TELE303 Mobile Systems

Lecture 1 – Introduction

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Outline

- Course outline
- Historical context
- Basic concepts related to transmission
  - Data
  - Signal
  - Bandwidth and data rate
  - Sampling
  - Shannon capacity theorem

Course Information

Teaching Team

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  - Wk 6-11: Matthew Cook (email: cooma376@student.otago.ac.nz)

What's in TELE303

- Wireless fundamentals, e.g.:
  - Signaling
  - Coding
  - Spread spectrum
- Routing and TCP performance
- Mobile application development
- Principles of modern technologies: Wi-Fi, GSM, WiMax, 3G/4G…
- Mobile ad hoc networking
- Security and management

Lecture #	Date	Topic	Tutorial / Laboratory
1	29/2	Mobile computing: overview	
2	1/3	Transmission	
3	7/3	Propagation	Tutorial 1 | Lab 1
4	8/3	Encoding	
5	14/3	Spread spectrum	Tutorial 2 | Lab 2
6	15/3	Medium access control	
7	21/3	MANETs & Routing	Tutorial 3 | Lab 3
8	22/3	TCP performance	
		Mid-semester Break	
9	4/4	Mobile Systems overview 1 (History)	Catch-up lab
10	5/4	Mobile Systems overview 2 (Hardware)	
11	11/4	Prototyping mobile apps	Project starts
12	12/4	Android Programming Basics 1 (Introduction)	
13	18/4	Android Programming Basics 2 (Activities)	Lab 4 (1st Milestone)
14	19/4	Android Programming Basics 3 (Events, Intents)	
15	26/4	Android Programming Basics 4 (Data handling)	Lab 5
16	27/4	Android Programming Basics 5 (Threads, NDK)	
17	2/5	Sensors 1	Lab 6 (2nd Milestone)
18	3/5	Sensors 2	
19	9/5	App Distribution / Future of mobile computing	Lab 7
20	10/5	Android Review	
21	16/5	Cellular Wireless Networks	Lab 8 (Final Milestone)
22	17/5	Wireless LANs and PANs	
23	23/5	Satellite Communications	Tutorial 4
24	24/5	Wireless Security	
25	30/5	Wireless Sensor Networks	
26	31/5	Review	

Resources

- Textbooks

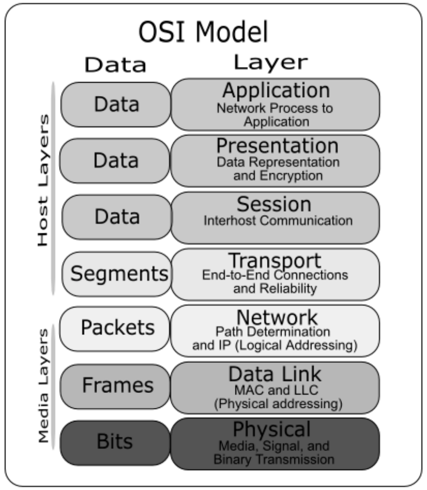
- Course website: www.telecom.otago.ac.nz/tele303/
- Piazza site – sign up *now*:
  - **piazza.com/otago.ac.nz/semester12016/tele303**
  - **Q&A,** notes and resources …
  - Announcements

Concepts and Terminology

Wireless Comes of Age

- The earliest form of telecommunications is ***wireless***.
- Guglielmo Marconi invented wireless telegraph in 1896.
- Shortwave radio started around 1930s.
- Communications satellites first launched in 1960s. (Sputnik 1957)
- Internet project began in 1960s.
- The newest wavefronts: Cellular, Wi-Fi, bluetooth, NFC …

Ok, shall we start … but where?



