

Lecture Note 2

Data Communication

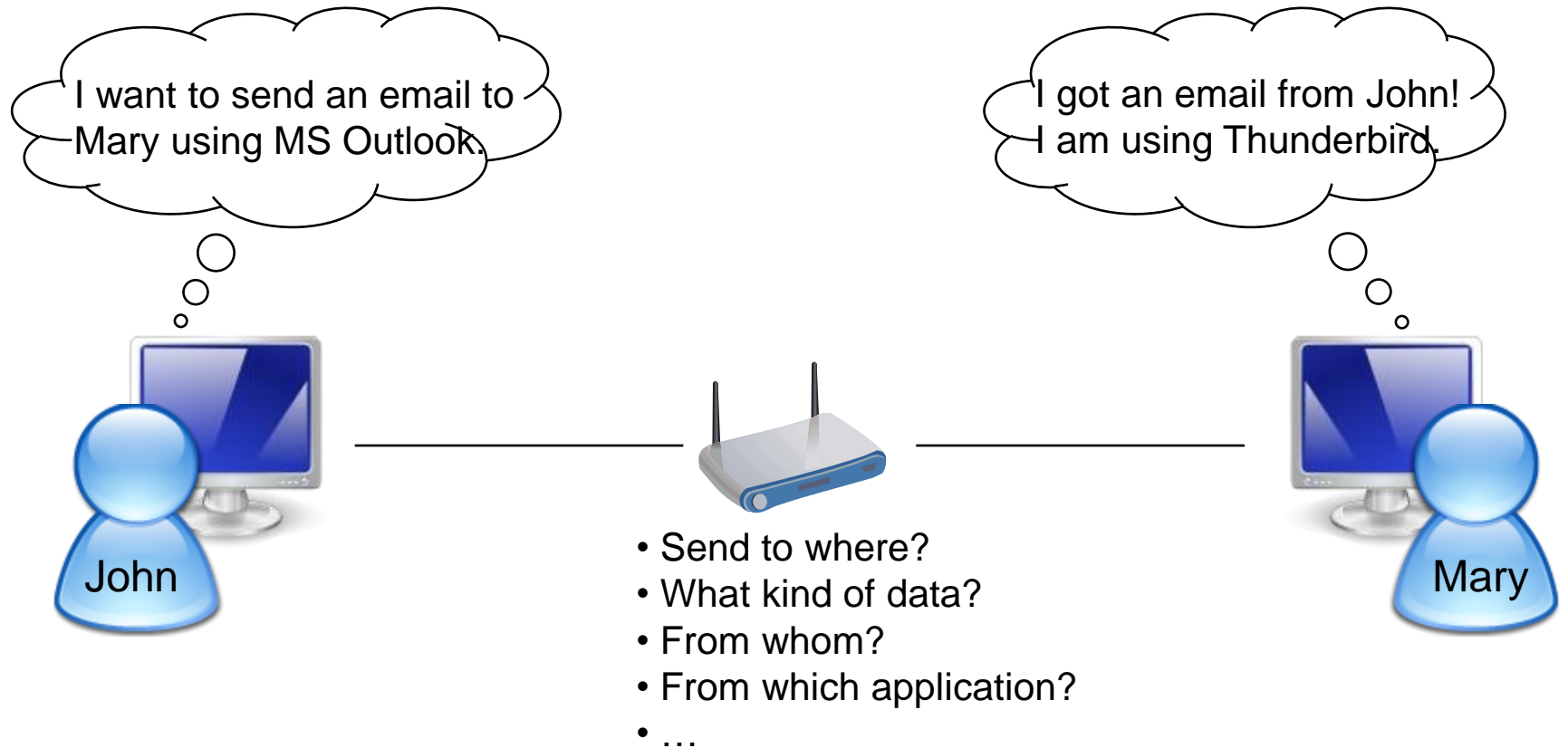
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Outline

- Our major question in this lecture:
 - How do computers communicate?
- Major elements that we will learn in this lecture:
 - Layer model
 - Port and Socket
 - Routing the data
 - Domain Name System
 - Media Access Control Address
 - Supernetting and Subnetting

Introduction (1 of 2)

- A computer system is very complex!

