ELEC3030 Computer Networks

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Download lecture slides from: http://www.ecs.soton.ac.uk/∼sqc/EL336/
or get them from Course Office (ECS Student Services)

Reading Text: A.S. Tanenbaum, *Computer Networks*, 4th edition, Prentice Hall, 2003.

2nd Reading Text: L. Chappell and E. Tittel, *Guide to TCP/IP*, 2nd edition, Thomson, 2004.

I will cover half of the unit, including

- **Introduction**
- **Data link layer**
- **Physical layer**
- **Network layer**

Overview

- Two most important aspects of computer networks are hardware and software
- Hardware: as communication is a primary concern in a network, we are dealing with both computers and communication technologies
- In terms of scale, historically computer networks are classified as
  - **Local area networks** (LAN): within room, building or campus, and size from 10 m up to a few km
  - **Metropolitan area networks** (MAN): size in tens km and may cover a city
  - **Wide area networks** (WAN): within a country or even whole continent, and size from 10 km to 100 km
  - **Internetworks**: deal with how to connect different kinds of networks $\longrightarrow$ resulting the Internet which really covers the whole Planet
- Software: what actually makes computer networks is software. With "software" we are not talking computer codes, but design thinking, methodology and framework

Overview (continue)

- It is useful to view computer networks software as consisting of
  - **Protocols**: describe how two communicating parties exchange information
  - **Services**: describe what a network offers to parties that want to communicate
  - **Interfaces**: define how the services offered by a network can be accessed

- Reference model is referred to as the way of organising network softwares

- Different people and organisations would like you to organise your network in their reference models, and some examples:
  - OSI 7-layer reference model (OSI: open systems interconnection)
  - TCP/IP model (TCP/IP: transmission control protocol/Internet protocol)
  - Hybrid 5-layer model we adopt: a compromise between OSI and TCP/IP

- Standardisation is critical in computer networks, and major players in standardisations include: ITU (international telecommunication union), ISO (international standards organisation) and IEEE

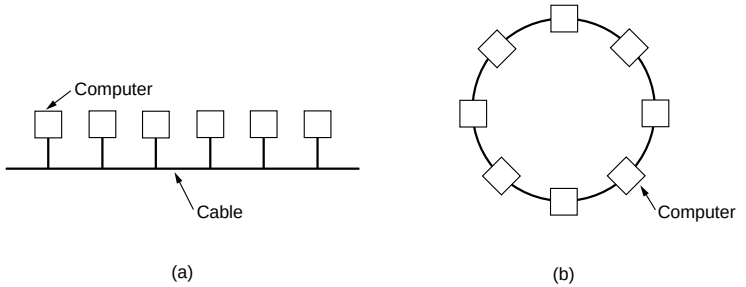
The Hardware

- Transmission technology: there are two basic methods
  - **Broadcast**: transmission is broadcasted to and received by all, as in broadcast networks such as packet radio, satellite and LANs
  - **Point-to-point**: transmission goes from sender to receiver possibly via some intermediate switching nodes, as in switched networks such as WANs and Internet

- Are wireless networks WIFI broadcast or point-to-point link based?

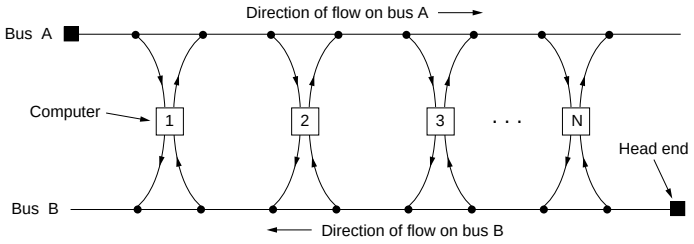
- LANs: use broadcast transmission technology

  Two typical topologies for LANs are bus and token ring



- MANs: are bigger versions of LANs

  Two examples are the distributed queue, dual bus on right and air interface for fixed broadband wireless access system (IEEE 802.16) WMAX

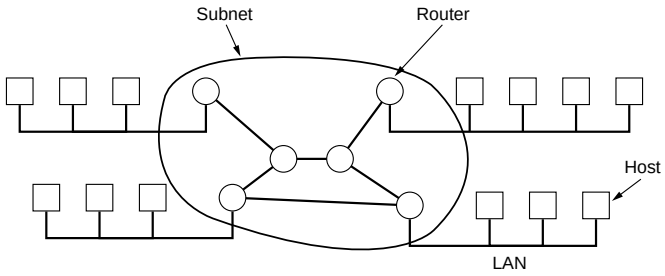


The Hardware (continue)

