Engineering Tripos Part IIA, 3F4: Data Transmission, 2019-20

Module Leader

Dr R Venkataramanan [1]

Lecturers

Dr R Venkataramanan, Prof. Ioannis Kontoyiannis [2]

Lab Leader

Dr J Sayir [3]

Timing and Structure

Lent term. 16 lectures

Prerequisites

Knowledge of 3F1 assumed.

Aims

The aims of the course are to:

- Cover a range of topics which are important in modern communication systems.
- Extend the basic material covered in the Engineering Part IB Communications course to deal with data transmission over baseband (low frequency) channels as well bandpass (higher frequency) channels.
- Analyse the effects of noise in some detail.
- Understand the technique of convolutional coding to protect information transmitted over noisy channels.
- To understand basic congestion control protocols (TCP/IP), and routing algorithms used in the Internet.

Objectives

As specific objectives, by the end of the course students should be able to:

- Understand the different components of a communication network, in particular the role of the physical layer versus the network layer.
- Be able to represent waveforms as vectors in a signal space.
- Appreciate that pulses may be shaped to control the bandwidth of a signal and reduce inter-symbol interference, and be aware of the limits on transmission rate if ISI is to be avoided.
- Be able to describe and analyse demodulation of digital bandpass modulated signals in noise.
- Calculate the probability of error of various modulation schemes as a function of the signal-to-noise-ratio.
- Appreciate how equalisation can correct for undesirable channel characteristics and be able to design simple equalisers.
- Understand the principles of Orthogonal Frequency Division Multiplexing for communication over multi-path wideband channels
- Understand the need for coding, i.e., adding redundancy to control the effects of transmission errors.

- Understand the principles of convolutional coding, and be able to design a Viterbi decoder for convolutional codes.
- Understand the operation of congestion control protocols (TCP/IP) and routing algorithms used in the internet

Content

Fundamentals of Modulation and Demodulation (7L)

- Introduction: The overall commuication network and the roles of the physical layer and the network layer
- Signal Space: representing waveforms as elements a vector space
- Baseband modulation: Desirable properties of the pulse for PAM; Nyquist criterion for no inter-symbol interference; Eye-diagrams
- Modelling the noise as a Gaussian random process. Additive White Gaussian Noise (AWGN)
- Optimal demodulation and detection at the receiver in the presence of AWGN: Matched filter demodulator, optimal detection using the maximum-a-posteriori probability (MAP) rule
- Passband modulation: QAM, M-ary FSK (Orthogonal signalling)
- Performance analysis of modulation schemes (PAM, QAM, Orthogonal signaling etc.): probability of detection error and bandwidth efficiency

Advanced Topics in PHY-layer (3L)

- Brief discussion of coded modulation
- Equalisation techniques to deal with inter-symbol interference: ZF and MMSE equalizers
- Orthogonal Frequency Division Multiplexing (OFDM)

Channel Coding (3L)

- Introduction to error correction and linear codes
- Convolutional codes: State Diagram and Trellis representations, Viterbi decoding algorithm
- Distance properties of convolutional codes using the transfer function derived from state diagram; free-distance of convolutional codes.

Network Algorithms (3L)

- Congestion control in the Internet: window-based congestion control: TCP-Reno; slow-start, congestion avoidance
- Routing algorithms in the Internet: Djikstra's algorithm, Bellman-Ford and the similarities to the Viterbi algorithm

Further notes

The syllabus for this module was updated (with significant changes) in 2017-18. A list of relevant past Tripos questions is available on Moodle.

Coursework

Digital transmission systems

Learning objectives:

- To investigate, using a hardware simulation of baseband transmission channels, the phenomenon of inter-symbol interference, and to measure bit error rate (BER) due to noise
- To use the eye diagram as a diagnostic tool, and to understand its limitations.
- To compare the measured dependence of BER on signal-to-noise Ratio (SNR) with theoretical predictions,

and explain the differences by considering how the assumptions made in the theoretical analysis compare with the real situation.

Practical information:

- Sessions will take place in EIETL, during week(s) [xxx].
- This activity involves preliminary work-- reading the lab handout [estimated duration: 1 hour].

Full Technical Report:

Students will have the option to submit a Full Technical Report.

Booklists

For Physical-layer communications (first 13L):

- B. Rimoldi, Principles of Digital Communication: A Top-Down Approach, Cambridge University Press, 2016]
- R. Gallager, Principles of Digital Communication, Cambridge University Press, 2008
- U. Madhow, Fundamentals of Digital Communication, Cambridge University Press, 2008

For network algorithms (last 3L):

- R. Srikant and L. Ying, Communication Networks, Cambridge University Press, 2014.

Examination Guidelines

Please refer to Form & conduct of the examinations [4].

Last modified: 03/09/2019 17:28

Source URL (modified on 03-09-19): https://teaching.eng.cam.ac.uk/content/engineering-tripos-part-iia-3f4-data-transmission-2019-20

Links
[1] mailto:rv285@cam.ac.uk
[2] mailto:rv285@cam.ac.uk, ik355@cam.ac.uk
[3] mailto:js851@cam.ac.uk
[4] https://teaching.eng.cam.ac.uk/content/form-conduct-examinations