Computer networks, data communication and Internet

Introduction

Computer networks: summary

The following gives an overview of computer networks and data communication:
- The basic principles
- Local area networks
- National computers networks
- International computer networks
- The Internet
- Future impact of digital communication networks
Computer networks: prerequisites

Before using computer networks, you should ideally have some knowledge and skills related to

- computer hardware
- computer software

Data communication: a definition

- Interpersonal communication
  » Telecommunication
    - Broadcast
    - Telephone
    - Data communication
      - Remote login
      - File transfer
      - Hypertext transfer
      - Electronic mail
Data communication: various views

User
(Applications)

Sociologist
(Sociological aspects)

Database producer
(Information)

Engineer
(Techniques)

Data communication: which types of ‘data’?

Linear text
Hypertext

Sound

Static images
Video

Multimedia / Hypermedia

Programs for computers

Digital information
Telecommunication: digital versus analogue

- Morse: digital
- Telephone: analogue (or digital)
- Data communication: digital

Data communication: which types of ‘data’?

- The same types of data (information) that can be stored and managed on a computer can be transferred over computer networks to one or several other computers.
- So the networks form an important extension of the stand-alone computers.
- “The network is the computer”
Data communication: applications  (Part 1)

- Hard-copy transfer (Fax)
- Online use of the processing power of a remote computer
- Online access to information sources!
  » library catalogues,
  » bookshop catalogues,
  » publisher’s catalogues,
  » campus-wide and community information systems,
  » (text or multimedia) databases,
  » network-based journals, ...

Data communication: applications  (Part 2)

- Software-downloading
- Electronic mail from a person to one or several persons
- Computer-network based interest groups
- Online talking / chatting (IRC,...)
- Video conferencing (Cu-seeme, ...)
- Selling, shopping, buying,...
- ...
Computer network applications: information and communication

1-way = information transfer = almost no interaction
- publications by e-mail / Internet radio
- file transfer
- (gopher) / core WWW based on http and static html pages
- network services based on databases (input or searches)
- e-mail communication / Usenet News
- chat / telephony / video conferencing

N-way = communication = highly interactive

Computer networks: an analogy

Traditional Networks
- Letter
- Envelope
- Mail-box
- Post office
- Roads
- Hypermedia
- Protocol
- Client
- Server
- Networks
**--Example**

**Computer network applications related to journalism**

- Journalists search for information online.
- Publishers make the products of the journalists available online.
- Journalists communicate with their readers by electronic mail.
- ...

***

**Data communication: problems, difficulties, limitations**

- Low transfer speed
- Technical complexity
Data communication: maximum transfer rate over dial-up lines

bits/s = bps


0 100 100 300 300 1200 2400 28800

?? Question ??

What is the maximum speed of a modern modem?
Standards for asynchronous communication over dial-up lines

<table>
<thead>
<tr>
<th>Maximum transmission speed (in bps = bits / second)</th>
<th>Standard by the CCITT</th>
<th>Year of release</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>300</td>
<td>V21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 200</td>
<td>V22</td>
<td>1995</td>
<td></td>
</tr>
<tr>
<td>2 400</td>
<td>V22bis</td>
<td>1996</td>
<td>Made slower standards obsolete</td>
</tr>
<tr>
<td>9 600</td>
<td>V32</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14 400</td>
<td>V32bis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>28 800</td>
<td>V34</td>
<td></td>
<td></td>
</tr>
<tr>
<td>33 600</td>
<td>V34 plus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>56 000</td>
<td>V56</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Data communication: modems

- description: MODulator-DEModulator: device to convert digital data signals into a suitable form for transmission along a telecommunications channel, and to convert them back upon receipt into machine readable form.
- types
  - (Acoustic coupler)
  - Free standing box
  - Board/card to plug-in microcomputer
Data communication: transmission modes

- **Simplex**
  Transmission in one way only

- **Half duplex**
  Transmission in both directions, but not at the same time

- **Full duplex**
  Transmission in both directions at the same time

?? Question ??

