Network Reading List:
TCP/IP, UNIX, and Ethernet

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Abstract

This annotated list of resources is intended for network managers, developers, and users at the University of Texas at Austin, or anywhere that TCP/IP, UNIX, and Ethernet are used to provide computer communications.* These three networking technologies share the same major attribute: they can be used to build interoperable network systems across a wide range of computer equipment. Because of their ability to provide the glue that holds networks together, TCP/IP, UNIX, and Ethernet are in wide use on campus and at many other sites.

*UNIX is a registered trademark of AT&T.

Introduction

This annotated list of resources was created to help you find information about TCP/IP, UNIX, and Ethernet. The list describes a number of items that cover the range from introductory to in-depth information.

This list is not comprehensive; instead it tries to describe those items that cover the territory well, and that deal with real-world problems found on growing networks. This list is not current, either; the amount of literature in this field is large and growing every day.

Why These Three Technologies?

The three technologies featured in this list are in wide use on campuses, at research centers and corporations, and at a rapidly growing number of sites worldwide. The popularity of TCP/IP, UNIX, and Ethernet is largely due to the vendor-neutral character of these technologies, which helps make interoperable networking possible.

All three technologies are ‘‘open’’ in that the software and specifications are readily available. The TCP/IP protocols were developed with public funding and are in the public domain. UNIX is provided by a wide range of vendors and has included support for TCP/IP protocols and Ethernet for many years. The specification for Ethernet was published by a multi-vendor consortium and has since become a world-wide standard. Any vendor can develop products based on these three widely available technologies, and many have. This openness is the key to the network interoperability that these technologies provide.

While there is no precise definition of network interoperability, it is often taken to mean a set of computers of widely varying types that are capable of working well together. In an interoperable network system you can get your work done across a range of computer systems linked by a common set of standard network protocols, network software, and network hardware.

In the network computing environment on campus today you will find equipment in use that comes from a wide variety of computer vendors. In such an environment interoperability isn’t just a desirable feature, it’s essential to the operation of the network system.

Another common feature of today’s networks is their growth and increasing complexity. TCP/IP, UNIX, and Ethernet have proven their ability to adapt as networks evolve and more and more users are added. These technologies make it possible to build large networks that are both reliable and fast, and that can support thousands of users.

Organization

The list was designed to be as self-contained as possible, and to make it easier for you to decide whether you want to follow up on a given resource.

ISBN book numbers are shown to make it easier to find and order the books listed here. Prices are included when available, quoted in US dollars. The prices should be treated only as a rough guide however, since they may have changed by the time you read this list.

Comments, corrections, etc. are welcome and may be sent to **rlist@utexas.edu.**

Section 3

This is Section 3 of a four-section document entitled ‘‘Network Reading List: TCP/IP, UNIX, and Ethernet.’’ The four sections of this annotated list of resources were created to help you find information about TCP/IP, UNIX, and Ethernet. The complete list describes a wide range of items, including both introductory and in-depth information.

Section 1 covers TCP/IP resources, Section 2 covers UNIX, Section 3, Ethernet, and Section 4, miscellaneous items.

3. Ethernet

Ethernet is a popular local area network (LAN) technology in wide use at sites around the world. Ethernet moves data between computers at a rate of 10 megabits per second over a wide variety of physical media including twisted-pair wire, coaxial cable, and fiber optic cable. A major reason for its popularity is that Ethernet is a very flexible and low cost network system. Ethernet’s popularity also provides a high level of network interoperability. Since Ethernet is so widely implemented you can link systems built by many different vendors using the same Ethernet LAN. Like TCP/IP and Unix, Ethernet is a technology that provides a common basis for supporting heterogeneous networks.

The 10 megabit Ethernet network standard has been in existence for over a decade, and is an international LAN standard. As a result, a large number of vendors sell Ethernet equipment and this helps keep the cost of the technology low. The large market for Ethernet equipment also leads to a steady stream of innovations, such as the use of thin coaxial and twisted-pair cabling, that makes it easier to build a reliable LAN in a wide variety of sites using standard Ethernet.

3.1. Introduction To LAN Concepts

- **Local Area Networks**
  An introduction to the technology
  John E. McNamara.
  Prentice Hall Agency, 1985, 165 pps. with index and glossary.
  $29.00
  ISBN 0-13-539669-7

This book provides a clear introduction to the essential ideas and basic technologies of LANs. McNamara keeps it simple, while managing to cover many different technologies. The author avoids covering specific products in favor of describing the general territory of LANs and their topologies. The special problems of extending LANs and supporting multiple protocol campus area networks are also discussed.

