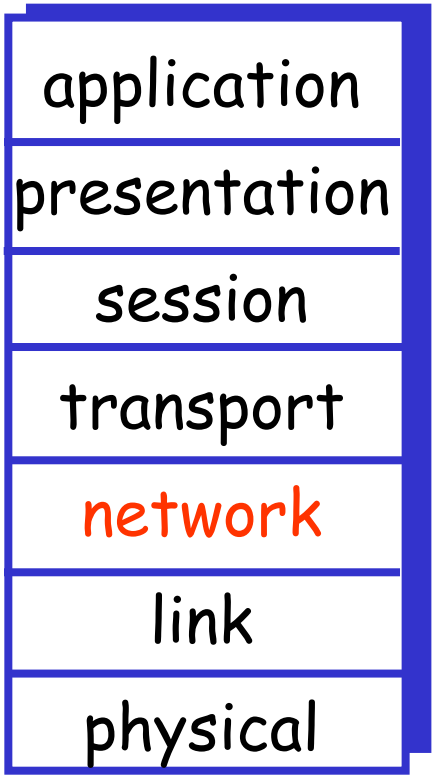
ISO/OSI reference model
(Data) Link Layer 連結層

- Unit of transmission: Frame
- data transfer between neighboring network elements
  在每個link上傳輸Frame(訊框)
- Deal with
  - Collision 蹤撞
  - Error Control 錯誤控制
  - Flow Control 流量控制
- Multiple Access Protocol
  - ALOHA
  - Slotted ALOHA
  - CSMA/CD (Ethernet)



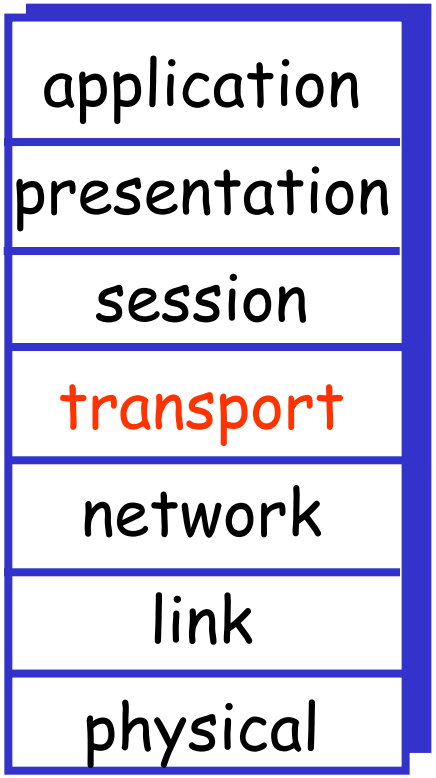
ISO/OSI reference model
Network Layer 網路層

- Unit of transmission: Packet
- Deal with:
  - Routing 尋找路徑
  - Congestion control 擁塞控制
  - Addressing 定址
- Routing protocol:
  - Distance vector
  - Link state



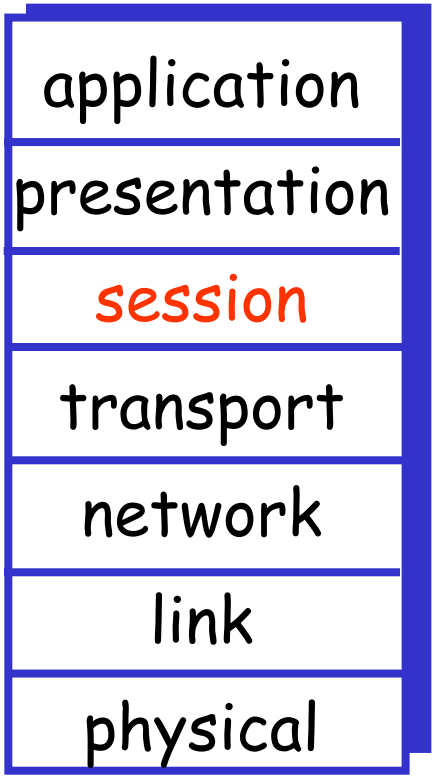
ISO/OSI reference model
Transport Layer 傳輸層