How long takes the transfer of the contents of a 200 page unformatted ASCII text document (like the text of a book for instance) using data communication through the classical voice telecommunication network with a modern modem?

How did you estimate/calculate this value?
How many characters (on average) could be received when transfer speeds were maximum 300 bits/s, 28 800 bits/s? Could the user read the incoming words well?

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Data-communication: Hard-copy transfer / Fax
Data communication: trade offs

<table>
<thead>
<tr>
<th>Cost</th>
<th>Speed</th>
<th>Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LAN</strong></td>
<td>High volume</td>
<td>(high cost)</td>
</tr>
<tr>
<td>(short distance)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Dial-up/PAD</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(low speed)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Computer network protocols: definition

- When 2 computer systems communicate via network, they do that by exchanging messages.
- The structure of network messages varies from network to network.
- Thus the message structure in a particular network is agreed upon a priori and is described in a set of rules, each defined in a protocol.
Computer network protocols: Open Systems Interconnection

The evolving international standard under development at ISO (International Standards Organization) for the interconnection of cooperative computer systems. An open system is one that conforms to OSI standards in its communications with other systems.
A local area computer network: scheme

Data communication with a server in a Local Area Network

- (Terminal)
- Microcomputer with serial line communications software / terminal emulation software
- Microcomputer with network card and network software
Which applications do you know of server computers in a Local Area Network (=LAN)?

Applications of server computers in a LAN

• Extra personal disk space for the users  
• Common files with programs and/or data for many users (e.g. an intranet)  
• Making files available from the institute to external users over the Internet (e.g. using ftp, gopher, or http/WWW!)  
• Executing programs on a server in the LAN (e.g. using Unix or Windows NT or Windows 2000, in multi-tasking / multi-user mode)  
• Electronic mail servers; Usenet servers;...
?? Question ??

Do you have access to a LAN in your organisation / institute / school / university?

?? Question ??

Do you have personal disk space available, through the LAN of your institute?
LAN software packages for homogeneous networks: examples

- Intel compatible processors:
  - LANtastic,
  - Novell,
  - Windows for Workgroups,
    - Windows 95, Windows 98, Windows ME,
    - Windows 2000, Windows XP...
  -...
- Apple, ...

LAN software packages for heterogeneous networks: examples

Based on TCP/IP (protocol suite used in Internet)

- For DOS:
  - NCSA (= National Center for Supercomputing Applications)
    - CUTCP, PC/NFS,...
- For Windows 3.x:
  - PC/NFS, PC/TCP, Trumpet TCP Manager,...
- For Windows 95, 98,...: included!
- For Windows NT, 2000,...: included!
?? Question ??

Which basic network software can you use in your institute?

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Computer networks, data communication and Internet

Packet switching
Packet switching in data communication networks: definition

- Communication is not through a continuous stream of bits, but in small packets.

- Routing, the followed route, may change during communication session.

Packet switching in data communication networks: scheme

[Diagram showing network connections and routing]

= Computer = "Packet Switching Exchange"
Packet switching in communications: advantages

- Economic usage/exploitation of existing communication lines in the network, resulting in
  » less network congestion
  » higher data communication speed
  » lower cost
- Less risk of interruptions due to breaks in a link of 2 nodes = higher reliability = less vulnerable
- Possibility of error correction of individual packets
Packet switching protocols: examples

- TCP/IP in the Internet
- X-25 in OSI networks
- ...

The X.25 data communication protocol

- protocol for packet switching in data network
- an alternative to dial-up over voice telephone lines with modems
- available in several “flavours”:
  » direct X.25 trunk connects over leased lines
  » through “PAD” interfaces
  » by ordinary dial-up modem access to X.25 “ports”
X.25 versus phone + modem for data communication

Whether you use X.25 or phone plus modem depends on a number of factors; usually the determining factor is cost.