From the Preface:

‘‘This book is intended for students, computer system managers, telecommunications managers, and others who want to become more familiar with local area networks. Since product offerings in this area are constantly changing, a deliberate attempt has been made to emphasize the general principles, operating characteristics, and problem areas of local area network hardware, rather than cite specific product examples.’’

‘‘The book begins with a general introduction, discussing the development of local area networks and emphasizing their possible uses. This is followed by more detailed treatment of physical factors: topology, media, and installation requirements. Next, the hardware that permits programs to access the local area network and transfer data is discussed. Then, software is covered, starting with an introduction to communications protocols. Finally, the combined base of hardware and software knowledge from the previous parts of the book are used in discussions of network services, network expansion, and the problems associated with creating large networks. The need for standards is implied throughout the book, and a brief final chapter discusses the creation of standards and their current status.''

3.2. Introduction to Three Ethernet Varieties

This short introduction to the three Ethernet technologies most widely used in office connections is provided to help you understand the references to these technologies in the resources that follow. After the IEEE published the basic thick coaxial Ethernet specifications in 1985 it went on to specify new varieties of Ethernet media, including thin coaxial Ethernet and twisted-pair Ethernet. There are currently three media systems designed to provide Ethernet service to an office. They include:

(1) **Thick Ethernet**
The original Ethernet system based on coaxial cable which uses a thick (0.4 inch) yellow cable. Computers are attached to the coaxial cable with an outboard Ethernet transceiver (also called a MAU) that is clamped to the cable. The transceiver, in turn, is connected to an Ethernet interface in the host computer by way of a transceiver cable (also called an AUI cable). This system is the one developed at Xerox, and could be called ``Ethernet Classic.'' The IEEE has assigned shorthand identifiers for each media variety of Ethernet. The identifier for thick Ethernet is 10BASE5, which stands for 10 megabit per second speed, baseband signaling, and 500 meter maximum segment length.

(2) **Thin Ethernet**
A coaxial-based Ethernet system that uses a thinner, more flexible coaxial cable than the original thick Ethernet system, and is known as thin Ethernet or ``Cheapernet.'' In the thin Ethernet system the transceiver is located inside the computer along with the Ethernet interface. This makes it possible to attach the thin Ethernet coax directly to the back of the host computer, reducing the number of devices and cables needed, and making the network connection more affordable. The IEEE identifier for thin Ethernet is 10BASE2, which stands for 10 megabit per second speed, baseband signalling, and, despite the ``2'' used in the shorthand identifier, 185 meters maximum segment length.

(3) **Twisted-Pair Ethernet**
The twisted-pair variety of Ethernet is based on the same low cost twisted-pair wiring used in telephone systems. The IEEE identifier for twisted-pair Ethernet is 10BASE-T, which stands for 10 megabits per second, baseband signalling, and twisted-pair media. The transceiver is located inside the computer in the twisted-pair system, which helps lower the cost of connecting to the segment. In the 10BASE-T system individual computers are attached to twisted-pair segments, which, in turn, are attached to a multiple-connection box called a multiport repeater or hub. A typical standalone hub supports 8 or 12 10BASE-T connections. Ethernet hubs can also be designed as modular systems called chassis hubs. Chassis hubs can support several media varieties of Ethernet, and not just twisted-pair. With its reliance on proven telephone system technology the twisted-pair variety of Ethernet provides a reliable, yet simple and low-cost method for attaching computers to an Ethernet system.

- **Ethernet Frequently Asked Questions (FAQ)**

Another handy guide to general Ethernet information can be found in the latest edition of the Ethernet FAQ. A FAQ is a list of frequently asked questions with their answers. The Ethernet FAQ was created for distribution over the Usenet group dedicated to the subject of Ethernet LANs. For more information about Usenet groups and the Ethernet group in particular see Section IV of this list.

For those without access to the Usenet, a copy of the Ethernet FAQ may also be acquire via anonymous FTP from **dorm.rutgers.edu** in **pub/novell/DOCS.**

3.3. Vendor Guides

Some very useful tutorial information on Ethernet may be found in a variety of publications available from vendors. Be warned that vendor guides are not very formal publications and may go out of print at any time. You also have to allow for the vendor-specific orientation, and understand that there may be other ways to do things. Nonetheless, despite the emphasis on a single vendor's products you can find good tutorial information in these guides. Listed next in no particular order are several guides that have proven useful.