- Process-to-Process
- Deal with:
  - The type of service 決定服務型態
  - Flow control 流量控制
- Connection-oriented service
  連結導向服務
  - Handshaking first
  - Quality Guaranteed
- Connectionless service
  無連結服務
  - No handshaking
  - Best-effort



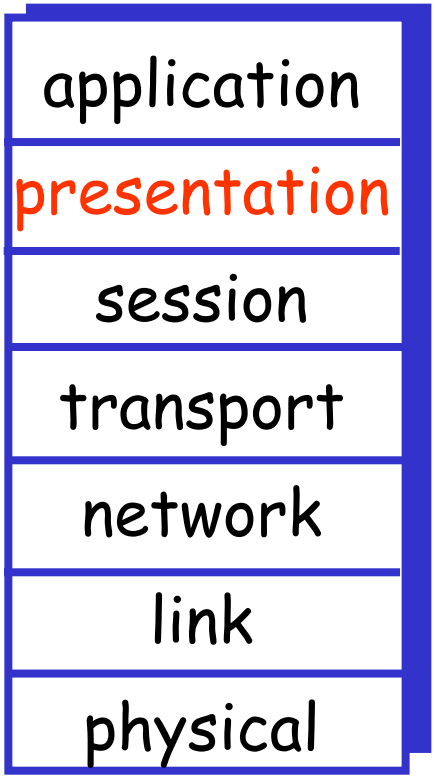
ISO/OSI reference model
Session Layer 會議層

- Session-to-session
- Deal with:
  - Manage dialogue control 決定誰可以傳資料
    - Traffic to go in both directions
    - Only one direction at a time
  - Token management
    - Who get the token
  - Synchronization 同步



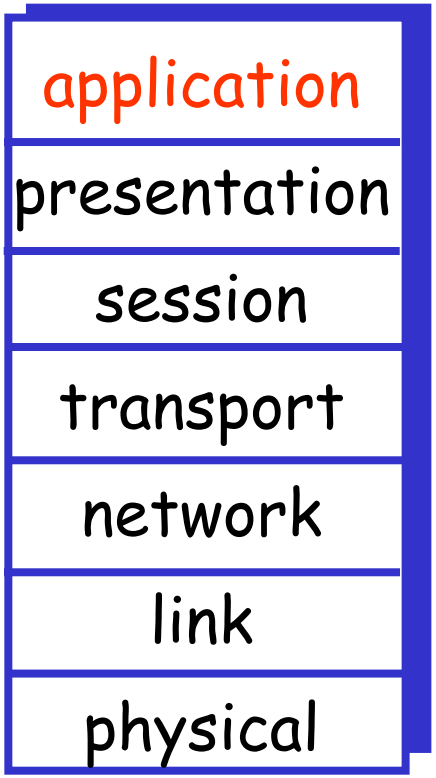
ISO/OSI reference model
Presentation Layer 表現層

- Encoding
  - From natural language to binary code
    將不同方式呈現的資料轉換成binary code



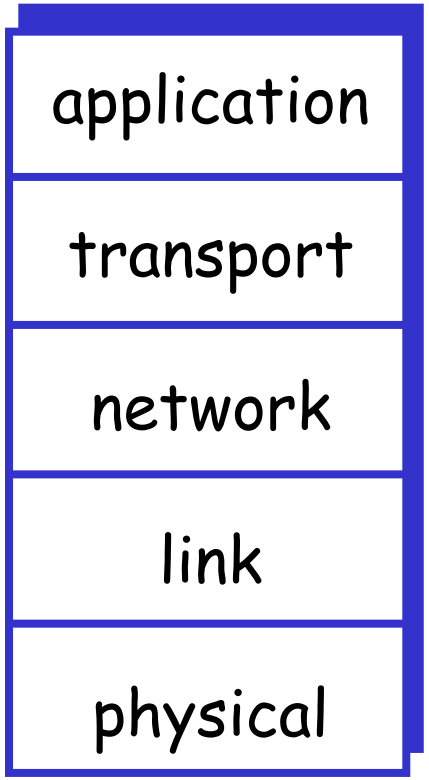
ISO/OSI reference model
Application Layer 應用層

