Open Systems Interconnection

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The subject of Open Systems Interconnection (OSI) standardization is becoming increasingly important to the telecommunications and information processing communities. A number of OSI standards have been completed, others are near completion, and initial product offerings by vendors have begun. This paper briefly defines what OSI is, the interrelationships of the various standards bodies, and the goals and benefits to users, vendors, country post telephone and telegraph bodies, common carriers, and governments. The IBM view of OSI and how it relates to Systems Network Architecture is also discussed.

Open Systems Interconnection (OSI) is an international standards activity that primarily defines formats and protocols to interconnect systems that have different architectures provided by different suppliers. OSI can also be used to interconnect sophisticated devices that operate on a peer-to-peer basis. This activity has had the strong support and involvement of manufacturers, users, governments, common carriers, and the government agencies for Post, Telephone, and Telegraph (PTTs). IBM has actively supported and participated in the OSI standards efforts since their start and has made numerous contributions to the technical work.

OSI activity was initiated in March 1977 by ISO, the International Organization for Standardization, and interest and participation in it have continued to grow. The objectives of OSI are

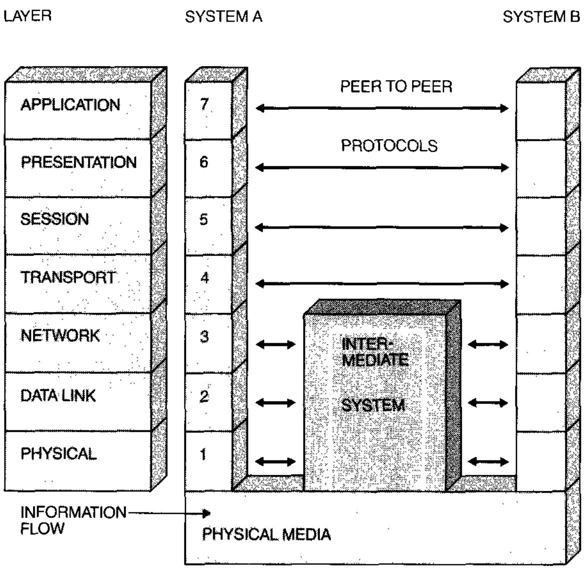
- Interconnection of the systems of different vendors
- Coordination of standardization activities in telecommunications and information systems
- Promotion of new information systems business

OSI standards are beginning to reach maturity. Many are approved, and a complete set is expected to be approved by 1988. OSI standards are a major activity not only for ISO but also in all of the major regional and international standards organizations, including the International Telegraph and Telephone Consultative Committee (CCITT), the European Computer Manufacturers Association (ECMA), and the Institute for Electrical and Electronics Engineers (IEEE).

Since its inception, OSI has grown in technical concept from the initial development of a telecommunications base to the current scope of effort, which includes subjects such as file transfer, job transfer, and message handling. The telecommunications base has expanded to incorporate technical innovations such as local-area networks (LANs) and integrated services digital networks (ISDNs).

OSI has the potential to create significant business opportunities in the information processing industry, especially in user multivendor system environments and in government procurements. Manufacturers are beginning to announce support of OSI standards that have reached completion. User groups are forming for the purpose of understanding and evaluating the usage of OSI in their system structures. Governments have made statements indicating their intentions to make OSI standards obligatory items for procurement. In addition, programs for verification and certification are being established in major countries and in the Commission of European Communities (CEC) in order to enforce the correct conformance to the OSI standards.

Figure 1 OSI Reference Model



ASCHENBRENNER - FIGURE 1

The remainder of this paper is devoted to some degree of elaboration on what OSI is, where it is going technically and according to its projected schedule, IBM's current position *vis-à-vis* technical, user, and product support, and some pros and cons of an approach based on the use of international and/or national standards.

