CSC8004: Computer Networks
Part 1 - Overview

Module Leader: Dr Ellis Solaiman

CSC8004 Practicalities

I am Ellis Solaiman, I am the module leader for the section of the module covering Networks (5 weeks).

Harold Fellermann will cover the section on Web Technologies (5 weeks).

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All notes and exercises will be placed on Blackboard.

CSC8004 Timetable

Lectures:

- Tuesdays 9:30am – 11:30am USB 4.005.
- Tuesdays 14:30 – 16:30pm USB 4.005

Practicals

- Tuesdays 16:30 – 18:30pm.
  - USB.3.005 (A):
  - USB.3.018 (C):

Assessment for CSC8004

Computer Networks (50%)

- Coursework (15%)
- Exam (35%)

Web Technologies (50%)

- Coursework (35%)
- Exam (15%)

Recommended reading

- Computer Networks
  - Andrew S Tanenbaum
  - Prentice Hall
  - 4th edition ISBN 7302172757
  - 5th edition ISBN 0132553171

What the introduction will cover

- What is a computer network?
- Network hardware
- Network software
- Reference models

What is a computer network?

- A computer network is a collection of computers connected by communication links
- Links can be point-to-point or broadcast
- Links are implemented using various transmission technologies
- The purpose of the network is to provide services to users (humans or applications)
- Services provided to users can vary widely (eg browser, file transfer, e-commerce)
- Information exchange can take many forms (eg text, audio, video)
- Services may need guaranteed bandwidth (circuit-switched) or expected bandwidth (packet-switched)

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Network Theory

- The entities (hosts, routers, servers, devices, programs, etc) are referred to as **nodes**.
- The connections between entities are known as **links** or **edges**.
- A **topology** refers to the physical layout of the network.

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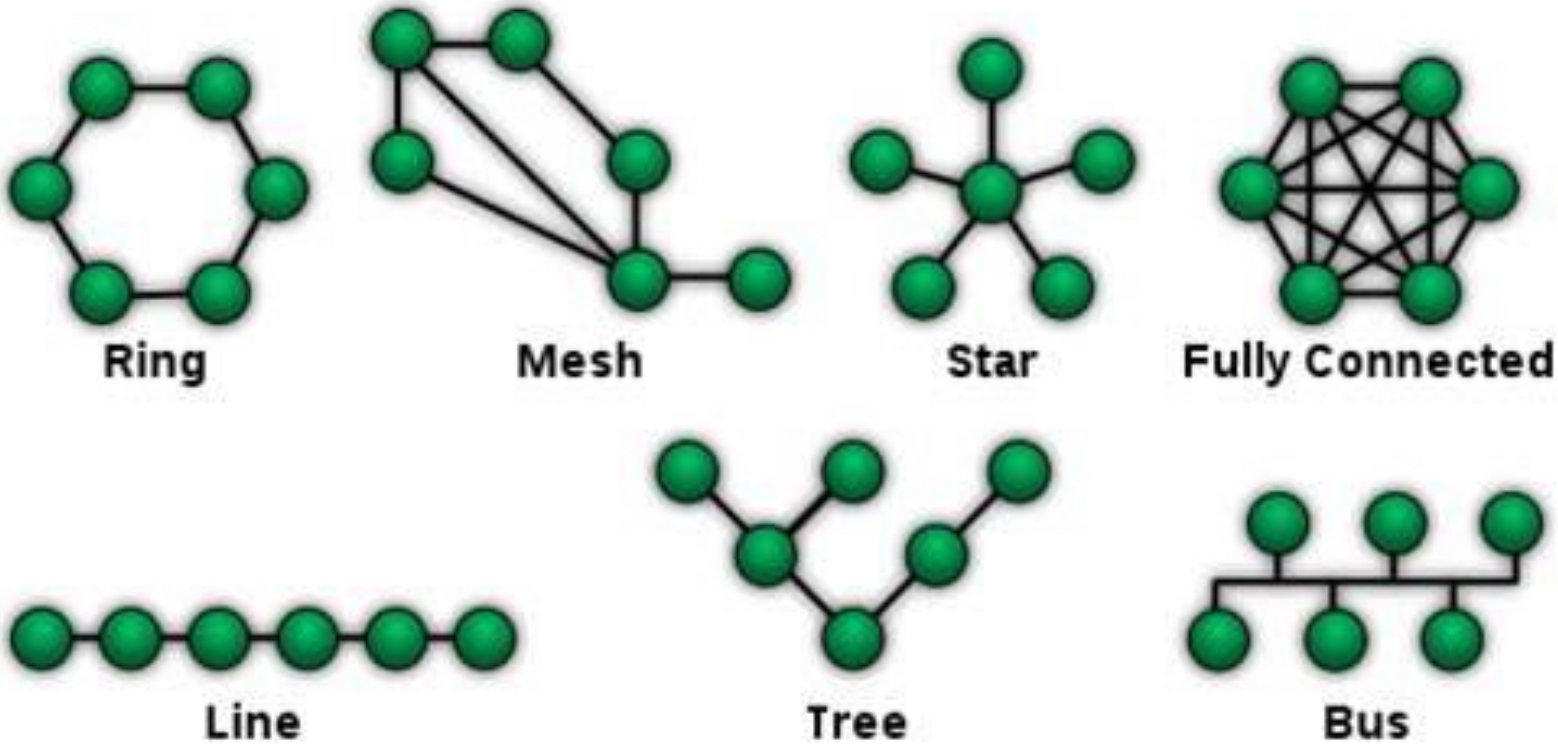
Topologies



Next

- What is a computer network?
- Network hardware
  - Personal Area Networks
  - Local Area Networks
  - Metropolitan Area Networks
  - Wide Area Networks
  - Internetworks (The Internet)
  - Wireless networks
- Network software
- Reference models

Network hardware

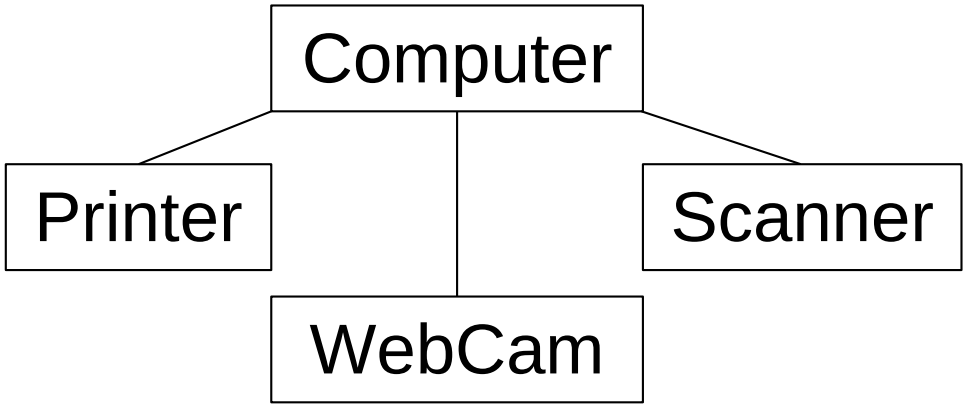
Interprocessor distance	Processors located in same	Example
1 m	Square meter	Personal area network
10 m	Room	Local area network
100 m	Building	
1 km	Campus	
10 km	City	Metropolitan area network
100 km	Country	Wide area network
1000 km	Continent	
10,000 km	Planet	The Internet

Space

Classification of interconnected processors by scale

Note: independent of implementation technology (copper, fibre)

Personal Area Networks



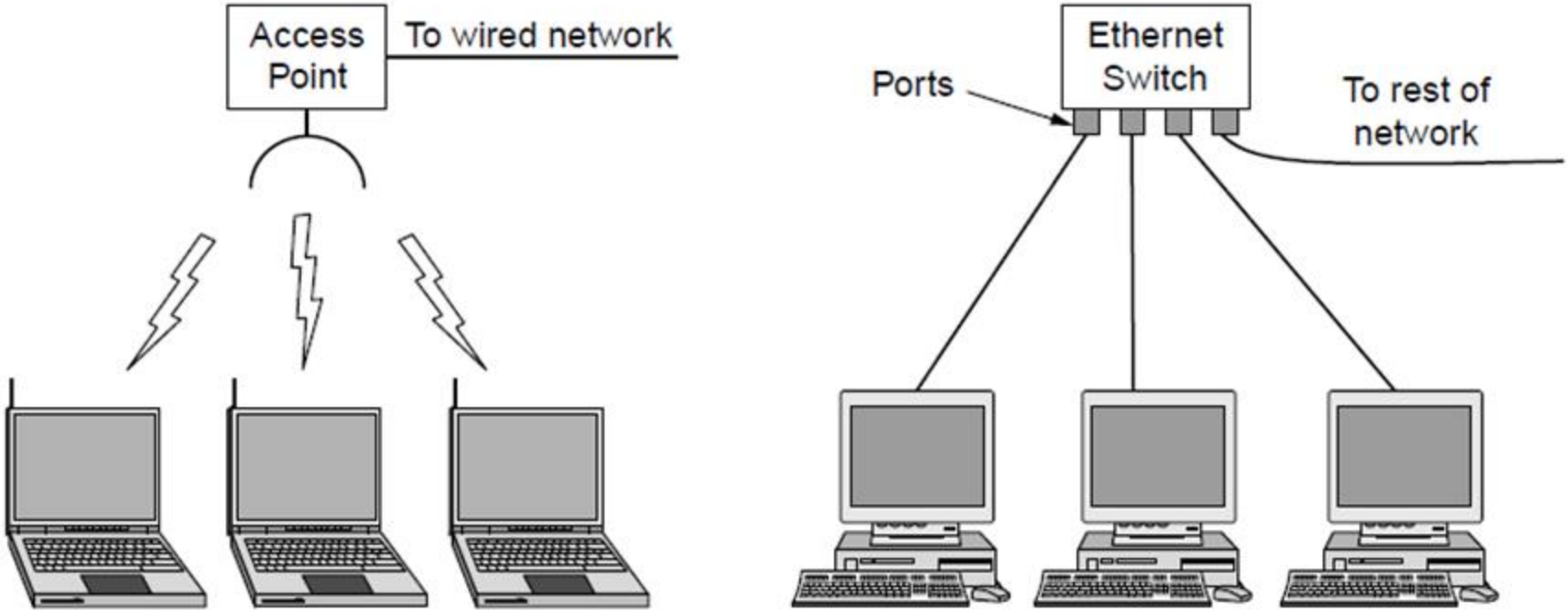
- Point-to-point
  - USB
  - Serial/Parallel (SATA/PATA)
  - Infrared
- Broadcast
  - Bluetooth

