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Scanning the Issue

THE SPECIAL ISSUE ON OPEN SYSTEMS INTERCONNECTION (OSI)—NEW INTERNATIONAL STANDARDS ARCHITECTURE AND PROTOCOLS FOR DISTRIBUTED INFORMATION SYSTEMS

STANDARDIZATION work began to focus on information systems and data communications during the early 1960's. At that time, the International Organization for Standardization (ISO) organized its Technical Committee 97 on Information Processing Systems and, along with a number of other Subcommittees, SC 6 on Data Communications. The International Telegraph and Telephone Consultative Committee (CCITT) formed Special Study Group A (now called Study Group XVII) to deal with data transmission over telephone networks. In addition, the European Computer Manufacturers Association (ECMA) and many national standards bodies established standards development activities to deal with the newly emerging computer technology.

Progress was slow during the first 10 years, but included the establishment of the well-known EIA RS-232 and CCITT V.24/V.28 physical interfaces. Work also proceeded with the development of character-oriented protocols for transmission of data. These protocols are based upon the International Alphabet Number 5 (IA5) and the U.S. equivalent, ASCII.

In 1968, CCITT recognized the advancements in technology and established a study effort to determine if there was a need for the establishment of telecommunication services specifically tailored for data communication applications. CCITT concluded at their Plenary Assembly in 1972 that data communications were important and should be supported by worldwide public telecommunications networks. Accordingly, CCITT formed Study Group VII, Public Data Networks, to pursue this work. Activity proceeded with developing standards for circuit-switched networks, along with a vague consideration of the emerging packet-switching technology.

At the same time, ISO was proceeding with the development of "bit-oriented" data link protocols to provide a more comprehensive and efficient mechanism for data transmission. ISO also maintained close liaison with the CCITT Public Data Network activity, while ECMA and participating national standards bodies contributed to the work.

Although the numerous standards development activities around the world were developing specifications, there was no master plan that would ensure that all system aspects and requirements were being addressed appropriately. Only standards dealing with the transmission of digital information were produced, and they did not ensure that full and meaningful communications could take place in an international heterogeneous environment. While there are many widely distributed user systems that are of different designs and different manufacture, the established standards have enabled bits of digital information to be transferred among them, but the information is very likely to be useless to the destination unless there is full compatibility in design.

This situation left many questions to be answered. While individual systems operate satisfactorily in their own "closed" environment, what is needed for them to become "open" so they can freely communicate with others? What orderly structure is needed for applications and requirements to be analyzed on a common basis? What standards are needed for creation of an "open systems environment" that will enable a continuing evolution for new requirements and advancing technology?

In wrestling with this problem, ISO Technical Committee 97 established a new subcommittee, SC 16, on Open Systems Interconnection (OSI). SC 16's task was to develop a reference model that would provide an architecture to serve as a basis for all future development of standards for worldwide distributed information systems. Once the architecture had been determined, existing standards were to be analyzed to determine whether they met the requirements of the reference model, and if not, what changes were needed to bring them into alignment. In addition, areas where no standards existed were to be identified and development action taken where appropriate.

SC 16 first met in March 1978, in Washington, DC, to commence this formidable task. The first two years of activity involved considerable technical and political controversy. Nevertheless, enthusiasm was strong among all participating elements, ranging from industry to users from many nations. CCITT also welcomed the ISO effort and appointed a Special Rapporteur to maintain close liaison and to apply the OSI architecture to CCITT applications.

In May 1983 the work finally resulted in the approval of ISO International Standard 7498 and CCITT Recommendation X.200, which specify the basic architecture of Open Systems Interconnection (OSI). While both versions are intended to be technically consistent, there are extensive editorial differences. In addition, CCITT X.200 has advanced further technically in some areas than 7498 has because, while the CCITT effort was still progressing, the ISO balloting period for approval was underway, pre-

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venting further technical change to 7498. Recognizing the potential for divergence between the two standards, ISO and CCITT have agreed to work out the differences and produce compatible texts, editorially and technically, by early 1984.

The fact that this monumental effort has reached the significant milestone of having an approved reference model with worldwide agreement exemplifies the strong support that has been received from diverse interest groups, which include manufacturers, users, and telecommunication service providers.

In March 1983, the British Department of Industry announced their support as a national policy for application of OSI in the United Kingdom. France has adopted OSI as "ARCHITEL," while many other countries are pursuing similar lines.

In their Master Plan, the American National Standards Institute (ANSI) requires that all related standards work be based on the OSI Reference Model. Every standards project must identify its approach to maintaining consistency with OSI.

