



# Introduction to Data Communications & Networking

## Introduction

This course looks at the basics of datacommunications and networking and provides a clear and straightforward understanding of many of the components and operation of data networks.

## Who should attend the course?

This course is designed as an introduction to datacommunications and networking. It does not pre-suppose the knowledge of the students, but is obviously appropriate to those who wish to develop an understanding of the techniques used in data networks.

## Course Length

2 days

## Course Agenda

- Data Communication & Data Networking Concepts
- Serial Networks & Protocols
- 'Analogue' Data Transmission
- Transmission Networks
- ISDN - Integrated Services Digital Network
- LANs - Local Area Networks
- Wireless Technologies - Wireless LANs, Bluetooth, WiMax & Mobile 'Telephone' Networks
- USB & Firewire
- IP - Internet Protocol
- Firewalls & Intrusion Detection & Prevention Systems
- Broadband Technologies
- Frame Relay
- ATM - Asynchronous Transfer Mode
- MPLS - Multi Protocol Label Switching

## 1 Data Communication & Data Networking Concepts

This section looks at many of the basic concepts of data communication in order to build a foundation to be used throughout the rest of the course.

- What is data communication & networking
- A look at binary
- Binary codes e.g. ASCII - American Standard Code for Information Interchange
- Serial data transmission
- Transmission 'speeds' - kbit/s, Mbit/s, Gbit/s etc.
- Section summary and end-of-section review

## 2 Serial Networks & Protocols

This section on serial networks and protocols is very much a historic one in that, while these technologies still do get used, they are very much legacy technologies that have been superseded by alternative ones

today.

- DTE - Data Terminal Equipment & DCE - Data Circuit-Terminating Equipment
- Flow control
  - Hardware: RTS/CTS, DTR/DSR
  - Software: Xon/Xoff
- V.24 & RS-232 interface
- V.11 interface
- X.21 interface
- Serial protocols: SDLC, HDLC
- Section summary and end-of-section review

### 3 'Analogue' Data Transmission

In the early days of communications, much of the infrastructure built was done so for the transmission of sound. This section looks at the ways in which data is carried across a telephone network by means of a device called a modem (modulator/demodulator).

- Analogue telephony
- Digital telephony
- The PSTN - Public Switched Telephone Network & The ISDN - Integrated Services Digital Network
- Analogue to digital conversion: PCM - Pulse Code Modulation
- Modems: V.21, V.22, V.32, V.34, V.90 & V.92
- Data compression
- Section summary and end-of-section review

### 4 Transmission Networks

Transmission networks were built to facilitate the transmission of large amounts of digital information. The original driver for this was to carry many 2.048Mbit/s 'primary' rate connections between telephone exchanges. The original network technology used was referred to as the PDH or Plesiochronous Digital Hierarchy. Subsequently, a much improved transmission technology known as the SDH or Synchronous Digital Hierarchy was deployed.

- Introduction to transmission systems
- The PDH - Plesiochronous Digital Hierarchy
  - E1 - 2.048Mbit/s, E2 - 8.448Mbit/s, E3 - 34.368Mbit/s, E4 - 139.264Mbit/s & E5 - 565.148Mbit/s
- The SDH - Synchronous Digital Hierarchy
  - The Add-Drop Multiplexer
  - SDH rates: STM-1, STM-4, STM-16, STM-64, STM-256
- DWDM - Dense Wave Division Multiplexing
- Framed versus unframed 2M circuit
- G.704 framed interface
- 64kbit/s circuit e.g. BT Kilostream
- Section summary and end-of-section review

### 5 ISDN - Integrated Services Digital Network

ISDN is a set of standards for the transmission of digital voice, digital video and data over the traditional digital circuits of the PSTN - Public Switched Telephone Network.

- Introduction to ISDN
- Primary Rate ISDN (PRI)
- Basic Rate ISDN (BRI)
- ISDN for voice
- ISDN for data
  - Circuit switched data
  - Packet switched data
- Section summary and end-of-section review

## 6 LANs - Local Area Networks

A LAN - Local Area Network is a data network that interconnects computers and other end-point devices such as VoIP (Voice over IP) phones in a relatively limited area such as an office or a home. Many different LAN technologies have been developed over the years but one is the dominant one today i.e. Ethernet.

