MJD: Advanced mobile systems
Online course specification

Target audience:
This online course is designed for those who are, or intend to be, involved in planning or commissioning LTE and 5G mobile systems.

Course aim:
This course describes the role of the functional elements of the various generations of mobile system and describes mobility in, and the provision of services over, LTE (4G) and 5G mobile systems.

Course level: Advanced
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 understand the principles of mobile communications. Therefore, familiarity with the material in the PTT courses "Introduction to mobile systems" and "Mobile radio communications" is desirable. Study of the PTT course "4G and 5G radio access networks" will also be beneficial.

Course structure:
The course consists of the following 4 modules:
1. System evolution
2. Quality of service
3. Mobility
4. Voice over LTE and 5G

Module 1: System evolution

Module aim: To describe how mobile systems have evolved to meet the demands for new improved services and compare the structure and functional elements of the various generations of those systems with emphasis on LTE and 5G systems.

After completing this module, a trainee will be able to:
- describe the various tasks a mobile system must perform.
- describe and compare the roles of the control and user plane of a mobile system.
- explain that the separation off control and user plane functional elements in LTE systems has been taken a step further in 5G systems.
- explain that the use of circuit switching in 2G and 3G systems for voice calls has been replaced with an all IP core network in LTE and 5G systems.
- describe the role of the various functional elements in 2G (GSM) and 3G (UMTS) systems.
- describe and compare the role of the various functional elements in LTE and 5G systems.
- explain that the use of network function virtualisation (NFV) in 5G systems provides greater flexibility for service provision.
- describe and compare the various options for the provision of a non standalone (NSA) 5G service that relies on an existing LTE infrastructure.

Module 2: Quality of service

Module aim: To describe the factors that determine the Quality of Service (QofS) requirements for a particular service and explain how LTE and 5G systems deliver the required QofS.

After completing this module, a trainee will be able to:

- explain the need for quality of service (QofS) guarantees as defined by specified limits for latency and error rate.
- explain that the QoS requirements for diverse types of traffic are catered for using class of service indicators.
- explain that 5G systems employ a greater range of class of service indicators than LTE to cater for uRLLC and mMTC services.
- explain the purpose of an Evolved Packet System (EPS) bearer in LTE systems with reference to the provision of data services with a defined QofS.
- explain and compare the purpose and benefits of default and dedicated bearers.
- explain the functions of the Policy and Charging Rules Function.
- describe the user equipment (UE) registration procedure with reference to the provision of a default bearer.
- describe how dedicated bearers are established with reference to the interaction of the LTE evolved packet core (EPC) and 5G core network (5GC) with an IP Multimedia System (IMS).
- explain how 5G systems cater for simultaneous access to many services each with their own QofS requirements while reducing set up times.

Module 3: Mobility

Module aim: To discuss the Evolved Packet Core (EPC) interfaces, protocols and procedures involved with mobility management and interworking with other mobile systems.

After completing this module, a trainee will be able to:

- explain mobility management with reference to the various LTE mobility states including Idle and Connected.
- explain that 5G systems employ an extra "Inactive" mobility state to match the requirements of machine type communications.
- describe the role and significance of tracking areas.
- describe the paging procedure that alerts user equipment (UE) to incoming calls or data.
- describe LTE handover procedures for various scenarios including intra SGW and inter SGW handover with reference to the role of, and interaction between, the various functional elements of the mobile system.
- describe 5G handover procedures for various scenarios including inter gNodeB and inter AMF with reference to the role of, and interaction between, the various functional elements of the mobile system.
- describe the role of the connections between systems necessary for handover between LTE and earlier generations of mobile system.

Module 4: Voice over LTE and 5G

Module aim: To describe and compare the various ways of providing a telephony and short message service over LTE and 5G mobile systems.

After completing this module, a trainee will be able to:
- describe the basic functions of the key components of an IP Multimedia Sub-system (IMS).

- explain the role of EPS bearers in establishing a Voice over IP (VoIP) call in a Voice over LTE (VoLTE) system.
- describe the interaction between a UE and an IMS in setting up a VoIP call in a VoLTE system.
- explain how a voice service can be provided by requiring a mobile device to handover from the LTE system to a 2G or 3G radio access network ("CS fallback") for voice calls.
- explain how a VoIP call can be maintained while handing over between an LTE radio access network (RAN) and a UMTS RAN.
- describe methods of providing a Short Message Service to a mobile device attached to an LTE radio access network.
- describe the setting up of a VoNR voice call over a 5G system with reference to the provision of default and dedicated QofS flows and the interactions between a UE and the IMS.
- explain the need for, and procedures involved in, interworking between LTE and 5G mobile systems with reference to EPS fallback and handover between LTE and 5G base stations.

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.