v 1.201

IPv6 Hands-On

Course Duration:

- 2 days

Course Description:

- This course describes in detail the limitations of IPv4 and the changes that have been introduced with IPv6
- We will start with a discussion of all IP header field elements, identify all parts that have been inherited from IPv4, clarify the terminology and explain all the new header elements, their purpose and intended usage.
- The IP header structure will be completed with the detailed consideration of the new concept of Extension Headers in IPv6 and the purpose and usage of each of the options.
- We will then thoroughly discuss the address structure of IPv6 with the formats of Unicast, Multicast and Anycast addresses and what the options are to obtain a valid IP address.
- The course will then explain, how ICMPv6 is structured and how it used to replace and incorporate all other support protocols known from IPv4. This will include detailed discussion of address generation options, including DHCP, Stateless Autoconfiguration, Neighbor Discovery and Duplicate Address Detection.
- Routing in IPv6 will be the next section, which identifies the protocol options within a domain and between domains and discussed the related protocols, such as RIPnG and OSPF.
- We will the investigate various operational issues, starting with security in IPv6, usage in VPN networks with IPSec mechanisms for authentication and ciphering.
- This will be followed by a study of Mobile IP with the basic operation and review of ICMP protocol enhancements for this case.
- Another important section deals with all aspects of Interworking with and Migration from IPv4. Here we will explain the necessity for dual stack architectures, NAT-PT / NAPT-PT concepts and discuss various tunneling options, such as Teredo, 6to4 etc.
- Finally, we will review IPv6 in certain network scenarios, such as 3GPP UMTS networks and IPv6 in the Internet

As in all INACON courses we integrated several interactive exercises for a perfect learning experience.
Many of these exercises are based on already prepared WIRESHARK logfiles which are provided to the students by the trainer. For those who don't have a PC with them or who do not use

WIRESHARK, the logfiles are made available as printouts.

Prerequisites:

- The student must possess a sound understanding of network architecture and packet routing in general and today's TCP/IP version in particular. There is no particular knowledge required regarding IPv6.
- We do recommend our webinar or web based training courses on IPv6 as preparation for the course in order to improve efficiency and comprehension.

Course Target:

- The student is enabled to develop, test and integrate IPv6-equipment and protocols and to operate related networks.

Some of your Questions that will be answered:

- How does the IPv6 protocol header differ from IPv4?
- Which elements are still used in IPv6 and what is the reason for changes in terminology?
- What are Extension Headers, which information do they convey and how and when are these extensions being used in IPv6?
- What is the structure of an IPv6 address and which parts are being used for public routing and how?
- What are the changes in the support protocols such as ICMP and what happened to ARP in an IPv6 environment?
- What is a Link-Local Address and how is that address obtained / generated?
- What is the process and the purpose of Stateless Autoconfiguration and how does a terminal / application obtain an IP address in IPv6?
- How do routing protocols such as RIP and OSPF operate and where are they used?
- Which are the security mechanisms provided with IPv6 and how is IPSec used for authentication and ciphering?
- How can Interworking with IPv4 and the migration from IPv4 be accomplished?
- What is the difference of the various tunneling mechanisms, such as Teredo, 6to4 and others and where are they used?
- What is Mobile IPv6, how does it operate and where is it used?
- How and where is IPv6 being used in 3GPP networks such as UMTS and LTE / SAE?

Who should attend this Course:

- Test engineers who need to understand IPv6-features and their implications in detail.
- Designers of IPv6 network domains who require a deep inside view of the various enhancements.
- Anyone who need to understand the IPv6 terminology, features, addressing and routing mechanisms and the applicability in future networks.

Table of Content:

Review of IPv4 and Differences to IPv6

- **IPv4 History and Weaknesses**

  ⇒ The IPv4 History

  ⇒ The TCP / IP Protocol Stack with IPv4
  Physical Access, Internet Protocol, Transport Layer Protocols, Application Layer

  ⇒ Review of the Data Link Layer Protocol Ethernet
  The Ethernet Frame, Ethernet Frame , Preamble, Source & destination address, Length/Type Field, Data Field, Frame Check Sequence, Ethernet Access Scheme, Backoff Time

  ⇒ IP Frame Structure and Addressing Review
  L2 Ethernet, Internet Layer, Transport Layer, Application Layer

  ⇒ IPv4 Addressing Summary
  Classful IP Addresses, Subnet Mask, Subnetting , Classless Inter Domain Routing (CIDR)

