Network & Operation Systems Essentials
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Contents

These lecture notes were collated by me from a mixture of sources , the two main sources being the lecture notes provided by the lecturer and the content presented in-lecture. All other referenced material (if used) can be found in the *Bibliography* and *References* sections.

The primary goal of these notes is to function as a succinct but comprehensive revision aid, hence if you came by them via a search engine , please note that they're not intended to be a reflection of the quality of the materials referenced or the content lectured.

Lastly, with regards to formatting, the pdf doc was typeset in LaTeX, using a modified version of Stefano Maggiolo's class

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1 Networks

1.1 *Introduction - Networked Systems*

1.1 definition. Networked System a collection of autonomous computing devices that exchange data to perform some goal

In this first part of the course we'll focus on 3 key aspects of these systems (1) how information is exchanged between the different devices involved ; (2) how we can build larger networks by linking devices ; (3) how systems communicate amongst themselves

1.2 definition. Signal a function which conveys information

1.3 definition. Communication Channel component of a a data transfer system responsible for carrying the signal

1.4 definition. Information Entrophy how much useful information a message is *expected* to contain

Claude Shannon the father of *Information Theory* showed that the amount of information that can be coded into a message could be quantified, and is known as *Information Enthropy*. Shannon stated that a data transfer system is composed of three parts: a source, a communication channel and a receiver. He identified the main problem within the system was to make sure that the information passed over the channel could be successuflly *recreated* by the source.

This encoding and decoding of messages can be done in several ways, some introduce more noise than others, but they all follow the same process of taking some form of physical signal (e.g. a wave) and converting it into some sort of simplied form of itself and then recreating it at the source end

Extra Information Enthropy Formal Definition

If we take X as the set of messages $\{x_1, \ldots, x_n\}$

1.5 definition. Analogue Signal a smooth continuum of values

1.6 definition. Digital Signal a discrete sequence of values

The simplest analogue signal is when information is encoded directly using amplitude (e.g. AM radio), however of particular interest to us is the process of converting analogue signals to digital, which can be done for any analogue signal. (see Physical Layer)

1.7 remark. the the rate at which the signal must be sampled for accurate reconstruction is given by the sampling theorem

Switching

1.8 definition. Codign the act of mapping information to symbols

1.9 definition. Link the combination of a signal with a channel

1.10 definition. Hosts receivers and sources

1.11 definition. Network a collection of connected links

Within a networked system, information flows via channels forming links which connect hosts. The devices connecting the links are called *switches* or *routers* depending on the type of network. This *network switching* is responsible for determining how the information flows through the network and can be setup so that there are dedicated connections between hosts - *circuit switching* - or by splitting the messages into smaller packets before transmission allowing several hosts to share the same channell - *packet switching*

1.12 definition. Circuit Switching a dedicated circuit between hosts

1.13 definition. Packet Switching a shared link where messages are split into packets before transmission

The main trade-off here is between capacity and availability. For example, traditional phone networks are circuit switched (the very first ones had actual humans switching the channels and connecting hosts) which means that the two hosts requested a channel and they had guaranteed capacity over that channel while the connection was active, but it also meant that if some other hosts needed to use any part of the same link then their connection would be refused.

The internet on the other hand, is packet switched, by breaking the messages apart into smalled chunks hosts can share links the catch here being that though connectivity is guaranteed the capacity/speed is dependent on how many users are using the same channel.

1.2 *Protocols*

The different building blocks of a network presented above allow for the transportation of information, but is is the use of protocols which provide the semantics. For a message to be decoded the parties involved must agree on some sort of well-defined syntax, so that noise can be separated from meaningul information, this is precisely the role of the various network protocols existing at all levels within a network.