Hewlett-Packard Manuals

- **LAN Cable and Accessories Installation Manual**
  Published by Hewlett-Packard Co, January 1986.
  Approx. 204 pps. with index.
  $43.00.
  HP Part No. 5955-7680.
  Order from HP Direct Ordering at (800) 227-8164

This slightly out-of-date manual from HP is still one of the better sources of tutorial information on how to deal with the thick and thin Ethernet varieties. The manual does not mention the twisted-pair Ethernet system. Despite the specific product orientation, the Ethernet configuration information is useful, and the guidelines for designing networks are clear and well written. Thin Ethernet is covered, using HP's ThinLAN name for the technology. In addition, the manual shows how to tap a thick Ethernet cable for installation of the typical transceiver connection.

One nit to pick is that the advice on running cable between buildings is based on older coax technology and does not take into account the newer IEEE Fiber Optic Inter-Repeater Link (FOIRL) standard. The FOIRL standard makes it possible to link Ethernets between buildings while preserving complete electrical isolation between the LANs. Such isolation is important when it comes to preserving the safety of the LAN system and preventing damage to the system components.

This manual really shines when it comes to descriptions of thick cable and thin cable tooling and details of cable construction. The wire strippers and connector crimpers required for each cable type are described, although only HP part numbers are cited for these tools. There are also diagrams showing how to prepare each kind of cable for connectors, and how to crimp on the N connectors and BNC connectors used with the thick and thin coaxial cables. The manual finishes with a short section on verifying the cables you've built, and a section on how to use a time domain reflectometer to test network cables.

Another useful feature of the manual are the safety warnings that explain the hazards of the crimping tools, and the various electrical dangers that may be present when working on network cable systems. While on the subject of safety warnings, it should be mentioned that the crimping tools shown in this manual use a mechanism that prevents them from opening until they have closed all the way. It can be painful if a finger, rather than a connector, gets into the works. The HP manual thoughtfully includes an appendix on how to get your finger out of a crimp tool, should the need arise.

- **HP SiteWire Twisted-pair Cabling Installation Guide**
  January 1988, Hewlett-Packard Company, Roseville Networks Division, 8000 Foothills Boulevard, Roseville, California 95678.
  Approximately 100 pps, with 11 sections, 2 Appendixes, and an Index.
  $40.00.
  HP Manual Part Number 5959-2208.
  Order From HP Direct Ordering at (800) 227-8164

Like the HP guide on coaxial cabling, this document is oriented to HP product offerings. Covering twisted-pair wiring for data communications, and including the Ethernet 10BASE-T variety, this guide provides instructions on how to test and install twisted-pair wiring for networks. While limited to HP offerings, it still provides a useful introduction and primer for for twisted-pair Ethernet installations.

The guide begins with a general introduction to twisted-pair connections. The system shown is not based on the widely used AT&T Premises Distribution System (PDS); instead the HP approach to wiring both telephones and data service for an office space is described. PDS equipment may be used with the HP approach however, and the guide notes that for large installations you may want to base your design entirely on the PDS system.

The guide explains the basics of how to build twisted-pair cables, test them for continuity, and install them in an office. The use of 66-type and 100-type punch-down tools and punch-down blocks is explained, along with the basics of making a host connection to a twisted-pair Ethernet.

The rest of the document describes how to install 10BASE-T hubs. The guide also shows the HP 10BASE-T interface boards for PCs that contain two modular jacks; one for connection to the building wiring system, and one for connection to a telephone. This allows you to support both telephone and data on the same twisted-pair cable, and you are shown how to install wiring for such a system.

DEC Manuals

- **Telecommunications and Networks Buyer's Guide**
  Published twice a year by Digital Press.
  Free.
  No part number. Ask for it by title from a DEC sales office. Call (800) 332-4636 if you don't have a local DEC sales contact.

This guide lists all communication hardware, communication software products, and network services that DEC provides. Of special interest are the configuration guidelines for DEC's 802.3/Ethernet products. Here you will find all manner of information about 802.3/Ethernet in general and the DEC product line in particular. Included is a description of DEC's building wiring standard, Open DECconnect.

You will also find media and topology information for fiber optic Ethernet connections, unshielded twisted pair, thin Ethernet and thick Ethernet. The guide includes illustrations and descriptions of many Ethernet components including barrels and terminators for thick Ethernet, DECconnect wiring equipment, and repeaters and bridges.

The guide is completely DEC-centric, of course, but the price is right and the information can be quite useful. The guide lists many other products, including DEC's offerings for the 100 Mbit/sec LAN standard known as FDDI.

