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IMPLEMENTING OSI NETWORKS

Gerald D. Cole

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AND NETWORKING FOR COMPUTER PROGRAMMERS

IMPLEMENTING OSI NETWORKS

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SERIES PREFACE

The Data Communications and Networking for Computer Programmers Series provides the information programmers and software engineers need to effectively deal with new data communications and networking technology. The series focuses on the educational needs of the computer systems analyst, systems programmer, and systems engineer, building on their existing computer knowledge base. The series as a whole provides an integrated view of such real-world topics as analyzing networks, implementing network protocols, developing local area and wide area networks, interconnecting networks, creating multivendor networks, and understanding network standards.

Because the breadth of the data communications field is beyond the scope of a single book, the information is presented in a series of books. Each book deals with a different aspect of the wide range of data communications topics. This division of information allows the different books to build on a level of knowledge defined by the other books in the series. When one book is used by a programmer, the other books in the series provide an established source for additional information. Overlap between the books is limited to essential information.

The authors of the series are working professionals in different networking and data communications areas. Each author writes using his or her experience in solving actual data communications problems in system development. The authors relate the data communications aspects to concepts already understood by experienced programmers, using similarities to extend the programmer's understanding from familiar computer programming concepts to different aspects of data communications networking. In many respects, data communications and networking can be viewed as a specialized form of I/O systems.

The complexity of data communications and networking, however, is not overly simplified. Unique data communications topics such as network error control and recovery, sequence and flow-control management, distributed fault

recovery mechanisms, and concurrent operation of atomic actions across the multiple resources of a network, are all addressed in detail. While the books emphasize similarities, aspects that differ are highlighted, still allowing the programmer to maximize the benefits from his or her existing knowledge.

Gerald D. Cole
Series editor

PREFACE

The objective of this book is to explain Open Systems Interconnection (OSI) and computer networking in a way that is useful to implementers of computer systems and applications that run on them. The audience is expected to include computer systems analysts, system programmers, and application programmers.

The intent of the book is to describe OSI in easy-to-read terms, given that the reader has some familiarity with data communications and networking concepts. Every attempt has been made to avoid the seemingly endless stream of verbose OSI terms such as CONNECT DATA OVERFLOW SPDU, (abandon) request primitive, GIVE TOKENS SPDU with token item parameter, and association-responding-reliable-transfer-protocol-machine. The OSI specifications are filled with such nomenclature, and these specifications are a necessary part of implementing OSI systems. However, these specifications are not the proper starting point for learning about OSI.

On the other hand, articles and books on OSI fill several bookshelves. Much of that information fails in the other extreme. Readers are left with too sketchy an understanding of what OSI is really about and what it can (and cannot) do for their systems. This book is targeted toward the center position. It provides the overall perspective of layered architecture with a detailed description of the services and protocols of each layer. It stops short of including all OSI details, but it does give examples so that the reader who needs to consult the detailed specifications will be able to do so.

The book begins with a description of the OSI Reference Model and the general concepts of OSI. It then covers the important issues of naming and addressing, as well as communications services. These topics are pervasive across the layers of protocol. The bottom two layers of OSI are considered point-to-point protocols, including the physical layer, the data link layer, and the overlapping media access control (MAC) sublayer of local area networks.

Current LAN standards are considered in sufficient detail to see their strengths and weaknesses and how they fit into OSI standardization efforts. Next, the network and transport layers are considered end-to-end services. Since these two layers are closely coupled, they are discussed in a single chapter.

The upper three layers provide support to applications. The OSI session layer provides synchronization, dialogue control, and other services that pass through the presentation and application layers. The OSI presentation layer allows applications to negotiate data representations. Associated with the presentation layer is the abstract syntax notation (ASN.1) that provides a notation for the representation of data structures, including application protocol header information.

The application layer service packages provide two forms of support to applications. First is a set of commonly used building blocks, such as the commitment, concurrency, and recovery package for applications that require atomic operations. Then there is a set of application-specific packages for file transfer, remote login, electronic mail, and similar uses. Thus, all three of the upper layers provide services to applications and are of particular concern to system developers.

