### SCHEDULE

<table>
<thead>
<tr>
<th>Week</th>
<th>1</th>
<th>2</th>
<th>3</th>
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<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monday 5 pm</td>
<td>ZS</td>
<td>ZS</td>
<td>ZS</td>
<td>PS</td>
<td>PS</td>
<td>PS</td>
<td>ZS</td>
<td>ZS</td>
<td>ZS</td>
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<tr>
<td>Wednesday 11am</td>
<td>ZS</td>
<td>ZS</td>
<td>ZS</td>
<td>PS</td>
<td>PS</td>
<td>PS</td>
<td>ZS</td>
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<tr>
<td>Wednesday 12am</td>
<td>ZS</td>
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<td>PS</td>
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<td>ZS</td>
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ZS: Dr. Z. Sun
PS: Dr. P. Sweeney
Aims and Objectives

**Module Aims**: To offer an introductory course in Computer and Data Networks to form the basis of further study for students in their degree course and in industry.

**Module Objectives**: To introduce students to the principles and practices of Computer and Data Networks and make them aware of the fundamental concepts associated with network design and performance evaluation techniques.
Syllabus (1 of 3)

- [1-2] Introduction to network hardware and software, the OSI/RM, TCP/IP reference model, examples of computer and data communication networks.
- [3-4] Theoretical basis for date communications, data transmission in the physical layer, transmission media, wireless transmission, telephone network systems.
- [5-6] Data link layer, framing, error control, flow control, error detection and correction, HDLC, LANs, IEEE Standard 802, repeaters, hubs, bridges and switches, VLAN
Syllabus (2 of 3)

- [7-8] Review of Maths and Statistics - probability, memoryless events, binomial distribution, Poisson distribution, exponential distribution, infinite series. Introduction to Queuing Theory - characteristics of queues, general results, Little’s result, birth/death systems
- [9-10] Single Server Queues - M/M/1 queues, effect of finite waiting space, effect of service time distribution. Sliding Window Protocols - stop and wait, go-back-n and selective repeat
Syllabus (3 of 3)

- [13-16] Network layer design, routing, congestion control, internetworking, network layer in the Internet.
- [17-18] Transport layer protocols and services, transport layer in Internet - TCP and UDP, higher level protocols
- [19-20] Application layer, DNS, Email and WWW

**Assessment:** Examination (80%) at end of Spring Semester and an Assignment (20%)
The assignment (1/3)

- **Aim of the assignment** is to examine the concept of networking hardware, software, protocols through the tasks to explore the network technologies, topologies, services, applications, tools, utilities, to make use of available tools, and to learn network programming.

- **Tasks**: are described in the following slides.

- **Assessment**: is based on your report on the tasks following the given structure. Marks will be distributed as follows:
  - Explanation of concepts 20%
  - Analysis of issues and results 20%
  - Insight gained from the tasks 20%
  - Presentation 20%
  - Quality of the report 20%

- **Warning**: Plagiarism will be heavily penalised
The assignment (2/3)

- **Task 1:** explore application programs and software tools available at the applications layer on the networks: `telnet`, `netstat`, `ping`, `traceroute`
- **Task 2:** Use a tool to measure RTT delay and build a RTT profile for connections within the University, to London, to Scotland, to Europe, US west or east with hourly measurement in one week, and discuss the results.
- **Task 3:** Write a client-server program using the socket API.

**Note**
- You can use information from book, manuals and Webs, and you can also ask people.
- You should do your own measurement and report.
- The report should be concise using figures and diagrams whenever possible.
- The assignment is compulsory (minimum mark 30% needed for the module to pass).
- The assignment will be due to hand in by the end of the Easter vocation.
The assignment report structure (3/3)

Your report should include the following sections:

- A short summary about the assignment (about 100 words)
- Introduction
- Task 1: description of your works
- Task 2: “describe how your measurements are carried out, results collected and analysed.”
- Task 3: “describe your program in flow chart & demonstrate that it works”
- Conclusions
- References (if any)
Text and reference books

- Stalling W. Data and computer communication, 6e. ISBN 013-048370-9, Prentice Hall, 2000. (C)
Sections of the book need more attention

