MED: Voice over IP systems
Online course specification

Target audience:
This online course is designed for those who will be responsible for the design or maintenance of Voice over IP (VoIP) telephony systems, particularly those providing a public service over a next generation network.

Course aim:
This course describes the functional components and operation of telephony systems based on the Internet Protocol (IP) with emphasis on those employing an IP Multimedia Subsystem (IMS).

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

Pre-requisites:
An understanding of the principles and operation of SIP-based Voice over IP systems. It is recommended that the PTT online course "Voice over IP" is studied before attempting this course.

Course structure:
The course consists of the following 6 modules:
1. Course introduction
2. Megaco VoIP sub-system
3. SIGTRAN protocols
4. PSTN VoIP interworking
5. Call control in NGNs
6. IMS-based PSTN emulation

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: Megaco VoIP sub-system

Module aim: To describe the components, facilities and operation of Megaco Voice over IP systems that use the gateway control protocol as specified by the ITU recommendation H.248.

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

- Explain the requirement to separate call control and transmission in a VoIP system providing public telephony services.
- Describe the relationship between the specifications produced by the IETF and the ITU for a gateway control protocol.
- Describe the role of a Media Gateway Controller.
- Describe the roles of residential and trunking gateways.
- Describe the role of a signalling gateway.
- Describe the role of the signalling protocols SIP, H.248, H.323 and SIGTRAN in a Megaco system.

- Explain the H.248 concepts Context, Termination and media streams and the relationship between them.
- Describe the role of H.248 commands including Add, Subtract, Modify, Notify, and ServiceChange.
- Explain the role of Media, Events and Signals Descriptors in H.248 commands.

Module 3: SIGTRAN protocols

Module aim: To describe the role and facilities provided by the various SIGTRAN protocols in relation to the transport of signalling messages between a circuit-switched network based on C7 signalling and a Voice over IP network.

After completing this module, a trainee will be able to:
- Describe the basic role of the Message Transfer Part (MTP) of C7 signalling with reference to the reliable, in sequence delivery of signalling messages to a particular signalling point.
- Compare the characteristics of a transmission path in a circuit-switched network to that provided by IP network.
- Explain the limitations of the transport layer protocols UDP and TCP with reference to the reliable in-sequence delivery of signalling messages over an IP network.
- Describe the role of the SIGTRAN protocol stack.
- Describe how SCTP introduces less delay than TCP with reference to SCTP's multistreaming facility.
- Explain the SCTP concepts of an Association and Streams.
- Explain the operation of SCTP with reference to the use of different types of sequence number (TSN and SSN).
- Describe the various facilities of SCTP including protection against denial of service attacks, multi-homing, unordered delivery option, and congestion control.
- Describe the role of a signalling gateway with reference to the SIGTRAN and C7 signalling protocol stacks.
- Compare the facilities offered by the SIGTRAN adaptation protocols M2UA, M2PA and M3UA when transporting C7 signalling between a PSTN and a Megaco media gateway controller.

Module 4: PSTN VoIP interworking

Module aim: To describe interworking between Voice over IP and circuit switched systems with reference to translation between C7 and SIP signalling and conversion between telephone numbers and SIP addressing.

After completing this module, a trainee will be able to:
- Describe the role and facilities provided by the SIP-I and SIP-T protocols with reference to the interworking between a circuit switched network and a SIP-based Voice over IP system.
- Describe how SIP-I ensures that the information provided by a C7 signalling system is preserved when transporting signalling over a Voice over IP system for PSTN to PSTN calls.
- Describe the role of User ENUM with reference to the translation between E.164 telephone numbers and other addressing formats with particular reference to the interworking between circuit switched and Voice over IP systems.
- Describe the User ENUM system with reference to its hierarchical structure and the role of service providers, the IETF, the ITU and end-users in its implementation and operation.

- Describe how a Private ENUM service avoids some of the potential problems that the User ENUM service could present.
- Explain the role of Private ENUM and Infrastructure ENUM in relation to peering arrangements between VoIP service providers and in solving number portability issues.
- Describe the role and relationship between ENUM servers, DNS servers, location servers and gateways.

Module 5: Call control in NGNs

Module aim: To describe the role of the functional components of an IMS and the associated transport control elements of a next generation network.

After completing this module, a trainee will be able to:
- Explain that the service provision and control aspects of a next generation network (NGN) are separated from the functional elements responsible for the transport of traffic over the network.
- Explain that one or more sub-systems can be included in the service control layer of an NGN each controlling a different type of service.
- Explain that IP Multimedia Sub-system (IMS) controls session-based services such as VoIP telephony.
- Describe the benefits of nomadic operation and the basic requirements of an NGN that allows this facility.
- Describe the role of an IP multimedia Services Identity Module (ISIM) in the authentication of IMS compatible user equipment
- Describe the roles of the various types of Call Session Control Function (CSCF).
- Describe the role of a Home Subscriber Server (HSS) with reference to authentication, service profiles and nomadic operation.
- Describe the role of application servers (AS) with reference to service profiles and the interaction of an AS with an S-CSCF.
- Describe the interaction of the various IMS elements during the registration process carried out by a user equipment from a visited network.
- Describe the interaction of the various IMS elements during the setting up of a VoIP call by a user equipment from a visited network.
- Describe the role of the Network Attachment Subsystem (NASS) and the Resource and Admission Control Sub-System (RACS) and their relationship with other NGN elements.
- Explain that the Session Initiation Protocol has been extended to meet the specific requirements of an NGN, giving examples.
- Explain the potential advantages of virtualizing the functions of an IMS.

Module 6: IMS-based PSTN emulation

Module aim: To describe how a next generation network can replace a PSTN and provide a similar service to existing customers without changes to their equipment while allowing calls to and from PSTNs.

After completing this module, a trainee will be able to:
- Describe the role of, and relationship between, media gateways and the media gateway control function with reference to resource reservation and the setting up of Megaco Contexts.

- Describe the role of a signalling gateway.
- Describe the role of the Breakout Gateway Control Function (BGCF) when a call is made from an NGN to a PSTN customer.
- Describe the relationship between the media gateway control function and the Interrogating CSCF when a call originates from a PSTN.
- Describe the role of a PSTN emulation service.
- Explain that a PSTN emulation service can be based on the use of an IP Multimedia Subsystem (IMS).
- Describe the role of, and relationship between, access gateways and the access gateway control function.
- Compare the operation of a voice gateway with that of an access gateway.
- Describe the role of a PSTN emulation application server.
- Describe the role of a multi-service access node (MSAN) in integrating voice, video and Internet services to customers.
- Explain that an MSAN can include the access gateway control function.
- Describe measures to maximise the availability of PSTN emulation services especially calls to the emergency services.
- Explain that the PacketCable specification for voice over IP calls over a Cable TV system includes the use of an IMS and media gateways.

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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