The new work in CCITT for Integrated Services Digital Networks (ISDN) is also incorporating the principles of OSI. The ISDN work is developing standards for a worldwide switched digital telecommunications system, which will support most of the familiar services, including voice, data, facsimile, electronic mail, video, etc. Newer requirements emerging from the ISDN work will also be reflected back to the OSI architecture in order to provide additions, enhancements, and adjustments needed to ensure its continuing evolution.

While OSI is becoming a familiar term throughout industry, the question is often asked, "When will OSI be completed, so implementations can proceed?" The answer is, "It will never become complete, because it is an ongoing evolution." The architectural principles have now been firmly established, with the definition of the seven layers of functions necessary to create an Open Systems Interconnection environment. Now is the time to join the evolution and apply the principles to new requirements and applications.

Another question that often arises is, "What is the relationship between OSI and IBM's SNA (System Network Architecture), and what will happen in the marketplace?" First one must realize that SNA was designed for a homogeneous environment, where all components are designed by the same manufacturer, while OSI has been standardized internationally to deal with the heterogeneous environment of diverse designs and manufacture. The two are not necessarily mutually exclusive. There are similarities in their basic layered structure. On the other hand, the protocols that are used are, for the most part, different. However, this should not preclude a longer term convergence, or at least coexistence of the two.

The basic OSI reference model is described in detail by Day and Zimmerman in the first paper of this issue. The next step in the OSI development process is to define the services and protocols associated with each layer. The fundamentals of these elements in the family of OSI standards are presented by Linington in the second paper. While good progress has been made with the specific layer service definition standards for the Network, Transport, and Session Layers, specifications are still developing with the other layers.

Another important element of the OSI work includes formal specification techniques not only for describing the OSI Reference Model, but also for the detailed protocols of each layer. These techniques will greatly facilitate producing clear, unambiguous specifications as well as consistent implementations. There are activities in this area in both ISO and CCITT. Dickson and de Chazal report on the status of the work in CCITT, while Vissers, Tenney, and Bochmann describe the formal description techniques being developed in ISO. It is anticipated that these two efforts will result in complementary, compatible solutions.

While the basic OSI Reference Model and the earlier service definitions and protocol specifications are connection-oriented, work is also underway to specify a connectionless mode of operation. Connection-oriented communications are analogous to the familiar telephone system type, where a communication takes place over a pre-established path—a connection. Connectionless communications do not pre-establish a path for information flow, but route individual pieces of information as they are passed node by node through the network. This is analogous to sending a letter through the post office. Chapin presents the issues related to the two modes of transmission, showing that each has an appropriate place in distributed information systems.

The next seven papers deal with each of the seven layers of the architecture, starting from the Physical Layer and sequentially working upward to the Application Layer. Each presents the basic service and protocol characteristics that are applicable.

McClelland describes the Physical Layer characteristics, which are specified in a number of existing standards. So far, little attention has been given to the Physical Layer service definition, which is in the early stages of development.

Conard presents the details of the Data Link Layer elements for which well-established standards already exist. Development of the Data Link Layer service definition, on the other hand, is still in the early stages.

Ware deals with the problems of the Network Layer and the conflicts related to handling the "real-world" situation. Recognized existing standards for the Network Layer include CCITT Recommendation X.25 for packet switching and Recommendation X.21 for circuit switching. Many papers have already been published elsewhere on these two standards so further detail is not included in this issue.

Another Network Layer issue, which is treated by Callon, relates to internetworking among different types of networks. The proposed OSI internetwork protocol is intended to facilitate routing of communications through tandem configurations of heterogeneous subnetworks.

Work on the Transport and Session Layers has been newly developed since the establishment of the OSI principles. The new protocols, which were jointly developed by ISO and CCITT, are now being balloted for approval as published standards. Knightson describes the details of the Transport Protocol work, while Emmons and Chandler cover the Session Protocol.

The upper two layers, Presentation and Application, are still in the early stages of development, but the work is advancing nicely. Hollis deals with the Presentation Layer activities, and Bartoli discusses common and specific elements of the Application Layer.

The next four papers deal with specific protocols of the Application Layer. Lowe presents the status of the Virtual Terminal work, which is progressing through the development stages. Lewan and Long describe the OSI Virtual File Service that is now reaching the more advanced stages and is expected soon to start the balloting process for approval. Langsford, Naemura, and Speth deal with the OSI Management aspects and the Job Transfer services, which are still in the early stages of development, but are actively gaining momentum. Cunningham describes the Message Handling System work of CCITT, which has now progressed to maturity through intensive work over the last two years. (Eight Message Handling System Recommendations will be presented for approval by CCITT in 1984.)