  ⇒ IPv4 Addressing Summary (continued)
  Private Networks / Intranets / NAT

  ⇒ IP Address Allocation and Distribution
  IANA, Regional Registers

  ⇒ The Main Problem Is: IPv4 Address Consumption

  ⇒ … and the Emergency Measures in IPv4 are

- **Overview of the IP Protocol Headers**

  ⇒ Protocol Elements Inherited from IPv4
  Address Range, Header Simplicity, Use of “Next Headers”

  ⇒ The IPv6 Protocol Format
  Hop-by-Hop Options Header, Destination Options Header, Routing Header, Fragment Header, Authentication Header, Encapsulating Security Payload Header

  ⇒ IPv6 Header Details
  Version, Traffic Class, Flow Label, Payload Length , Next header, Hop Limit, Source Address, Destination Address, Example of an IPv6 Frame

  ⇒ IPv6 Extension Header Concept
  Hop by Hop and Destination Option Headers, Hop by Hop Header – Jumbograms, IPv6 Routing Header, Next Header, Header length, Type, Segments left, Addresses, IPv6 Fragmentation Header, Next header, Fragment offset, Res, M Flag, Fragment Identification, Fragmentation in IPv4 and IPv6, Fragmentation Example in IPv6, Authentication Header, Next Header (8 bit), Payload Length (8 bit), Reserved (16 bit), Security Parameters Index (SPI) (32 bit), Sequence Number (32 bit), Authentication Data (n bit), Encapsulated Security Payload (ESP) Header, Security Parameters Index (SPI) (32 bit), Sequence Number (32 bit), Payload Data (n bit), Padding (0 – 255 octets), Padding Length (8 bit), Next Header (8 bit), ESP Authentication Data (n bit)

  ⇒ Comprehension Check and exercise

Details of IPv6 Addressing

- **IPv6 Address Types**

  ⇒ IPv6 Addressing Scheme

  ⇒ IPv6 Address Type Overview
  Unicast Addresses, Multicast Addresses, Anycast Addresses, Reserved Multicast Addresses, The Global Unicast Address Format, The Global Multicast Address Format, IPv6 Predefined Multicast Addresses, The Link Local Address Format, Unique Local Unicast Addresses (ULA), Pseudo Random Algorithm for Global ID Generation

  ⇒ IPv6 Address Notation
  Address Examples and Notation Alternatives, Comprehension Check and Exercise

- **Comprehension Check and exercise**
- **Details of ICMPv6**

  ⇒ Overview of Important Messages
  Error Messages, Destination Unreachable, Packet Too Big, Time Exceeded, Parameter Problem, Important Informal Messages, Echo Request, Echo Reply, Multicat Listener Query, Multicast Listener Report, Multicast Listener Done, Router Solicitation, Router Advertisement, Neighbor Solicitation, Neighbor Advertisement, Redirect

  ⇒ ICMP Pseudo Header

  ⇒ Details of the Destination Unreachable Message
  ICMP Extension Objects

  ⇒ Details of the Packet Too Big Message

  ⇒ Details of the Time Exceeded Message
  ICMP Extension Objects

  ⇒ Details of the Parameter Problem Message

  ⇒ Details of the Echo Request and Echo Reply Messages

  ⇒ Example: ICMPv6 Echo Request and Reply

  ⇒ Details of the Router Solicitation Messages
  Related IPv6 header parameters, ICMP Fields:

  ⇒ Details of the Router Advertisement Messages
  Related IPv6 header parameters, ICMP Fields:

  ⇒ Details of the Neighbor Solicitation Messages
  Related IPv6 header parameters:

  ⇒ Details of the Neighbor Advertisement Messages
  ICMP Fields:

  ⇒ Details of the Redirect Messages
  Related IPv6 header parameters:, Summary of other Informal ICMPv6 Messages, Home Agent Address Discovery Request, Home Agent Address Discovery Reply, Mobile Prefix Solicitation, Mobile Prefix Advertisement

- **Address Configuration Options**
  Selection of Address Configuration , Managed Address Configuration Flag (M-flag), Other Stateful Configuration Flag (O-Flag), Overview of Configurations with M and O flags in ICMPv6 RA Messages