- **OPEN DECconnect Building Wiring Components and Applications Catalog**
  1990, Digital Equipment Corporation.
  Free.
  No part number. Ask for it by title from DEC sales office. Or call the DEC pre-sales support group at (800) 344-4825

The components and applications catalog lists individual parts of the DECconnect wiring system including a description and order number. Line drawings for each part are shown. The second half of the catalog shows some typical wiring applications and how they are configured to use the DECconnect system.

MOD-TAP

- **MOD-TAP Applications Manual 1993**
- **MOD-TAP Components Catalog**
  MOD-TAP, 285 Ayer Road, PO Box 706, Harvard, MA 01451-0706, (508) 772-5630.
  Applications Manual $5.00, Components Catalog Free.

MOD-TAP supplies communications cabling products for computer users. Their applications manual covers a wide range of communications cabling applications for several different network standards. Of interest here is their support for 10BASE-T Ethernet. The applications manual describes some basic concepts for building cabling design, and also goes into detail on the wide variety of twisted pair wiring schemes in use today.

A major benefit of this manual is the information on the various twisted pair wiring schemes currently in use and how they can be used to support 10BASE-T twisted pair Ethernet. The manual also describes some basic wiring installation techniques, including how to develop a cable numbering scheme to help keep it all straight.

The components catalog describes the entire line of MOD-TAP products. Included are a set of charts that show the twisted pair wiring schemes used in the USOC, AT&T 258A, AT&T 356A, ROLM, DEC, EIA, and 10BASE-T standards. The building you may be trying to wire for 10BASE-T Ethernet may include twisted-pair wires installed according to any one (or more) of these standards. The information shown here can be invaluable for figuring out how to get the signals from the 10BASE-T hub in the wiring closet to show up on the user's desk.

3.4. Ethernet Hardware and Vendors

Ethernet hardware comes in several forms. At the physical media level there are basic pieces of hardware: coaxial cable, twisted-pair cable, and connectors. The next level up features components such as transceivers, transceiver cables, and Ethernet interfaces. At the higher levels of network concatenation are devices such as multiport transceivers, Ethernet repeaters, chassis hubs, and bridges.

Just to keep things interesting, the different media varieties of Ethernet require different components. For instance, thick Ethernet media systems use different low-level hardware and components than twisted-pair media. Moreover, every vendor seems to have its own special design for equipment such as Ethernet hubs. It's a large market, and impossible to cover in any short list of resources such as this one. Lists of vendors and products may be found in buyer's guides published by some of the LAN magazines shown in the next section.

Shown next are a few representative examples of equipment and hardware catalogs from equipment distributors.

- **Anixter Wiring Systems Product Catalog**
  Anixter Bros., Inc.
  4711 Golf Road
  Skokie, IL 60076
  Phone (312) 677-2600

The Anixter Wiring Systems Product Catalog is a vast compendium that lists many different vendors, supplying all manner of communications equipment. The catalog describes the full range of products supplied by Anixter, but does not include pricing.

The catalog has separate sections for both Ethernet and DEC's special Ethernet wiring system (called DECconnect). The catalog also features a glossary of communications industry terms, and an index. All in all, this catalog is a useful resource for the LAN manager. Catalogs are available from your local Anixter distributor, or call the main office in Skokie.

- **Anixter Networking Products Guide**
  4711 Golf Road
  Skokie, IL 60076
  Phone (800) 622-6415 (orders) (800) 622-6417 (technical assistance)

This 166 page catalog is also called ‘‘One Network Place’’ and features a selection of networking equipment including Ethernet products. The catalog lists components used in twisted-pair wiring systems, basic networking devices like transceivers, Ethernet interfaces, and hubs, and network devices such as Ethernet bridges. Prices are included for all items.

- **AT&T Systimax PDS Components Catalog**
  For access see a local AT&T representative or call:
  (800) 344-0223 ext 1102 (USA)
  32-2-676-3623 (Europe)
  (416) 756-5118 (Canada)

This catalog describes the wiring components used in the AT&T Premises Distribution System (PDS). AT&T’s PDS is a widely adopted scheme for installing twisted-pair wire in commercial buildings. The design of the Ethernet twisted-pair standard allows it to operate over PDS wire systems. There are no prices in this catalog and no tutorial information. Instead it provides you with a description of the wiring components used in one of the most widely adopted twisted-pair wiring systems for buildings.

- **Hubbel Premise Wiring Inc.**
  Full Line Catalog #1100R
  14 Lord’s Hill Road
  PO Box 901
  Stonington, CT 06378-0901
  (203) 535-3809 or (800) 626-0005

Another catalog listing a complete line of premise wiring for twisted-pair systems. Includes some information on the EIA/TIA Commercial Building Wiring Standard. A useful catalog for anyone implementing a twisted-pair Ethernet system.