The beginning of OSI

In March of 1977, the International Organization for Standardization Technical Committee 97 on Information Processing (ISO/TC97) approved the formation of Subcommittee 16 (SC16) on OSI. SC16 was established as a result of several British contributions to TC97 that stated the need to bring some order into the standards process. They proposed a new committee to provide a collection of standard formats and protocols which would permit meaningful interconnection of heterogeneous systems.

The mission of SC16 was to develop an architecture that would form the basis for the further development of a set of intersystem standards. The architecture would be documented in a reference model and standardized. The range of these standards would extend from the physical interface to the PTT–common-carrier facility all the way through the networking area and would include application communication. Therefore, items such as data, word processing, security, job transfer, and file transfer were all considered part of the study.

ISO Reference Model

The basis of OSI standardization is a reference model for the coordination of standards development. Existing standards will be placed in perspective within the overall Reference Model, which is organized in functional layers. The Reference Model is sufficiently flexible that, as technology and user demands expand, it can accommodate such advances.

Figure 1 depicts the layers of the OSI Reference Model. Each open system is logically composed of an ordered set of subsystems (layers) which together with the physical media provide a complete set of communication services. The functioning of the layers is governed by OSI services standards. Peer-to-peer protocols based on the services at any layer are independent of the protocols at any other layer.

Following is a brief excerpt from the description of the layers from the OSI Reference Model IS 7498 that identifies some of the services provided by each layer:

- The Application Layer provides identification of intended communications partners (e.g., by name, by address, by definite description) and identification of the subjects to be communicated (e.g., banking, text processing, airline reservations, determination of adequacy of resources, agreement on resources, and agreement on privacy mechanisms).
- The Presentation Layer provides data transfer and selection of the user data syntax.
- The Session Layer provides session connection establishment and release, turn management, session synchronization, and exception reporting.
- The Transport Layer provides end-to-end sequence control, flow control, error recovery, multiplexing, and blocking.
- The Network Layer provides quality of service, sequencing, network flow control, and segmenting.
- The Data Link Layer provides error detection and correction, establishment and release of data link connections, link flow control, identification, and parameter exchange.
- The Physical Layer provides mechanical, electrical, functional, and procedural means to activate, maintain, and deactivate physical connections, and transparent transmission of bit streams.

In general, it is the purpose of the OSI Reference Model to identify areas for developing or improving standards, and to provide a common reference for maintaining the consistency of all related standards. It is not the intent of the Reference Model to serve as an implementation specification nor as a basis for appraising the conformance of actual implementations, nor to provide a sufficient level of detail to define precisely the services and protocols of the interconnection architecture. Rather, the Reference Model provides a conceptual and functional framework that allows international teams of experts to work productively and independently on developing standards for each layer of the OSI Reference Model.

The OSI standardization effort is to provide a means to interconnect systems that have different architectures.

OSI is characterized in its Reference Model as follows:

- "In the concept of OSI, a system is a set of one or more computers, associated software, peripherals, terminals, human operators, physical processes, information transfer means, etc., that forms an autonomous whole capable of performing information processing and/or information transfer. An application process is an element within a system that performs the information processing for a particular application."
- "Application processes can be manual processes, computerized processes, or physical processes."
- "While the scope of the general architectural principles required for OSI is very broad, it is the primary intent of these International Standards to consider systems comprising terminals, computers, and associated devices, and the means for transferring information between such systems."
- "OSI is concerned with the exchange of information between systems and not the internal functioning of each individual system."

The above definition of OSI states that the intent of the OSI standardization effort is to provide a means (a set of standards) to interconnect systems that have different architectures. The internal functioning of the individual systems, such as a Systems Network Architecture (SNA) system, would not be affected.

However, since the start of OSI in early 1977, technology has advanced to the point where devices such as personal computers could have sufficient intelligence to act as a system. It is anticipated that OSI systems will comprise interacting systems of different architectures and that an OSI system could be implemented in one box.