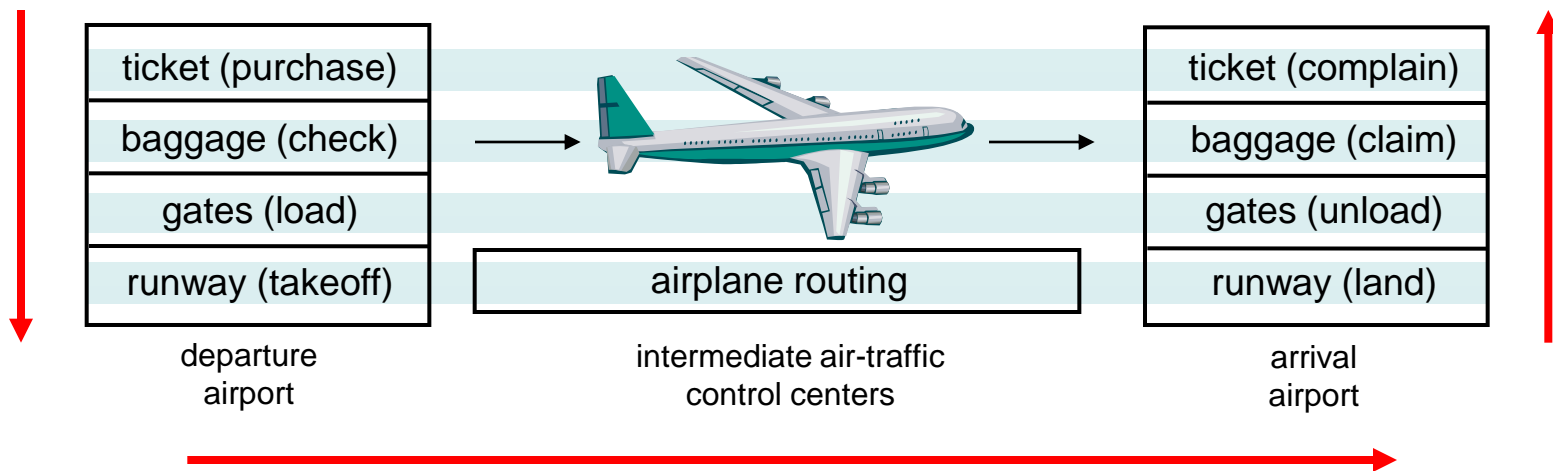


Introduction (2 of 2)

- We need to divide the tasks \Rightarrow We need to have standard!
 - Unfortunately, there are many standard-setting organizations...
 - ANSI (American National Standards Institute)
 - ITU (International Telecommunications Union)
 - ISO (International Organization for Standardization)
 - IEEE (Institute of Electrical and Electronics Engineers)
 - EIA (Electronic Industries Association)
 - ...
 - “TCP/IP Protocol Suite” versus “OSI seven layer model”

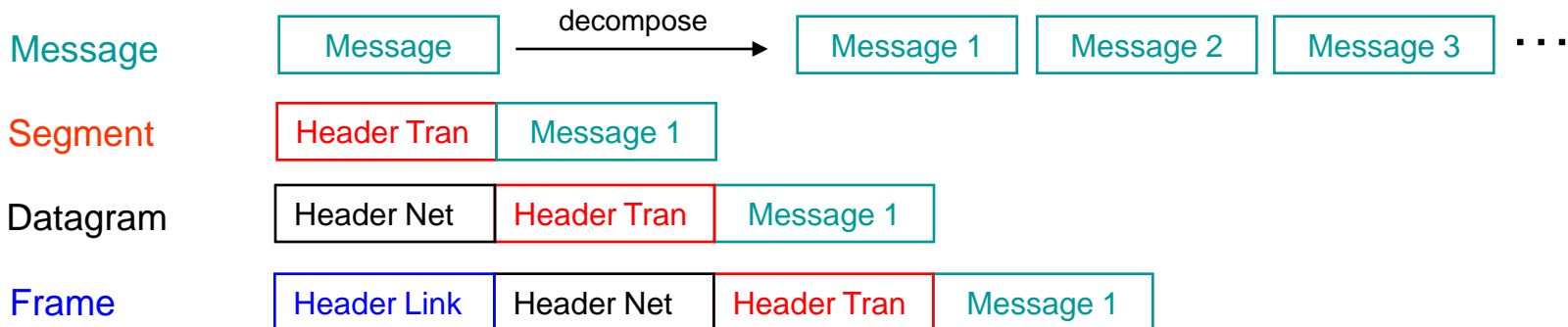
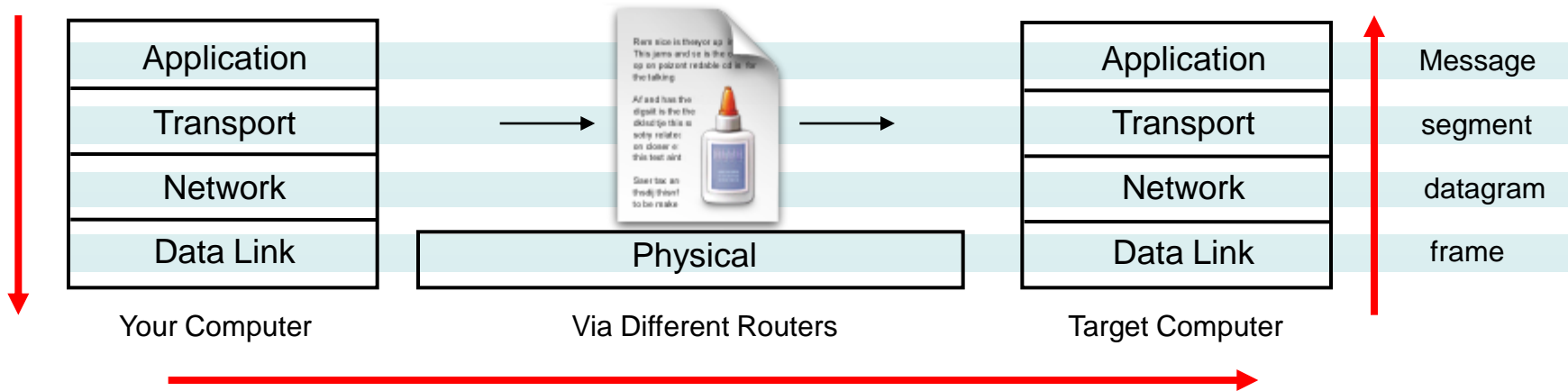
An Airplane Trip

- Before we talk about how the data are sent via the network...
 - Let's consider: How we take an airplane trip?



Computer Communication

- Internet as a layered architecture



Question 1: Why we have to decompose the original message?

Question 2: Why we have to add "header" and "trailer"?

Different Standards

- Open Systems Interconnection (OSI) model


- Suggested by ISO
- Contains 7 layers

Application
Presentation
Session
Transport
Network
Link
Physical

- Internet Protocol Suite (a.k.a. TCP/IP)

- Define a set of protocols
- Contains 4 layers

Application
Transport
Network
Link & Physical

- Although OSI has a more structural framework, we use TCP/IP. This is because... 

How the Layers Communicate?