- **Network Electronics LAN Catalog**
  4801 N. Ravenswood Ave.
  Chicago, IL. 60640-4496
  (312) 784-5100

Newark has branch offices all over the US. This catalog provides access to the network products that Newark carries, including coaxial and twisted-pair Ethernet. Also included are a wide range of network cabling components. Prices are included for all items listed.

3.5. Network and LAN Troubleshooting Guides

- **Network Troubleshooting Guide**
  August 1990, Digital Equipment Corporation
  Approx. 278 pps. with index and glossary.
  $95.00
  Digital part number is EK-339AB-GD-002.
  Digital Direct phone is (800) 344-4825.

While the price is steep, this is a useful guide to a variety of techniques for testing and troubleshooting networks that support both DECnet and TCP/IP protocols. The guide begins with a brief description of how both DECnet and TCP/IP function, including details of addressing in both protocol suites.

Chapter 2 describes how to develop a basic network troubleshooting methodology for your site. Following this is a chapter on network management and troubleshooting tools, listed alphabetically, and including both VMS and ULTRIX-based tools. The emphasis is on Digital applications, but more general applications such as ‘‘ping’’ and ‘‘traceroute’’ are also shown.

Chapter 4 describes resources for troubleshooting. These include various ULTRIX and VMS log files that contain information on problems that may have occurred with software running the DECnet and TCP/IP protocols.

Chapter 5 is the largest chapter of the guide. It describes network troubleshooting procedures for a wide variety of common network problems in both DECnet and TCP/IP. The problems are categorized as ULTRIX host problems, VMS host problems, LAN problems, WAN problems, and cross-category problems that include two or more of the preceding problems.

This chapter explains how to interpret common error messages seen, and how to go about troubleshooting the source of the error. Each problem is described and troubleshooting procedures explained. An example for TCP/IP includes the the error message ‘‘connection timed out.’’ A variety of errors that could cause this message are explained, and a troubleshooting strategy is listed. You are shown how to use ‘‘ping’’ to check for connectivity, ‘‘netstat’’ to check for errors on the host interface, etc.

While the guide focuses on DEC equipment running VMS and ULTRIX operating systems, there is still much useful information provided for debugging complex network problems in a mixed vendor environment. For example, many of the utilities described for ULTRIX are commonly available on other Unix systems. Although the guide assumes you have a DEC LAN Traffic Monitor (LTM) available, this is not a severe limitation. You can replicate much of the information you can get from the LTM by running commonly available applications such as ‘‘etherfind’’ or ‘‘tcpdump’’ on your system.

This guide has two major advantages; the structured approach to troubleshooting and the unusual mix of both DECnet and TCP/IP troubleshooting procedures in the same manual. While the troubleshooting information appears to list more DECnet-based errors than TCP/IP ones, the guide manages to present quite a lot of technical information about both protocol suites and their possible failure modes in a clear and well organized format.

- **LAN Troubleshooting Handbook**
  Mark A. Miller
  1989, M&T Publishing Co., Redwood City, CA., 309 pps. with index.
  $29.95.
  ISBN 1-55851-054-0

A wide-ranging guide to troubleshooting information for several LAN technologies including Ethernet. The author manages to fit a surprising amount of technical information about three LAN technologies, Ethernet, token ring, and ARCNET, into one volume. Though there isn’t any tutorial information about Ethernet, the troubleshooting information is clear and the book is well illustrated.

The material on Ethernet covers two sections: one on coaxial cable based Ethernets (both thick and thin), and one on twisted-pair Ethernet technology, including Synoptics LattisNet and AT&T StarLAN products. The IEEE 10BASE-T unshielded twisted-pair system is also briefly described. This book provides quick access to some essential troubleshooting information for the three main varieties of Ethernet.

From the Preface:

‘‘This book has a very fundamental thesis: how to keep your local area network alive. There are three parts to that goal. First, you must understand how the LAN should operate if you are to properly define when it is not operating. Secondly, you must have the proper hardware and software tools readily available to troubleshoot problems. Third, you must take preventative measures to keep those failures from recurring in the future.''

''To accomplish this goal, the book is divided into ''network generic'' and ''network specific'' chapters. Chapters 1, 2, 3, and 4 address the generic issues of LAN standards, Documentation, Test Equipment, and Cabling. Chapters 5, 6, 7, and 8 address specific issues associated with popular LAN architectures: ARCNET, Token Ring, Ethernet, and StarLAN, respectively. Also included in the network-specific chapters are examples of protocol analysis of Novell's NetWare, IBM's NetBIOS, DEC's DECnet, and TCP/IP. Chapter 9 concludes with a dose of preventative medicine.''