Organization structure. The first plenary session of SC16 took place in February 1978 in Washington, D.C. The American National Standards Institute of the United States was assigned the responsibility for the secretariat. The chair of SC16 was also filled from the United States, since it is customary that the holder of the chair be from the country assigned the secretariat. The result of this meeting was a first draft of the architectural Reference Model with seven layers.

SC16 had five plenary sessions, the last being held in Canada in October 1983. SC16 structured itself into four Working Groups (WG) to cover

1. Architecture, all seven layers (WG1)
2. Systems Management (WG4)
3. Presentation and Application Layers (WG5)
4. Transport and Session Layers (WG6)

There have been numerous meetings of the Working Groups and their *ad hoc* groups since the first plenary of SC16. The plenaries are primarily used to endorse the work and establish schedules for future work. The actual technical development work gets done in the Working Groups.

During 1983–84, TC97 decided to reorganize in order to better serve the standards community. SC16 was merged with segments of other TC97 subcommittees to form Subcommittee 21 (SC21) on Open Systems. The first plenary of SC21 took place in February 1985 in Paris. At that time Layer 4 on Transport Services and Protocols was assigned to ISO/TC97/SC6 on Data Communications. SC6 had previously been responsible for the three OSI lower layers.

WG5 and WG6 reorganized to form WG6 for Session, Presentation, and the Common Application Service

Elements (CASE), part of the Application Layers, whereas WG5 has the Special Application Service Elements (SASE) work on File Transfer, Access, and Management (FTAM), Job Transfer and Manipulation (JT&M), and Virtual terminals. SC21 has widened the scope of OSI to include two major subjects, Graphics under WG2 and Data Base Management under WG3.

During the tenure of SC16, the OSI Reference Model and many of the OSI layer standards either were approved or were entering the final stages (see Figure 2 for the status of all major OSI standards).

SC21 is a subcommittee under ISO/TC97 on Information Processing. SC21 consists of member body delegations representing the national standards organizations of 21 countries. Each member body has its own standards organization—for example, the American National Standards Institute (ANSI) in the United States and the Deutsches Institut fuer Normung (DIN) in West Germany. The participants in these national organizations come from several sources, such as manufacturers, government agencies, users, and the common carriers or PTTs. When they participate in their national standards bodies, they represent their private interests; however, when they are chosen by their national standards bodies to attend an international OSI meeting, they present and support the agreed-on national positions.

OSI standards development

Other groups

CCITT. The International Telegraph and Telephone Consultative Committee (CCITT) and the European Computer Manufacturers Association (ECMA) have cooperated closely with ISO and have made major contributions to the OSI effort.

There are at least eight ISO and CCITT standards that are basically identical except for the introductions used in the documents. This similarity demonstrates the high degree of cooperation that has developed between ISO and CCITT during these last four years of OSI progress.

It is anticipated that the recent increase in mutual development and adoption of OSI standards by ISO and CCITT will continue. It would likely be beneficial to vendors and PTTs to have one set of standards that address both user requirements and the requirements created by PTT services. The PTTs could possibly benefit from the competitiveness of off-the-shelf products that can utilize PTT services. This could also make it easier for vendors to become PTT suppliers as well, where the services include options or requirements for the user to acquire the equipment from the PTT.

Many of the OSI standards included in the lower three layers come directly from CCITT, i.e., the V and X series such as V.24, X.21, and X.25. CCITT recommendations for Teletex, i.e., T.62 and T.70, have been incorporated into the OSI Transport and Session layers. The CCITT X.400 series of recommendations for message handling sit on top of T.70 in the Session layer. Another major CCITT effort, Integrated Services Digital Networks (ISDN), is considered to be part of the OSI family.

ECMA. ECMA has made major contributions to ISO and CCITT in the area of OSI. The objective of ECMA activities is to create documents reflecting the best technical knowledge of manufacturers and propose them as working papers to the international standardization bodies. ECMA usually aligns its own standards with those of ISO after ISO reaches final approval on the corresponding standard.