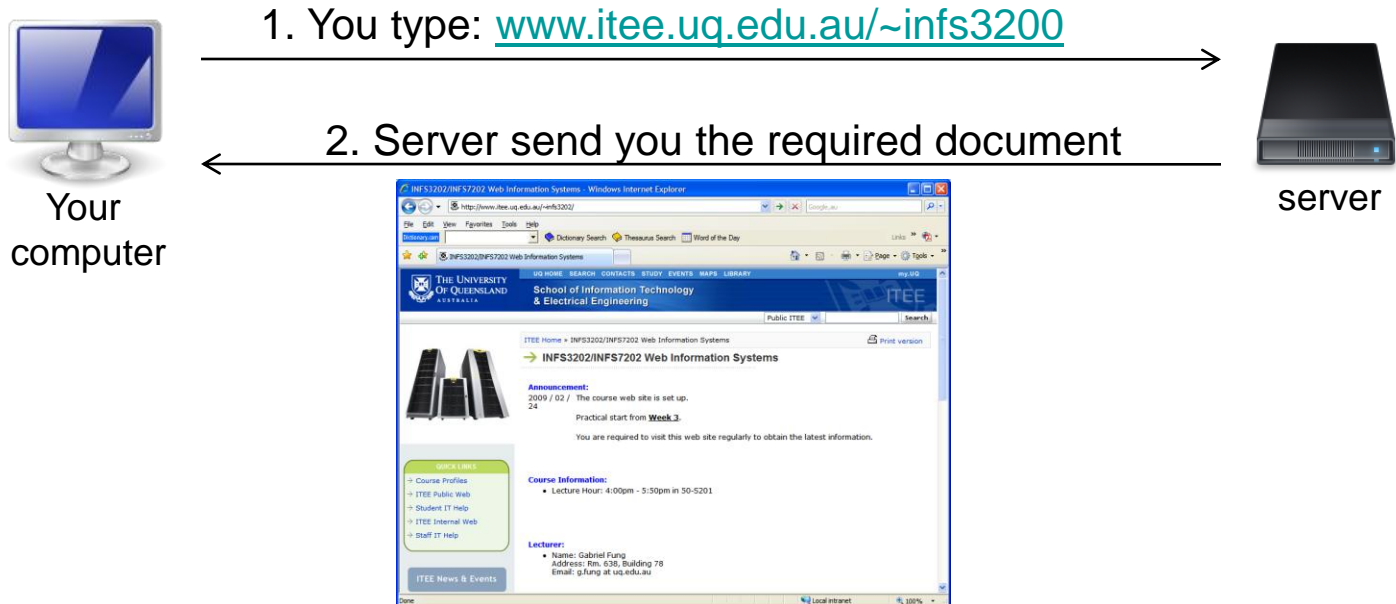
- Using Protocol
 - Set of rules/agreements in telecommunication
 - So that we can understand (encode/decode) the data by following some standards.
 - Example:
 - HTTP, FTP, STMP, IP... (we will discuss them shortly)
- Note
 - Same layer in different computers is communicated by using some standard protocols
 - Different layers do not need to communicate
 - Layer A only needs to route the data to Layer B. Layer B does not need to *understand* the data
 - Difficult to understand? Try to think about the situation of an airplane trip!
 - » E.g. The immigration department does not need to know where have you bought the ticket.

Internet Protocol Suite (1/6)

- Strictly speaking:
 - When you try to exchange data via Internet Protocol Suite, you need to specify protocol and port number in the application.
 - A computer just like an airport.
 - A port just like a gate in the airport.
 - There are totally 65535 ports
 - E.g. Access web page – 80; Send email – 25; ...
 - For example, the format of URL (Uniform Resource Locator) is:
 - Format:
 - Protocol :// Host : Port / File
 - Example:
 - http :// www.google.com.hk : 80 / index.html
 - » try with different port number, e.g. 25
 - » Do you know why we never need to specify 80?
 - You do not need to specify them because the application already “completed” for you 😊

Internet Protocol Suite (2/6)

- Example:
 - Request a web page
 - www.itee.uq.edu.au/~infs3202
 - From a user point of view:



- What is the underlying mechanism?

Internet Protocol Suite (3/6)

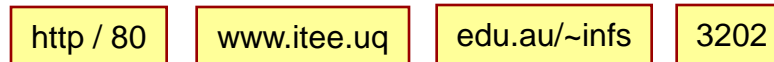
- The basic idea:



Your computer

1. After you typed: www.itee.uq.edu.au/~infs3202

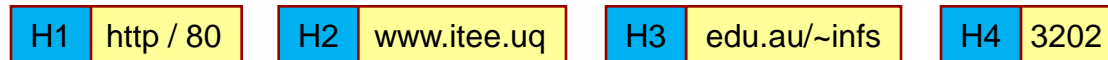
- Application layer determine your protocol and port
 - For web searching, by default, it is “http” (protocol) and “80” (port)
- Application layer decompose your message into several smaller ones:



- Each piece is then send to the transport layer

2. Transport layer:

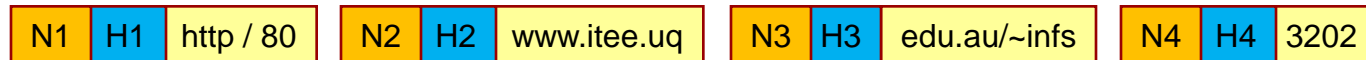
- TCP (Transmission Control Protocol) add some information.



- Each piece is then send to the network layer

3. Network layer:

- IP (Internet Protocol) add some information.



