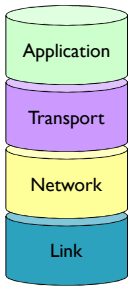
Computer network

Computer network

- Network: an connected system of things or people -- Webster dictionary
- Computer network: a linked computer system such that applications on different machines can exchange messages and collaborate.

Outline

- Layer approach and protocol
- Link layer
- Network layer/Transport layer
- Application layer



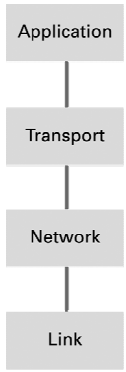
A story

某日，某資工系某家族決定要去新竹某餐廳家聚。他們決定先在某資電館前集合，再出發到餐廳。家族共有12人，某學長有一輛車，可以坐4人，另外還有2個人有摩托車，共可以載4人，另外4個人決定坐公車。某學長車上有GPS，可以找出路要怎麼走；有摩托車的同學上網查出地圖路線；要坐公車的同學查出要轉一次車，再走一小段路就可以到餐廳了…

Layered approach

- 去竹北某餐廳家聚 → Application layer
  - Decide where to go and what to do
- 4人坐車， 4人騎車， 4人搭公車 → Transport layer
  - Decide the transportation methods
- GPS,地圖路線,公車班次 → Network layer
  - Decide the routes from the source to the destination
- 汽車,摩托車,公車,司機,馬路,紅綠燈,路標…
  - Make the real transportation happen → Link layer

Network layers



- **Application**: Constructs message with destination address
- **Transport**: Provides reliable data transfer services
- **Network**: Handles routing through the network
- **Link**: Handles actual transmission of packets

Layered approach: why?

- Each task in different layer can be handled more easily without considering the details of the tasks in other layers.
  - For example, they can decide a "best" restaurant without considering how to go there
- Methods in different layers can be changed easily.
  - For example, different applications can use the same transport protocol.

Protocols

- A set of rules used to communicate with each other across a network.
  - Example 1:先在資電館前集合，再出發到餐廳
  - Example 2: bus route and schedule
  - Example 3: traffic regulations
- Protocol is a special (distributed) *algorithm* that enables and controls the data communications.

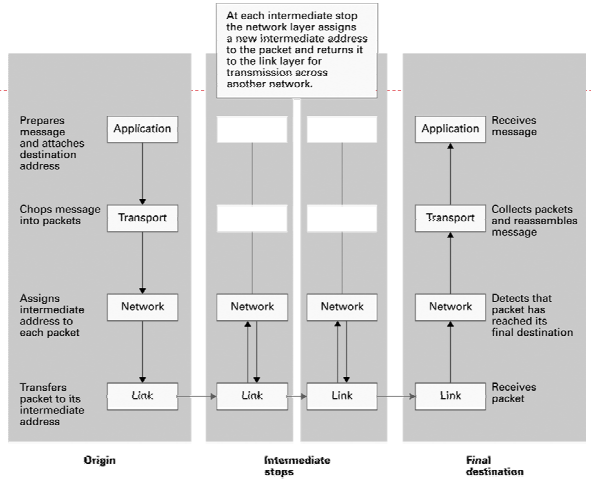
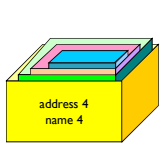
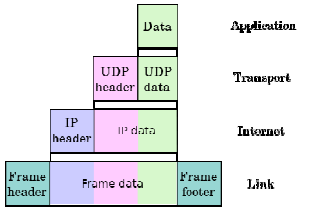


Figure 4.14 Following a message through the Internet

Message encapsulation

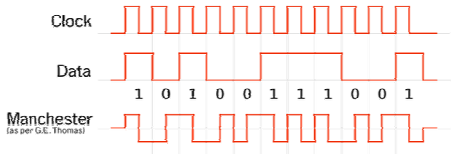
- To transmit the data, each layer appends some information to the original message.
- The corresponding layer in the receiver side needs to "decapsulate" the message.





Data transfer

- Many media can transfer binary data
  - Voltage
  - Voltage change



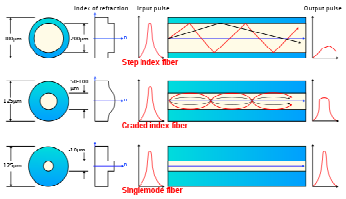
  - Voice: telephone line (modem)
  - Electromagnetic wave: radio
  - Light: infrared, laser, optical fiber

- Different media have different characters. Need different protocols.

Optical fiber

- Charles K. Kao 高錕 won the 2009 Nobel Prize in Physics for "groundbreaking achievements concerning the transmission of light in fibers for optical communication".

- Different types of optical fibers

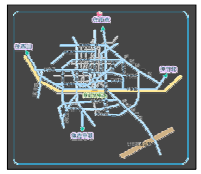


Data communication rates

- Measurement units
  - bps: Bits per second
  - Kbps: Kilo-bps (1,000 bps)
  - Mbps: Mega-bps (1,000,000 bps)
  - Gbps: Giga-bps (1,000,000,000 bps)
- **Multiplexing**: make single communication path as multiple paths
- **Bandwidth**: maximum available data transmission rate

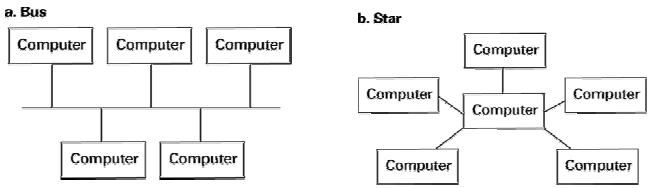
LAN, MAN, WAN

- Network can be classified by the scope
  - Local area network (LAN)
  - Metropolitan area (MAN)
  - Wide area network (WAN)
- Network for different scopes uses different media and has different protocols.



Network topology

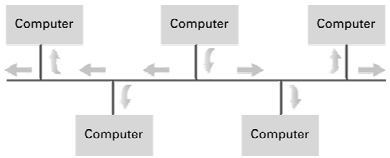
- Popular network topologies used in LAN
  - Bus (Ethernet)
  - Star (Wireless network with central Access Point, AP)



- Different topology uses different protocols.

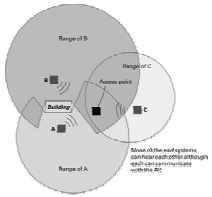
Ethernet and CSMA/CD

- CSMA/CD: protocol for Ethernet
  - **C**arrier **S**ense, **M**ultiple **A**ccess with **C**ollision **D**etection
  - Broadcast messages to all machines on the bus
  - Resend message if detecting more than one messages sent at the same time (collision)



WiFi and CSMA/CA

- CSMA/CA: protocol for WiFi
  - **C**arrier **S**ense, **M**ultiple **A**ccess with **C**ollision **A**voidance
- Similar to CSMA/CD
  - Sensing carriers before sending
- WiFi cannot detect collisions perfectly
  - Self signal drowns out others
  - Hidden terminal problem



Collision avoidance

- Before sending data, a node listens to the channel for a period.
  - If the channel is silent, it sends data.
  - If the channel is busy, it waits another random period. After waiting, if the channel is silent, it sends data immediately.
- Cannot avoid collisions totally.
  - Handshaking: Before sending data, a node sends a request to AP. AP sends an acknowledgement to all nodes after receiving the request.

Network equipments for LAN

- **Hub**: relays signals it received
- **Repeater**: connects two buses
- **Bridge**: similar to repeater, but only forwards necessary messages
- **Switch**: a bridge that connects multiple buses
  - All those do not change the protocol