Local Area Networks (LAN)

- Typically privately-owned, inside a building or on a campus, length typically less than 2 km
- Connect PCs, workstations in offices etc. for resources sharing (printers, data, files)
- Broadcast medium is a cable
  - Typical speeds are 10 Mbps to 100 Gbps
  - Also moving to 400Gbps
- Broadcast medium is radio (WLAN)
  - Typical speeds are 11 Mbps to hundreds Mbps (WiFi)
- Standards available at:

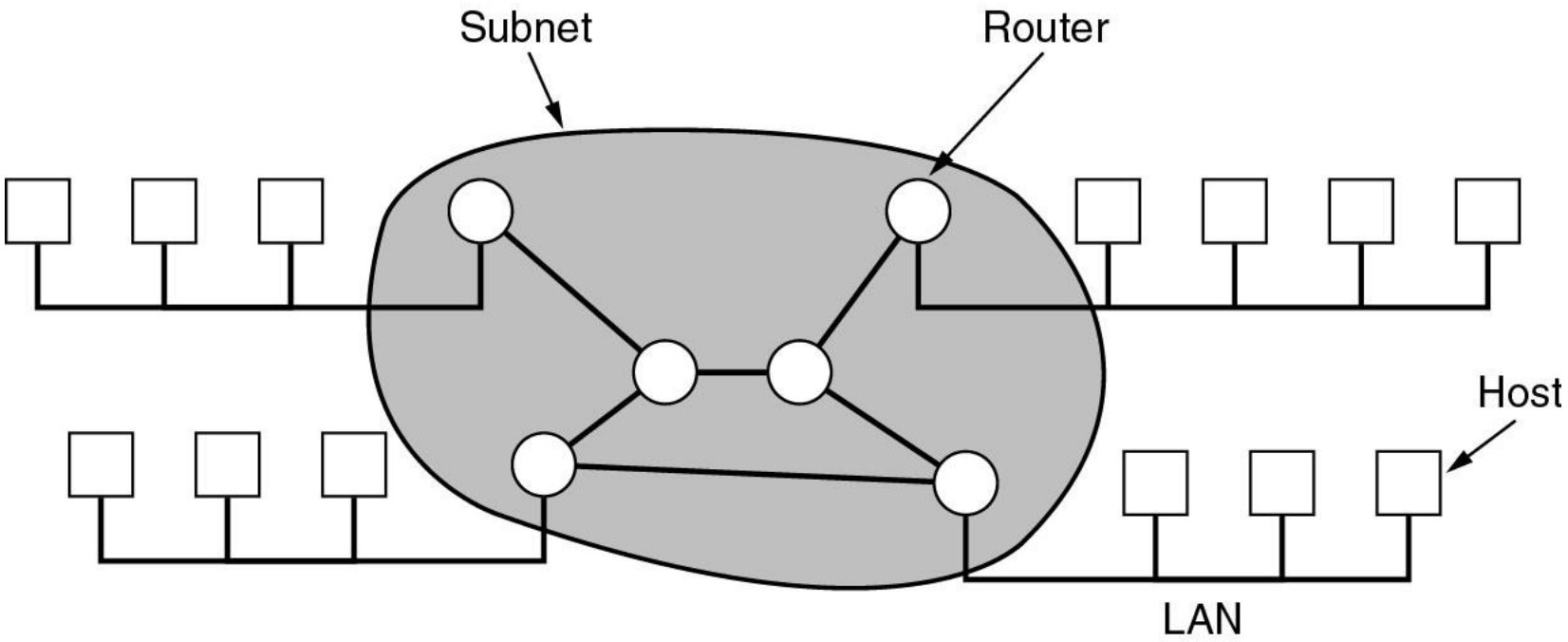
  http://en.wikipedia.org/wiki/IEEE_802

Local Area Networks



Wireless and wired LANs. (a) WiFi. (b) Switched Ethernet.

Wide Area Networks (WAN)



Router is just a computer providing a communications service

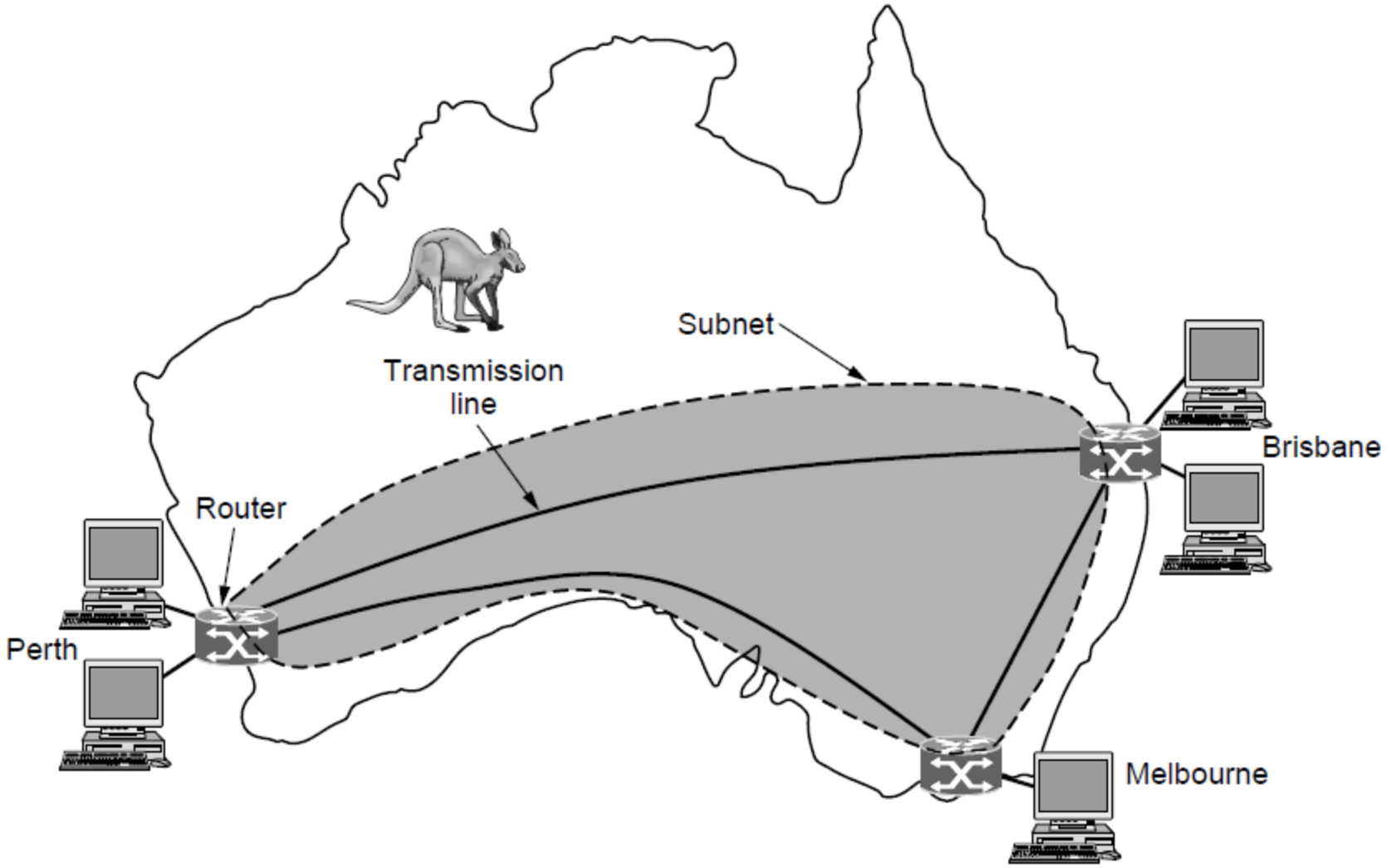
A subnet is a collection of routers (using common technologies)