1.14 definition. PDU stands for protocol data unit, and is the basic unit of information for any given protocol

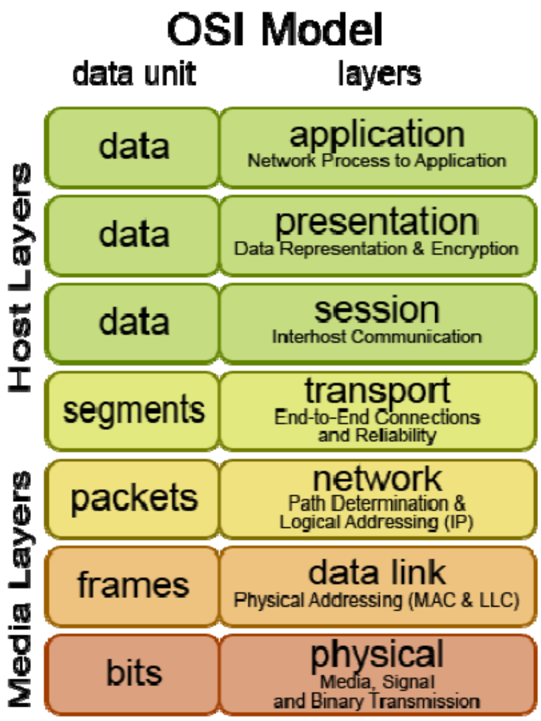
PDUs can be textual where rules of syntax and grammar are used to implement behaviour (e.g. HTTP), or binary where similar appropriate rules are used (e.g. TCP/IP). It is the role of PDUs to define what messages are legal to send, but is up to protocol semantics to define when to send them and what should be expected in response

Layers

Communication systems are tipically organised into layers, which reduces complexity at each layer's level. Peers on the same layer, use that layer's protocol to communicate using services provided by the well-defined interfaces of the lower layers

1.15 definition. OSI Model stands for *Open Systems Interconnection Model* and is a conceptual model that characterises and standardises the communication functions of a telecommunication or computing system without regard to its underlying internal structure and technology.

A design tool used widely to model layered communication channels is the *OSI model*. It is merely a design tool, real implementations are more complex and usually the boundaries between layers are not so well defined.



1.3 *OSI - Physical Layer*

The physical layer is concernerd with the transmission of raw data bits. In order for this to be possbile, the information needs to be transformed and encoded and a decision on the best medium for the job (e.g. cables, fibre optic etc.) and their phyiscal properties needs to be taken.

Transmission Channels - Enconding & Modulation

1.16 definition. Wired Data Trasmission the signal is transmited over a cable and is *directly* enconded onto the channel, by varying the voltage/light intensity

1.17 definition. Wireless Data Transmssion the signal is transmitted without the aid of an electrical conductor, most commonly using radio waves and some kind of modulation

A signal can travel with or without the aid of an electrical condutor, if it is directly encoded into a cable, then one of several *enconding schemes* can be used in order to change the signal into discrete pieces of data (e.g. bits).

High $\approx [3,5]v$ *, and Low* $\approx [0,3)$
NRZ : Non-Return to Zero

- **NRZ :** 1 – High ; 0 – Low

- **NRZ Inverted :** 1 – Change ; 0 – Constant
- **Manchester :** 1 – High-Low ; 0 – Low-High

To do (??)

Alternatively one can encode information onto a channel by varying the properties of the carrier signal via a modulating signal, a process know as *modulation* which allows the same channel to be shared by different signals
To do (??)

Bandwith, Capacity & Noise

1.18 definition. Bandwith determines the frequency range it can transport

1.19 definition. Sampling Theorem states that to accurately digitise an analogue signal, $2H$ samples per second are needed, where H is the bandwith in Hz

1.20 definition. Signal-to-Noise Ratio the ration between signal power and noise floor, typically quoten in $\text{dB} = 10\log(\frac{S}{N})$

The bandwidth of a channel is determined by physicial limitations of the channel, and given the existence of noise in the real worl, the *Signal-to-Noise* ratio and the bandwidth represent the fundamental limits for the rate at which information can be transmitted

1.21 remark. The maximum transmission rate of a channel grows lograithmically to the SNR

Extra Theoretical Maximum Transmission Rate

$$R_{max} = 2H \log_2 V$$

where:

R_{max} = max trasmission rate in bits/s

H = bandwith in Hz

V = # of discrete values per symbol

Extra Shannon's Theorem

$$R_{max} = H \log_2(1 + SNR)$$

Summary

- **PDU :** bits
- **Function :** transmit a sequence of bits over an analogue channel

To do...

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