3.6. The Ethernet Standards

Ethernet became the first non-proprietary LAN technology with the publication of the original multi-vendor Ethernet specification in 1980.

There are two basic Ethernet standards: one issued by the multi-vendor consortium in 1980, and one developed by the Institute of Electrical and Electronics Engineers (IEEE). The multi-vendor standard is known as the DIX standard, so called due to the initials of the three participants: Digital Equipment Corp, Intel, and Xerox. The DIX standard includes versions 1.0 and 2.0.

In 1985 the IEEE 802.3 CSMA/CD standard for Ethernet technology was released. Based on the DIX Ethernet standard, the IEEE version brought the thick Ethernet system into the world of international standards. While they may appear quite different at first, the DIX version and the IEEE version of the standard are functionally similar. Many vendors rate their Ethernet hardware for use in both IEEE 802.3 and DIX version 2.0 systems. Of course, the prudent networker makes sure that all of the hardware used to attach a computer to the Ethernet is based on a single version of the standard.

Most of the changes that the IEEE version of the standard made were at the level of the Ethernet frame, which is the set of bits that carry the data between computers. However, both IEEE and DIX Ethernet frames can coexist on the same Ethernet LAN without problems.

The next several items list an introduction to IEEE standards and describe the formal Ethernet standards in use today. The formal standards are the technical documents for Ethernet/802.3 LANs, and they can be heavy going for non-engineers. There is no tutorial information in the standards, and the technical jargon they use makes them difficult to read. The newer IEEE standards use a special language developed for open systems standards that can bewilder the unprepared. The book listed next provides a guide to the newcomer to IEEE standards.

- **LANs**
  Applications of IEEE/ANSI 802 Standards
  Thomas W. Madron.
  1989, John Wiley & Sons, New York, NY, 308 pps. with index and glossary
  $34.95.
  ISBN 0-471-62049-1.

An introduction to LANs from the point of view of the evolving network standards. This book presents the world of network standards and how they're organized. The various standards agencies are described and the Open System Interconnection (OSI) model is explained. Following this, the IEEE 802 standards are described, and the way that the IEEE standards fit within the OSI organization is explained.

The bulk of the book describes the individual IEEE LAN standards. The book closes with a explanation of the basics of TCP/IP operation, including the function of LANs in the delivery of TCP/IP services.

From the Preface:

‘‘The object of this book is to provide a reasonably detailed overview of contemporary LAN standards, especially those developed through the auspices of the Institute of Electrical and Electronics Engineers (IEEE). To be meaningful, however, the discussion of the IEEE standards is placed in the context of the development of standards generally, then in the framework of the Open System Interconnection (OSI) Reference Model of the International Organization for Standardization (ISO). After describing the IEEE standards (from 802.1 through 802.6), the way in which the standards can be applied in ’real’ networks is illustrated through a discussion of the Manufacturing Automation Protocol (MAP) and the Transmission Control Protocol/Internet Protocol (TCP/IP), in Chapters 9 and 10 respectively.’’

3.6.1. The DIX Standard

- **Version 2.0, DEC-Intel-Xerox (DIX) Ethernet Standard**
  Ethernet Local Area Network Specification Version 2.0. November, 1982
  Digital Equipment Corporation, Intel Corporation, Xerox Corporation, 103 pps.
  $31.00.
  DEC Part Number: AA-K759B-TK.
  Available from DEC-Direct by calling (800) 344-4825.

This is Version 2.0 of the original 10 Mbit/sec thick Ethernet specification. The newer IEEE 802.3 standard supersedes the DIX spec listed here, but many network protocol implementations still use the Ethernet frame from the DIX specification.

This specification is organized according to the OSI model, but uses somewhat less technical jargon than newer standards. That makes it a document that is more approachable by the non-expert than the IEEE standard tends to be. The DIX specification is still a technical standard, however, and contains no tutorial information on the design and operation of Ethernets. Just the facts.