Hosts send packets of data to each other via the LANs and routers

Wide Area Networks

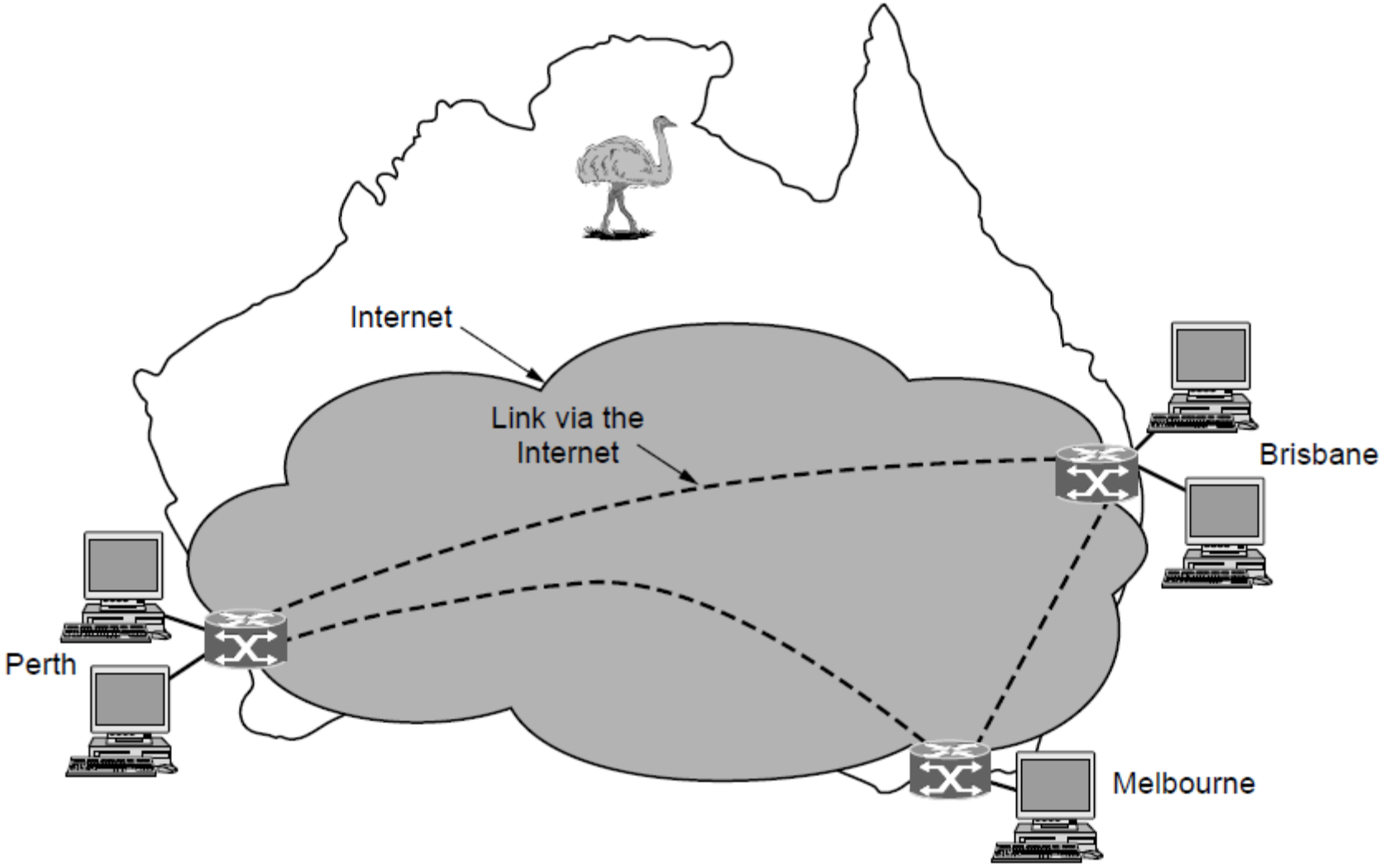
- Spans large geographical area
- Consists of point-to-point (private) connections
- End systems (hosts) are interconnected via a communication sub-network called subnet
- The subnet is composed of lines (wires) and switches
- The subnet may be based on packet-switched and/or circuit-switched technologies
  - Packet switched means users compete for bandwidth
  - Circuit-switched means users are guaranteed bandwidth

Wide Area Networks



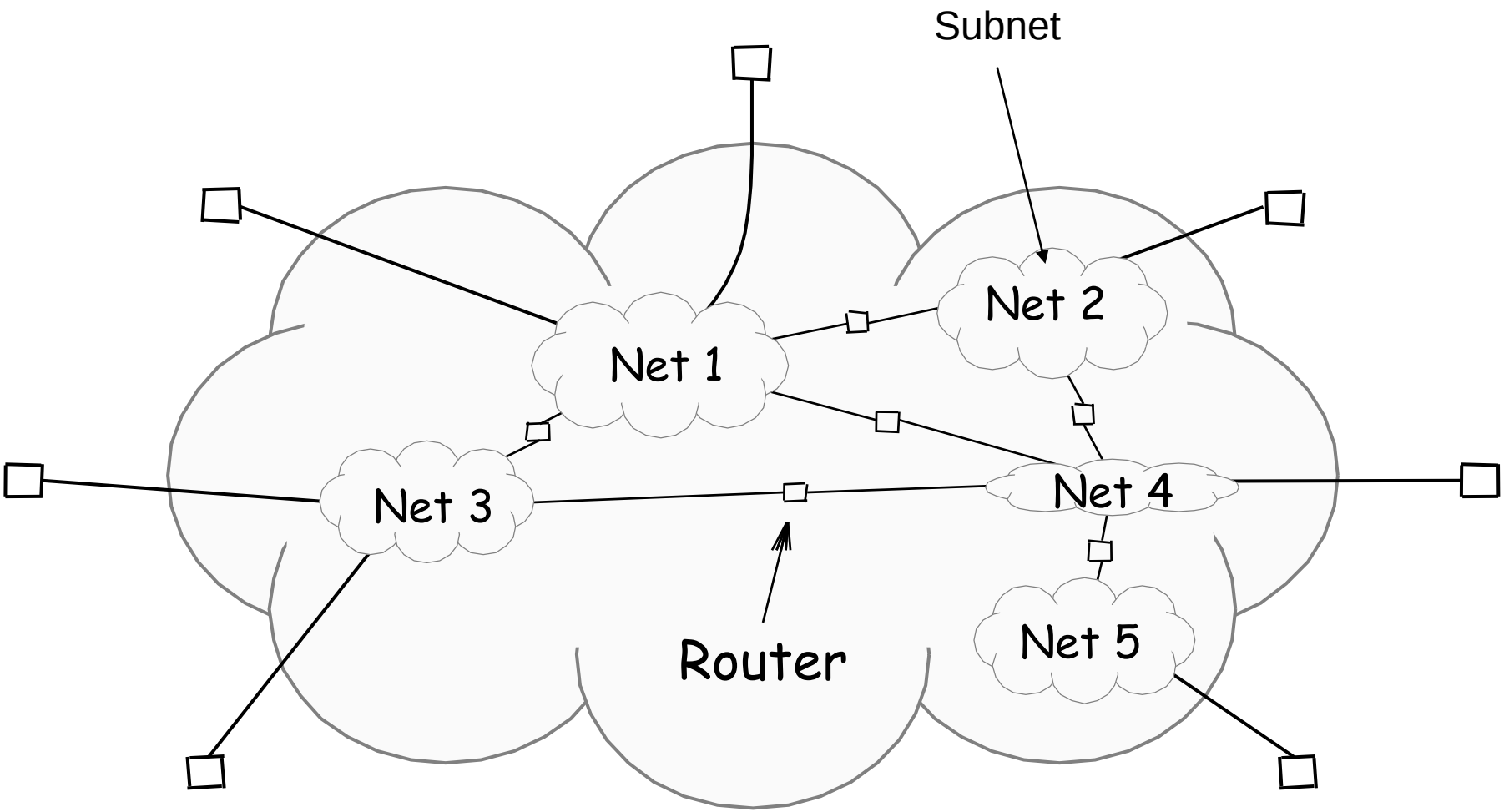
WAN that connects three branch offices in Australia

Wide Area Networks



WAN using a virtual private network.

Internetworks – The Internet



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The Internet

- Universities, companies, and other organisations, want to connect their computers together into a Wide Area Network
- Telephone lines, cables (copper, fibre optic) and radio links are used to connect LANs and subnets together
- Connecting networks together to form a network of networks is called an internet
- The largest (worldwide) internet is called the Internet (note capital)
- The number of computers on the Internet is greater than 7 billion
- Devices include vehicles, parking meters, vending machines, domestic appliances, etc! (Pervasive Computing)
- An intranet is just an internet which uses security mechanisms to restrict access to limited number of users (usually within single organisation)
- An extranet is an intranet to which an organisation's customers also have access