» In North America, using a high speed modem over a telephone line tends to be less expensive.

» In Europe, the phone system structure usually makes X.25 more cost-effective.

Computer networks, data communication and Internet

National Wide Area Networks
National Wide Area Networks

- Public access national packet switching networks
- Research computer networks
- Public access made available by Internet Service Providers
- ...

---Examples

National public access computer networks: examples

- Belgium: DCS (Data Communication Service)
- Nederland: Datanet
- United Kingdom: PSS (Packet Switching Service)
- France: Transpac
- ...

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National research computer networks: examples

- Belgium: BELNET
- Finland: FUNET
- Germany: DFN
- The Netherlands: Surfnet
- United Kingdom: JANET (Joint Academic Network)
- ...

Computer networks, data communication and Internet

International computer networks
International computer networks: examples

- National public data communication networks linked together
- FidoNet
- Bitnet / EARN
- Usenet
- Internet!
- ...
Computer networks, data communication and Internet

The Internet data communication network

?? Question ??

What is the Internet?
The Internet data communications network (Part 1)

- “Internet” is not well-defined.

- A network of smaller networks:
  The global collection of interconnected local area, regional and wide-area (national backbone) networks which use the TCP/IP suite of data communication protocols.

The Internet data communications network (Part 2)

- Links computers of various types.

- Is constantly growing.

- The analogy of a superhighway has been used to describe the emerging system of networked computers.

- The Internet has no owner, and is not managed by one organization.
!! Task - Assignment !!

Learn from the following training materials:
Module 5: The Internet as an information resource.
Lesson 1: How the Internet works [online]
Available from:
http://www2.unescobkk.org/elib/publications/ictlip/module5/
[cited 2005]

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The Internet:
access from your Local Area Network

Your microcomputer

Local Area Network (LAN)

One of the national networks

The global Internet
Host computers in the Internet: definition

- A host (computer) is a domain name that has a unique IP address record associated with it.
- Could be any computer connected to the Internet by any means.
- For instance: www.vub.ac.be

Data communication layer architecture
Internet data communication layers and protocols (Part 1)

**USER**

*Application programs*, using application protocols such as smtp, pop, imap, nntp, telnet, ftp, gopher, http...

TCP = host to host transfer control protocol

IP = Internet protocol

different physical nets

Internet data communication layers and protocols (Part 2)

**USER**

Client

Computer

Client application programs

*Application protocols*

TCP

IP

different physical nets

Server

Computer

Server application programs

*Application protocols*

TCP

IP

different physical nets
**Question**

Why are most models/architectures for data communication networks named “layer models/architectures”?

**Question**

Which advantages are offered by a layer architecture in a computer system?
Give some examples of layer = onion skin architectures/models in the area of information and communication technology, and describe each layer briefly.

Transmission Control Protocol / Internet Protocol (TCP/IP)

- the main suite of transport protocols used on the Internet for connectivity and transmission of data across heterogeneous systems
- “glue that holds the Internet together”
- an open standard
- available on most Unix systems, VMS and other minicomputer systems, many mainframe and supercomputing systems and some microcomputer and PC systems
TCP/IP hardware

The most common hardware system/solution used for actual physical connections using TCP/IP in a Local Area Network is Ethernet, but TCP/IP will also run on Token-Ring, serial lines (modems, serial connections) and other systems as well.

!! Task - Assignment !!

You can learn the basics of digital data communication by looking at the video movie “Warriors of the net” [online]

Available free of charge from: http://www.warriorsofthe.net/movie.html [cited 2005]
TCP/IP:
Serial Line Internet Protocol (SLIP)

- SLIP is a standard on the Internet for RS232 serial line and modem connectivity between two systems. This allows any one SLIP client to connect to a SLIP server to provide connectivity between different IP hosts.

- Both systems must have TCP/IP stacks running.

- SLIP packages are available for PC systems.