- Chapter 1: “Network hardware”, “Network software”, “Reference models”
- Chapter 3: “Framing”, “error control and flow control”, “error correction and detection”, “HDLC”
- Chapter 4: IEEE802 LANs, “Ethernet”, “WLAN”, “Link layer switching”
- Chapter 5: “Distance vector routing”, “link state routing”, “the Internet protocol”
- Chapter 6: “The internet transport protocols: TCP and UDP”
- Chapter 7: “DNS”, “Email” and “WWW”
Problems and exercises

- Chapter 1: 7, 11, 12, 14, 15, 17, 18 (13, 11, 21, 17, 18, 21, 22)
- Chapter 2: 3, 4, 5, 7, 9, 17, 18, 22 (3, 4, 5, 7, 9, 22, 23, 29)
- Chapter 3: 2, 3, 5, 9, 22, 23 (2, 3, 5, 14, 15, 16)
- Chapter 4: repeater, hub, bridges, switches, LAN/VLAN
- Chapter 5: 3, 8, 11, 14, 26, 28 (3, 9, 12, 16, 37, 39)
- Chapter 6: 2, 13, 19, 23 (2, 20, 29, 14)
- Chapter 7: DNS, Email and WWW

Note: the numbers in brackets are for the 4th edition of the book
1. Introduction
Outline

- Introduction
- LAN, MAN and WAN
- Protocols, services and interfaces
  - The ISO/OSI seven layer Reference Model,
  - The TCP/IP reference model,
  - International standards
1. Introduction

- Technology in 18th Century: Industrial Revolution;
- In the 19th century: the age of steam engine
- In the 20th century: Information gathering, processing and distributions; telephone, radio and television, satellite, computer and data network, Internet, ....
- Now in the 21th century:
  - Computer networks can be see in universities, schools, companies, homes, ...
  - What services are we using: WWW, email, video conference,
  - Access to remote information, person to person communication and interactive entertainment, e-commerce
  - Wireless and mobile
Network hardware - LAN, MAN, WAN

- **Examples of networks**
  - **LANs**: Ethernet, Token ring, token bus
  - **MAN**: FDDI, DQDB
  - **WAN**: store and forward, packet switched subnet

<table>
<thead>
<tr>
<th>Distance</th>
<th>Processors located in same</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1 m</td>
<td>Circuit board</td>
<td>Data flow machine</td>
</tr>
<tr>
<td>1 m</td>
<td>System</td>
<td>Multicomputer</td>
</tr>
<tr>
<td>10 m</td>
<td>Room</td>
<td>Local area network</td>
</tr>
<tr>
<td>100 m</td>
<td>Building</td>
<td>Metropolitan area network</td>
</tr>
<tr>
<td>1 km</td>
<td>Campus</td>
<td>Wide area network</td>
</tr>
<tr>
<td>10 km</td>
<td>City</td>
<td></td>
</tr>
<tr>
<td>100 km</td>
<td>Country</td>
<td>The Internet</td>
</tr>
<tr>
<td>1,000 km</td>
<td>Continent</td>
<td></td>
</tr>
<tr>
<td>10,000 km</td>
<td>Planet</td>
<td></td>
</tr>
</tbody>
</table>

Fig. 1-2. Classification of interconnected processors by scale.
LAN, MAN and WAN transmission

- LAN use broadcast medium
  - Restricted in size, Low delay, few errors
  - Transmission technology: often share single cable
  - Topology: bus, ring
  - Speed: 10-100 Mbit/s and 1-10 Gigabit/s
- MAN also use broadcast medium (as the cable TV)
- WAN is a subnet of routers interconnected by cables of telephone lines, using principle of point to point, store and forward, or packet switch
- They are not isolated but connected into a global networks
Network software and protocol hierarchies

- **Layers or levels**: each offers certain services to the higher layers and shields details of how the services are actually implemented
- **Protocols**: rules and conventions
- **Peers**: entities of corresponding layers on different machines
- **Interface**: between the layers
- **Architecture**: A set of layers and protocols
- **Protocol stack**: list of protocols, one protocol per layer

Fig. 1-9. Layers, protocols, and interfaces.
Example of layering and data format

- A message is produced by an application at layer 5 and give layer 4 for transmission.
- Layer 4 puts a header in front of the message to identify the message and passes it to layer 3.
- Layer 3 breaks the message into two smaller parts, adds header and gives to layer 2.
- Layer 2 adds headers and trailers and gives to layer 1.
- Layer 1 carries out the transmissions.