The Internet

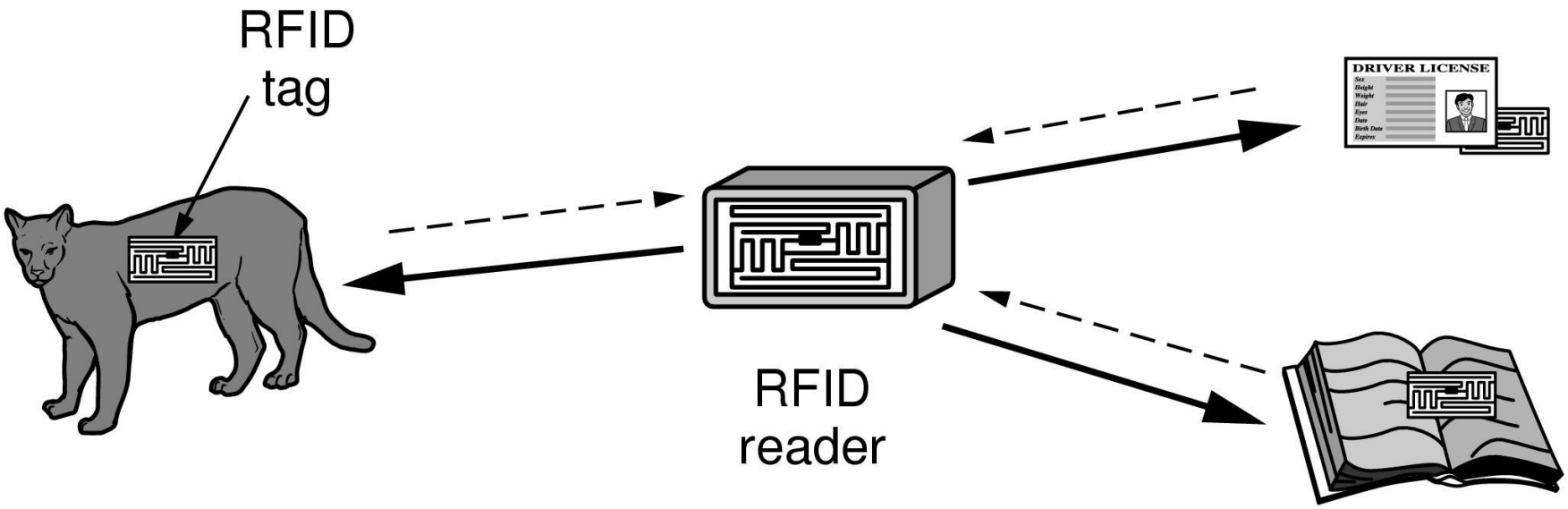
- The Internet is not the same as the World Wide Web
  - The Internet is an infrastructure that allows many different application programs to interact to provide services to users
  - The World Wide Web is just another service that uses The Internet
- The Internet (1969) existed before the World Wide Web (1992) and will probably outlive it
- The Web uses a lot of resources on The Internet, but that is still only the tip of the iceberg

The Internet

What happens when you access a page on the web?

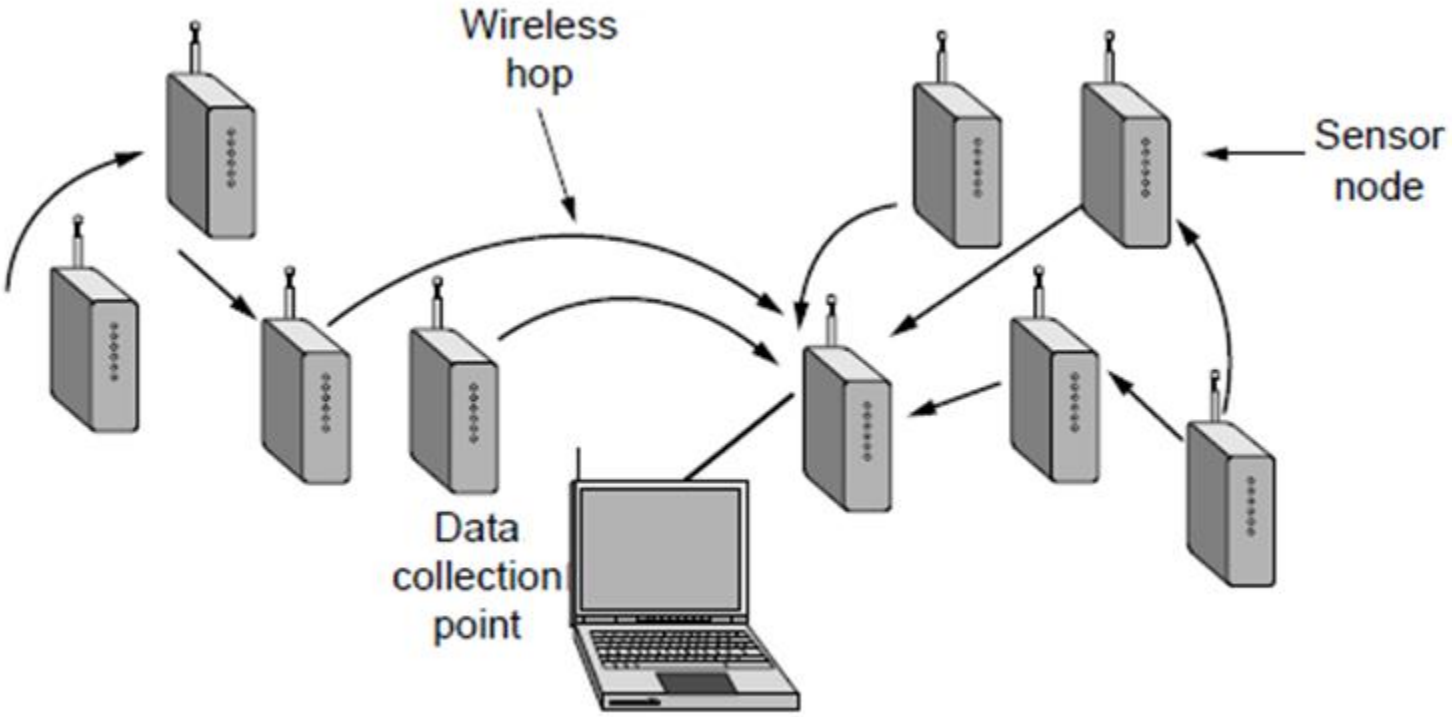
- Your computer contacts the local router through the LAN
- Your computer obtains the numerical address of the remote server where the web page resides. This involves sending a query out onto the Internet
- Your computer establishes a connection with the remote server
- Information is transferred to and from the server over a large number of links, routers and networks

RFID Networks



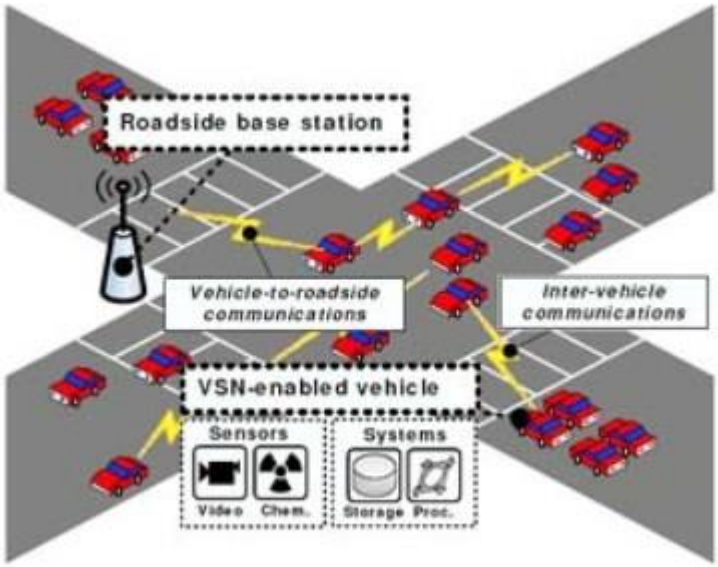
RFID used to network everyday objects.

Sensor Networks



Multihop topology of a sensor network

Sensor Networks



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Next

- What is a computer network?
- Network hardware
- Network software
  - Communication protocols
  - Connection-oriented and connectionless services
  - Protocol/service hierarchies
- Reference models

Communication protocols

- Communication protocols consist of a set of rules governing the interaction of processes in a network
- A protocol defines:
  - The service it provides
  - The assumptions about the environment where it executes, including the services it uses
  - The type and format of the messages (called frames or packets) used to implement it
  - The rules (algorithms) guarding the consistency of message exchanges and the integrity of the service provided

Connection-oriented service protocol: connection-oriented packet switching, also known as virtual circuit switching

- It works in a similar way to the telephone system
  1. Establish a connection ("Are you there?")
  2. Once the connection is established, use it for data transfer (push data in one end of the "wire" and take it out at the other)
  3. Release the connection (disconnect)
- Optionally, a reliable service with acknowledgement can be provided: data is always delivered and in the order sent

Connectionless service protocol: connectionless packet switching, also known as datagram switching;

- It is similar to the way that the postal system works
- There is no attempt to set up a connection
- Each message carries the full destination address
- Each message is routed through the network independent of all the others
- This is often called a datagram service
- Acknowledged datagram service is like registered post