- Each piece is then send to the link layer

4. Link layer:

- Transmission begins. Each piece of data is regarded as a frame
 - Header information should be added, but is omitted in this example for clarity

Internet Protocol Suite (4/6)

- Due to a number of reasons, the frames received at the sever side may be out of order.



1. Link layer:

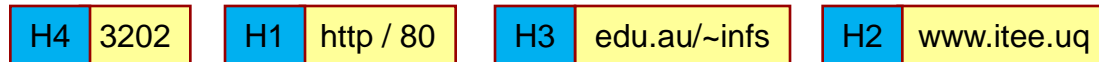
- It receives:



- Each pieces is then sent to network layer.

2. Network layer:

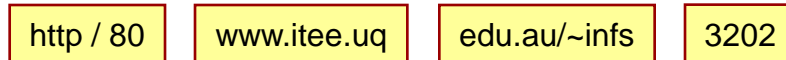
- Ensure the information correct. Remove the header:



- Each piece is then send to the transport layer.

3. Transport layer:

- Reorder the data. Ensure the information correct. Remove the header:



- Send to the application layer.

4. Application Layer:

- Understand we should use HTTP to read the data
- Check whether the port number is correct
 - If Yes, send you the request page.
 - If No, send you some error information.

Internet Protocol Suite (5/6)

- If a frame is lost...



server

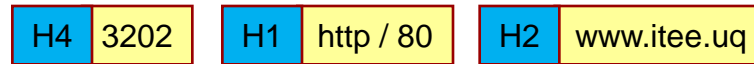
1. Link layer:

- It receives:



2. Network layer:

- Ensure the information correct. Remove the header:



3. Transport layer:

- Reorder the data



- Identify a data is missing (H3). Request the missing data.
- Send information to network layer:

Request H3

4. Network layer

- Add some information and send to link layer:



5. Link layer:

- Route back to your computer to request the missing information

Internet Protocol Suite (6/6)

(Cont'd)



Your computer

1. Link layer:

- It receives:



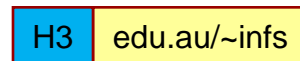
2. Network layer:

- Ensure the information correct. Remove the header:



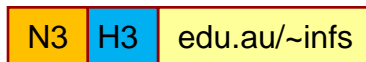
3. Transport layer:

- Identify it is a request of a missing data (H3). Pass the missing data to the network data.



4. Network layer

- Add some information and send to link layer:



5. Link layer:

- Route to the destination computer again.

The whole process continue until the transport layer at the server side received all of the data, and then pass to the application layer in there.

Application Layer and Transport Layer

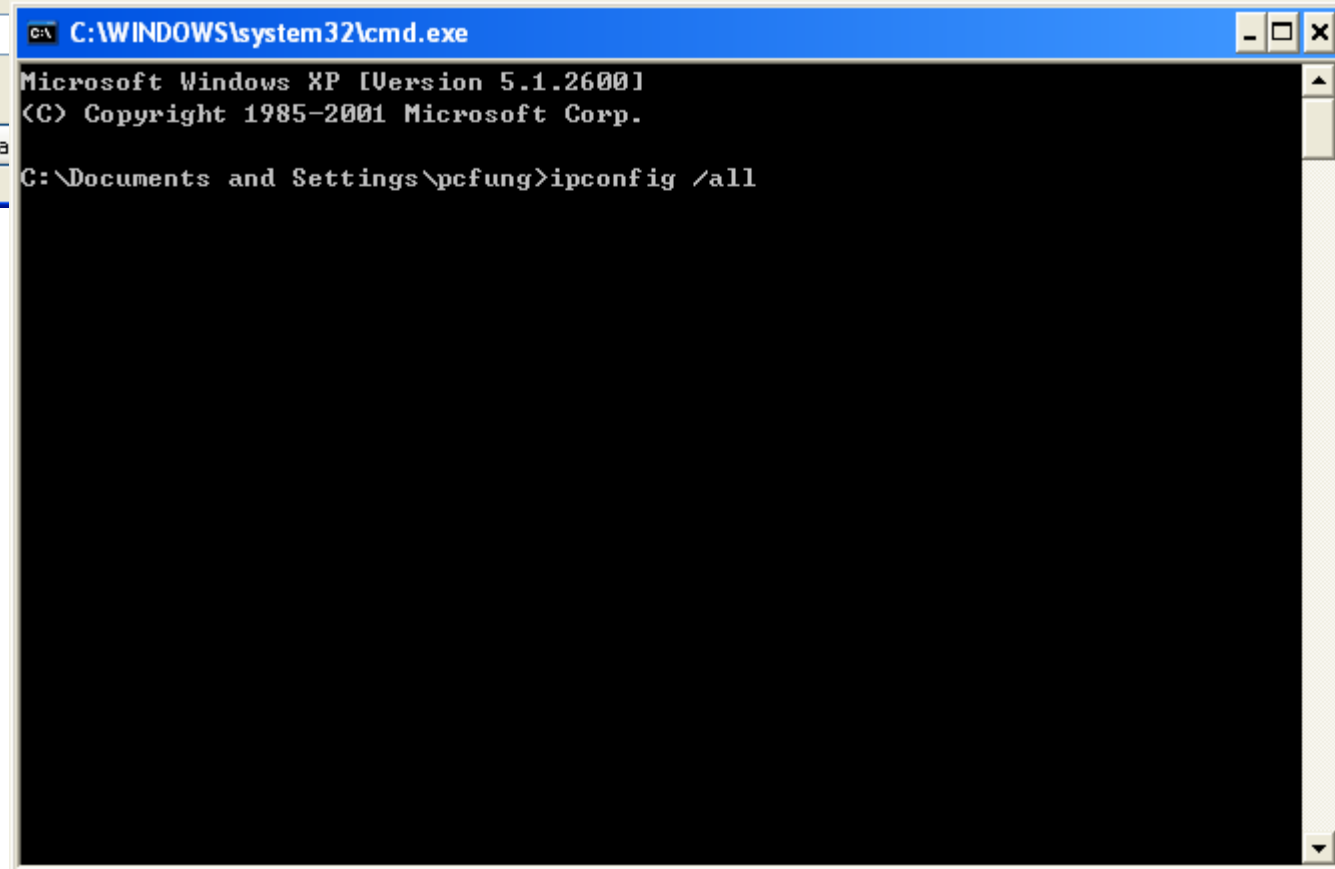
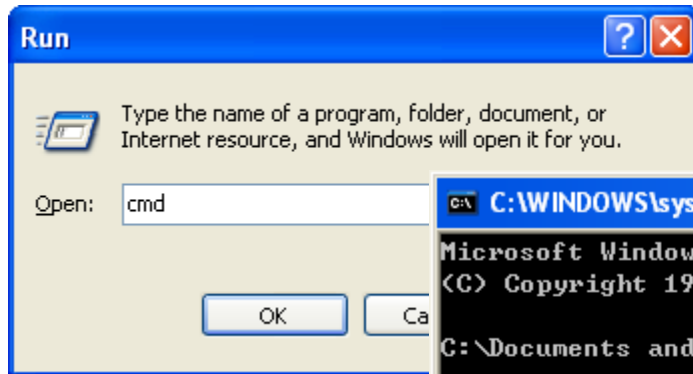
- Application layer:
 - Support network applications
 - Internet, Email, Instant messaging (MSN, Skype), P2P file transfer (BT), Network Game, Remote desktop, Internet telephony ...
 - Web – HTTP (Hyper Text Transfer Protocol)
 - Email – SMTP (Simple Mail Transfer Protocol)
 - File Transfer – FTP (File Transfer Protocol)
 - ...
- Transport layer
 - Manage the received data
 - TCP – Transmission Control Protocol
 - UDP – User Datagram Protocol
 - ...