- Defined by user
  - HTTP
  - FTP
  - Email
  - P2P
  - Skype
  - DNS
  - ……
- 執行應用程式



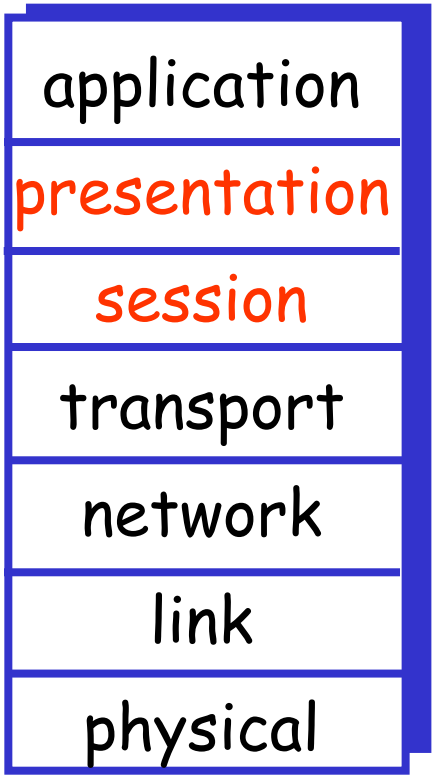
Internet protocol stack
網際網路協定堆疊

- Application 應用層: supporting network applications
  - FTP, SMTP, HTTP
- Transport 傳輸層: process-process data transfer
  - TCP, UDP
- Network 網路層: routing of datagrams from source to destination
  - IP, routing protocols
- Link 鏈結層: data transfer between neighboring network elements
  - PPP, Ethernet
- Physical 實體層: bits "on the wire"