3.6.2. The IEEE 802.3 Standard (ISO 8802.3)

The IEEE 802.3 standard is the current standard for thick Ethernet as well as for all newer varieties. However, nothing stands still very long in the standards world, and the IEEE standard is no exception. Starting as a multi-vendor standard (DIX), the Ethernet system then became a national standard (IEEE/ANSI), and the IEEE specs are now incorporated in an international (ISO/IEC) standard. This explains why the IEEE organization now sells the ISO volume of specifications, instead of the older IEEE 802.3 volume. The name of the latest international ‘‘Ethernet-like’’ standard is (take a deep breath):

- **(ISO/IEC) (ANSI/IEEE Std 802.3, 1992)**
  Information Processing Systems - Local and Metropolitan Area Networks -
  Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD)
  Access Method and Physical Layer Specifications (ANSI)
  ISBN 1-55937-049-1
  IEEE product number: SH13482
  $75.00 (from IEEE publications catalog)
  Available from:
  IEEE Customer Service
  445 Hoes Lane
  PO Box 1331
  Piscataway, New Jersey 08854-1331
  or by calling (800) 678-4333 (IEEE).
  Outside US and Canada call, (908) 981-1393.
  The FAX number is (908) 981-9667

These are the current specifications for an Ethernet-like CSMA/CD LAN. Despite the major reworking of the original DIX standard by the IEEE, and despite changes made in the way some things work, the IEEE and DIX specs have a strong functional similarity at the hardware level.

Old and new hardware can interoperate well on Ethernet/802.3 LANs, despite the differences in the specifications. Many network protocol implementations (TCP/IP among them) continue to use the original DIX Ethernet frame, for example. Campus Ethernets used to interconnect computers equipped with hardware built according to both the DIX and 802.3 specs can interoperate on the same Ethernet LAN. The standards were written so that mixing things together like this on the same Ethernet system still works.

3.6.3. Twisted-Pair Ethernet Specifications

Since the creation of the twisted-pair Ethernet standard in 1990 the twisted-pair Ethernet market has seen extraordinary growth. The twisted-pair system makes it possible to install Ethernet in an office using standard twisted-pair wiring. This has led to the twisted-pair Ethernet system becoming the system of choice at many sites. The twisted-pair specification is described in a supplement from the IEEE. Eventually the twisted-pair standard will be incorporated in the ISO 8802.3 standard document. Until that happens you need to acquire this document to get the formal twisted-pair specifications. This supplement also contains some newly written guidelines for building large, multi-segment Ethernets using a mix of Ethernet varieties. The title is (take an even deeper breath):

- **802.3i-1990 IEEE Supplement to Carrier Sense Multiple Access with Collision Detection CSMA/CD Access Method and Physical Layer Specifications: System Considerations for Multisegment 10 Mb/s Baseband Networks (Section 13) and Twisted-Pair Medium Attachment Unit (MAU) and Baseband Medium, Type 10BASE-T (Section 14)**
  ISBN 1-55937-070-X
  IEEE Product Number SH13763
  Price $26.00, from IEEE catalog. Same access for IEEE as above.

3.7. Ethernet Numbers

This section describes two sets of numbers used in the Ethernet system. Both sets are useful in network troubleshooting. The standards agencies that oversee the administration of these numbers are also listed.

3.7.1. Ethernet Type Numbers and Addresses

The Ethernet frame specified by the DIX standard contains a Type field. The DIX Ethernet Type field contains a type number that describes the type of high-level network protocol (such as TCP/IP) being carried by the Ethernet frame. This information can be quite handy when you're troubleshooting a LAN problem and trying to figure out which high-level protocol may be involved.

In the new IEEE 802.3 frame specification, the type field was replaced by a more general, but more complex, set of frame specifiers. Nevertheless, many network software implementations still use the DIX frame specification with its accompanying Ethernet type field.

The addresses used in Ethernet frames are also useful to the network troubleshooter. The 48-bit Ethernet address is called an ''Organizationally Unique Identifier'' (OUI) and is divided into two 24-bit portions. The first portion is assigned to a specific manufacturer by the IEEE and the second portion is used by that manufacturer to create a unique address for each Ethernet interface. The total result is a 48-bit address for each Ethernet interface consisting of a 24-bit pattern that is assigned by the IEEE and another 24 bits assigned by the manufacturer to each interface.

If you know the manufacturer's number, you can frequently identify which computer may be causing network problems. This is not a foolproof mechanism, since some vendors may buy their boards from other manufacturers. Nonetheless, in many cases knowing the Ethernet addresses assigned to a manufacturer can help track down a malfunctioning device.

3.7.2. IEEE OUI List

The IEEE used to treat all OUI assignments as confidential information. The latest policy is that the address assignment will be made publicly available unless the vendor requests privacy. Vendors may regard the number of OUIs they request as confidential information, so the public list of OUIs assigned by the IEEE must be assumed to be incomplete.

