Introduction to networking

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Educational Course on DICOM-RT

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Outline

- Computer network or distributed system
- Why are networks useful ?
- Client/server and peer-to-peer models
- Layers model (*network architecture*)
- TCP / IP
- How HTTP works ?

Computer network

- Collection of autonomous interconnected computers.
- Hardware with operating system, like Windows, Unix, MacOS, etc.
- Example : computers in a company
- *Internet is not exactly a computer network but a network of networks.*

Distributed system

- Collection of independent computers appearing to its users as a single coherent system.
- Software system built on top of a network.
- Example : World Wide Web

Why are networks useful ?

- Business applications
- Home applications
- Mobile users

Business applications

- Resource sharing
  e.g. shared printer, shared scanner, etc.
- Information sharing
  e.g. clients database, Medline, etc.
- Communication medium among people
  e.g. e-mail, videoconferencing, etc.
- E-business
  e.g. B2C, B2B, etc.

Home applications

Internet access

- Access to remote information
  e.g. online journals, newspapers, etc.
- Person-to-person communication
  e.g. e-mail, chat, etc.
- Interactive entertainment
  e.g. video on demand, game playing, etc.
- E-commerce
  e.g. e-shopping, e-banking, etc.

Mobile users

- Mobile people using notebook computers.
- Portable office, like e-mail, access remote files, log on to remote machines, etc.
- Mobile phones with WAP (*Wireless Application Protocol*) system.
- Portable payment system for credit cards.
- M-commerce (*mobile commerce*).

Client-server model

- A server is a powerful computer containing data. It is housed and maintained by a system administrator.
- A client is a common computer used to access remote data.
- Clients and servers are connected by a network.

Client-server model

- The client sends a request over the network to the server.
- The server gets the request, does the job and sends back a reply.
- Example : access a page on the Web
  - Server : remote Web server
  - Client : Web browser

Peer-to-peer model

- Every person can communicate with one or more other people.
- Example : Napster for music exchange
  - Members registered their songs lists in Napster database.
  - Users checked Napster database to find out who had the requested song and then got it directly from there.
  - *Napster was shot down because it infringed copyright.*