- LANs and MANs do not have any switching nodes: the wire (or wireless) does all the work → This makes them extremely efficient but harder to get bigger

- WANs: hosts are connected to a subnet, which contains routers (switching nodes) and trunks

  Routers generally adopt a store-and-forward (packet-switched) principle

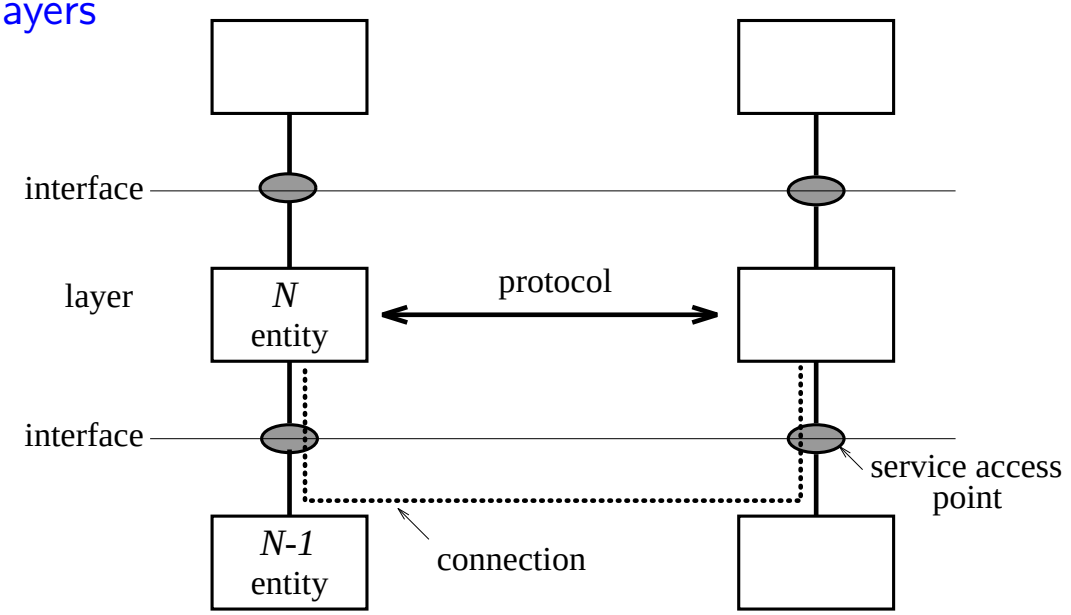


- Internetwork: many networks exist with very different hardware and software, and interconnecting different networks is called internetwork
  - Connect a collection of different LANs within a department
  - Connect different LANs through a WAN, with WAN acting as a subnet
  - Connect different WANs to each other by means of gateways → the Internet

- **Subnet**: collection of routers and trunks; **Network**: combination of a subnet and its hosts; **Internetwork**: distinct networks interconnected together

Layered Structure and Protocol

- A complete communication task across network is very complicated → most network architectures or softwares are organised as a series of layers
  - Each layer performs a related subset of the functions required to communicate with another system
  - It relies on the next lower layer to perform more primitive functions and to conceal the details of how those functions are actually implemented



- Logically, peer layers across the network talk to each other using **protocols**
- The communication is actually carried out using some **services** provided by lower layer
- Adjacent layers in the same machine communicate via an **interface**
- Interface is realised in one or more **service access points**, which function in the manner of ports

Services

- There are two different types of services: connection-oriented and connectionless
  - **Connection-oriented**: the user first establishes a connection, then uses the connection to communicate, finally releases the connection (think this as using telephone)
  - **Connectionless**: each data unit has the complete destination address and is routed through the network to the destination independently (think this as posting a letter)
- Each service offers certain **quality**: e.g. whether ordered delivery and how reliable
- A service is specified by a set of **primitives** (operations) available to a user to access the service
  - Four classes of service primitives are:

request	entity wants the service to do some work
indication	entity is to be informed about an event
response	entity wants to response to an event
confirm	response to earlier request has come back