The IEEE list can be retrieved via anonymous FTP from host **ieee.org** in the **info/stds** directory as filename **info.stds.oui**. You may also retrieve a copy of the IEEE list by sending an e-mail message to **info.stds.oui@ieee.org** and a copy of the list will be sent to you in return.

3.7.3. MIT Numbers List

The IEEE does not supply a list of DIX Ethernet Type fields, since the IEEE does not assign Type fields. Also, the IEEE list of OUIs is necessarily incomplete. To help overcome these problems a publicly available list of type fields and vendors' addresses has been compiled by network administrators who have observed and analyzed Ethernet traffic on their networks. This list too is necessarily incomplete, but nonetheless provides a wealth of useful information.

The list of OUIs and Type fields may be found via anonymous FTP on host **ftp.lcs.mit.edu** in directory **pub/map** as filename **EtherNet-codes**. If you have discovered a new vendor's address or other Ethernet number that you would like to add to this list, you can send your entry to **map@lcs.mit.edu.**

3.7.4. Assigned Numbers RFC

A list of Ethernet numbers for troubleshooting, including both the type field numbers and the Ethernet address numbers, can also be found in the Assigned Numbers RFC. The Assigned Numbers RFC is an RFC for the TCP/IP protocol suite that also contains a list of some of the Ethernet numbers. This RFC may be retrieved as described in the section on TCP/IP and the RFCs.

3.7.5. Administration of Ethernet Numbers

Type Field

Since the type field is part of the older DIX specification, Xerox manages the administration of Ethernet type fields. The Ethernet patents are owned by Xerox as well, and licenses to build Ethernet equipment using these patents can be obtained from the same source. Anyone wishing to apply for a new type field should contact Xerox at the following address:

Xerox Corporation
Xerox Systems Institute
3400 Hillview Ave.
P.O. Box 10034
Palo Alto, CA 94303
(415) 813-7164

As stated in Xerox literature: ''Per Appendix B of the Ethernet Specification, a Ethernet type field will be assigned on written request to each licensee of Ethernet patents. The licensing fee is $1000.00. Others wishing to obtain type field assignments may do so by including a $300.00 administrative fee with their written request.''

IEEE 802.3 Addresses

All new Ethernet addresses (OUIs) are assigned by the IEEE, although older ones assigned by Xerox are still valid. Anyone attaching a computer to an Ethernet system need not concern themselves with addresses, since a unique Ethernet address is assigned to each Ethernet interface at the factory. On the other hand, for the curious, a block of addresses costs $1000.00. The address for inquiries is:

IEEE Standards Office
820 Second Avenue, 7th Floor
New York, NY 10017-4504
(201) 981-0060

3.8. Ethernet Performance Analysis

Ethernet has been around for a while and provides network communications at many sites, so you'd think that the performance characteristics would be well established. Nonetheless there have been surprising claims made about Ethernet's ability to transmit data. Some of the claims have been based on papers written about the Ethernet system over the last several years, and a number of these papers have based their performance analysis on simulations and simplifications of the Ethernet protocols. This has inadvertently helped to establish a mythology about Ethernet performance limits. Fortunately there has been some empirical analysis that demonstrates the actual performance of Ethernet.

- **Measured Capacity of an Ethernet: Myths and Reality**
  David R. Boggs, Jeffrey C. Mogul, Christopher A. Kent.
  Proceedings of the SIGCOMM '88 Symposium on Communications
  Architectures and Protocols, ACM SIGCOMM, Stanford, CA., August 1988,
  31 pps.

This technical report from Digital's Western Research Lab presents empirical evidence showing that the 10 Mbit/sec Ethernet system is capable of transmitting at the full 10 megabit data rate. Also useful is the analysis of what makes a good Ethernet implementation. The report includes a brief set of network design guidelines for network managers who want to optimize their Ethernet system.

From the Abstract:

''Ethernet, a 10 Mbit/sec CSMA/CD network, is one of the most successful LAN technologies. Considerable confusion exists as to the actual capacity of an Ethernet, especially since some of the theoretical studies have examined operating regimes that are not characteristic of actual networks. Based on measurements of an actual implementation, we show that for a wide class of applications, Ethernet is capable of carrying its nominal bandwidth of useful traffic, and allocates the bandwidth fairly.''

This paper is available over the Internet via electronic mail from the DEC Western Research archive server. Send a message to the automatic mail server with the word ''help'' in the Subject line of the message for detailed instructions. The address of the DEC technical reports mail server is **WRL-Techreports@decwrl.dec.com.**

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