Understanding Ethernet

Introduction

While being, fundamentally, a well established technology, Ethernet continues to develop and evolve. First came 10Mbit/s Thick Ethernet (although actually there was an earlier version), this was followed by Thin Ethernet and Ethernet over (Unshielded Twisted Pair) UTP and fibre. Other developments have taken the technology to 100Mbit/s and 1Gbit/s and more recently 10Gbit/s.

This course provides a comprehensive look at Ethernet technologies from the ground up to where things are today.

Learning Objectives

At the end of the course, the delegates will understand:

- How Ethernet operates
- How Ethernet cabling systems work
- How an Ethernet switch operates
- How VLANs work

Hands-on Exercises

- The use of an Ethernet LAN Network Analyser
- Configuration of an Ethernet switch including VLANs
- Network design using Ethernet switches

Course Length

2 days

Course Agenda

- Introduction to, overview of and history of Ethernet
- Ethernet frames, MAC addresses, collisions and CSMA/CD
- The older Ethernet - 10BASE-5 (Thick Ethernet) and 10BASE-2 (Thin Ethernet)
- Ethernet on UTP - Unshielded Twisted Pair
- Ethernet on fibre (fiber) optic cable
- 10Mbit/s Ethernet
- Fast Ethernet - 100Mbit/s Ethernet
- Gigabit Ethernet - 1Gbit/s Ethernet
- Switched Ethernet
- Spanning Tree with Ethernet switches
- VLANs - Virtual LANs using Ethernet switches
- 10 Gigabit Ethernet - 10Gbit/s Ethernet

1 Introduction to, Overview of and History of Ethernet

In this section we look at what LANs are all about, looking at some of the general uses that they are put to. We also look at the background and history of Ethernet. Did you know that it is derived from a ground-based radio system? However, before we get into that, we take a quick and practical look at the

ISO seven-layer model.

- Protocol concepts and a practical perspective on the ISO seven-layer model
- What are LANs and what are they used for?
- The background to Ethernet - ALOHA - Xerox, DEC, Intel and Xerox (DIX) and IEEE 802.3

2 Ethernet frames, MAC addresses, collisions and CSMA/CD

There are two basic frame formats commonly used on Ethernet LANs. These include the original format defined in the DIX Ethernet V2 specification and the other defined in IEEE 802.3. A variant on the IEEE 802.3 format is also a format called SNAP or Sub-Network Access Protocol. This section looks at these various frame types with a look at how they may be differentiated between and why and what systems/protocols use each type. We also look at the concepts of collisions in Ethernet and a mechanism that is used to prevent issues of collisions i.e. CSMA/CD - Carrier Sense Multiple Access with Collision Detection.

- The frame format defined in Ethernet V2 specification
- The frame format defined in IEEE 802.3
- The Ethernet Sub Network Access Protocol (SNAP) frame format
- The MAC address - Physical/Unicast, Multicast and Broadcast
- How CSMA/CD works
- Various causes of collisions

Some general packet related terms - Runt/Fragment, Jabber, Jam, Inter-Packet Gap, Slot-time etc…

3 The older Ethernet - 10BASE-5 (Thick Ethernet) and 10BASE-2 (Thin Ethernet)

The original form of 10Mbit/s Ethernet ran on a coaxial cable type of 50 ohm impedance. This was named Thick Ethernet. 10BASE2 - Thin Ethernet was developed to offer a cheaper and simpler method of implementing an Ethernet LAN. As with Thick Ethernet, Thin Ethernet operates on coaxial cable. In order to extend a 10BASE-5 and/or a 10BASE-2 Ethernet LAN, a device called a repeater is used. We also cover some of the aspects of operation of an Ethernet repeater.

- What is Thick Ethernet / 10Base-5
- The Attachment Unit Interface (AUI)
- What is Thin Ethernet / 10Base-2
- Encoding on 10Base-5 and 10Base-2 Ethernet - Manchester encoding
- How collisions work on 10Base-5 and 10Base-2 Ethernet
- The Ethernet repeater

4 Ethernet on UTP - Unshielded Twisted Pair

Most Ethernet networks today operate over Unshielded Twisted Pair (UTP) cable as opposed to the older coaxial cable based Ethernet. This section gives an introduction to UTP as a precursor to looking at its use in various types of Ethernet (i.e. 10Mbit/s, 100Mbit/s etc). We look at some of the key attributes that UTP must have in order to support such high-speed data as Ethernet generates along with the various standards for UTP cable. We cover the operation of a UTP hub, also sometimes called a multi-port repeater. Finally we see how it is possible, in some circumstances, to disable CSMA/CD thus increasing the potential throughput of Ethernet.