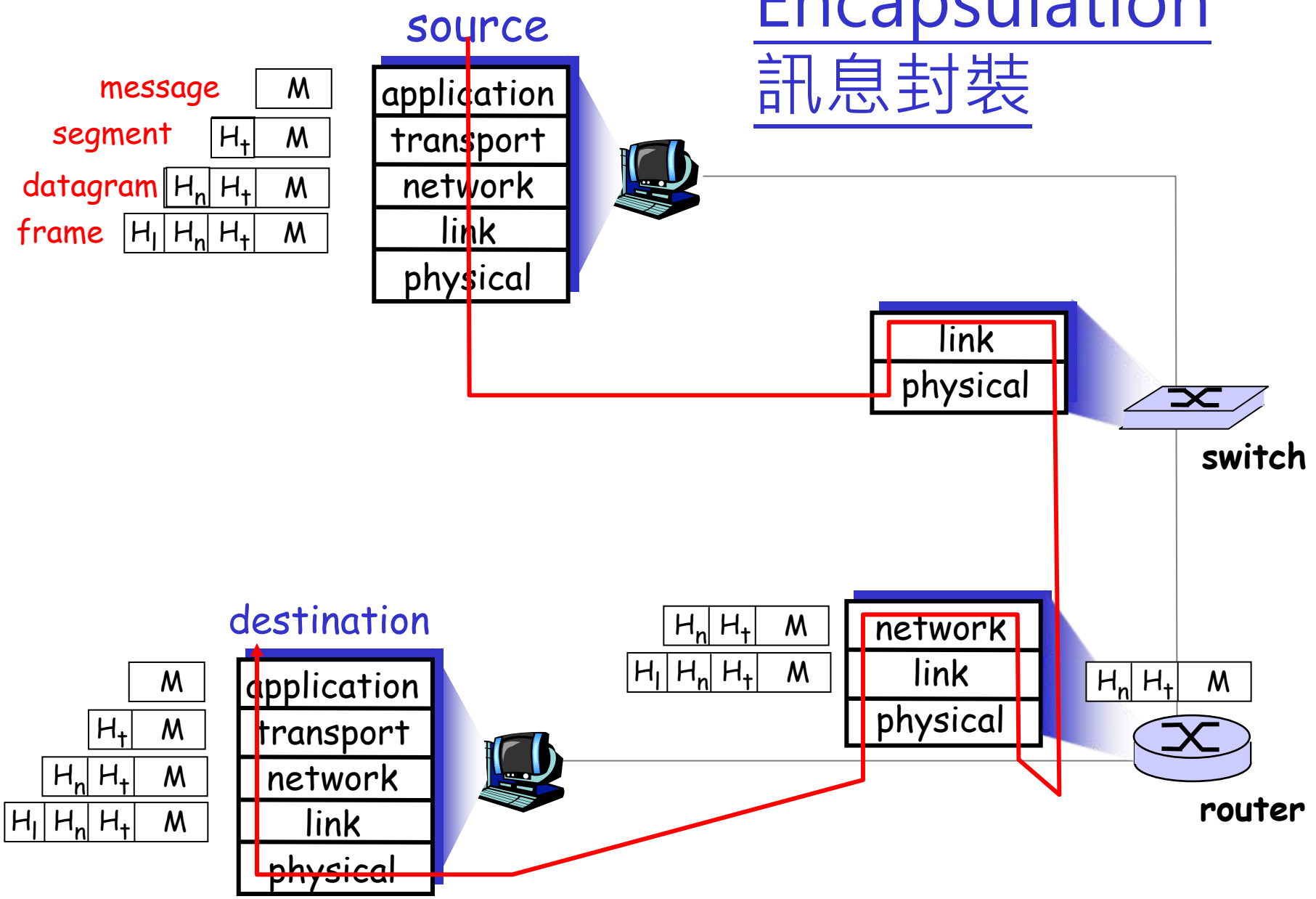


ISO/OSI reference model
ISO/OSI 參考模型

- Presentation展現層 & Session 會議層
- Internet stack "missing" these layers!
  - these services, *if needed,* must be implemented in application
  - needed?



Encapsulation
訊息封裝



補充資料

- Circuit-switching vs. Packet switching
  The way the network works
- Connection-oriented vs. Connectionless
  The service transport layer provides
- TCP vs. UDP
  The protocol in transport layers

Chapter 1: roadmap

1.1 What *is* the Internet?

1.2 Network edge

- end systems, access networks, links

1.3 Network core

- circuit switching, packet switching, network structure

1.4 Delay, loss and throughput in packet-switched networks

1.5 Protocol layers, service models

1.6 Networks under attack: security

1.7 History

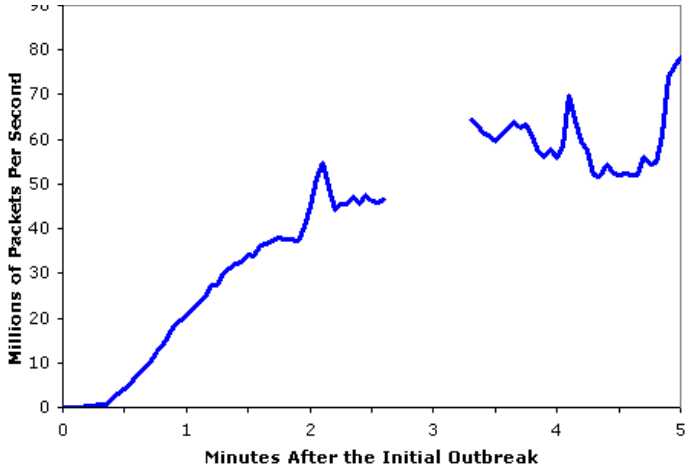
Network Security 網路安全

- attacks on Internet infrastructure:
  攻擊網路基礎架構
  - infecting/attacking hosts: malware, spyware, worms, unauthorized access (data stealing, user accounts)
  - denial of service (DOS): deny access to resources (servers, link bandwidth)
- Internet not originally designed with (much) security in mind
  - *original vision:* "a group of mutually trusting users attached to a transparent network" ☺
    原本的願景：" 一群互信的人連接到一個透明的網路"
  - Internet protocol designers playing "catch-up（警察捉小偷）"
  - Security considerations in all layers!