TCP/IP:
Point to Point Protocol (PPP)

- successor to SLIP

- built in operating system software Windows 95,…
Internet application protocols / services based on the Internet (1)

- telnet: protocol for remote terminal login
- ftp: file transfer protocol
- gopher: communication using gopher menus
- WAIS, Z39.50 for database searching
- http: hypertext transfer protocol (WWW)

Internet application protocols / services based on the Internet (2)

- smtp: simple mail transfer protocol (e-mail) to send messages
- pop: post office protocol (e-mail) to read e-mail messages
- imap: another protocol for reading e-mail messages
- nntp: network news transfer protocol in Usenet
- ...
Internet: addresses of computers with the Domain Name System

- Internet style = Domain name system
- The Internet naming scheme consists of a hierarchical sequence of names from the most specific to the most general (left to right), separated by dots.
  - computer.subdomain.domain.(country if not USA) OR
  - n1.n2.n3.n4
    - where n is a natural number (8-bit)

***Examples

The Internet Domain Name System
DNS: examples

- Belgium:
  - ftp.vub.ac.be
  - www.vub.ac.be
- U.S.A.:
  - dialog.com
  - ftp.cs.widener.edu
Internet domain names in the United States

Most Internet sites in the US, Canada and US overseas installations follow a breakdown into six generic domains:

» EDU: educational sites, such as universities
» COM: commercial sites, generally large corporations
» GOV: non-military government sites
» MIL: military installations
» ORG: non-commercial, non-network sites and gateways
» NET: other networks to which e-mail must traverse a gateway

!! Task - Assignment !!

Read
Brain, Marshall
How domain name servers work. [online]
Available from:
http://computer.howstuffworks.com/dns.htm
[cited 2005]
Internet: growth in number of hosts worldwide: linear plot

January of each year

Internet: number of hosts 1991-1997
(plot downloaded from the net)

Source: http://www.nw.com
Internet: number of hosts 1994-1998
(plot downloaded from the net)

New survey data
Adjusted old survey data

Source data: M. Lottor
Network Wizards
<www.nw.com>

Internet: the basic methods to connect
(Part 1)

• **Method 1:** Connect your computer to
  » the LAN of your institute, that includes a server computer
    connected to an Internet Service Provider, or
  » an Internet Service Provider, using a a cable modem + a
    public cable network

• **Method 2:** Dial from your computer into an external
  Internet Service Provider,
  using a modem + the public voice telephone network

• (Method 3: Connect your computer to an external Internet
  host that provides Internet services.)
Internet: the basic methods to connect (Part 2)

Method 1: full-time Internet host

Method 2: part-time Internet host

(Method 3: using another Internet host)

Internet: TCP/IP in the basic methods to connect

Method 1: TCP/IP between your computer and the rest of the Internet, at high speed.

Method 2: TCP/IP between your computer and the rest of the Internet, but speed limited by the modem and the telephone network

(Method 3: TCP/IP between the Internet host you connect to and the rest of the Internet, but not between your computer and that Internet host.)
Internet: trade offs in the basic methods to connect

- **Cost**
- **User interface**
- **Speed**
- **Direct access**
- **(SLIP or) PPP**
- **Shell-account on a server**

**Task - Assignment**

You can learn the basics of Internet online starting from [http://www.bbc.co.uk/webwise/course/coursemenu.shtml](http://www.bbc.co.uk/webwise/course/coursemenu.shtml)
**Question**

A way of describing the Internet is (select 1):
1. A network of computers in an office, building or company
2. An alternative to the telephone directory
3. A network of networks of computers that can "talk" to each other
4. An interconnected mess of computer cables

**Question**

Who's in charge of the Internet?
1. Bill Gates
2. No-one
3. The US senate
4. The World-Wide Web
The Internet is commonly referred to as (select 1):
1. The Hard Drive
2. The Net
3. The Waste of Time
4. The Web

Internet Service Provider = ISP

Internet Service Providers provide their clients access to Internet + in many cases
- an email address / server
- space for a web site
- software tools to start
- training
- technical support
- an accessible location for a WWW site of the client
- assistance with WWW site design and promotion
**Question**

What is an Internet Service Provider or ISP? (select 1)
1. A company that allows access to their customers email messages
2. A company that provides an internet connection to its customers
3. A company that provides internet connected computers
4. A company that maintains the structure of the internet

**Question**

How to select an Internet services/access provider?
How to evaluate Internet services/access providers?
?? Question ??