Packet Switching: Datagram Approach

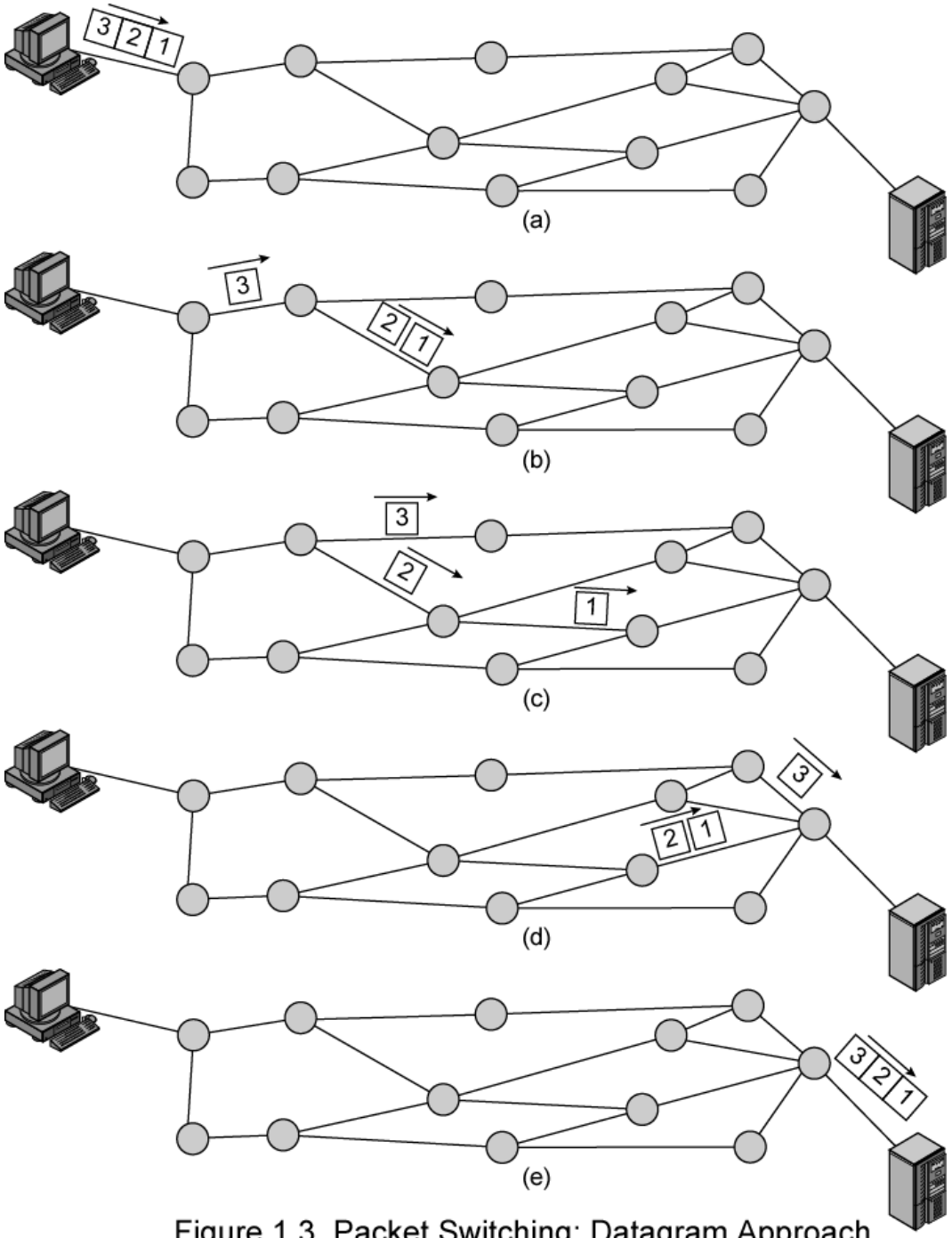


Figure 1.3 Packet Switching: Datagram Approach

Packet Switching: Virtual-Circuit Approach

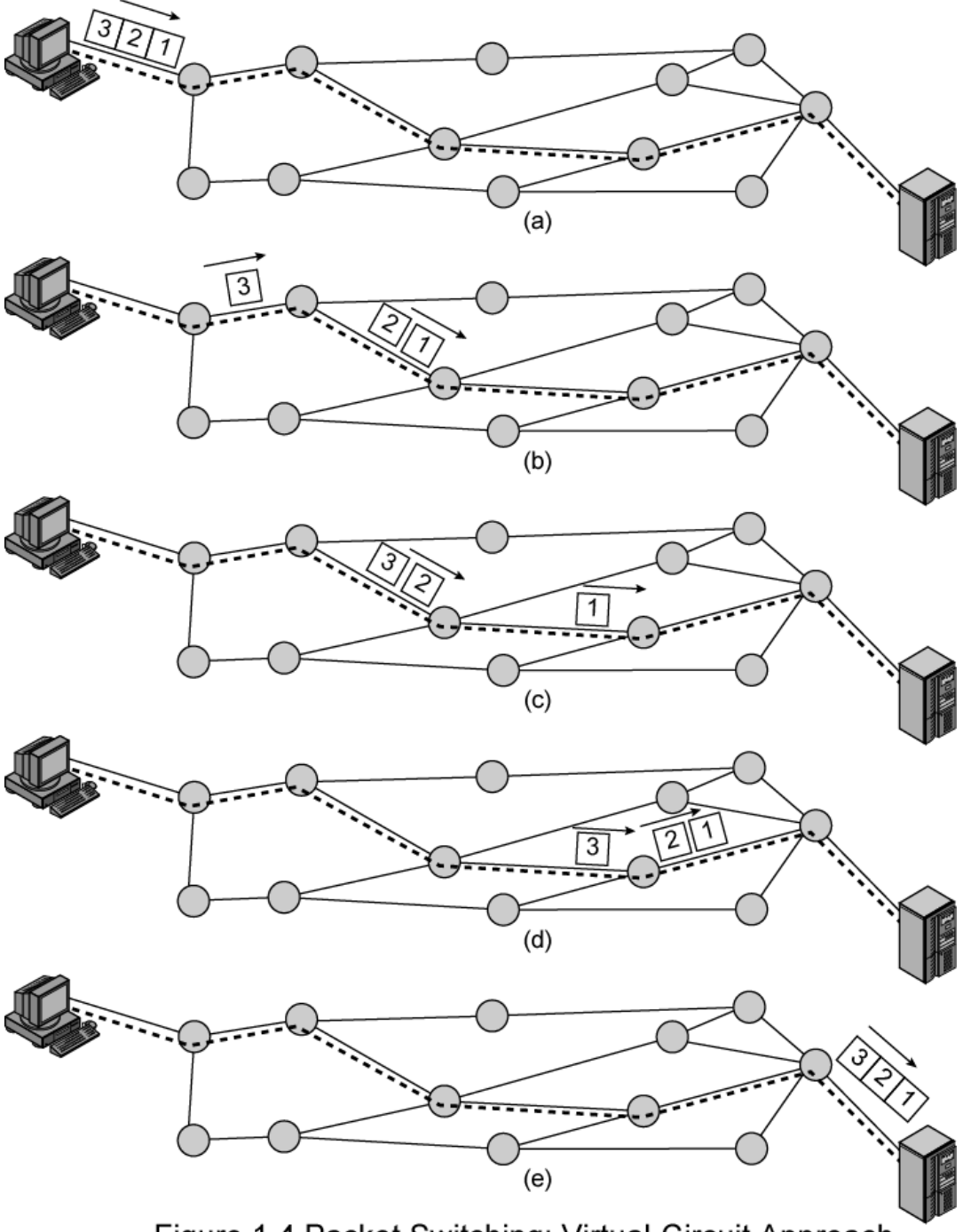
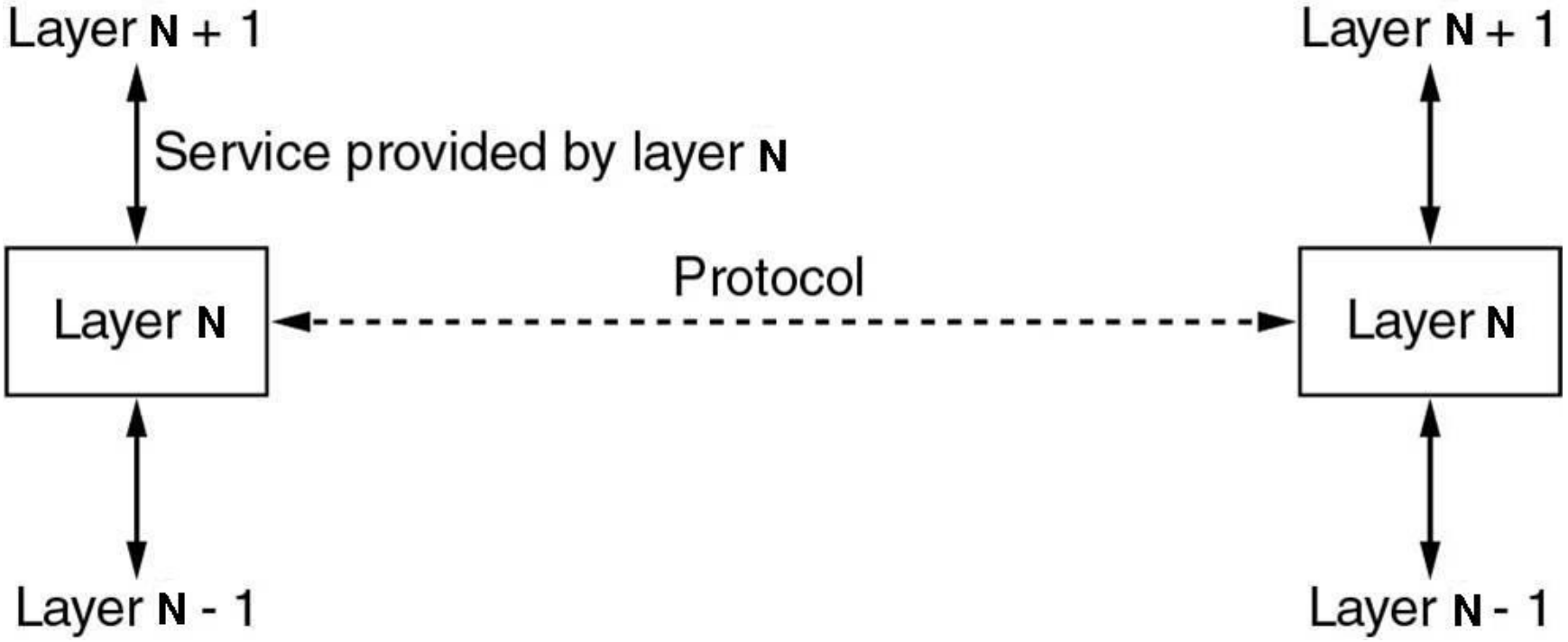


