Introduction to Networked Systems

Networked Systems (H)
Lecture 1
Lecture Outline

• Course Administration
  • Aims, Objectives, Intended Learning Outcomes
  • Course Outline
  • Labs and Assessment
  • Reading List

• Introduction to Networks
Course Administration
Contact Details and Website

• Lecturers
  • Dr Colin Perkins (Glasgow) and Dr Ian Thng (Singapore)
  • No scheduled office hours – make appointments by email to discuss the course outside scheduled lecture or lab times if necessary

• Lecture notes and other material on online:
  • https://csperkins.org/teaching/2015-2016/networked-systems/ (or on the School’s Moodle site)
  • Paper handouts will not be provided – the act of taking notes helps learning
Aims and Objectives

• To introduce the fundamental concepts and theory of communications
• To provide a solid understanding of the technology that supports modern networked computer systems
• To introduce low-level network programming
• To give students the ability to evaluate and advise industry on the use and deployment of networked systems
Intended Learning Outcomes

• By the end of the course, students should be able to:
  • Describe and compare capabilities of various communication technologies and techniques;
  • Know the differences between networks of different scale, and how these affect their design;
  • Describe the issues in connecting heterogeneous networks;
  • Describe importance of layering, and the OSI reference model;
  • Understand demands of different applications on quality of service requirements for the underlying communication network;
  • Demonstrate an understanding of the design and operation of an IP network, such as the Internet, and explain the purpose and function of its various components; and
  • Write simple communication software
## Course Outline

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<th>Lecture Slot 1</th>
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<th>Laboratory Session</th>
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<td>Protocols and layers</td>
<td>Network programming in C</td>
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<td>Physical layer</td>
<td>Data link layer</td>
<td>Debug and extend a simple web server</td>
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<td>3</td>
<td>Media access control</td>
<td>Bridging</td>
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<td>Internetworking</td>
<td>Addressing</td>
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<td>Intra-domain routing (1)</td>
<td>Intra-domain routing (2)</td>
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<td>Inter-domain routing</td>
<td>Transport layer</td>
<td>A map of (part of) the Internet</td>
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<td>TCP</td>
<td>Congestion control</td>
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<td>UDP</td>
<td>NAT</td>
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<td>Transport security</td>
<td>Writing secure code</td>
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<td>Higher-layer protocols</td>
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Assessment

• Assessed exercise: 20%
  • One formative exercise: an introduction to network programming in C
  • Two summative exercises (10% each):
    • Debug and extend a simple web server
    • A map of (part of) the Internet
    • *Do not leave the summative exercises until the last minute: they’re designed to be completed over several weeks, and are too large to complete in a hurry over a couple of days.*

• Examination: 80%
  • Exam format: answer all three questions
Required Reading

• Any good text on computer networks, for example:

• You are expected to read-along with the lectures – the lectures introduce the concepts, and the books provide detail
Introduction to Networked Systems
Networked Systems

• Autonomous computing devices which exchange data to perform some application goal

• The exchange of data is explicitly visible to the application – the system is aware of the network

• Applications using the Internet is one example, but other networks in widespread use:
  • Digital broadcast TV (e.g., FreeView in the UK)
  • Mobile voice telephony
  • Controller area networks connecting sensors and other components within vehicles or aircraft
  • Sensor networks
  • …
Networked Systems

Communication
– how is information exchanged across a single link?

Networking
– how are links interconnected to build a wide-area network?

Networked System
– how do systems communicate across the network?
Communication

- Messages transferred from source to destination(s) via some communications channel
  - Size of messages might be bounded
  - Communication might be simplex, half- or full-duplex
Information

• Messages convey information
  • The amount of information in a message can be characterised mathematically – *Information Theory*

• Capacity of channels to convey information can also be modelled
  • How much? How fast? How much power used?
  • Physical limits exist on the capacity of a channel
Signals

• Physical form of a message is a *signal*
  • May be a material object (carrier pigeon, CD, …)
  • Usually a wave (sound, electrical signal, light, radio, …)

• Signal may be analogue or digital
  • Analogue: a smooth continuum of values
  • Digital: a sequence of discrete *symbols*
    • Mapping information to symbols is known as *coding*
Analogue Signals

- Simplest analogue signal: amplitude directly codes value of interest
  - AM Radio, analogue telephones
- Can be arbitrarily accurate
- Susceptible to noise and interference on channel
- Difficult to process with digital electronics
Analogue Signals

Any analogue signal can be represented digitally: **sample** the signal at a suitable rate, **quantise** to nearest allowable discrete value, and convert to digital representation

- The **sampling theorem** determines the rate at which the signal must be sampled for accurate reconstruction (→ lecture 3)

```
0101
0111
1001
1001
1000
...```

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Digital Signals

- Digital signals comprise a sequence of discrete symbols – fixed alphabet, not arbitrary values
  - But underlying channel is almost always *analogue*
  - Modulation used to map a digital signal onto the channel (→ lecture 3)

- Example: non-return to zero modulation:

![Graph showing non-return to zero modulation with voltage on the y-axis and time on the x-axis. The graph illustrates the transition from 0-2V codes 0 to 3-5V codes 1.]
Digital Signals: Baud Rate

• Computing systems use *binary* encoding
  • The digital signal comprises two symbols: 0 and 1

• Networked systems often use non-binary encoding
  • Example: wireless links frequently use *quadrature amplitude modulation* with either 16, 64, or 256 possible symbols (→ lecture 3)
  • Number of symbols transmitted per second is the *baud rate*
Channels and Network Links

• A signal is conveyed via a channel
  • May be directly conveyed – electrical signals in a cable
  • May be modulated onto an underlying carrier – radio

• The combination of signal and channel forms a link
From Links to Networks

- A link directly connects one or more hosts

- A network comprises several links connected together
  - The devices connecting the links are called either *switches* or *routers* depending on the type of network
Circuit Switched Networks

- A dedicated *circuit* can be set up for A and B to communicate
  - A and B exchange arbitrary length messages
  - Guaranteed capacity once circuit is created
  - But – the dedicated circuit can block other communications (e.g. the C to D path); the capacity of the network gives the blocking probability
  - Example: traditional telephone network

C-D circuit fails, since link is used
Packet Switched Networks

- Alternatively, messages can be split into small *packets* before transmission
  - Allows A-B and C-D to communicate at the same time, sharing the bottleneck link
  - Connectivity guaranteed, but the available capacity varies depending on how many other people are using the network
  - Packets are small, and have a size constraint; a message can consist of many packets
  - Example: the Internet
Networked Systems

- All networked systems built using these basic components:
  - Hosts – the source and destination(s)
  - Links – physical realisation of the channel, conveying messages
  - Switches/routers – connect multiple links

- Layered on top are network protocols which give meaning to the messages that are exchanged
Summary

• Communication → networking → networked systems