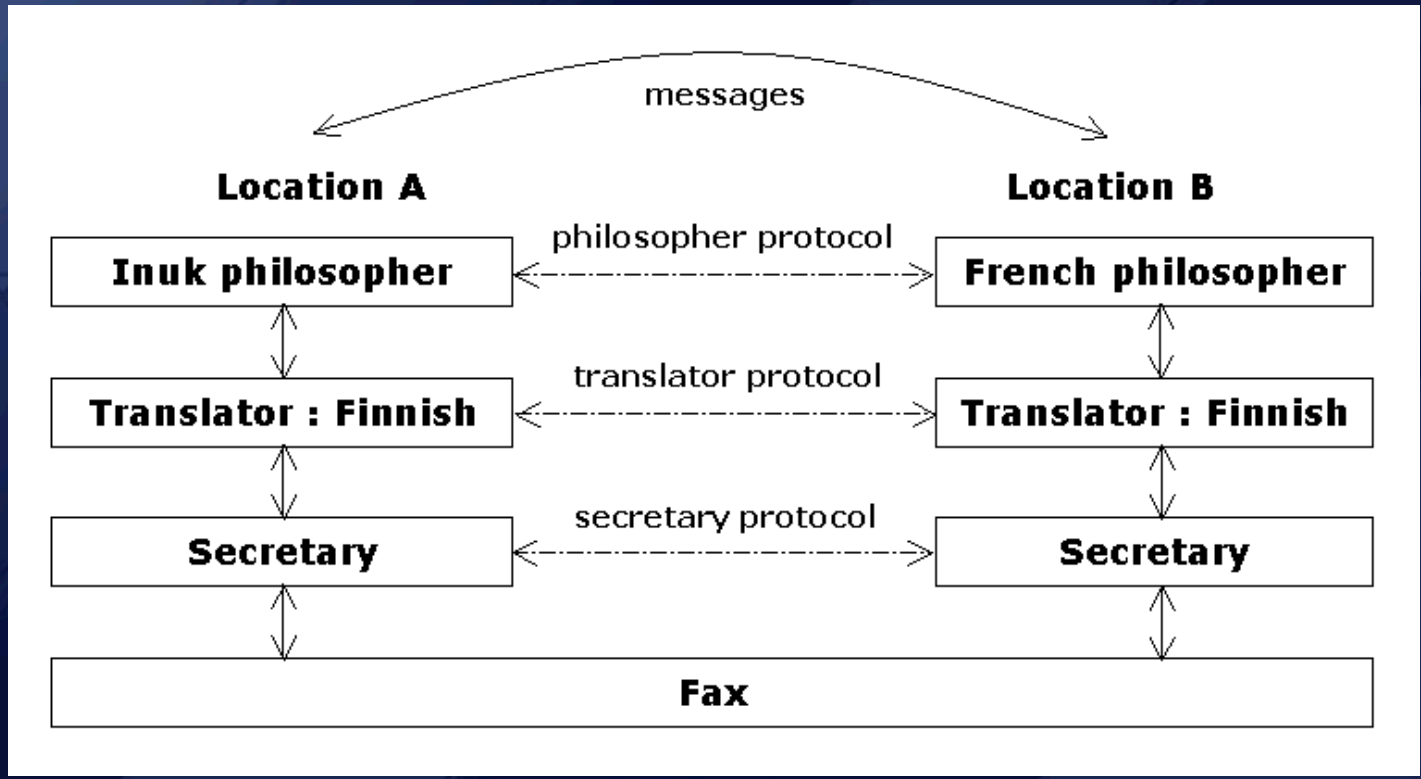
Use of computer networks

- Monolithic view : one single huge program to manage all communications.
  - Hard to create
  - Too complex to be maintained
  - Too many different programs
- Structured view : using different layers to manage all communications.
  - General idea : *divide and conquer*

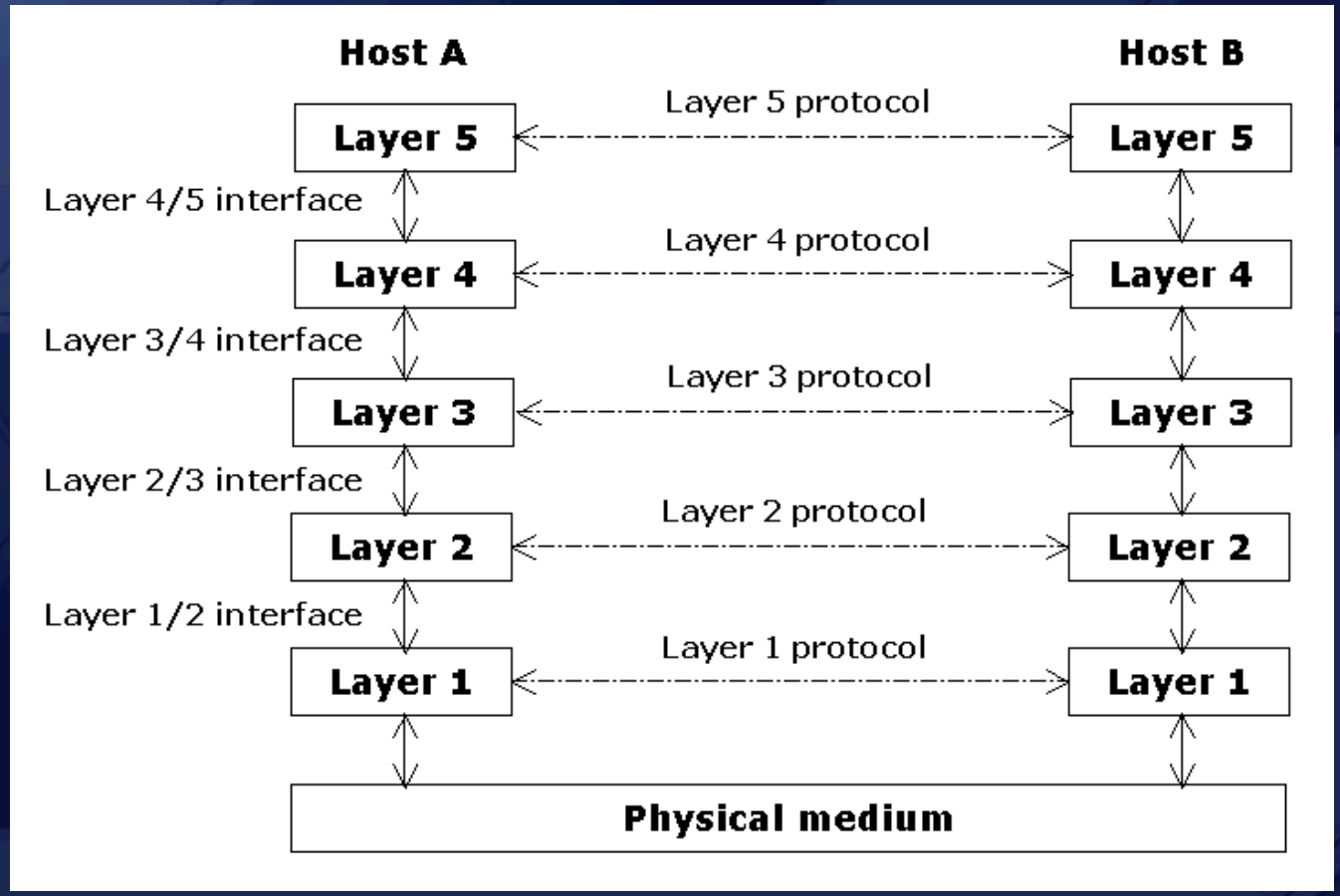
Layers model

- Networks are organized as a stack of levels or layers (network architecture).
- Each layer offers certain services to the upper layer.
- The layer *n* on host A communicates with the layer *n* on host B using the layer *n* protocol.
- A protocol is an agreement between communicating parties on how communication is to proceed.