Since OSI is intended to provide interoperability across multi-vendor computing environments, it is important to be aware of the potential problems influencing interoperability. This is the subject of a chapter covering profiles, conformance testing, and interoperability testing. Profiles define subsets of protocols that are to be implemented, with the idea that interoperability is more likely if only the needed portion of protocols is implemented. Conformance testing is intended to determine if an implementation complies with a test suite. The final *proof of the pudding* is actual interoperability testing with other vendors' equipment.

Network management is considered an OSI application layer function that deals with data about each of the other layers. Network management is the subject of a separate chapter and may be skipped if not of interest to a given reader. However, anyone developing applications that employ networking should have at least some knowledge of network management capabilities. Hopefully, that knowledge will provide insight into potential problems and performance limitations that may affect an application.

The final chapter is a brief look forward to see what is in OSI's future. Expected trends include more distributed applications and transparent forms of networking, greater use of connectionless forms of networking, and attempts

at vendor enhancements to OSI implementations. The future also holds better conformance and interoperability tests and improved migration strategies.

In this book the approach is to provide a comprehensive analysis of each protocol, with an emphasis on the services it provides and the way it performs its functions. This approach has been successful in courses taught by the author at several universities including UCLA Extension and the University of Southern California. More recently the author has used this approach in courses offered by Learning Group International.

The author acknowledges the cooperation of Learning Group International during the writing of this volume, and thanks that organization for permission to include in this book figures developed by the author for use in Learning Group's networking courses.

Gerald D. Cole

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1

INTRODUCTION

Open Systems Interconnection (OSI) promises to end the dependence of computer system users and administrators on a single vendor's networking products. The idea is that IBM, DEC, Unisys, Hewlett-Packard, and other systems will all be able to share access to information and other computer services, without requiring that the user attempt to translate between differing internal representations of data. Don't throw out those terminal emulation boards and software, and don't *trash* the DECnet, IBM System Network Architecture (SNA), or Transmission Control Protocol/Internet Protocol (TCP/IP) networking software right away. Getting OSI in place and fully operational will take time — probably the rest of the decade.

OSI is a large and complicated subject. Unfortunately, people often limit their views of OSI to the OSI Reference Model and the resulting OSI protocols. The basic components of OSI include not only the OSI Reference Model and protocols, but also the OSI profiles, implementation agreements, conformance tests, and interoperability tests discussed in Chapter 7. People also often overlook OSI network management, which is the subject of Chapter 8. However, an understanding of these areas is dependent upon a solid understanding of the OSI protocols, and that is the principal focus of this book.

What are open systems? It is often easier to define a new concept by stating what it is not. The opposite of an open system is a closed, vendor-proprietary system. In this case, the information about the networking approach is vendor-proprietary data. That leaves the possibility of a published, open-literature networking approach that is still owned by a particular vendor. Is that open? And what about public domain networking descriptions such as TCP/IP? Is TCP/IP an open system? One could debate these matters at length, and many people have. For this discussion, the issues are moot. An open system is one in which the protocols follow international standards developed from the OSI Reference Model.

OSI standards come about from the joint efforts of two major international standardization groups. One is the Consultative Committee for International Telephone and Telegraph (CCITT). The other is the International Standards Organization (ISO).

CCITT is an agency within the United Nations, with one voting member per country. This voting member is typically the post, telephone, and telegraph (PTT) from each country. The PTT is the government-directed monopoly that provides the postal system, telephone, and telegraph services. The United States does not have a PTT, so the State Department represents the U.S. in the CCITT. Every fourth year the CCITT issues its standards in the form of recommendations (to distinguish them from regulations). Regulations carry the force of law. Recommendations generally do not, at least not in the U.S., although they do in some European countries.