The issue of complying with protocol specifications has long been of great concern. When does an implementation conform to the standard? Linn and Nightingale describe the National Bureau of Standards' work in developing test programs for verifying OSI protocol implementations. Establishment of consistent testing procedures will greatly facilitate operational compatibility among different implementations.

Davidson describes how a recent development of a military network was handled in an early effort to apply the OSI principles in the real world. The architectural elements of OSI were used to the greatest extent possible, but where various management and protocol aspects had not been refined, solutions were developed using the designer's best estimation of the direction of the OSI work.

Another application area for OSI is treated by Foley. He describes the use of OSI for business data communications, including financial industry, commerce, and electronic message applications dealing with information movement.

Finally, my co-editor, Richard desJardins, presents the concluding paper, as an Afterword. He describes the current status and further considerations in the evolution from today's implementations toward OSI and the support that has been demonstrated by industry around the world.

This issue of PROCEEDINGS OF THE IEEE contains, for the first time, a comprehensive set of papers treating the Open Systems Interconnection architecture and protocol work in detail. Most of the authors have been intimately involved in the development of OSI, either from the beginning or for several years. Therefore, these papers represent very authoritative views.

As stated earlier, now is the time to start applying the OSI principles to the enhancement of existing implementations and to new designs for satisfying the next generation of requirements. In areas where the OSI work is still developing, interim solutions can be used. As the OSI work advances, integration of new protocols and technology, accomplished without disrupting all the elements that are in place, is facilitated by the modular design of the layered architecture of OSI. The OSI revolution has started and will continue to evolve. It provides the essential foundation for advancing technology in the establishment of worldwide distributed information systems from a diversity of sources.

In conclusion, I would like to acknowledge the outstanding work of all the participants from the many countries who developed OSI. Without their close cooperation and intense effort over the past 6 years, this significant milestone of international agreement would not have been reached. I also would like to thank my co-editor, Richard desJardins, and the 29 authors who spent considerable time and personal sacrifice to meticulously prepare the high-quality, professional papers that present the background and technical details of OSI for this special issue of the PROCEEDINGS OF THE IEEE.

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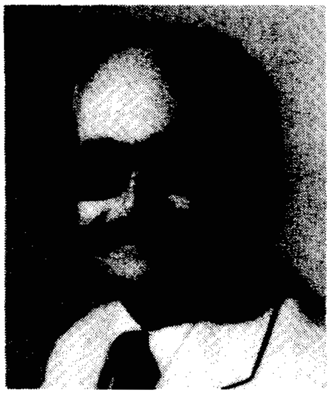
Guest Co-editor



Harold C. (Hal) Folts *received the B.Sc. degree in electrical engineering from the Tri-State University, Angola, IN, in 1959, and the M.Sc. degree from the University of Southern California, Los Angeles, in 1973.*

He is a leading participant in national and international standards development activities. He has been active in the development of the OSI Reference Model in both ISO and CCITT and has been directly associated with the development of CCITT public data network Recommendations X.25, X.75, X.3, X.28, and X.29. Additionally, he was a principal developer of the new EIA RS-449, RS-442, and RS-423 Physical Layer interface characteristics. He is the Chairman of the ANSI Task Group X3S3.7 on public data network interface protocols and was the CCITT Special Rapporteur on the X.21 circuit-switched public data network interface. He is Executive Director and founder of OMNICOM, Inc., which provides information, education, and consultation services relating to the new Open Systems Interconnection (OSI) architecture and protocols for distributed information systems. In the past he has been deeply involved with a number of large telecommunication (voice and data) system implementations. He has published numerous papers in the area of data communications and is Editor of Edition II of McGraw-Hill's Compilation of Data Communication Standards.

Richard desJardins *received the M.A. degree in mathematics from the Catholic University, Washington, DC, and the M.S. degree in computer science from the University of Maryland, College Park.*

He is Vice President of Computer Technology Associates, Inc. (CTA), a systems engineering consulting company headquartered in Englewood, CO. He is also the current Chairman of the International Organization for Standardization (ISO) Subcommittee 97/16 on Open Systems Interconnection (OSI) and the past Chairman of the American National Standards Institute (ANSI) Technical Committee X3T5 on OSI; these committees are responsible for International Standards and American National Standards, respectively, for higher layer computer networking protocols. Previously, he was Head of the Information Technology Office at NASA Goddard Space Flight Center (GSFC) and Senior Systems Engineer of the Mission Operations Division. He received the GSFC Engineer-of-the-Year Award in 1977. He has published over 30 articles and reports on space and information systems engineering, and is a frequent speaker at computer conferences and symposia.