Example


messages
Location A
Location B
philosopher protocol
Inuk philosopher
French philosopher
translator protocol
Translator : Finnish
Translator : Finnish
secretary protocol
Secretary
Secretary
Fax

Layers model



TCP / IP

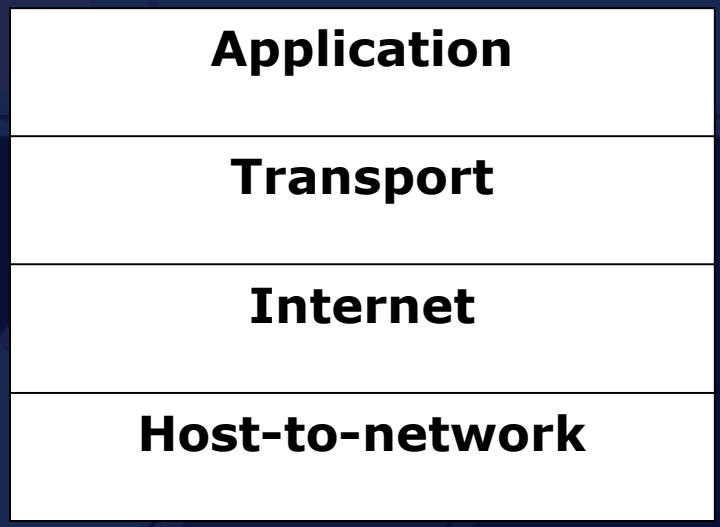
- ARPANET (*Advanced Research Projects Agency Network*) was a research network sponsored by the DoD (*U.S. Department of Defence*), 21/11/1969 UCLA-Stanford.
- It became TCP / IP (*Transmission Control Protocol / Internet Protocol*) Reference Model in 1974.
- ARPANET used TCP / IP on 1/1/1983.

TCP / IP

The main goals were

- Ability to connect multiple and heterogeneous computers and networks.
- Ability to survive loss of subnet hardware.

TCP / IP layer model



Host-to-network layer

- Main service : transfer data on physical medium
- LAN (*Local Area Network*)
- Ethernet is one implementation (R. Metcalfe, 1973, Xerox)

Internet layer

- Main service : packet routing
- Permit packets to be sent into any network (*IP over everything*)
- IP (*Internet Protocol*) is the official packet format and protocol

Internet Protocol

- An IP number (also called IP address) identifies a machine on the network.
- A machine may host several applications. Each application is accessible via a communication port.
- To send data to an application running on a specific machine, the IP number and the application port number are required.
- A socket is a pair <IP number, port number>

Transport layer

- Main services : rearrange packets in original order and error control
- TCP (*Transmission Control Protocol*) is a reliable connection-oriented protocol

Application layer

- Main service : user applications
- High-level protocols
  - FTP (*File Transfer Protocol*)
  - HTTP (*HyperText Transfer Protocol*)
  - SMTP (*Simple Mail Transfer Protocol*)
  - Etc.

HTTP

- The Web (*World Wide Web or www*) was invented at CERN in 1989.
- The Web is a huge distributed system with millions of clients and servers based on a simple interface (NCSA Mosaic 1993).
- HTTP (*HyperText Transfer Protocol*) is a protocol for fetching pages on the Web.

How HTTP works ?

- The URL (*Uniform Resource Locator*) http://www.unine.ch is typed in the browser.
- Ann would like to call Bob but doesn't know his phone number.
- The browser asks the DNS (*Domain Name Service*) for the IP address.
- Ann calls the directory service (111) to ask for Bob's phone number.

How HTTP works ?

- The DNS replies with 130.125.1.11
- The directory service replies with +41 32 718 00 00
- The browser makes a TCP connection to port 80 on 130.125.1.11
- Ann dials the +41 32 718 00 00

How HTTP works ?

- The browser asks for file /console.asp
- Ann says « Hello Bob, are you coming for dinner tonight ? »
- The www.unine.ch server sends the file /console.asp
- Bob answers « Hi Ann, yes, I'm coming. »

How HTTP works ?

- The TCP connection is released.
- When the conversation is over, Ann and Bob hang up and the connection is released.
- The browser displays the received Web page.

Conclusion

- TCP / IP will remain the standard for WAN (*Wide Area Network*).
- Mobile and wireless (for LAN ?)
- Security is still a major issue
- Metcalfe's law : utility of a network
  Utility (N) = N^2 , N = number of users

More on this topic ?

- Computer Networks,
  A. Tanenbaum, Prentice Hall, 2003
- Data and Computer Communications,
  W. Stallings, Prentice Hall, 2003
- http://www.vitels.ch/
- http://courses.cs.vt.edu/~cs4254/
- http://courses.cs.vt.edu/~cs5516/