Source: Wikipedia

Data Communication Terms

- Data - entities that convey meaning, or information
- Signals - electric or electromagnetic representations of data
- Transmission - communication of data by the propagation and processing of signals

Electromagnetic Signal

- Function of time
- Can also be expressed as a function of frequency
  - o Signal consists of components of different frequencies
- Analog signal - signal intensity varies in a smooth fashion over time
  - o No breaks or discontinuities in the signal
- Digital signal - signal intensity varies only on constant levels over time

Time-Domain Concepts

- General sine wave
  - $s(t) = A \sin(2\pi ft + \phi)$
- Peak amplitude (A)
- Frequency (f)
- Period (T = 1/f)
- Phase (ϕ)
- Wavelength ($\lambda = c$T)

➢ see Fig.2.3

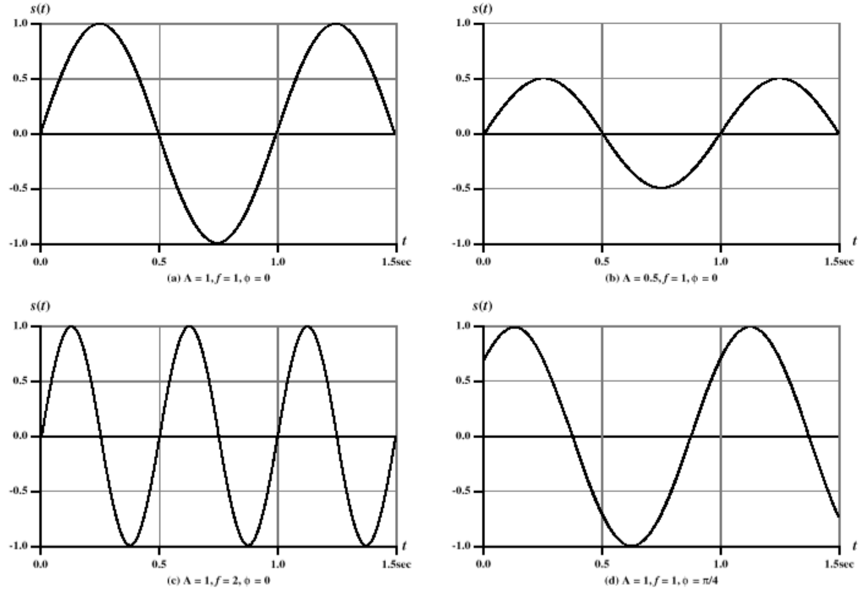


Figure 2.3

Frequency-Domain Concepts

- When all frequency components of a signal are integer multiples of one frequency, it's referred to as the **fundamental frequency**.
- **Spectrum** - range of frequencies that a signal contains
- **Bandwidth** - the band of frequencies that *most* of the signal's energy is contained in.

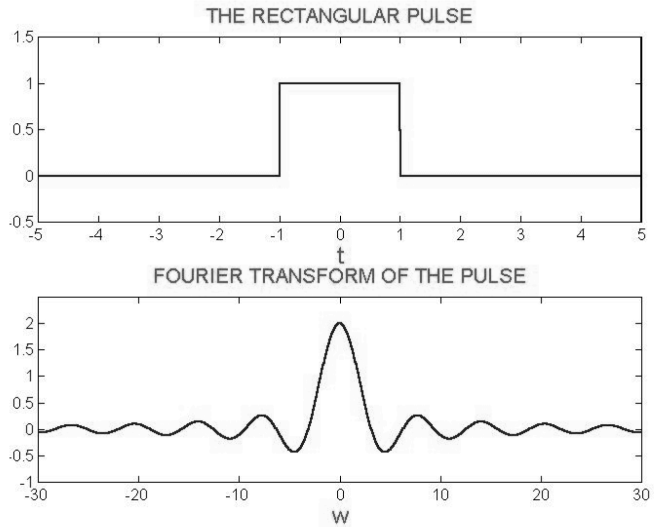
Analog Signals

- A continuously varying electromagnetic wave that may be propagated over a variety of media, depending on frequency
  - E.g. video & audio signals
- Examples of media:
  - Copper wire media (twisted pair and coaxial cable)
  - Fiber optic cable
  - ➢ Atmosphere or space propagation
- Analog signals can propagate analog and digital data