Figure 1.4 Packet Switching: Virtual-Circuit Approach

Protocol/service hierarchies

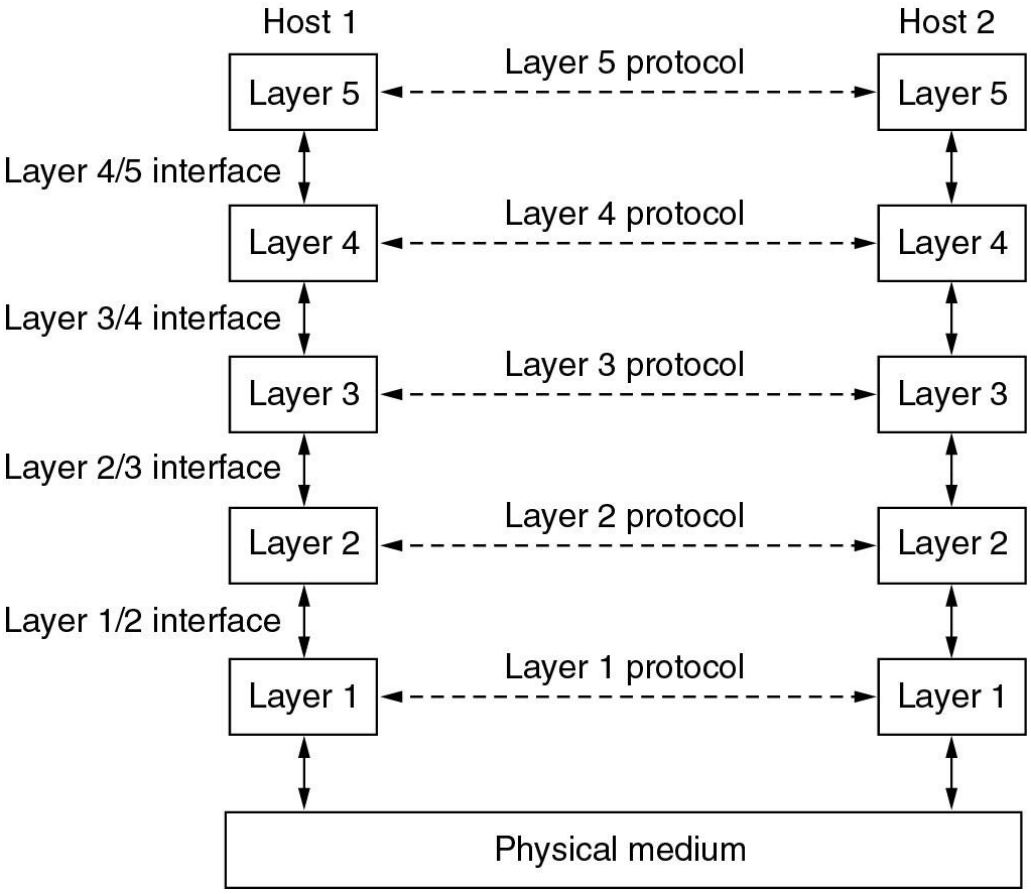
- Networks are organised as a series of layers, each one built on the one below it
- Each layer offers services to the upper layers, shielding them from the details how the services are actually implemented
- Layer N on one machine holds a conversation with layer N on another machine (called a peer). The rules and conventions are called protocols. Data is sent indirectly between the peers, by using the services of the lower layers

Protocol/service hierarchies



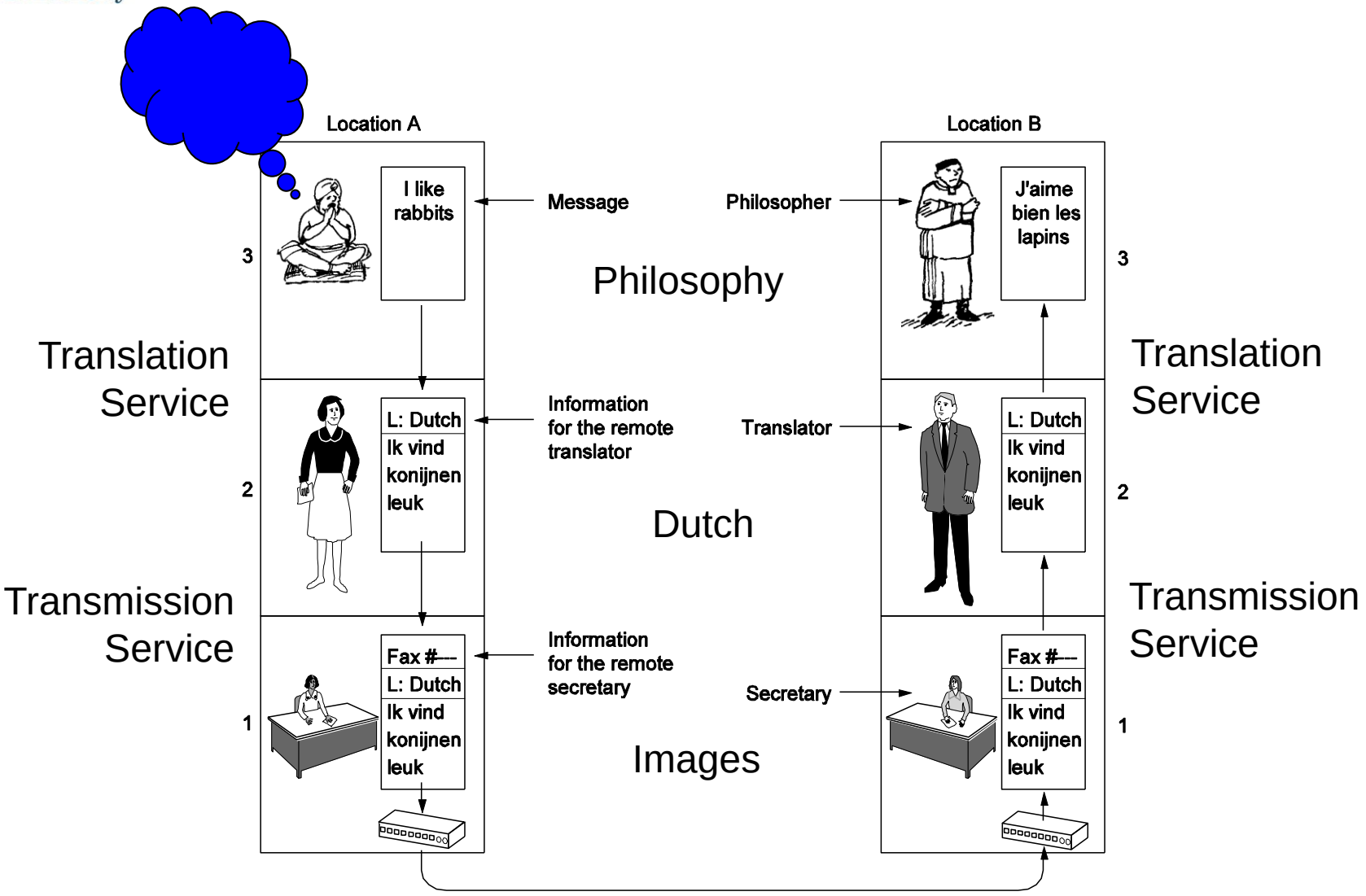
The relationship between a service and a protocol

Protocol/service hierarchies



Layers, protocols, and interfaces

Protocol/service hierarchies



The philosopher-translator-secretary architecture.

Encapsulated services (secretaries can't speak Dutch!)

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Next

- What is a computer network?
- Network hardware
- Network software
- Reference models
  - The OSI Reference Model
  - TCP/IP Reference Model

The OSI Reference Model

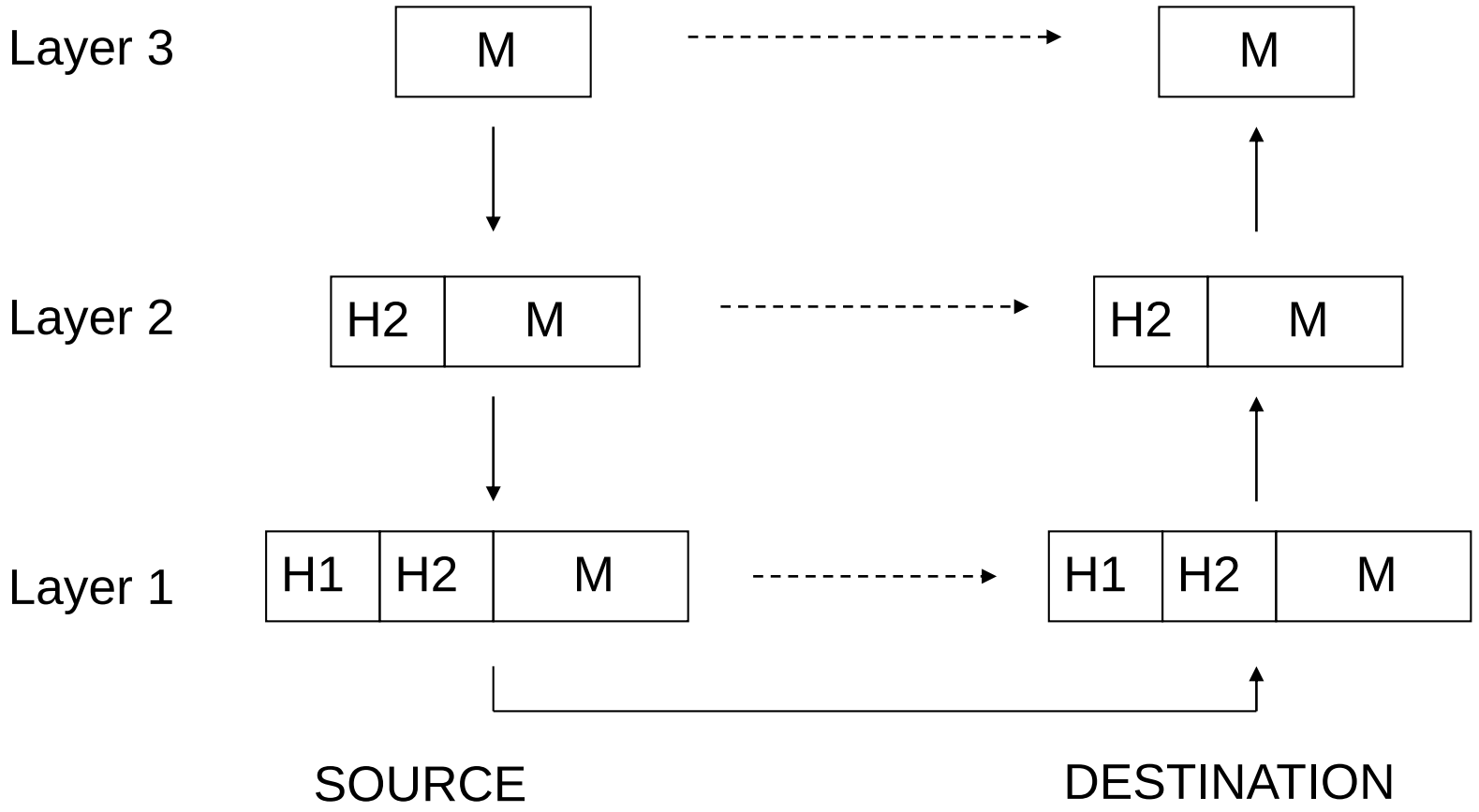
- ISO defined the Open Systems Interconnection model in the 1970's to help with the creation of interoperable network implementations
- They divided the problem of communication into 7 smaller and more manageable problems, by creating layers
- The lower three layers deal with the physical network while the upper four layers deal with applications

