MOF: **LTE (4G) mobile radio networks**
Online course specification

Target audience:
This online course is designed for those who are, or intend to be, involved in planning or commissioning LTE mobile systems.

Course aim:
This course introduces the features, structure and operation of the radio access network and evolved packet core of a LTE (Long Term Evolution) mobile system.

Course level: Intermediate
An explanation of PTT course levels is given at the end of this document

Pre-requisites:
You will get the most out of this course if you already have an understanding of the principles of mobile communications. Therefore, familiarity with the material in the PTT course "Introduction to mobile systems" is desirable. Ideally, you should also have a detailed understanding of 3G mobile systems.

Course structure:
The course consists of the following 6 modules:
1. Course introduction
2. Developments beyond 3G
3. System evolution
4. LTE air interfaces
5. Frequencies for LTE
6. LTE RAT processing

Module 1: Course introduction

Module aim: To summarise the aims of each module and introduce the navigation and learning facilities provided by the course.

Module 2: Developments beyond 3G

Module aim: To explain the need for mobile systems with capabilities beyond those of 3G and the work of 3GPP to standardise systems to meet those needs.

After completing this module, a trainee will be able to:
- explain the drawbacks of existing 3G networks in terms of throughput and latency.
- describe the extra demands placed by "all IP" networks carrying diverse traffic streams.
- explain the 3GPP work towards satisfying those drawbacks and demands.
- describe the 3GPP documentation system and the significance of the "Release" system.
- indicate which releases are relevant to the development of Long Term Evolution (LTE) systems.

Module 3: System evolution

Module aim: To explain the development of core network structures through HSPA+ to System Architecture Evolution (SAE).

After completing this module, a trainee will be able to:
- explain how HSDPA and HSUPA brought about changes to system architectures.
- describe the features of HSPA+ with particular reference to core network developments.
- explain the concept of System Architecture Evolution (SAE) and its essential function in LTE.
- describe the functions of the elements of the LTE radio access network and the Evolved Packet Core and explain how they differ from the similar functions of earlier dual circuit-/packet-switched systems.
- describe the role of an IP Multimedia Subsystem (IMS) with reference to the evolution of mobile systems to an 'All IP' environment.

Module 4: LTE air interfaces

Module aim: To explain LTE standards for the downlink and uplink of the air interface and why different technologies have been chosen.

After completing this module, a trainee will be able to:
- describe OFDM and its diverse uses, including in WiFi and WiMAX.
- describe the spectral efficiency advantage of OFDM and define PAPR (Peak to Average Power Ratio), explaining the problems of using OFDMA for uplinks.
- explain SC-FDMA (Single Carrier-FDMA), how it is derived from OFDM and why it lessens the PAPR problem.
- state that LTE can use either Frequency Division Duplex (FDD) or Time Division Duplex (TDD) and explain the advantages of each.
- describe the use of carrier aggregation to increase data transfer rates.

Module 5: Frequencies for LTE

Module aim: To explain considerations applying to frequency allocations for LTE.

After completing this module, a trainee will be able to:
- describe the importance of 'harmonised' frequency allocations.
- describe how frequencies are assigned with reference to auction procedures and other methods.
- explain what is meant by the 'digital dividend' and its possible effect on frequencies for LTE.
- explain LTE's flexible bandwidth approach and the meaning of 'radio resource block'.

Module 6: LTE RAT processing

Module aim: To describe processing used over the LTE radio access technology.

After completing this module, a trainee will be able to:
- explain Hybrid ARQ (HARQ), Incremental Redundancy (IR) and Adaptive Modulation and Coding (AMC).
- describe Multiple-In Multiple-Out (MIMO) multi-antenna techniques and their uses on downlinks and uplinks to improve radio link performance and throughput.
- describe downlink and uplink logical and physical channels.

- describe how the Multimedia Broadcast and Multicast Service (MBMS) is accommodated.
- explain the need for, and methods of, power output control.

Course access requirements:
To access the course, a computer running a browser such as Google Chrome, Safari etc is required. The computer should have Internet access. A screen resolution of at least 1024x768 is necessary.

Learning facilities:
This online course employs interactive simulations, hypertext links to an online glossary and multiple-choice question sessions to fully involve the trainee in the learning experience. Each module provides revision links to previously studied, relevant topics. A record of progress and level of achievement is recorded for each trainee. Once studied as a structured, assessed course, the content can be browsed for revision or reference.

PTT course levels:
PTT online courses are categorised by one of three levels according to the depth of treatment they provide:

1. **Introductory:**

   PTT Introductory courses are designed for those with no previous experience or knowledge of telecommunications. These courses provide an overview of telecommunications or discuss the fundamentals of electronic communications. The study of general science at secondary (high) school is a typical pre-requisite for PTT Introductory courses.
   PTT Introductory courses are suitable for those joining the telecommunications sector particularly those in an apprenticeship programme.

2. **Intermediate:**

   PTT Intermediate courses are designed for technicians and engineers requiring an understanding of a certain aspect of telecommunications. Those planning to study an Intermediate course should have an understanding of the basic principles of electronic communications.
   The depth of treatment provided by Intermediate courses is typically equivalent to level 3 of a UK national vocational qualification (NVQ). PTT Intermediate courses can be used to support the attainment of a Communications Technology NVQ at level 3.

3. **Advanced:**

   PTT Advanced courses are designed for those who require an in-depth treatment of a certain aspect of telecommunications. Such courses are suitable for system designers as well as those who will be responsible for the maintenance of the system described in the course.
   Those planning to study a PTT Advanced course should have a background in telecommunications, and an understanding of telecommunications fundamentals and the principles of the type of telecommunications system described in the course.

PTT
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