What can bad guys do: malware? 惡意軟體

- Spyware: 間碟軟體
  - Usually distributed as a Trojan horse 特洛伊木馬
  - infection by downloading web page with spyware
  - records keystrokes, web sites visited, upload info to collection site
- Virus 病毒
  - Require some form of user interaction
  - infection by receiving object (e.g., e-mail attachment), actively executing
  - self-replicating: propagate itself to other hosts, users
- Worm: 蠕蟲
  - Can enter a device without any explicit user interaction
  - infection by passively receiving object that gets itself executed
  - self- replicating: propagates to other hosts, users

Sapphire Worm: aggregate scans/sec
in first 5 minutes of outbreak (CAIDA, UWisc data)

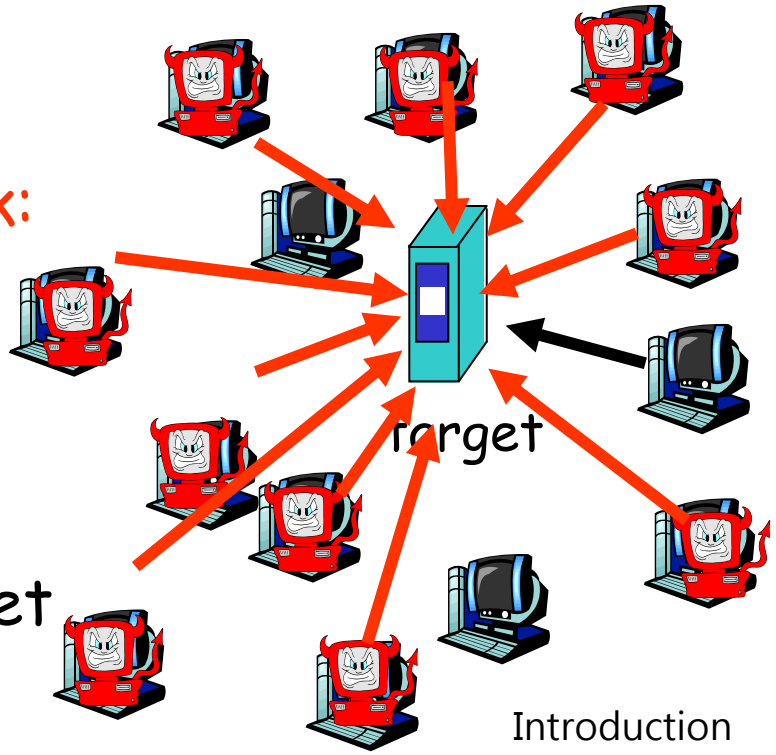


Denial of service (DoS) attacks 服務阻斷攻擊

- attackers make resources (server, bandwidth) unavailable to legitimate traffic by overwhelming resource with bogus traffic
- Three types of DoS attacks:
  - Vulnerability attack – attack a vulnerable application or OS
  - Bandwidth flooding
  - Connection flooding

Distributed Dos (DDos) attack:

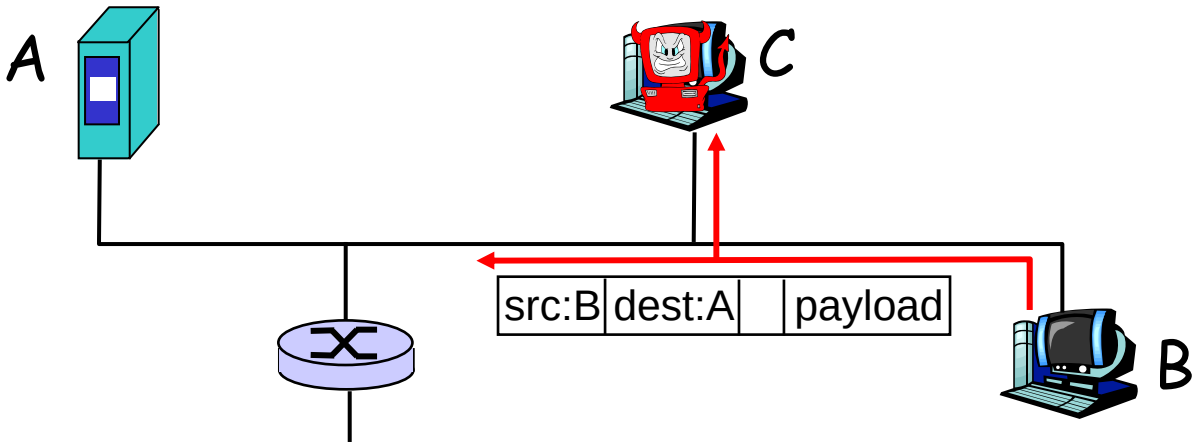
1. select target
2. break into hosts around the network (see malware)
3. send packets toward target from compromised hosts