OSI terminology

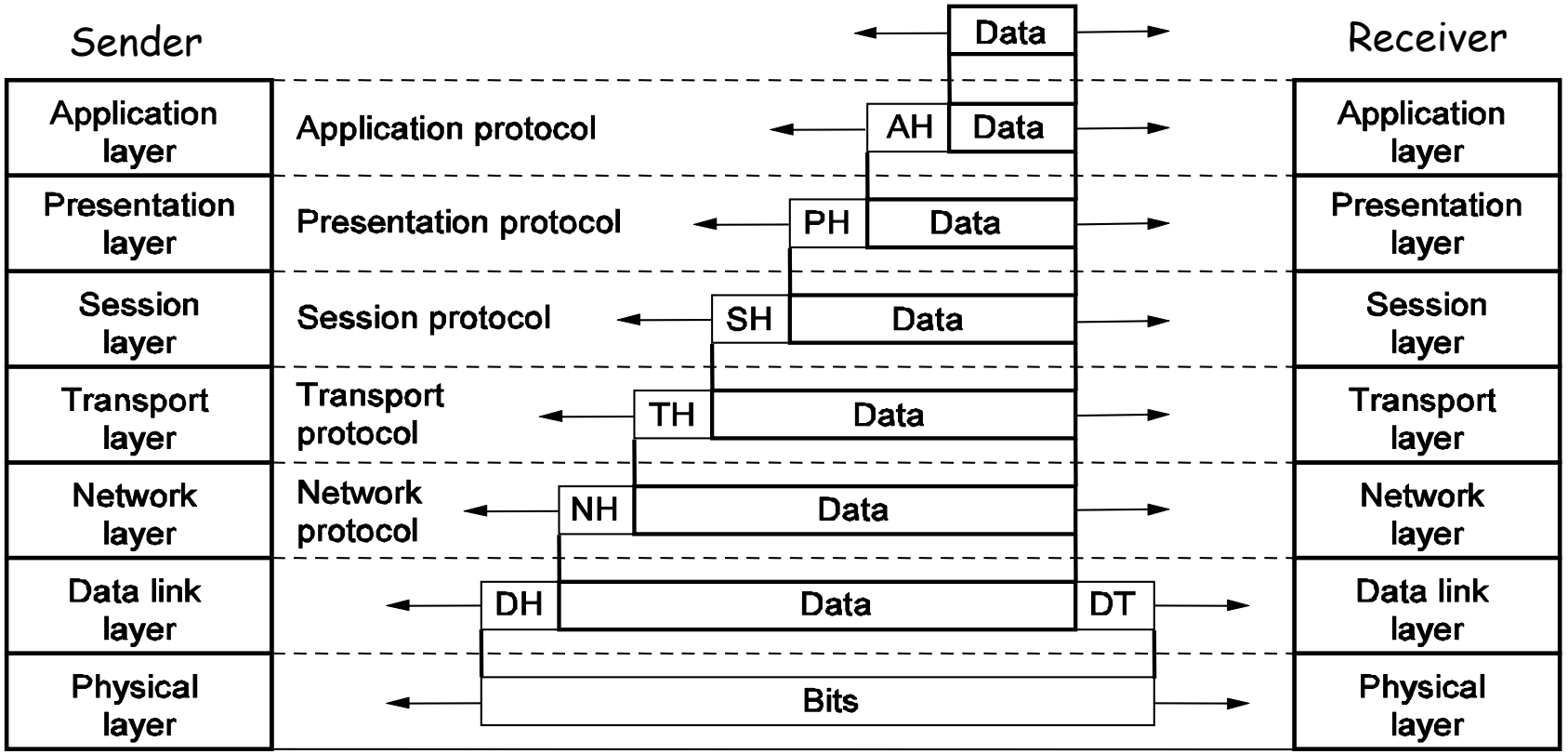
- Active elements in each layer are called **entities** (software or hardware)
- Entities in the same layer on different machines are called peer entities. They exchange Protocol Data Units (PDU)

OSI encapsulation

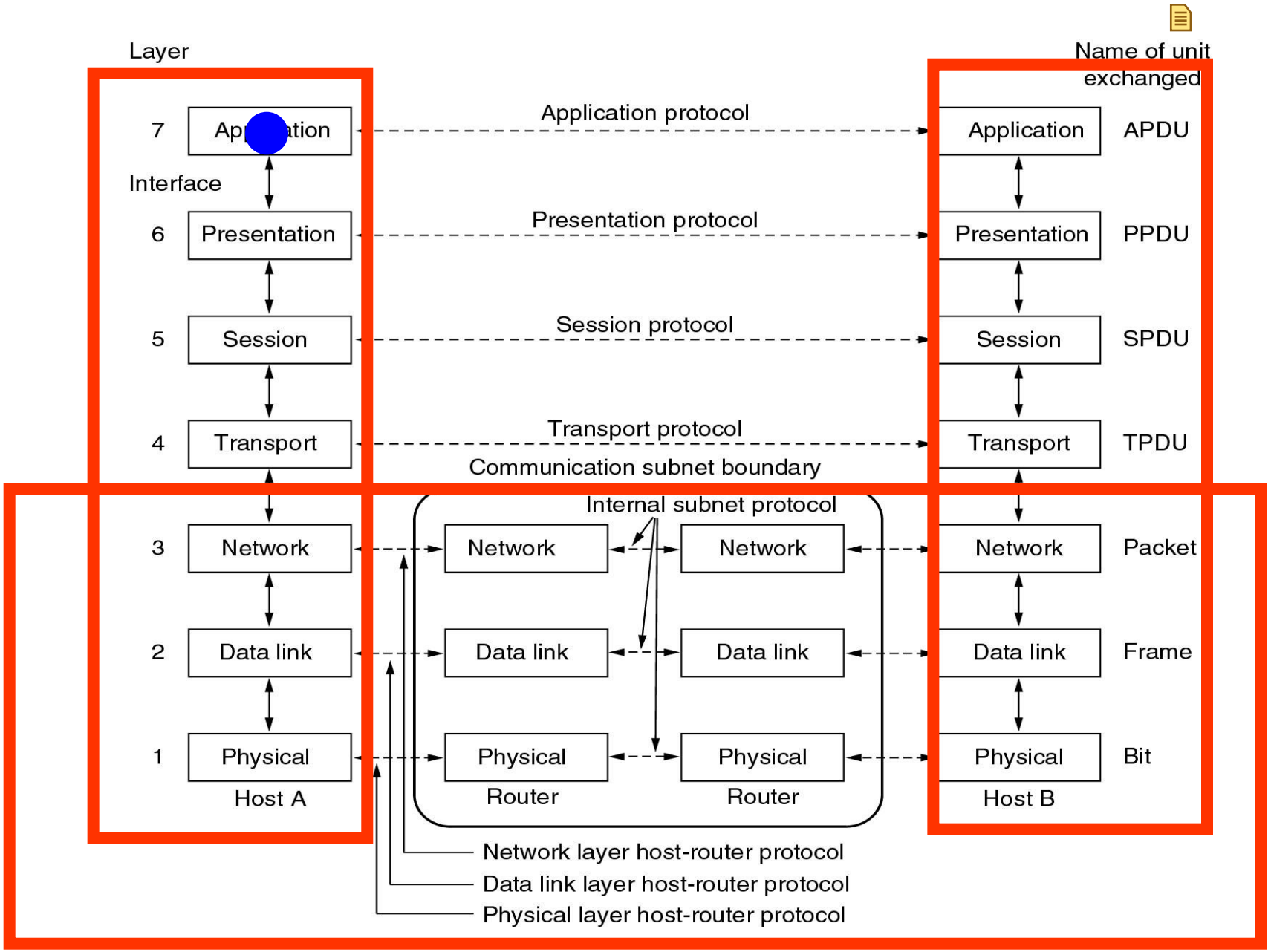
- As each data unit is passed down the layers, more headers are added
- As each data unit is passed up the layers, headers are removed