How are you connected to the Internet? What is the name of your Internet access provider?

Internet end-user equipment

Several types of equipment allow connection to Internet:

• PC + Internet connection!

• WebTV

• Webphone = Screenphone (based on for instance JavaOS by Sun)
!! Task - Assignment !!

Read
Tyson, Jeff
How Internet infrastructure works. [online]
Available from:
[cited 2005]

The Core Internet and the Consumer Internet

- **Core Internet** = all computers that can *provide* interactive Internet services (such as telnet, ftp, gopher, http,...) using server programs

- **Consumer Internet** = all computers that can *use* interactive Internet services, using client programs (such as WWW browsers)
?? Question ??

Being online means (select 1):
1. You are connected to the internet
2. Your computer is switched on
3. You can read your email without paying phone costs
4. All your computer files are organised in the right order

Internet:
WAP = Wireless Application Protocol

- A public/open, global specification that empowers mobile users with wireless devices to easily access and interact with information and services instantly over the Internet.
- It allows to deliver and to access information even when the full screen environment is either not available or not necessary.
Internet WAP: problems

- Wireless devices represent the ultimate constrained computing device with limited CPU, memory, and battery life, and with only a simple user interface.
- Wireless networks are constrained by low bandwidth, and unpredictable availability and stability.

Internet WAP: the architecture
A network-based course about computer networks

Internet in schools: aims and applications

- Applications by the teachers.
- Applications by the students.
- + stimulates interest in information technology in general.
Internet-assisted teaching and learning: advantages (1)

• For many people the learning materials are accessible fast and at low cost. (However, a version printed in multiple copies can be cheaper than a version printed by individual users.) The updates, corrections and improvements of the course material are accessible faster than when print is used for distribution.

Internet-assisted teaching and learning: advantages (2)

• Links to other Internet-based information sources can be offered in the course material, better than in a printed course.

• Permanent self assessment by students can work better than with printed course material.
Internet-assisted teaching and learning: advantages (3)

- Communication
  students - professor - teaching assistant(s) - administration/secretariat
can be offered, based on an e-mail group, a Usenet Newsgroup or a web-based group, for each course. Furthermore, an archive of messages can be stored and can be made searchable.
In this way one can save time and costs related to travel to a classroom and communication is not limited to fixed contact hours.

Internet-assisted teaching and learning: advantages (4)

- Multimedia
  (coloured graphics, sound, animations, video,...)
can be integrated well in the course material.
Internet-assisted teaching and learning: advantages (5)

• To create a better social environment for study, professors as well as students can make information about themselves available through the web for the students.

• Adaptive hypertext is possible, but more complicated to develop.

Internet-assisted teaching and learning: limitations

• Students should have access to a suitable computer and to Internet at an acceptable price.

• The contents of the computer-based course should be easily conveyable without personal contacts and practical work.