A full set of CCITT recommendations contains about 20,000 pages, packaged as 60 volumes taking up four linear feet of shelf space. Few people purchase the entire set in any case, because it costs several thousand dollars. The principal recommendations of concern are in three of the approximately two-dozen different series: the V-series on modem-related standards, the X-series on digital networking standards, and the I-series on Integrated Services Digital Network (ISDN) that covers digitized voice and data. The principal concern in this book is the X-series.

The second major international networking standardization organization group is ISO. Unlike CCITT, ISO is a voluntary group, but it too has a member from each country. The U.S. representative to ISO is the American National Standards Institute (ANSI). The ISO charter is much broader than that of CCITT. However, the two organizations have overlapping interests in data communications and networking, as shown in Figure 1-1. The figure shows the broad charter of ISO — everything from screw threads to solar energy, including data communications and networking. The figure also shows CCITT living up to its name, developing standards for telephone, telegraph, networking, and messaging systems. Other organizations actively participating in OSI standards development are the European Computer Manufacturers Association (ECMA) and the Institute of Electrical and Electronics Engineers (IEEE).

Both ISO and CCITT are developing standards for data communications and networking. The idea expressed in the figure is that both CCITT and ISO develop their own versions of standards and then attempt to reconcile their differences through a coordination process to bring them into technical alignment. Both publish their own versions as standards. Both make a good bit of income selling their copyrighted standards; as a result, those standards are not as freely available as comparable documentation such as the TCP/IP standards.

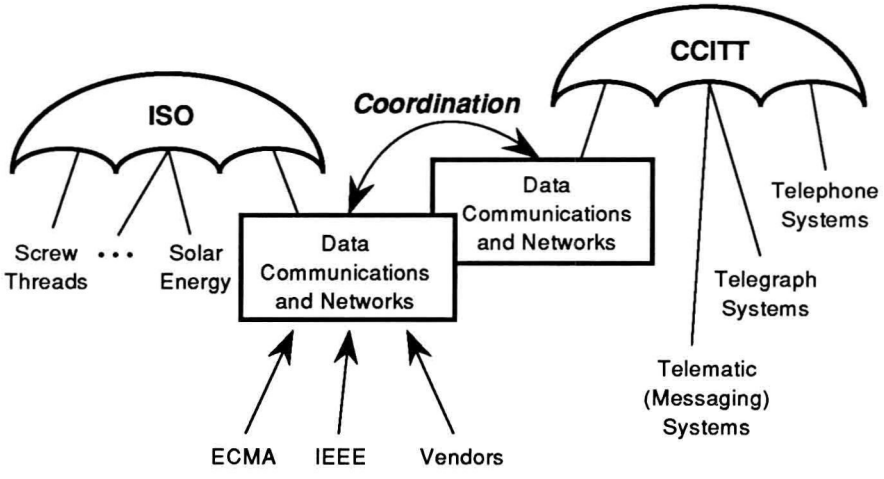

Illustration courtesy of Learning Group International

FIGURE 1-1 ISO and CCITT interests overlap in OSI.

Both CCITT and ISO have published a wide variety of networking standards including the basic document for Open System Interconnection, namely the OSI Reference Model.

THE OSI REFERENCE MODEL

The OSI Reference Model is relatively brief (approximately 50 pages) and describes how computer networking should be accomplished in terms of seven functional layers. Its primary purpose is to serve as a framework for the development of standards at each layer. In effect, it provides a top-level specification for the services that each layer is to provide and the functions (i.e., mechanisms) to be implemented that will provide these services. For example, a typical service of a layer is to provide error-free delivery. The corresponding function (mechanism) is to provide error detection and recovery. Figure 1-2 summarizes the OSI Reference Model.

The OSI Reference Model was developed during 1977-79 based on existing computer network architectures such as SNA, DECnet, and TCP/IP. That makes it more than a decade old. However, it has become a living set of documents: various addenda include issues such as addressing, network security, and connectionless service, none of which were considered in the original effort. The basic reference model is documented as CCITT X.200 and ISO