Industry. Additionally, industry organizations have been involved in the OSI effort. Examples of such activity in the United States are the IEEE 802 standards for local-area networks and the Electronic Industry Association (EIA) standards for the physical layer. The LAN standards have been proposed to ISO, and many have already been approved via an ISO accelerated process.

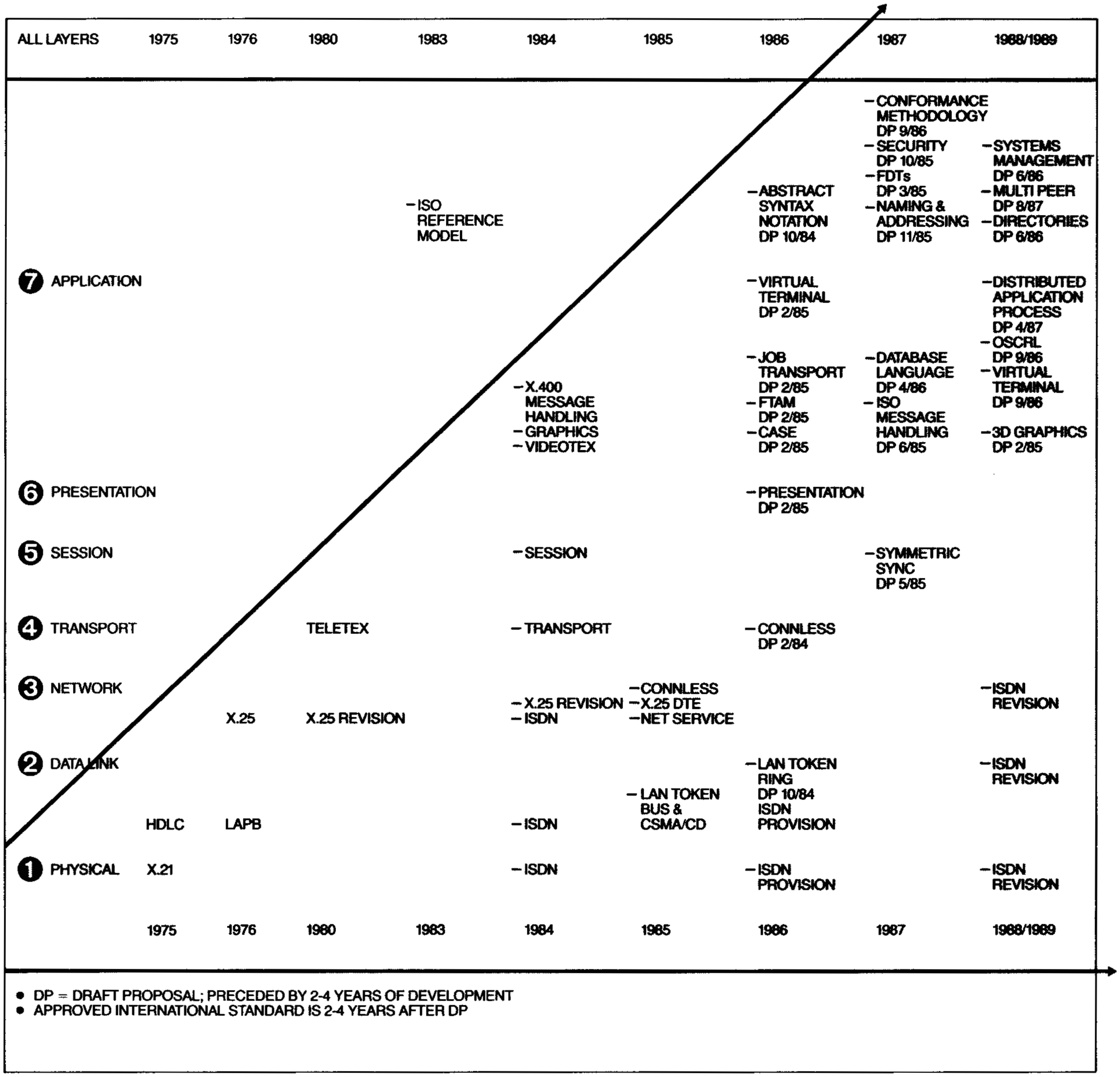
OSI standards status. OSI as conceived by ISO in 1977 has become a generic term and has substantial technical interrelationships with all of the industrial, national, regional, and international organizations of the world dealing with the telecommunications and information processing industries.

