The University Of Sheffield.

Electronic & Electrical Engineering.

EEE6432 WIRELESS PACKET DATA NETWORKS AND PROTOCOLS

Credits: 15

Course Description including Aims

The aim of this module is to give an understanding of the functionality of packet switching protocols at different layers of a wireless system and to appreciate how these protocols achieve reliable data delivery in wireless communication systems. An outline of the syllabus includes an introduction to packet switching in wireless networks; radio link protocols: forward error detection and correction, CRC, Checksum, backward error detection, ARQ and hybrid-ARQ; MAC protocols; packet scheduling and differentiated quality of service; radio resource management, network planning and optimisation; network examples – WiFi, HSPA or LTE.

This unit aims to introduce and provide an understanding of:

1. Packet switching in wireless networks;
2. Radio link protocols: forward error detection and correction, CRC, Checksum;
3. Backward error detection and correct: Stop-and-Wait ARQ, Go-back-N ARQ, Selective-Repeat ARQ, and hybrid-ARQ;
4. MAC protocols: random access protocols (Aloha, CSMA, CSMA/CD, CSMA/CA), channelization (FDMA, TDMA and CDMA) and controlled access;
5. Radio resource management (RRM);
6. Network planning and optimisation;
7. Network examples – WiFi, HSPA or LTE

Outline Syllabus

- Lectures 1-4: Packet switching principles in wireless networks and OSI model;
- Lectures 5-10: Radio link protocols: forward error detection and correction;
- Lectures 11-16: Radio link protocols: backward error detection and correction;
- Lectures 17-20: MAC protocols;
- Lectures 21-23: Radio resource management (RRM);
- Lectures 24-26: Network planning and optimisation;
- Lectures 27-29: Network examples – WiFi, HSPA or LTE;
- Lectures 30: Recent advances of coding, HARQ and RRM in 4G/5G/B5G/WiFi

Time Allocation

30 lectures, 6 problem solving classes and 38 hours of coursework exercises.

Recommended Previous Knowledge

UG level 3 (or equivalent) understanding of basic electronic and electrical engineering, digital communications theory and communications networks.

Assessment

Two hour examination.
Essay/Coursework.

Recommended Books

Data Communications and Networking, Behrouz A. Forouzan, 4th and 5th Edition, The McGraw-Hill Companies, Inc.

Computer Networks: A Systems Approach, Larry L. Peterson, Bruce S. Davie, Morgan Kaufmann

Wireless Communications and Networks, William Stallings, Prentice Hall

Computer Networks: International Version, Andrew S. Tanenbaum, David J. Wetherall, Pearson

WCDMA for UMTS: HSPA Evolution and LTE, Harri Holma, Antti Toskala, John Wiley & Sons

LTE for UMTS: Evolution to LTE-Advanced, Harri Holma, Antti Toskala, John Wiley & Sons

Objectives

By the end of the module a successful student will be able to:

1. Appreciate packet switching principles in wireless networks;
2. Understand the fundamentals of reliable packet exchange;
3. Understand and analyse prevailing channel access protocols;
4. Analyse and design RRM policies for wireless networks;
5. Plan wireless network deployments;
6. Understand & appreciate prevailing network architectures.

Detailed Syllabus

- Lectures 1-4: Packet switching principles in wireless networks and OSI model;
- Lectures 5-10: Radio link protocols: forward error detection and correction, linear block codes, Hamming distance, Hamming codes, CRC, Checksum;
- Lectures 11-16: Backward error detection and correction: Stop-and-Wait ARQ, Go-back-N ARQ, Selective-Repeat ARQ, and hybrid-ARQ;
- Lectures 17-20: MAC protocols: random access protocols (pure Aloha, slotted Aloha, CSMA, CSMA/CD, CSMA/CA), channelization (FDMA, TDMA and CDMA) and controlled access (polling, token passing, reservation);
- Lectures 21-23: Radio resource management (RRM): channel allocation, power control, admission control, handover;
- Lectures 24-26: Network planning and optimisation: cellular concepts, network capacity for FDMA, TDMA and CDMA networks; link budget calculation, uplink and downlink coverage calculation, radio propagation models; system level simulation; base station / access point location optimisation;
- Lectures 27-29: Network examples – WiFi, HSPA or LTE, co-existence of LTE-LAA and WiFi, IoTs;
- Lectures 30: Recent advances of coding, HARQ and RRM in 4G/5G/B5G/WiFi

UK-SPEC/IET Learning Outcomes

Outcome Code	Supporting Statement
SM1m / SM1fl	The understanding of the functionality of packet switching protocols at different layers of a wireless system and how these protocols achieve reliable data delivery. Topics covered include principles of packet switching, radio link protocols such as CRC, ARQ and hybrid-ARQ, MAC protocols, packet scheduling, routing, IP protocol and radio resource management, network planning and optimisation, and how they are implemented in some network examples – WiFi, HSPA or LTE. The ability to exploit these ideas is tested in the exam.
SM2m	The application of statistical tools such as Poisson distribution and/or Markov chain to MAC protocol performance analysis. The understanding of these ideas is tested in the exam.
SM4m	The understanding of latest development in 4G/5G mobile and WiFi networks. Such as dense small cell deployment, interference control in heterogeneous networks (HetNet), joint indoor-outdoor HetNet planning and optimisation. The understanding of these ideas is tested in the course work.
SM6m	The knowledge of commercial network planning and optimisation tools such as iBuildNet and use it to plan in-building cellular and WiFi networks. The ability to write own programs (e.g., in Matlab or C/C++) to simulate ARQ, HARQ and MAC protocol performances. These will be learned in practical/tutorial classes.
SM2fl	The understanding of latest development in 4G5G mobile and WiFi networks. Such as dense small cell deployment, interference control in heterogeneous networks (HetNet), joint indoor-outdoor HetNet planning and optimisation. The understanding of these ideas is tested in the course work.
SM3fl	The knowledge of commercial network planning and optimisation tools such as iBuildNet and use it to plan in-building cellular and WiFi networks. The ability to write own programs (e.g., in Matlab or CC++) to simulate ARQ, HARQ and MAC protocol performances. These will be learned in practical/tutorial classes.
EA2m	Use mathematical modelling techniques to analyse performance of random access protocols such as CSMA, Aloha and WCDMA network capacity.
EA3m	Use mathematical modelling techniques to analyse the capacity of WCDMA communications systems. Analyse the impact of interference, quality of service requirement and service data rate on network capacity.
EA5m	The ability to use the knowledge learned from this module to investigate organisation and operation of communications networks, network architectures, and to investigate and develop new ARQ, HARQ, MAC protocols. This is tested in coursework.
EA2fl	The ability to use the knowledge learned from this module to investigate organisation and operation of communications networks, network architectures, and to investigate and develop new ARQ, HARQ, MAC protocols. This is tested in coursework.