Digital Signals

- A sequence of voltage pulses that may be transmitted over a copper wire medium
- Generally cheaper than analog signaling
- Less susceptible to noise interference
- Any digital waveform will have infinite bandwidth.
- Suffer more from attenuation
- Digital signals can propagate analog and digital data

The Square Wave



Transmission Basics

Analog Transmission

- Transmit analog signals *without* regard to content
- *Attenuation* limits length of transmission link
- Cascaded amplifiers boost signal's energy for longer distances but cause *distortion*
  - o Analog data can tolerate distortion
  - o Introduces errors in digital data

Digital Transmission

- Concerned with the content of the signal
- Attenuation endangers integrity of data
- Digital Signal
  - o Repeaters achieve greater distance
  - o Repeaters recover the signal and retransmit
- Analog signal carrying digital data
  - o Retransmission device recovers the digital data from analog signal
  - o Generates new, clean analog signal

Channel Capacity

- Impairments, such as noise, limit data rate that can be achieved

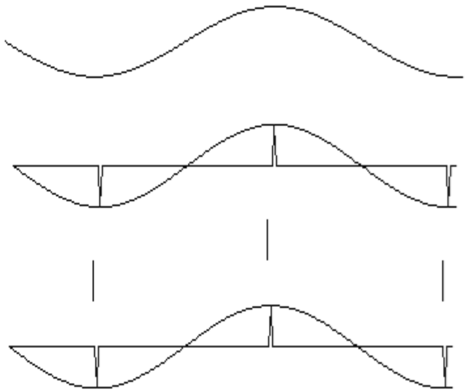
- Channel Capacity – the maximum rate at which data can be transmitted over a given communication path, or channel, under given conditions

Some Related Concepts

- Data rate - rate at which data can be communicated (bps)
- Bandwidth - the bandwidth of the transmitted signal as constrained by the transmitter and the nature of the transmission medium (Hz)
- Noise - average level of noise over the communications path
- Error rate - rate at which errors occur
  - o Error = transmit 1 and receive 0; transmit 0 and receive 1

Nyquist Sampling: $f_s = 2f_{max}$

- Analog ➔ Digital conversion requires sampling.
- A signal sampled twice per cycle has enough information to be reconstructed.
  - o Q: CD samples at 44,100 Hz, reproducing audio quality up to .... Hz.
- Lower sampling frequencies cause *aliasing*.



Nyquist Bandwidth

- Given a channel bandwidth of *B* Hz, the highest **signal rate** that can be carried is 2*B* Hz.
- For binary signals (two voltage levels), data rate is
  - o $C = 2B$ bps
- With multilevel signaling, data rate is
  - o $C = 2B \log_2 M$ bps
    - M = number of discrete signal or voltage levels

Signal-to-Noise Ratio

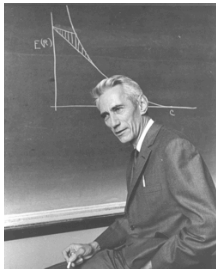
- Ratio of the power in a signal to the power contained in the noise that's present at a particular point in the transmission
- Signal-to-noise ratio (SNR, or S/N) usually expressed in decibels:

$$(\mathrm{SNR})_{\mathrm{dB}} = 10\log_{10}\frac{P_s}{P_n}$$

- A high SNR means a high-quality signal, low number of required intermediate repeaters

➲ SNR sets upper bound on achievable data rate

Shannon Capacity



➲ $C = B\log_2\left(1+\mathrm{SNR}\right)$

- o C: capacity, B: bandwidth

- Represents theoretical maximum that can be achieved under given *B* and SNR
- In practice, only much lower rates achieved
  - o Formula assumes white noise (thermal noise)
  - o Impulse noise is not accounted for
  - o Attenuation distortion or delay distortion not accounted for

Recap

- This lecture: terms and concepts
  - o Data & signals
  - o Digital vs analog
  - o Sampling
  - o Shannon capacity
- Next lecture: "Transmission"
- Spectrum
  - o Fourier transform
  - o How to 'spread' spectrum
- Transmission media
- Multiplexing and duplexing