- Introduction to LANs
- OSI 7 layer model and TCP/IP model (4 layers)
- Various 'older' LAN technologies
  - Token Ring - IEEE 802.5
  - 10VG-AnyLAN
  - FDDI - Fibre Distributed Data Interface
  - CDDI - Copper Distributed Data Interface
- Ethernet technologies
  - 10Base5 - Thicknet
  - 10Base2 - Thinnet
  - Ethernet on twisted pair
    - 10Base-T
    - 100Base-T
    - 1000Base-T
    - 10GBase-T
  - Ethernet on optical fibre
    - 10Base-F
    - 100Base-FX, 100Base-SX, 100Base-BX & 100Base-LX10
    - 1000Base-CX, 1000Base-SX, 1000Base-LX, 1000Base-LX10, 1000Base-BX10 &

### 1000Base-ZX

- Ethernet data frames
- Ethernet MAC addresses
- Ethernet repeaters/hubs
- Ethernet bridges
- Ethernet switches
  - VLANs - Virtual LANs
  - STP - Spanning Tree Protocol and RSTP - Rapid Spanning Tree Protocol
- 'Higher layer' protocols used on Ethernet
  - IP, IPX, DecNet, SNA, Appletalk, NetBios etc
- Section summary and end-of-section review

## 7 Wireless Technologies - Wireless LANs, Bluetooth, WiMAX & Mobile 'Telephone' Networks

Much of today's data communication and networking is done wirelessly and there are many wireless technologies in use. This section looks at some of the key ones that are used on a day-to-day basis.

- Introduction to wireless LANs
- Various WLAN standards
  - IEEE 802.11a, IEEE 802.11b, IEEE 802.11g & IEEE 802.11n
- WLAN devices
  - Endpoints
  - Access Points (APs)
  - Wireless bridges
  - Antennas
- WLAN security
  - WEP - Wired Equivalent Privacy
  - WPA - WiFi Protected Access
  - WPA2 - WiFi Protected Access version 2
- Bluetooth
- Mobile Telephone/Data networks
  - Analogue
  - 2G
  - 2.5G
  - 3G
  - 3.5G
  - 4G
  - LTE
- WiMAX
- Section summary and end-of-section review

## 8 USB & Firewire

USB and Firewire are two technologies often used for communications between computers and peripheral devices.

- USB 1.0
- USB 2.0
- USB 3.0
- USB Device classes
- USB Connector types
- USB Transfer rates
- Firewire
- Section summary and end-of-section review

## 9 IP - Internet Protocol

IP technology has been around for a very long time - since the early 1970s - and is the most common data networking protocol in existence today, as a result of its use in the Internet. This section gives a brief look at many of the aspects of IP networks and many data protocols used in making the network work. Historically, the term IP has tended to imply the use of IP version 4 (IPv4) although, as the IPv4 address space is practically exhausted, the newer IPv6.

- IP addressing
  - IPv4
  - IPv6
- Subnetting IPv4 address space
- CIDR - Classless Inter-Domain Routing

- Private addressing
- NAT & PAT - Network Address Translation & Port Address Translation
- ARP - Address Resolution Protocol
- ICMP - Internet Control Message Protocol
- DHCP - Dynamic Host Configuration Protocol
- DNS - Domain Name System
- IP routing
- Dynamic routing protocols
  - RIP - Routing Information Protocol
  - OSPF - Open Shortest Path First
  - IS-IS - Intermediate System to Intermediate System
  - BGP - Border Gateway Protocol
- 'Transport' layer protocols
  - TCP - Transmission Control Protocol
  - UDP - User Datagram Protocol
- Applications
  - FTP, Telnet, SMTP, DNS, TFTP, HTTP, POP3 etc
  - Voice over IP
- Section summary and end-of-section review

## 10 Firewalls & Intrusion Detection & Prevention Systems

Security is a key part of data networks today. If your computer or network is connected to the Internet, then it is essential that you use a firewall at the very least, in order to minimise threats coming in from the Internet.

Intrusion detection and prevention systems go beyond what firewalls do and are used to monitor the activities occurring in a computer system or network and analysing them for signs of possible incidents which violate security policies, and attempting to stop them.