Sniff, modify, delete your packets
竊聽、修改、刪除封包

Packet sniffing:

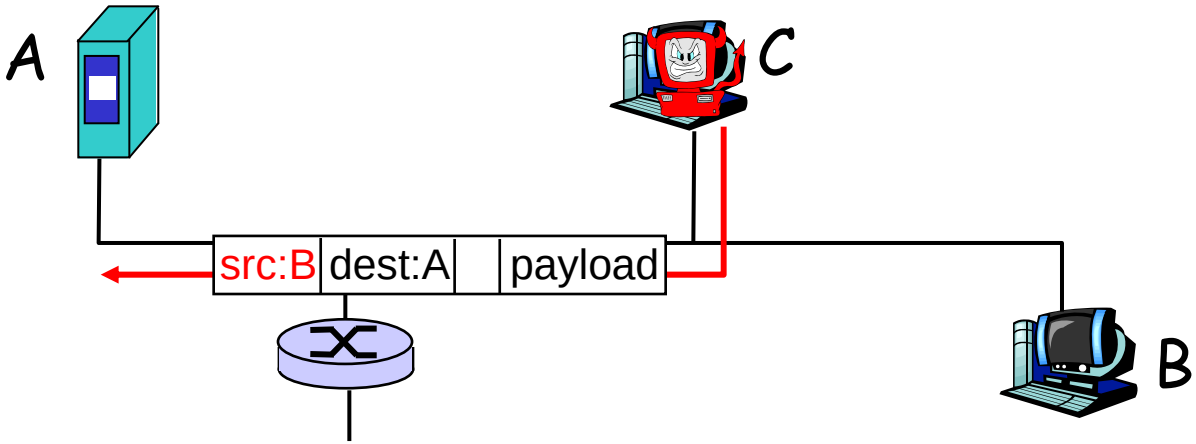
- broadcast media (shared Ethernet, wireless)
- promiscuous network interface reads/records all packets (e.g., including passwords!) passing by



- Ethereal software used for end-of-chapter labs is a (free) packet-sniffer
- more on modification, deletion later