• Interactive work that requires real-time access to the server computer can be too expensive due to the telecommunication cost.
**Windows software versions:**
their suitability for Internet usage

<table>
<thead>
<tr>
<th>Licensing fee / price / costs</th>
<th><strong>Windows 3.x</strong></th>
<th><strong>Windows 95, 98, ME, 2000, XP...</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower!</td>
<td>Higher</td>
<td></td>
</tr>
<tr>
<td>Less!</td>
<td>More</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>Yes!</td>
<td></td>
</tr>
<tr>
<td>Less easy</td>
<td>Easier!</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>Yes!</td>
<td></td>
</tr>
<tr>
<td>Many</td>
<td>Few!</td>
<td></td>
</tr>
</tbody>
</table>

- RAM required
- Includes TCP/IP stack
- Set-up of Internet applications
- Allows (faster) 32-bit programs
- Problems with limitations of Windows “resources”

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**Computer networks,**
data communication and Internet

**Miscellany**
Integrated Services Digital Network: What is it?

- Integrated Services Digital Network = ISDN
- intended as a worldwide upgrade to digital status for the Public Switched Telephone Network
- 64 kbits/s up to 2 Mbits/s available (which is higher than with a modem)
- designed to be delivered over existing copper wires
- allows simultaneous transfer of sound, text and numbers, graphics (fax),...

Integrated Services Digital Network: applications

- backup of leased lines
- interconnection of LANs
- home-office use
- home use: telephone, fax, network access,...
- supporting existing analogue equipment if necessary
- ...

***-

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Money transfer via the networks:
increasing importance

- Money transfer over the Internet and public access networks is not secure without precautions.

- Several systems will allow secure money transfer, even for small amounts of money, with only small transfer costs: “Digital cash”, “Cyberbucks”, ...

Money transfer via the networks:
impact on services offered

- Many services and sources of information, offered free of charge previously, may start charging money.

- Many services and sources of information, which were previously not offered, because there was no good charging and paying mechanism available, may be offered at a price.
Dictionaries / glossaries about networks and Internet

- Available online free of charge:
  http://dir.yahoo.com/Computers_and_Internet/Internet/Dictionaries/

!? Question !?

Which ways of data communication do you know to access online information systems?
Microcomputer -- external computer: some ways of data communication

Computer networks, data communication and Internet

The future impact of digital communication networks
Future impact of
digital communication networks

Extreme scenarios:

• Boom scenario: evolution to ‘computopia’
• Doom scenario: evolution to a digital ‘brave new world’

Computer-based communication:
boom scenario

Evolution to ‘computopia’

• International, interpersonal communication increases, using the international computer communication networks.
• Information gap (between information rich and information poor) disappears: access from everywhere (even from developing countries) to internationally available information.
• Capitalism and repression disappear.
Computer-based communication: doom scenario

Evolution to a digital ‘brave new world’
- Face-to-face, interpersonal communication disappears.
- Information gap
  (between information rich and information poor) becomes larger.
- Capitalism uses the evolving techniques for increased control and repression.

The world of information from your desktop
Computer networks, data communication and Internet

Data transfer rate
between components of computer systems

Data transfer rates:
introduction

• The speed of delivery of information = data transfer rate.
• This is always limited by the weakest component.
• High quality graphics, audio, animation, video,… typically require a high transfer speed.
• When a transfer system (medium, channel,…) is used (shared) by more than one user, the effective, practical transfer rate decreases of course.
**Question**

Compare transfer rates in computer networks with the transfer rates of CD-ROM systems.

### Data transfer rate of various computer systems/media

<table>
<thead>
<tr>
<th>Type</th>
<th>Transfer rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>14.4 kbits/s modem</td>
<td>1.8 KB/s</td>
</tr>
<tr>
<td>28.8 kbits/s modem</td>
<td>3.6 KB/s</td>
</tr>
<tr>
<td>ISDN</td>
<td>7-16 KB/s</td>
</tr>
<tr>
<td>T1 Internet line</td>
<td>30 –200 KB/s</td>
</tr>
<tr>
<td>1x CD-ROM</td>
<td>150 KB/s</td>
</tr>
<tr>
<td>Ethernet</td>
<td>1 000 KB/s</td>
</tr>
<tr>
<td>24x CD-ROM</td>
<td>3 600 KB/s</td>
</tr>
<tr>
<td>USB</td>
<td>12 000 KB/s</td>
</tr>
</tbody>
</table>
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