- Consider a simplest connection-oriented service with 8 primitives

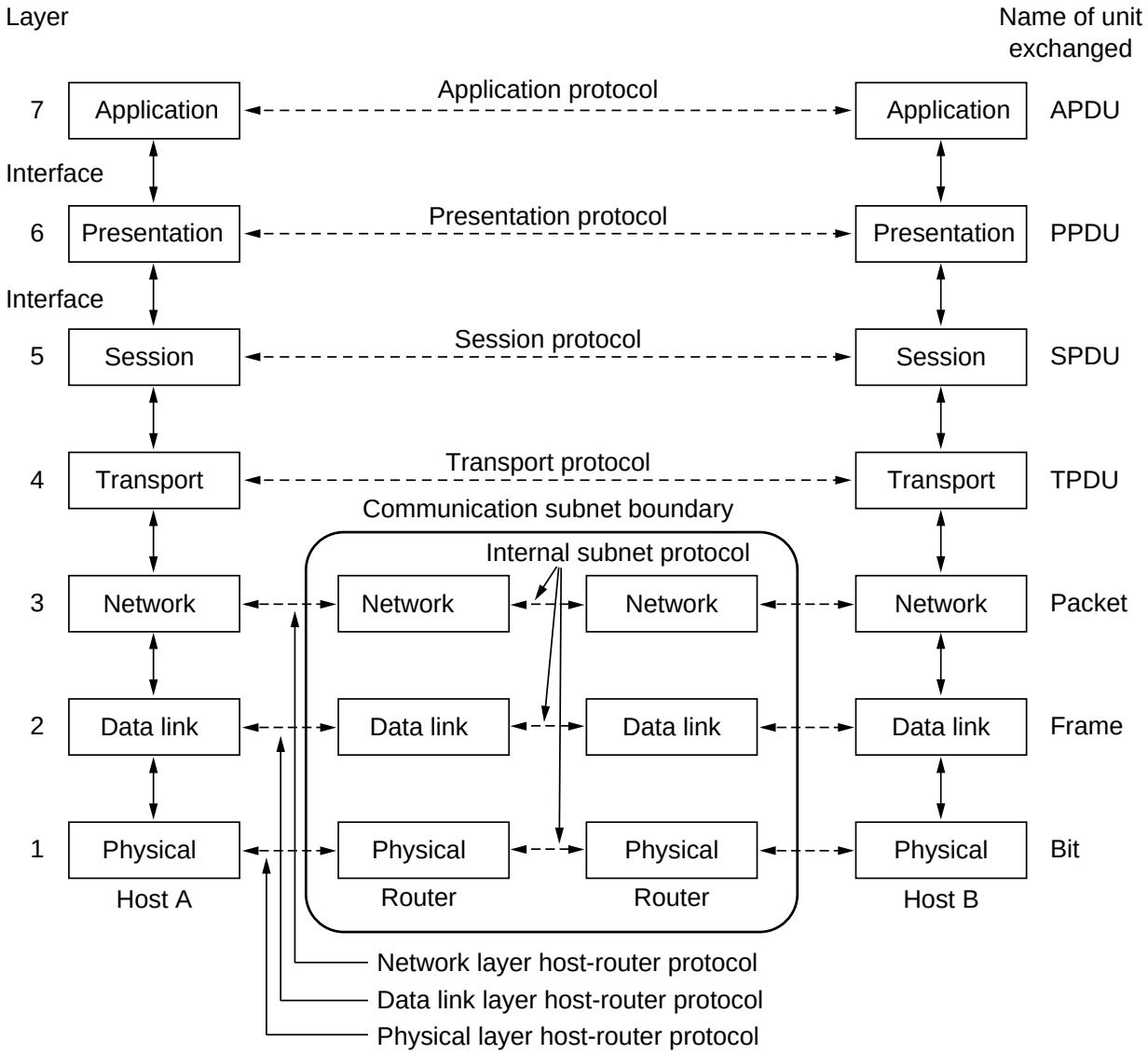
1.	CONNECT.request – request a connection to be established	(dial a phone number)
2.	CONNECT.indication – signal the called party	(phone rings)
3.	CONNECT.response – used by the callee to accept/reject calls	(pick up the phone)
4.	CONNECT.confirm – tell the caller whether the call was accepted	(caller hears ringing stop)
5.	DATA.request – request that data be sent	(say something)
6.	DATA.indication – signal the arrival of data	(callee hears you)
7.	DISCONNECT.request – request that a connection be released	(caller hangs up)
8.	DISCONNECT.indication – signal the release of the connection	(callee hears busy tone)

OSI 7-layer Reference Model

- Recall that software makes computer networks and layered structure is a basic principle in organising computer network software

- In design, one would like to have a **framework** for dividing network software into several layers, defining what each layer does, and finally providing implementation specifications → This kind of framework is called **reference model**

- A well known example is the OSI 7-layer reference model specified by ISO



OSI 7-layer Model (continue)