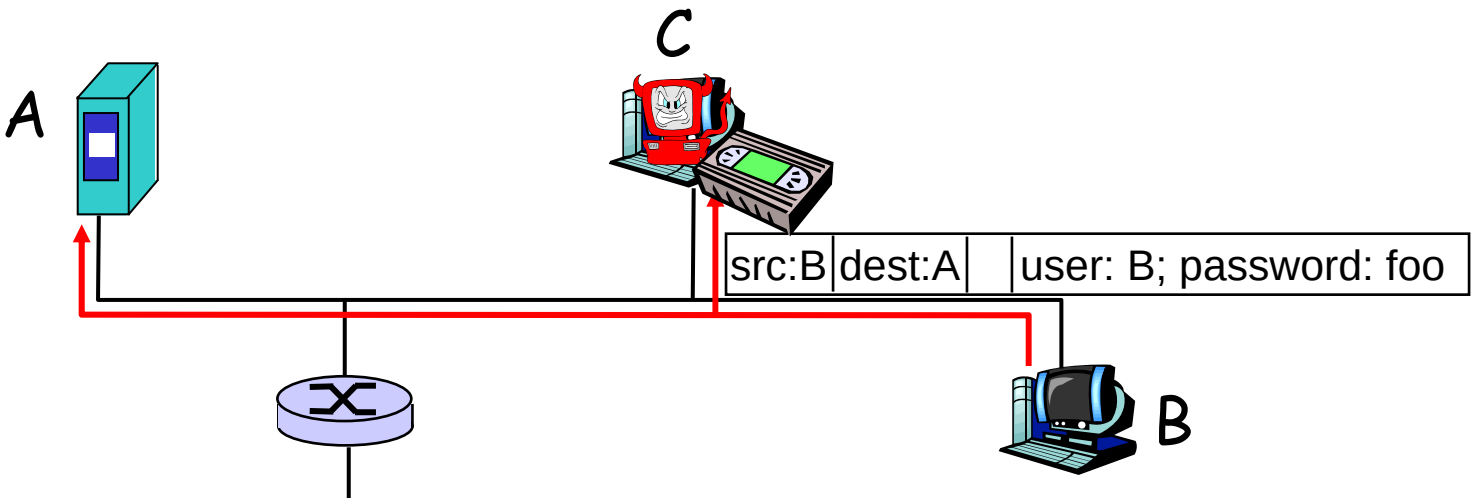
Masquerade as you 偽裝

- *IP spoofing:* send packet with false source address



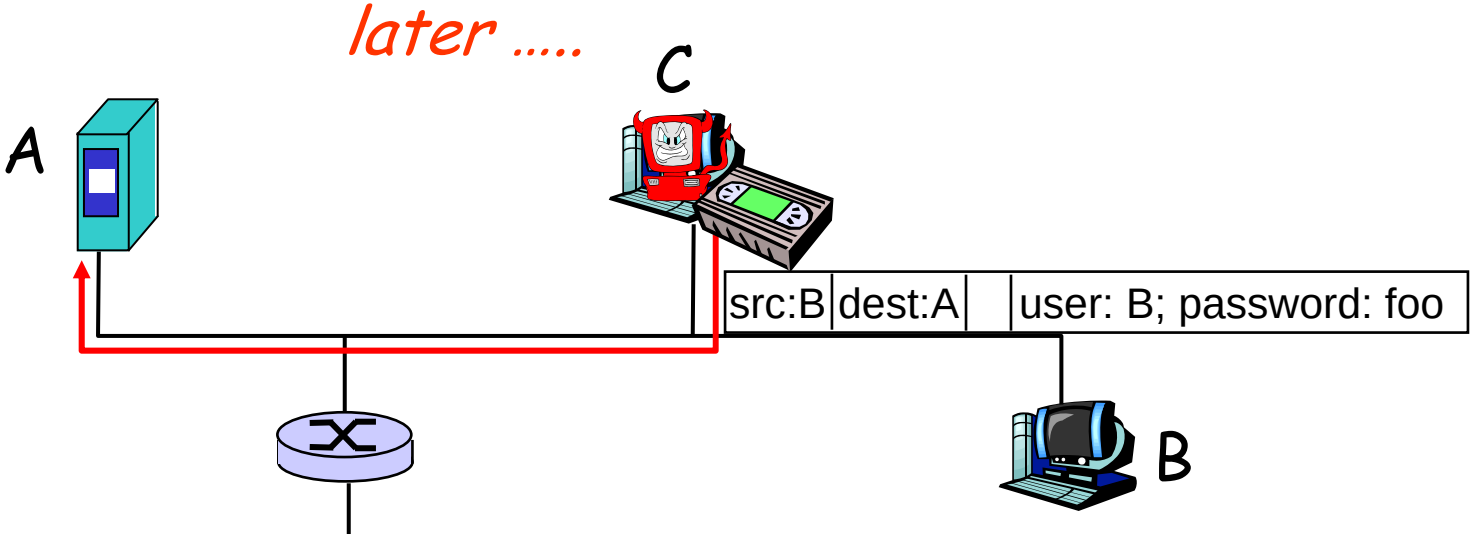
Masquerade as you

- *IP spoofing:* send packet with false source address
- *record-and-playback*: sniff sensitive info (e.g., password), and use later
  - password holder *is* that user from system point of view