Network Layer (1/2)

- Network layer
 - Route the data
 - IP – Internet Protocol
 - In order to route the data, we need two information:
 - IP Address (like your home address)
 - Logical address
 - In the following form: xxx.xxx.xxx.xxx
 - Identify the physical location of the computer
 - » In UQ domain, all computers are: 130.102.xxx.xxx
 - Media Access Control (MAC) Address (like your passport)
 - Physical address
 - The identity of the network card
 - » of coz, without a network card, you cannot online...
 - ALL network card in the world have DIFFERENT MAC Address!!!
 - » IEEE standard – 2^{24} combinations, i.e. 281474976710656

Network Layer (2/2)

- Find your IP address and MAC address:



Link and Physical Layer

- Link and Physical Layer:
 - Data transfer between neighbouring network elements
 - Bits on the wire

More About IP Address and MAC Address

- How can we know the IP address of the target computer? (e.g. www.google.com.au)
 - Use DNS (Domain Name System)!
- How can we know the MAC address of the target computer? (e.g. www.google.com.au)
 - Use ARP (Address Resolution Protocol)!

Domain Name System (DNS)

- DNS

- IP Address is too difficult to remember.



- We need meaningful name!

- Actually, when we type: www.google.com, our computer will map it to the IP address: 64.233.189.104 automatically

- Try it out!

- How to do the mapping?

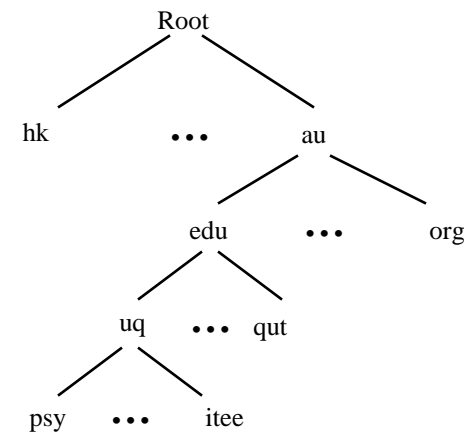
- In the past, the “hostnames to IP address” are mapped in a local file using a large table
 - As the Internet grows, it becomes impossible to keep all of the information in any local file system. We need a systematic structure

- i.e. DNS

DNS Structure

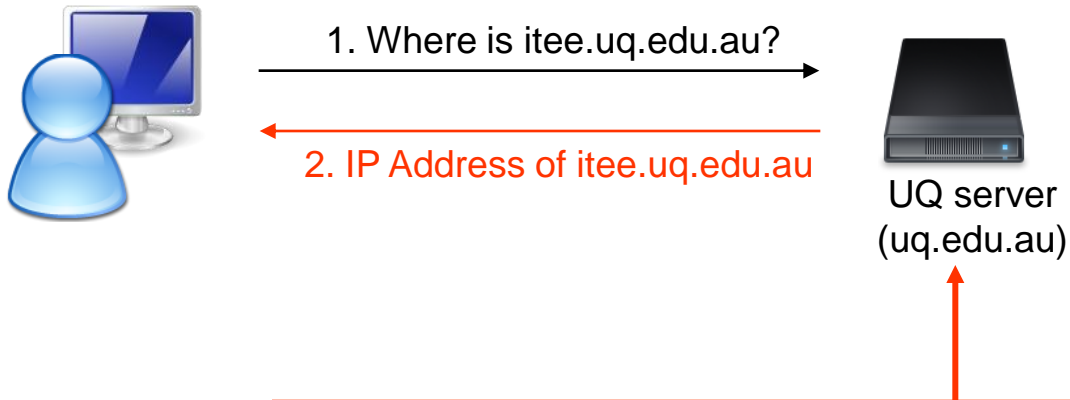
- DNS has a hierarchical structure
 - Three letters and two letters code:
 - The last two letter codes was intended to indicate the country of origin hosting the site
 - They are defined in ISO 3166
 - Have you ever think about why there is no “.us” site? (e.g. NO `www.google.com.us`)
 - The component before the country code was intended to indicate the type of organization