- Introduction to firewalls
- Packet filters
- Access control lists
- Stateful inspection
- Application layer filtering
- VPNs
  - IPSec
  - SSL
- Intrusion Detection & Prevention Systems
  - Signature-based detection
  - Anomaly-based detection
  - Stateful protocol analysis
- Section summary and end-of-section review

## 11 Broadband Technologies

Broadband technologies typically are used for providing Internet access across telephone lines traditionally used for simply providing telephony connections. There are quite a few different broadband technologies that have evolved over a matter of years. This section discusses some of the different broadband technologies. In addition, we will also talk about some fibre-optic solutions including FTTC - Fibre To The Cabinet and FTTP - Fibre To The Premises.

- Introduction to xDSL technologies
- How a telephone line supports high bit-rate data
- DSLAM - Digital Subscriber Line Access Multiplexer
- A number of DSL technologies
  - ADSL - Asymmetric Digital Subscriber Line / ADSL2 / ADSL2+
  - HDSL - High bit-rate Digital Subscriber Line / HDSL2
  - SHDSL - Single-pair High-speed Digital Subscriber Line
  - VDSL - Very-high-bit-rate Digital Subscriber Line / VDSL2
- Fibre optic solutions
  - FTTC - Fibre To The Cabinet
  - FTTP - Fibre To The Premises
- Section summary and end-of-section review

## 12 Frame Relay

Throughout the 1980's, LAN technology and its implementation grew at a phenomenal rate. By the 1990's, the ability to inter-network LANs via the wide area was limited to relatively slow speed and inefficient mechanisms. The need to inter-network LANs at higher speeds using more effective communication methods led to the development of Frame Relay.

- Introduction to Frame Relay
- Brief overview of X.25 - Predecessor to Frame Relay
- PVCs - Permanent Virtual Circuits and SVCs - Switched Virtual Circuits
- The Frame Relay frame structure
  - DLCI - Data Link Connection Identifier
  - FECN/BECN - Forward Explicit Congestion Notification/ Backward Explicit Congestion Notification
  - DE - Discard Eligibility
- Traffic contracts and parameters
  - CIR - Committed Information Rate
  - Bc - Committed Burst Size
  - Be - Excess Burst Size
- Frame Relay applications
  - LAN interconnection
  - VoFR - Voice over Frame Relay
- Section summary and end-of-section review

## 13 ATM - Asynchronous Transfer Mode

Back in the late 1990s and early 2000s, ATM technology was seen by many as being the technology of the future for the transport of all types of communication i.e. voice, video and data. It was designed from the ground up to provide all the necessary service characteristics to support these different traffic types. In practice, ATM has been superseded by alternative technologies. It is however still used in many core networks as well as having a significant place in the 3G mobile telephone/data network and in ADSL technologies.

- Introduction to ATM - Asynchronous Transfer Mode
- PVCs - Permanent Virtual Circuits and SVCs - Switched Virtual Circuits
- The ATM Cell
  - GFC (Generic Flow Control)
  - VPI/VCI (Virtual Path Identifier, Virtual Channel Identifier)
  - PT (Payload Type)

- CLP (Cell Loss Priority)
- HEC (Header Error Control)
- AALs - ATM Adaptation Layers
  - AAL1, AAL2, AAL3/4 & AAL5
- ATM service categories and traffic management
  - CBR (Constant Bit Rate), VBR (Variable Bit Rate) - rt and nrt, ABR (Available Bit Rate), UBR (Unspecified Bit Rate), UBR+ (UBR Plus) and GFR (Guaranteed Frame Rate)
  - Traffic parameters - SCR (Sustainable Cell Rate), PCR (Peak Cell Rate), MBS (Maximum Burst Size), MCR (Minimum Cell Rate) etc..
- QoS routing - PNNI -
- Private Network-Network (Network-Node) Interface
- ATM applications
  - Data & voice integration
  - ATM in the 3G mobile telephone/data network
  - ATM in DSL technology
- Section summary and end-of-section review

## 14 MPLS - Multi Protocol Label Switching

Multiprotocol Label Switching (MPLS) is a mechanism in high-performance telecommunications networks that directs data from one network node to the next based on short path labels rather than long network addresses as with IP, avoiding complex lookups in a routing table. It is commonly used as the underlying network technology supporting IP networks.

- Introduction to MPLS
- MPLS defined
- Routing protocol overview
- Label Distribution Protocol (LDP)
- Traffic engineering with MPLS
- QoS and MPLS
- VPNs and MPLS
- Section summary and end-of-section review

## HN Networks

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