The lower three layers of OSI can be implemented today. Many standards are already defined and in use, such as High-Level Data Link Control (HDLC), the V series, and the X series. These standards will be supplemented by LAN and ISDN standards.

The OSI standards for layers four and five, which include CCITT recommendations for Teletex, are also completed and approved.

The standards for the upper layers are still being defined, but several are near completion. Significant

Figure 2 Status of major OSI standards with wedge chart shown on overlay



progress was made in the SC21 February 1986 meeting in Paris, and these standards will materialize over the next two years.

Users will implement OSI through layer five in the near term and adopt their own layer six and seven and system management solutions until OSI solutions become available.

Schedule of OSI standards. The SC21 schedule for standards in Figure 2 shows that the vast majority are expected to be approved before the end of 1988. At the Draft Proposal (DP) stage, a standard is still unstable but is conceptually structured to a point that permits architectural product development work to begin. At the Draft International Standard (DIS) stage, the standard is stable enough to permit product development work to begin. Because the processing between the DIS stage and the International Standard (IS) stage is essentially administrative, there is no technical reason to wait for the IS stage before starting implementation.

Figure 2 also depicts the evolution of OSI over time. The lower layers continue to address new requirements such as LANs and ISDNs, while the increasing development activities in each ascending layer have formed a wedge of standards reaching the application layer and cross-layer standards in the recent years.

The placement of a standard on the "wedge" chart overlaid on Figure 2 is based on the scheduled date of an approved ISO DIS or a CCITT-approved recommendation that was established at the respective meetings of ISO and CCITT in the fall of 1985. In either case the standard is considered to be a sufficient specification level for implementation.

OSI today. Today's environment for OSI and OSI-like requirements is evidenced for very explicit applications, all of which are of an advanced nature, i.e.,

- Interconnection of academic and research institutions
- Provision of public services (Videotex, Teletex, Telefax)
- Advanced industry systems (predominantly banking and manufacturing industries)
- Supranational needs (i.e., CEC)
- Large customers with heterogeneous installations (e.g., General Motors, state governments, national government agencies)

Goals and benefits of vendors. OSI has received very strong support and participation from all major telecommunications and information system suppliers or vendors. Many of the system houses have also shown a keen interest. There is general agreement that products supporting one set of OSI International Standards would be the most economical and marketable approach, rather than products supporting a number of incompatible user and/or national solutions. Some vendors see OSI as a *fait accompli* because of the positions taken by some governments.

Vendor business implications. Some vendors who began development of their telecommunications networking approach in the same time frame as this OSI work (e.g., Honeywell and CII BULL) have developed their network architectures on the basis of OSI concepts. Others have made public statements that they will offer OSI in addition to their own architectures; e.g., Digital Equipment Corporation has stated that it will integrate OSI into its own architecture. As OSI standardization progresses, more vendors will make statements regarding their views of OSI and their support plans.

IBM's support of OSI is addressed later in this paper.

Governmental view. There is strong support and involvement by many governments in OSI standards activities. Governments are major users of telecommunications products and systems. They view OSI as a potential solution to the problem of interconnecting different architectures.

Some governments are opposed to using vendor proprietary architectures. In addition, they have their own standards organizations, and, sometimes in conjunction with the PTTs or government science research groups, they may prefer to develop their own standards and enforce them in public procurement. In Europe, Japan, Canada, and the United States, the OSI efforts are supported by substantial government resources.