OSI encapsulation



The OSI Reference Model



OSI layer 1 – physical layer

- Layer 1 defines the electrical, mechanical, procedural, and functional specifications for:
  - activating the physical link between end systems
  - maintaining the physical link between end systems
  - deactivating the physical link between end systems
- It deals with:
  - voltage levels
  - timing of voltage signals
  - physical data rates
  - maximum transmission distances
  - physical connectors

OSI layer 2 – data link layer

- Layer 2 provides a data transmission service free of transmission errors between adjacent nodes using the physical layer
- It breaks data from the network layer into frames, transmits these sequentially to the other side and re-assembles. It must:
  - process acknowledgements
  - detect and recover from damaged, lost and duplicate frame problems
  - make sure the transmitter does not drown the receiver (flow control)
  - control the access to the medium in broadcast networks
    (MAC- Medium Access Control sublayer)

OSI layer 3 – network layer

- Layer 3 controls how a packet is routed from source to destination through a subnet. It must:
  - determine the route for each source/destination pair
  - perform congestion control (when there are too many messages in transit)
  - overcome the problem of interconnecting heterogeneous subnets (LANs and WANs, each with different protocols)

OSI layer 4 – transport layer

- Layer 4 is the real (lowest) end-to-end layer between source and destination applications
- It creates a distinct network connection for each transport connection
  - or creates multiple connections and divides the data among those connections to improve performance
  - or shares several transport connections onto the same network connection to reduce cost
- It provides end to end flow control (data link layer only deals with adjacent nodes)
- It provides end to end error detection and correction
- It may provide additional congestion control

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OSI layer 5 – session layer

- Token management
  - Who has access to shared resource?
- Data synchronisation
  - Where were we before the line went down?

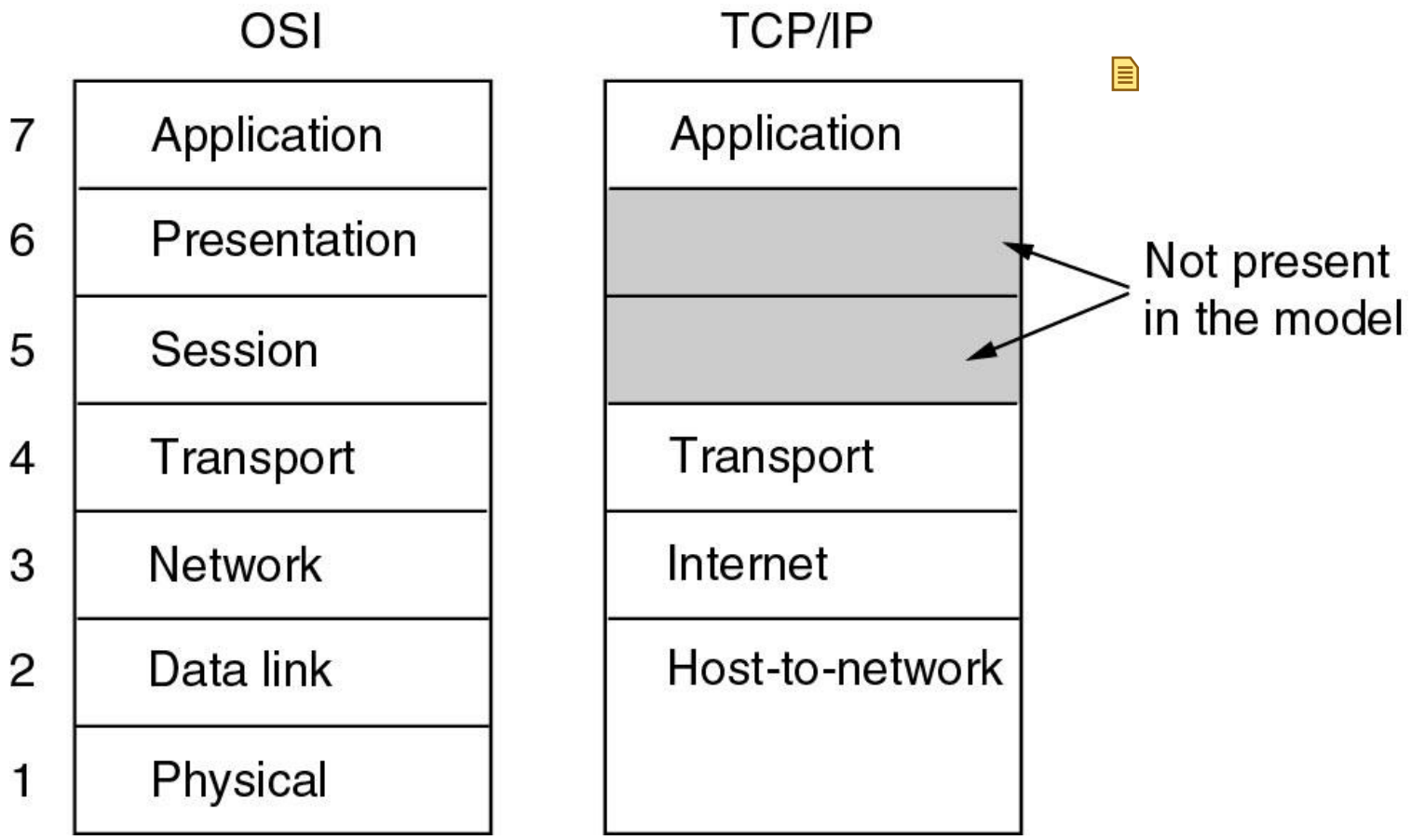
OSI layer 6 – presentation layer

- Concerned with syntax and semantics of data rather than it's transmission
- Provides common data abstractions to allow communication between heterogeneous computers

OSI layer 7 – application layer

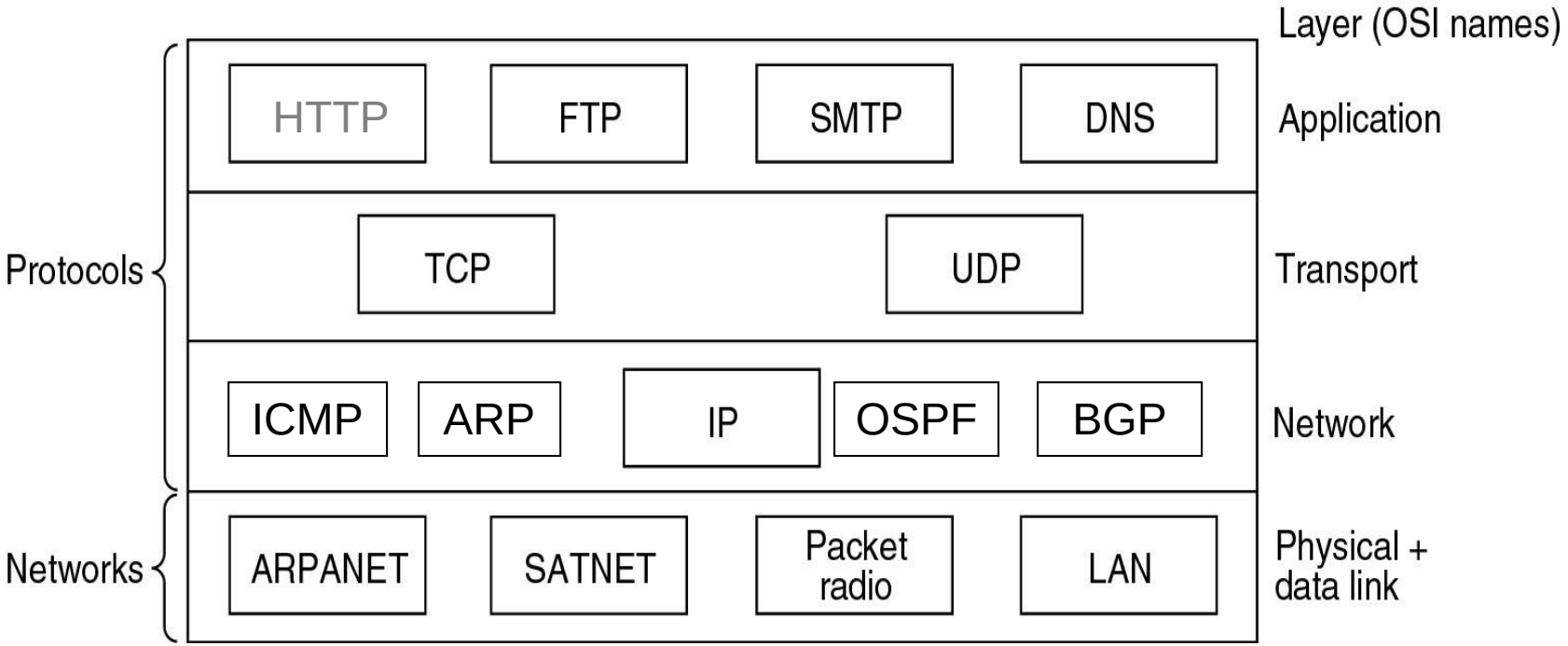
- This is where the applications reside:
  - Network virtual terminals (TELNET)
  - File transfer (FTP)
  - Electronic mail (SMTP)
  - Newsgroups (NNTP)
  - Web (HTTP)
  - Directory lookup (DNS)
  - Electronic commerce
  - Etc. etc.

The TCP/IP Reference Model



The main difference between OSI and TCP/IP is that the Presentation and Session layers are not used in TCP/IP

TCP/IP Protocols



Example Protocols and Networks in the TCP/IP model