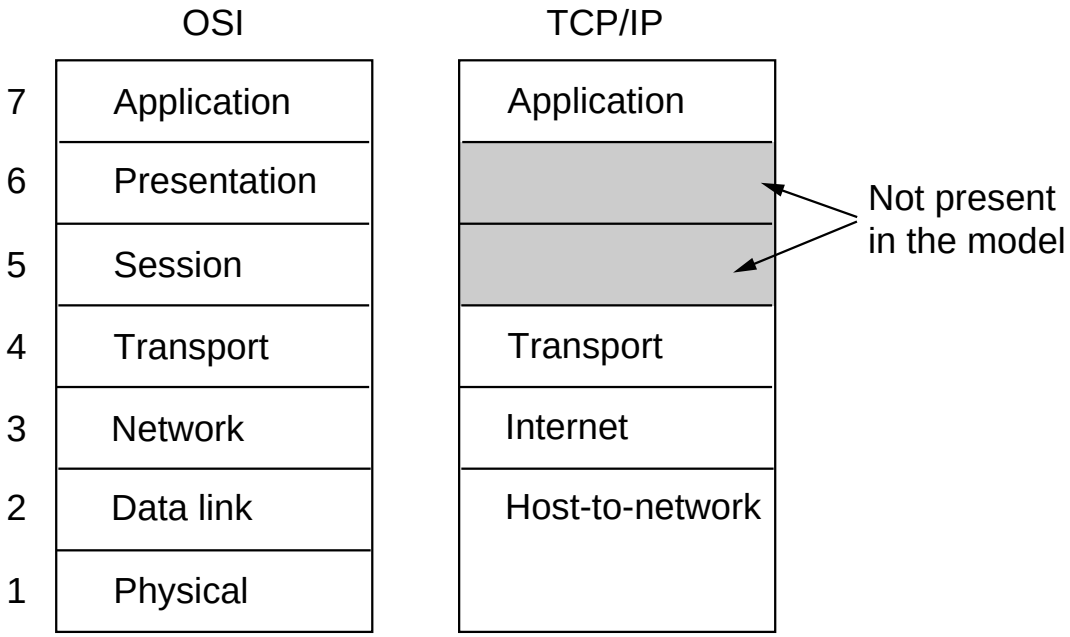
1. **Physical layer**: is concerned with the transmission of raw bits, and deals with mechanical, electrical and procedural interfaces, and physical transmission medium
2. **Data link layer**: describes how a shared communication medium can be accessed, and how to make an unreliable noisy link reliable
3. **Network layer**: is concerned with controlling the operation of subnet, for example, how routing is done
4. **Transport layer**: provides the actual network interface to applications, jobs like making network connections, multiplexing, flow control. It is a true end-to-end layer, from source to destination
5. **Session layer**: tells how to set up "long-lasting" communications (sessions). This is the dumbest and ill-defined
6. **Presentation layer**: describes everything that is needed to exchange data in a platform-independent way. An example is data encoding
7. **Application layer**: contains the stuff that user can see, such as e-mail, file transfer, remote login, web's exchange protocols

Note that the **user-network interaction** occurs at the bottom three-layer levels: the "net" is essentially unconcerned with higher layers

TCP/IP Reference Model

- This is where Internet started: used to be a wild cowboy's world but now is better standardised

1. **Application layer**: does similar things as OSI application layer
2. **Transport layer**: does similar things as OSI transport layer
   Two end-to-end protocols are defined: TCP – transmission control protocol (for reliable connection-oriented) and UDP – user datagram protocol (for unreliable connectionless)
3. **Internet layer**: similar in functionality to OSI network layer



4. **Host-to-network layer**: anything below the internet layer, not very well defined

- Two reference models represent two different views of the world: telecommunication camp and computer camp. OSI camp views the world (i.e. the network) as rigid, well defined and organised, TCP/IP camp historically views the world as hostile and chaotic
  New standards are now often defined with **best** of **both** reference models

Comparison of OSI and TCP/IP Models

- Three important concepts, **services**, **interfaces** and **protocols**, are well defined in OSI model, but not in original TCP/IP model
- **Transport** layer does the hardest job, dealing with end-to-end "connection"
- **Data link** layer is also very important: An end-to-end "connection" consists of many "links", and each possibly noisy link need to be made reliable
- On the other hand, no one really knows precisely what session layer does
- It may also be argued that a separate presentation layer is not strictly necessary
- Based on comparison, we will adopt the hybrid **5-layer reference model**:

  This is a good **framework** for discussion of computer networks

5	Application layer
4	Transport layer
3	Network layer
2	Data link layer
1	Physical layer

Summary

- Computer network hardware overview

  Two communication technologies: broadcast and point-to-point transmissions

  Networks in terms of scale: LAN, MAN, WAN, internetwork

- Computer network software overview:

  Layered structure, definitions of protocol, service and interface

  Connection-oriented and connectionless services, service quality, service primitives

- Reference models: OSI 7-layer, TCP/IP and hybrid 5-layer