Code	Traditional Meaning
com	Commercial
edu	Educational
gov	Government
int	International Organization
mil	Military
net	Network related
org	Miscellaneous



DNS in Action – Intranet

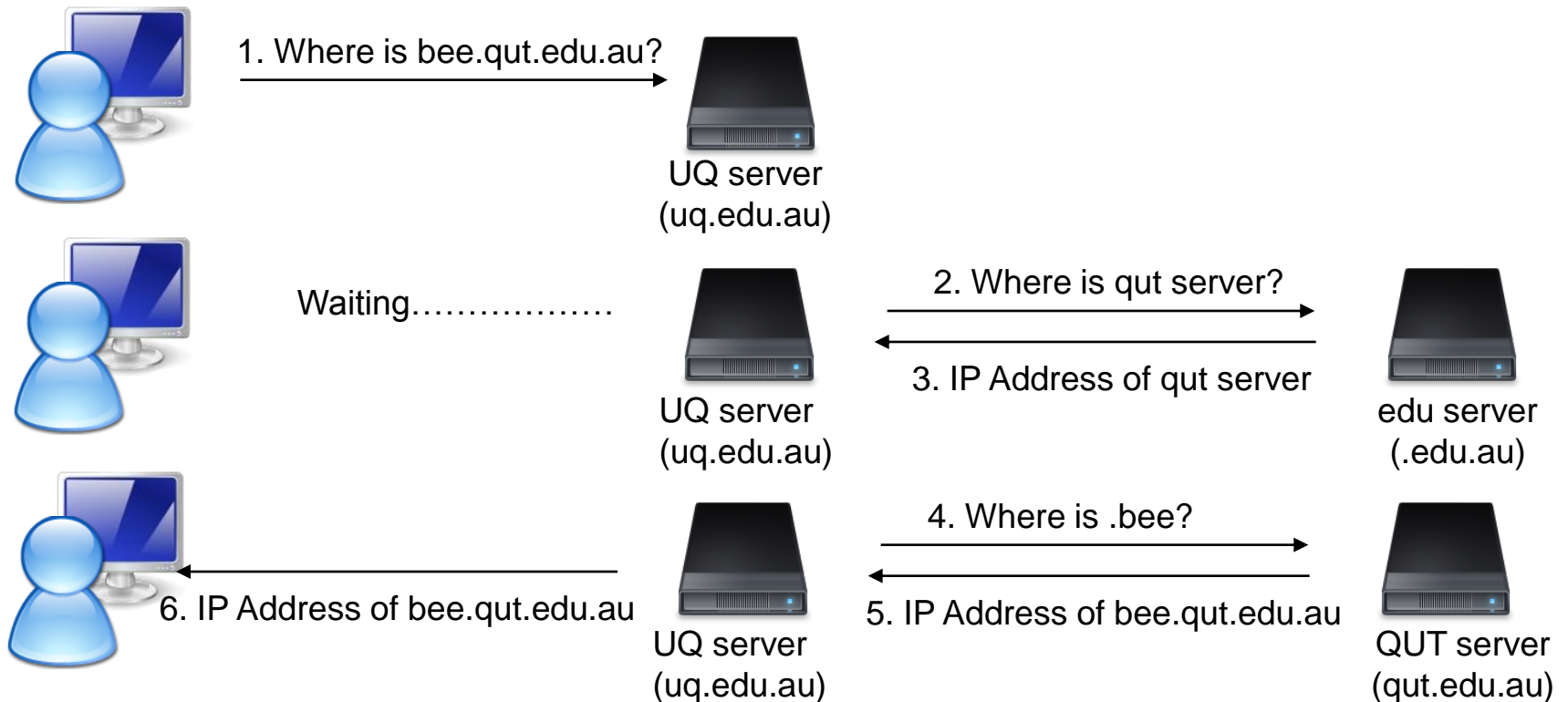
- Within the same network:
 - You are using a computer in UQ
 - You want to find the IP address of itee.uq.edu.au