- Introduction to Ethernet on UTP
- UTP cable - Category 5 (Cat 5), Category 5 Enhanced (Cat 5E) and Category 6 (Cat 6) and a look at the various standards
- The RJ45 interface connector and pins used for Ethernet

- The UTP hub
- Introducing the ability to turn off CSMA/CD and use full-duplex Ethernet

5 Ethernet on fibre (fiber) optic cable

Copper cable is used extensively in very many networking applications. However, with the increased speed capabilities of Ethernet today, the need for the use of fibre optic cable rather than copper is ever increasing. Standards exist for all speeds of Ethernet operating over fibre, all the way from 10Mbit/s Ethernet to 10Gbit/s Ethernet. In fact, 10Gbit/s Ethernet is defined only to operate on fibre and not copper. This section looks at some of the reasons for using fibre and looks at the standard ways of using it with Ethernet.

- Introduction to fibre - Multi-mode and Single/Mono-mode
- The differences between using fibre and copper based media
- How Ethernet operates on fibre

6 10Mbit/s Ethernet

In this section, we look at the specifics of 10Mbit/s Ethernet. This includes a look at 10Base-T and 10Base-FL, but also shows the way that 10Mbit/s Ethernet may operate across and between 10BASE-5, 10BASE-2, 10Base-T and 10Base-FL.

- 10Base-T
- 10Base-FL
- Integrating 10BASE-5, 10BASE-2, 10Base-T and 10Base-FL
- System design considerations for 10Mbit/s Ethernet. Rule 1 - The 5 - 4 - 3 rule: 5 Segments, 4 repeaters and 3 active segments and rule 2, the calculation method.

7 Fast Ethernet - 100Mbit/s Ethernet

For many years, 10Mbit/s Ethernet satisfied the needs of most LAN users. However, during the 1990's a growth of computing power amongst other things brought around the need for more network capacity. At the same time, Ethernet was up-rated to operate at 100Mbit/s also known as Fast Ethernet.

- The driving factors for Fast Ethernet
- Fast Ethernet repeaters
- The Media Independent Interface (MII): The 100Mbit/s equivalent of AUI
- 100Mbit/s physical level encoding
- Various types of Fast Ethernet - 100Base-TX, 100Base-FX, 100Base-T2, 100Base-T4
- Fast Ethernet design considerations

8 Gigabit Ethernet - 1Gbit/s Ethernet

Gigabit Ethernet is the next evolution from 100Mbit/s Fast Ethernet. Essentially it is simply Fast Ethernet yet ten times faster. However, as a consequence of this increased operating speed, a number of issues can result. While these issues are very much implementation dependent, techniques have been built in to Gigabit Ethernet to circumvent them. This section looks at how Gigabit Ethernet works, yet also provides an insight into the potential issues of its use as well as the mechanisms designed to overcome them.

- Why Gigabit Ethernet
- How it works - A look at IEEE 802.3z
- Carrier extension and frame bursting with Gigabit Ethernet
- Gigabit Ethernet repeaters
- Using Gigabit Ethernet in a switched environment

9 Switched Ethernet

Switched Ethernet is used extensively today as a way to bring improved performance to an Ethernet network along with other capabilities such as the ability to extend a LAN across a WAN infrastructure.

- The predecessor to Ethernet switching - Bridging
- Why switch?
- How a switch works: Cut-through Ethernet switching / Fragment-free Ethernet switching / Store and forward Ethernet switching
- Full duplex operation
- Auto-negotiation
- Flow control
- Why moving from shared to switched Ethernet can create problems

10 Spanning Tree with Ethernet switches

When creating a switched Ethernet network environment, it is commonly a requirement to implement resilience through the use of redundant paths. Because of the way that Ethernet switches work, this creates the issue of loops where data frames can potentially loop around indefinitely. The standard mechanism used to overcome this loop issue is to use a protocol known as the Spanning Tree protocol.

- Why use Spanning Tree?
- How Spanning Tree works
- Root bridge, root ports and designated ports

11 VLANs - Virtual LANs using Ethernet switches

VLANs allow specific stations to participate in a LAN (more specifically defined as a broadcast domain) without necessarily being physically attached to the same LAN. This function can be brought about through the use of Ethernet switches.

- What is a VLAN?
- Different ways of implementing VLANs - Port based, MAC address based, protocol based etc.
- Frame encapsulation methods - Cisco's ISL, IEEE 802.1Q
- Trunking protocols - Cisco's VTP, GVRP

12 10 Gigabit Ethernet - 10Gbit/s Ethernet

Yet again, Ethernet has grown by another order of magnitude. 10Gbit/s Ethernet is ten times faster than Gigabit Ethernet yet still uses the same frame format. It does, however, have some significant differences to previous Ethernet versions, most notably that it will only operate on optical fibre and will only operate in full-duplex mode (meaning that the collision detection mechanisms are unnecessary. Furthermore, in addition to the normal LAN physical interface, 10 Gbit/s Ethernet also has a WAN physical interface (PHY) defined for use across a WAN.

- Introduction to 10 Gigabit Ethernet
- A look at the LAN physical interfaces
- A look at the WAM physical interfaces

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