Masquerade as you

- *IP spoofing:* send packet with false source address
- *record-and-playback*: sniff sensitive info (e.g., password), and use later
  - password holder *is* that user from system point of view



Chapter 1: roadmap

1.1 What *is* the Internet?

1.2 Network edge

- end systems, access networks, links

1.3 Network core

- circuit switching, packet switching, network structure

1.4 Delay, loss and throughput in packet-switched networks

1.5 Protocol layers, service models

1.6 Networks under attack: security

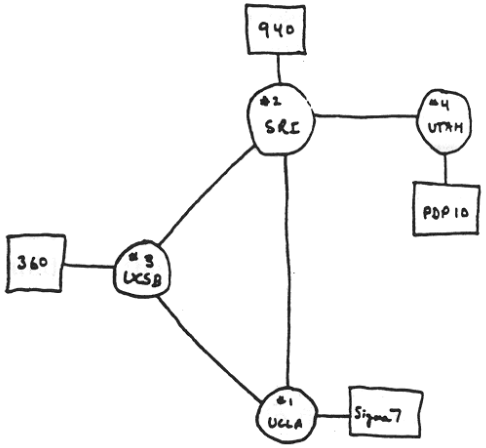
1.7 History

Internet History 網際網路的歷史

1961-1972: Early packet-switching principles

- 1961: Kleinrock - queueing theory shows effectiveness of packet-switching
- 1964: Baran - packet-switching in military nets
- 1967: ARPAnet conceived by Advanced Research Projects Agency
- 1969: first ARPAnet node operational

- 1972:
  - ARPAnet public demonstration
  - NCP (Network Control Protocol) first host-host protocol
  - first e-mail program
  - ARPAnet has 15 nodes



THE ARPA NETWORK

Internet History

1972-1980: Internetworking, new and proprietary nets

- 1970: ALOHAnet satellite network in Hawaii
- 1974: Cerf and Kahn - architecture for interconnecting networks
- 1976: Ethernet at Xerox PARC
- ate70's: proprietary architectures: DECnet, SNA, XNA
- late 70's: switching fixed length packets (ATM precursor)
- 1979: ARPAnet has 200 nodes

Cerf and Kahn's internetworking principles:

- minimalism, autonomy - no internal changes required to interconnect networks
- best effort service model
- stateless routers
- decentralized control

define today's Internet architecture

Internet History

1980-1990: new protocols, a proliferation of networks

- 1983: deployment of TCP/IP
- 1982: smtp e-mail protocol defined
- 1983: DNS defined for name-to-IP-address translation
- 1985: ftp protocol defined
- 1988: TCP congestion control

- new national networks: Csnet, BITnet, NSFnet, Minitel
- 100,000 hosts connected to confederation of networks

Internet History

1990, 2000's: commercialization, the Web, new apps

- Early 1990's: ARPAnet decommissioned
- 1991: NSF lifts restrictions on commercial use of NSFnet (decommissioned, 1995)
- early 1990s: Web
  - hypertext [Bush 1945, Nelson 1960's]
  - HTML, HTTP: Berners-Lee
  - 1994: Mosaic, later Netscape
  - late 1990's: commercialization of the Web

Late 1990's – 2000's:

- more killer apps: instant messaging, P2P file sharing
- network security to forefront
- est. 50 million host, 100 million+ users
- backbone links running at Gbps

Internet History

2007:

- ~500 million hosts
- Voice, Video over IP
- P2P applications: BitTorrent (file sharing) Skype (VoIP), PPLive (video)
- more applications: YouTube, gaming
- wireless, mobility

Introduction: Summary

Covered a "ton" of material!

- Internet overview
- what's a protocol?
- network edge, core, access network
  - packet-switching versus circuit-switching
  - Internet structure
- performance: loss, delay, throughput
- layering, service models
- security
- history

You now have:

- context, overview, "feel" of networking
- more depth, detail *to follow!*