Fig. 1-11. Example information flow supporting virtual communication in layer 5.
Network Design issues

- **Rule of data transfer**: simplex, half-duplex, full duplex communications
- **Error control**: error correction or retransmission
- **Order of messages**: sequence number is required to preserve the order and put the message back together properly
- **Flow control**: for fast sender & slow receiver
- **Handle long messages**: Disassembling, transmission and reassembling
- **Multiplexing**: identifiers are needed to use the same paths for different connections
- **Naming and Addressing**: identify who and where in the messages
- **Routing**: find the right path to send the message from sources to destinations
Connection oriented and connectionless

- Telephone services as an example of connection oriented services: set-up connection, transfer data with the connection identifier, and release the connection
- Postal service as connectionless: send data with destination and source addresses
- Quality of services (QoS): reliable using acknowledgement and retransmission schemes versus best effort

Fig. 1-13. Six different types of service.

<table>
<thead>
<tr>
<th>Service</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reliable message stream</td>
<td>Sequence of pages</td>
</tr>
<tr>
<td>Reliable byte stream</td>
<td>Remote login</td>
</tr>
<tr>
<td>Unreliable connection</td>
<td>Digitized voice</td>
</tr>
<tr>
<td>Unreliable datagram</td>
<td>Electronic junk mail</td>
</tr>
<tr>
<td>Acknowledged datagram</td>
<td>Registered mail</td>
</tr>
<tr>
<td>Request-reply</td>
<td>Database query</td>
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</table>
Service primitives

- A service is formally specified by a set of primitives (operations) for users or other entities to access the services.
- It is defined between layers (Protocols is a set of rules and conventions between the peers in the same layers).

<table>
<thead>
<tr>
<th>Primitive</th>
<th>Meaning</th>
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<tbody>
<tr>
<td>Request</td>
<td>An entity wants the service to do some work</td>
</tr>
<tr>
<td>Indication</td>
<td>An entity is to be informed about an event</td>
</tr>
<tr>
<td>Response</td>
<td>An entity wants to respond to an event</td>
</tr>
<tr>
<td>Confirm</td>
<td>The response to an earlier request has come back</td>
</tr>
</tbody>
</table>

Fig. 1-14. Four classes of service primitives.
The ISO OSI Reference model

The principles that were applied to arrive at the seven layers:

1. A layer is a different level of abstraction
2. Each layer performs a well defined function
3. The function of each layer should be chosen to lead to internationally standardised protocols
4. The layer boundaries should be chosen to minimise information flow across the interface
5. The number of layers should be large enough but not too large
The TCP/IP Reference Model

Main applications:
- Email
- Remote login / Telnet
- FTP for File transfer
- HTTP for WWW

Fig. 1-18. The TCP/IP reference model.

Fig. 1-19. Protocols and networks in the TCP/IP model initially.
International Standard Organisations

- **ISO - International Standard Organisation**
  - members are national standard organisations
  - 200 technical committees (TC) - divided into SCs, WGs
  - TC97 deal computer & information processing

- **ITU - International Telecommunication Union (Formally known as CCITT)**
  - three main sectors: ITU-T, ITU-R and ITU-D
  - five classes of member: Administrative (PTT), Private operators (BT), Regional telecom organisation (ETSI), Telecom vendors and scientific organisation, others
  - Study group, work parties, expert teams, ad hoc groups,
Internet Standards

- **DoD IAB (1983)** - Internet Activities/Architecture Board
- Technical report RFCs (Request for Comments)
- **IRTF/IETF (1989)** - Internet Research/Engineering Task Force (long term research / short term engineering)
  - Internet society (1992)
- More formal standardisation processing (learn from ISO)
- RFC -> Proposed standard -> Draft standard -> Internet standard
- Rough consensus and running code
Summary

- Introduction to LAN, MAN and WAN
- Protocols, services and interfaces
- The ISO OSI seven layer Reference Model,
  - The TCP/IP reference model,
  - International standards