  ⇒ How a Host may obtain an IP-Address
  IPv4 and DHCP, How to create EUI based Interface Identifiers, IEEE EUI-64 Identifiers, IEEE EUI-48 Identifiers (from IEEE 48-bit MACs), Non Global Identifiers, Practical exercise: Generation of an EUI-64 Identifier from IEEE 48 Bit MAC, IPv6 and “Stateless Autoconfiguration”, Stateful and Stateless Address Configuration with DHCPv6, Stateful Message Exchange, Stateless Message Exchange, Rapid Commit Option, Overview and DHCP Message Comparison DHCPv4 vs DHCPv6, SOLICIT, ADVERTISE , REQUEST , RENEW, REBIND, REPLY, RELEASE, INFORMATION-REQUEST, DECLINE, RECONFIGURE, CONFIRM , RELAY-FORW, RELAY-REPLY, DHCPv6 Relay, Important DHCP Parameters, DHCP Unique Identifier (DUID), Identity Association Identifier , IA Timer T1, IA Timer T2

- **Name Resolution in IPv6 – DNS**

  ⇒ Overview and Review of DNS

  ⇒ Example of the DNS Hierarchy
  DNS, ENUM, IN-Addr, IP6

  ⇒ IPv6 Enhancements

IPv6 Routing Concepts

- **The Hierarchical Routing Architecture**
  Public Topology, Site Topology, Interface Identifier

  ⇒ Multi-Homing and Provider Changes / Renumbering

  ⇒ Provider Independent Address Range
  Example: Provider Independent (PI) Address Calculation, Exercise: PI Address Calculation for New York

- **Overview of IP Routing Types**
  Intra Domain Routing (IGP), Static Routing, Dynamic Routing, Distance Vector Routing, Link State Routing, Hybrid Routing, Inter Domain Routing (EGP), Path Vector Routing

  ⇒ Routing Criteria
  Minimum Cost Routing, Minimum Distance Routing, Minimum Hop Routing, Minimum Load Routing, Imposed Routing

  ⇒ Example: Routing Information Protocol (RIP, RIP-2, RIPng / RIPv6)
  Routing Information Protocol (Example)

  ⇒ RIP Version Differences

  ⇒ Open Shortest Path First (OSPF, OSPFv6)
  Autonomous systems (AS), OSPF Areas, Backbone area and area 0, Internal Router (IR), Backbone Router (BR), Area Border Router (ABR), AS Boundary Routers (ASBR)

  ⇒ OSPF Operation
  Link State Advertisements (LSA), Hello, Database description, Link state request, Link state update, Link state acknowledgement: , Link State Routing

Operation of IPv6

- **Security, VPN Configuration and Operation**
  - ⇒ Threats and Security Attacks regarding IP
    Privacy, Alteration, Spoofing
  - ⇒ Alternatives for Network Security
    Encryption and Authentication on Layer 1 / 2, Encryption and Authentication on the Network Layer, Encryption and Authentication on higher layers
  - ⇒ VPN Operation Modes
    IPsec in Transport Mode, IPsec in Transport Mode, Transport Mode and AH, Transport Mode and ESP, IPSec in Tunnel Mode, Tunnel Mode and AH, Tunnel Mode and ESP
  - ⇒ Establishment of an IPsec-Relationship
    Establishment of an IPsec-Relationship
- **Mobile IP in IPv6**
  - ⇒ MIP Operation Principles
    Host A – also called Corresponding Node (CN), Home Agent (HA), Foreign Agent (FA), Mobile Host B – also called Mobile Node (MN), Route Optimisation in IPv6
  - ⇒ MIP in Trusted Non-3GPP RATs
  - ⇒ Example: PMIPv6 Signaling in Trusted non-3GPP Networks
  - ⇒ Example: Mobility Options in Destination Header
- **QoS Mechanisms with IPv6**
  - ⇒ The QoS-Hierarchy
    Services, Traffic Classes, QoS-Profiles and Parameters, QoS-Parameter Settings, Physical Processing Rules
  - ⇒ End-to-End View
  - ⇒ QoS Methods in IP
    DiffServ, IntServ, MPLS
  - ⇒ Details of Diffserv Operation
    Details of the AF(X,Y) PHB (Assured Forwarding), Details of the EF PHB (Expedite Forwarding)
- **Summary of IPv6 Advantages**

Interworking and Migration IPv4 to IPv6

- **Interworking and Migration IPv4 to IPv6**
  IPv4 Address compatible to IPv6, Dual Stack IP Support, Tunneling
- **Dual Stack Principle**
- **Automatic 6 to 4 Tunneling Principle**

- **Teredo Tunneling Architecture**
  Teredo Client, Teredo Server, Teredo Relay, Host specific Teredo Relay, Cone-NAT, Limited NAT

  ⇒ Teredo Operation – Initial Configuration

  ⇒ Teredo Address Format

Solutions for the practical excercises