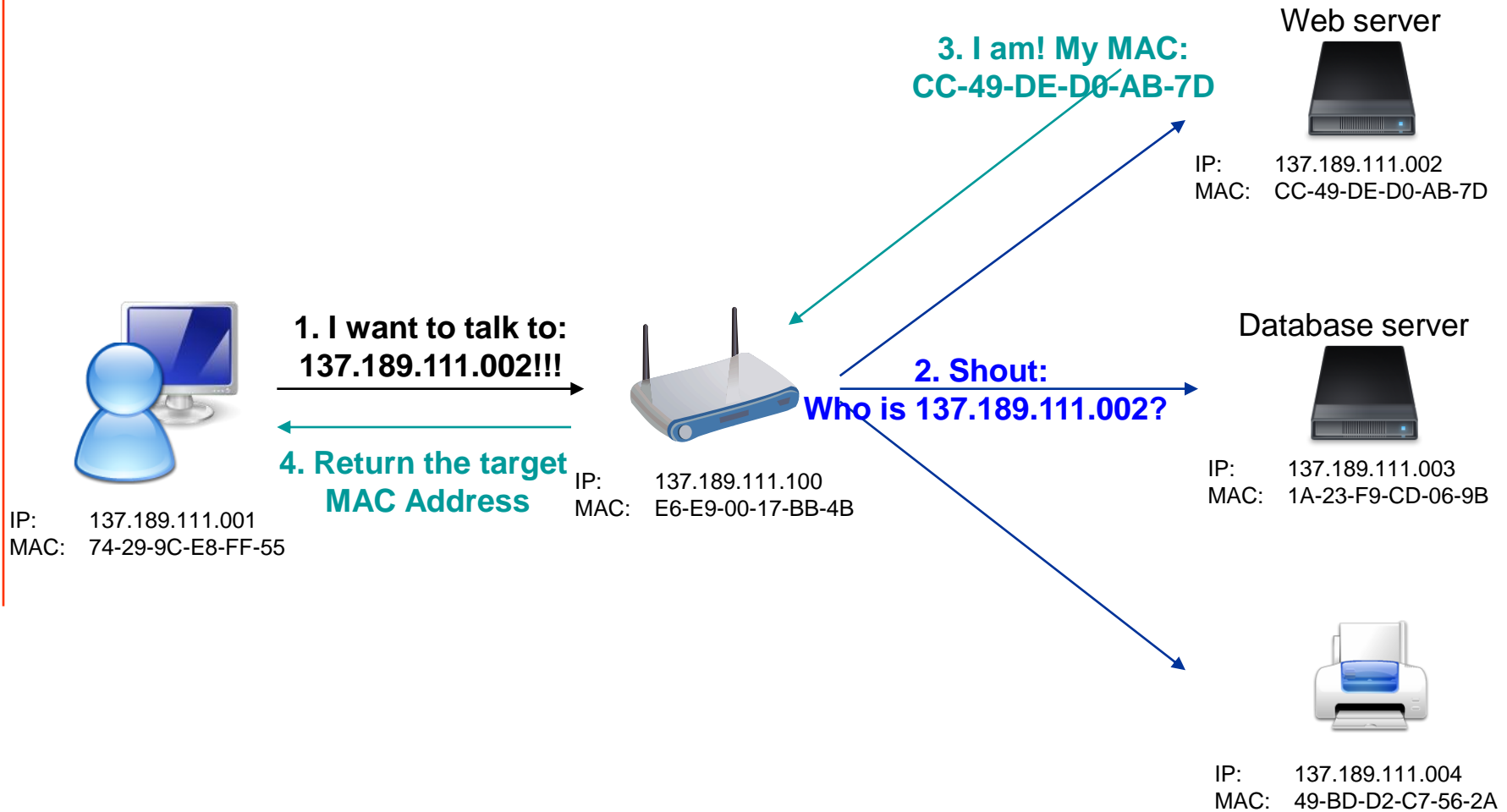
itee.uq.edu.au must be in the “host name / IP address” table in the UQ server.
UQ is responsible to maintain this information!
(Just like a company, the CEO is responsible to maintain the structure of his company)

DNS in Action – Internet

- In the case of Internet:
 - You are using a computer in UQ
 - You want to find the IP address of bee.qut.edu.au

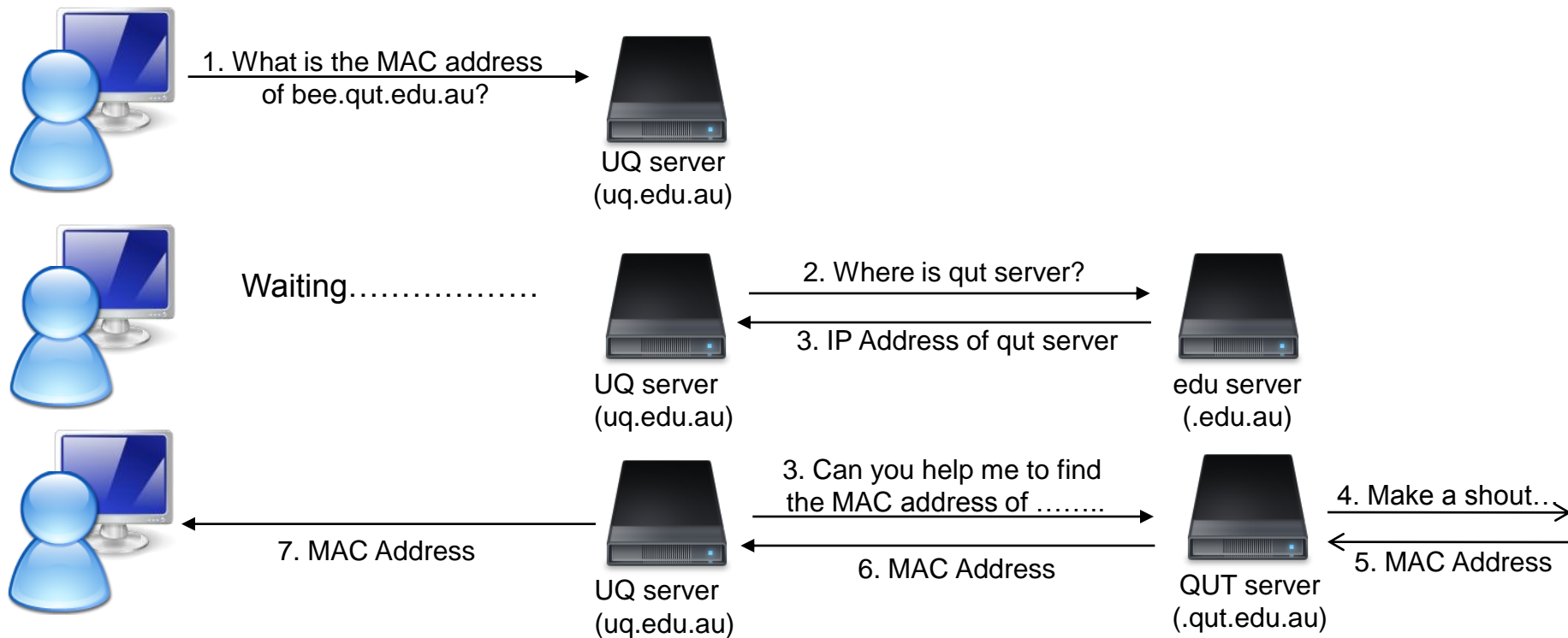


Obtain the MAC Address – Intranet



Obtain the MAC Address – Internet

- In the case of Internet:
 - Obviously, you cannot “shout” to ALL computers in the world!
 - What you need to do is:
 - Ask the target router to make a “shout” to its own network.