Certification or conformance. In June 1983 a five-nation OSI workshop hosted by the French government was held in Paris to discuss OSI as a common direction. Invited were delegations from Canada, West Germany, the United Kingdom, and the United States. Emphasis was placed on cooperation among the governments in establishing a common understanding of OSI requirements, certification processes, and procurement procedures. All of the countries agreed that OSI was an acceptable direction in which to go and that it was achievable. There were some differences as to how soon OSI could be implemented and what level of control was required for certification or verification.

Follow-on meetings were held in Ottawa, Canada, in 1984 and in Cambridge, England, in 1985. A fourth meeting is tentatively planned for early 1987 in West Germany. There were eleven national delegations at the last meeting. Principal topics of discussion centered on national implementation activities and progress toward the goal of achieving international test centers with common conformance criteria, methodology, and test suites. For example, there was some discussion of single-layer versus multilayer testing. The latter method is favored by IBM because it provides more flexibility and freedom of design and can more closely simulate actual operating conditions.

There was also discussion about the possibilities for first-, second-, and third-party testing and verification for conformance to OSI standards. Simply put,

IBM believes that first-party verification must be permitted.

in first-party testing, the manufacturer does the testing with its own test tools using a set of tests that are acceptable to the user or verification body, e.g., a national test house. In second-party testing, the manufacturer performs testing with another manufacturer or a verification body, and in third-party testing, the equipment is moved to an off-site facility and tested without the involvement of the manufacturer. IBM believes that first-party verification must be permitted in order to facilitate the development process and continue the close user-vendor relationships that exist today.

CEC. In Europe, national actions are being supported by the concerted activities of the Committee of European Communities (CEC), which created a working group on standards with a specific committee for OSI matters. CEC is involved not in the standards development process but rather in standards promotion, application, and conformity. With respect to OSI, the CEC has initiated several actions:

1. OSI promotion
   - Monitoring and promoting OSI (tutorial on the OSI Reference Model and a catalog of OSI standards).
   - Initiating and funding GILT (Get Interconnected Local Text systems), a research project for the use of protocols of the upper layers (4–7) for text interchange.
   - Harmonization and European normalization activities by the European Committee for Standardization and the European Committee for Electrotechnical Standardization (CEN/CENELEC).
2. Procurement
   - The CEC procurement policy requires implementation of existing standards. It has already stated that provision of OSI standards will be mandatory for its future bids. Manufacturers have been asked to guarantee that provision of OSI support will be available within six months of the approval of each standard.
3. Verification
   - Verification is seen by the CEC as a key factor in the success of OSI. To ensure that verification will be applied, the CEC has funded studies on this subject and is promoting European testing, collaborating with national research and standards organizations.
4. Work on interconnection of the different internal CEC data processing installations in the Interinstitutional System for Integrated Services (INSIS).
5. Initiation of a large research and development program for information technology known as ESPRIT. One of the project areas addresses the information exchange network, including neutral communication protocols. The CEN/CENELEC/CEPT (Conference of European Postal and Telecommunications Administration) for ESPRIT/IES (Information Exchange System) group has called for European Harmonization (HD 40.001) in order to harmonize the various national developments of OSI-based networks during their early phases. CEC and the European Nuclear Research Center (CERN) are participating in this with countries such as Denmark, France, West Germany, Greece, Ireland, Italy, the Netherlands, and the United Kingdom.

PTT and common-carrier influence. The PTTs and common carriers see OSI as a way to increase the use of a value-added network and to add information-system services or functions to their networks. In various countries, the PTTs are owned and operated by their governments. PTTs and common carriers heavily influence and utilize CCITT recommendations. They also participate in and influence the national and international bodies such as ISO, ANSI, BSI, DIN, and AFNOR (Association Française de Normalisation).