Note (1/2)

- Obviously, all servers will cache the recent records of the IP addresses and MAC addresses.
 - So that we do not always need to make such a lengthy and complicated process
- What I have shown in the previous slides are some simplification of the real life situations.
 - It is far more complex to obtain the MAC address in the case of Internet.
 - The detailed mechanism would be in the area of Network Communication, which is out of the scoop of this course.
 - We are dealing with Web Information Systems, which has a higher level of perspective of the whole situation.

Note (2/2)

- Can we change the MAC address?
 - Yes! Why not? 😊
 - Why do we need to change the MAC Address?
 - A number of reasons...
 - Then... How? 🤔
- Hacking? Not really, but... 😜

Demo: Send Email – SMTP

- When you send email...
 - C: Client (You) S : Server
 - C: telnet mail.uq.edu.au 25
 - S: 220 smtp3.uq.edu.au ESMTP Sendmail.....
 - C: HELO Gabriel
 - S: 250 smtp3.uq.edu.au Hello XXX
 - C: MAIL FROM: <xxx@uq.edu.au>
 - S: 250 2.1.0 <xxx@uq.edu.au>... Sender ok
 - C: RCPT TO: <yyy@hotmail.com>
 - S: 250 2.1.5 <yyy@hotmail.com>... Recipient ok
 - C: DATA
 - S: 354 Please start mail input. (End with "." on a line by itself)
 - C: This is a testing email.
 - C: Just for some demonstration.
 - C: .
 - S: 250 Mail queued for delivery
 - C: QUIT

Supernetting (NAT)

- We do not have enough IP Address!
 - IPv4 defines IP address as 32 bits long
 - We can have only a limited number of IP address!
- Solution: Supernetting (a.k.a Network Address Translation, NAT)!
 - Having a large number of IP address for internal use, and only ONE address for external (Internet) use

Private IP Address:

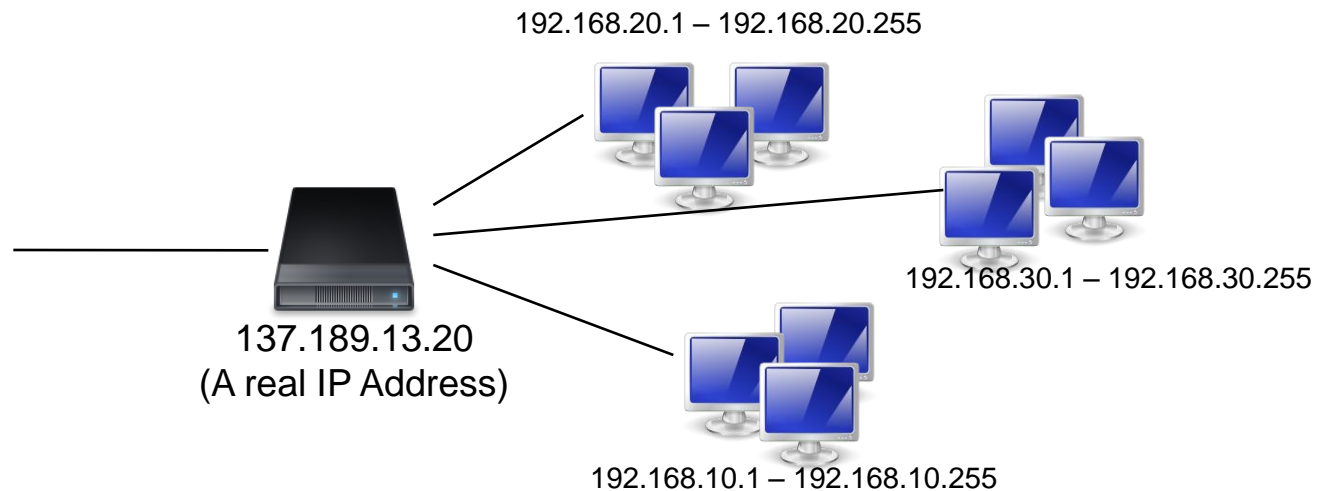
10.0.0.0 - 10.255.255.255

172.16.0.0 - 172.31.255.255

192.168.0.0 - 192.168.255.255

Subnetting

- Divide the network into several sub-network (e.g. itee network, psy network, ...)
 - For better resources management
 - Setting up a subnet need to use “subnet mask”
 - We are not interested in how to set up a subnet. Details may refer to some courses related to Computer Networking.



Summary

- Internet is a layered model:
 - Communicate via a particular Port in the Socket
 - Application layer:
 - HTTP, FTP, STMP
 - Transport layer:
 - TCP, UDP, SCTP
 - Network layer:
 - IP, ARP
 - Link layer:
 - PPP
- DNS, MAC address and Routing
- Subnetting and Supernetting (NAT)

References

- Books:
 - Behrouz A. Forouzan. Data Communications and Networking. McGraw Hill. 4th Edition. 2007.
 - James F. Kurose and Keith W. Ross. Computer Networking. Addison Wesley. 3rd Edition. 2004.