Until recent years the PTT services primarily were used to provide basic transportation of information, with the addition of some traditional offerings such as Telex. Services such as those provided over public packet data networks and teleservices such as Teletex and Videotex include functions beyond traditional basic transportation. The PTTs have steadily expanded their repertoire and now have some services that are more data-processing-oriented than transmission-oriented. Examples of these are Prestel in the United Kingdom and Bildschirmtext in the Federal Republic of Germany.

The PTTs have become increasingly aware of the business implications and the technical complexity of OSI and also of the need for international cooperation beyond the traditional telecommunications environment. The universal objective of arriving at one international set of standards is now more realizable. As stated before, this thus becomes an advantage to both vendors and PTTs. If the vendors incorporate certain relevant options of OSI in their products, they inherently support the CCITT services, thus enhancing the PTT business direction by supporting an array of products which can be used with PTT services.

Users. General Motors Corporation has adopted a corporate direction called Manufacturing Automation Protocol (MAP) to facilitate information interchange pertaining to plant-floor process computers. The MAP recommendations are structured according to the OSI Reference Model. The lower layers are either CCITT X.25 or IEEE 802.4 (token-bus LAN). Layers four and five will be OSI transport and session. A MAP users' group has formed as a result of the General Motors work and now includes international participation. Live demonstrations of MAP protocols among many different vendors were made at the National Computer Conference in 1984 and the Autofacts Conference in 1985.

Another users' group has formed in the United States to select OSI standards for the office environment. Called TOP, for Technical and Office Protocols, the group has decided to use basically the same set of OSI protocols as MAP but supports the use of Carrier Sense Multiple Access/Collision Detection (CSMA/CD) LAN protocols rather than token-bus. They are looking at the use of a token-ring LAN as a possible option.

Corporation for Open Systems. Beginning in May 1985, senior executives from 20 computer and communication companies met to review the status of standardization efforts aimed at achieving OSI. The executives concluded that it is in the best interests of both vendors and users to move aggressively to make OSI a reality as soon as possible.

From these meetings, an organization called the Corporation for Open Systems (COS) was set up. The first meeting of COS took place in January 1986. IBM was in attendance. The long-range objective of COS is to accelerate the development and the commercial availability of computer and communications products and services that conform to international standards in order to permit open-system interconnection and interoperations.

It is unrealistic to expect that interconnection will take place exclusively within a single vendor architecture.

The original operating strategies, which may change as the technical work proceeds, are

- To coordinate member companies' efforts in OSI, ISDN, and related standards development, protocol selection, conformance testing, and certification
- To work through established standards bodies to expedite the development of OSI, ISDN, and related standards
- To establish a single consistent set of test methods, test beds, and certification procedures for world markets

In February 1986 IBM joined COS as a charter member. IBM employees serve on the board of directors, the executive committee, and several of the technical subcommittees. There are groups in Europe and Australia that are also addressing OSI function selection and conformance needs. To date, these groups have limited their membership, and IBM, along with users and other vendors, has not been asked to join. IBM has joined such a group in Japan. It is hoped that all of the groups will establish active liaison in order to minimize the possibilities of incompatible proposals and processes.

Future of OSI. In the future almost any installation will be affected, even down to the intelligent end-user terminal, which will be able to implement the required OSI protocols and thus become an OSI open system in itself.

During the late 1980s many industries will expand their information processing activities to interenterprise communication. This may be on a peer-to-peer basis (e.g., banking, aerospace) or in a client/server relationship (e.g., insurance, manufacturing distribution, automobile sales). In both cases it is unrealistic to expect that such interconnection will take place exclusively within a single vendor architecture such as SNA. This new business opportunity will likely be based on OSI protocols.

IBM and standards

IBM believes that standards are beneficial as long as they

1. Correspond to actual user requirements
2. Do not prevent or restrict the development of new concepts or applications, nor the implementation of new technology
3. Are realistic and economically viable

To attain these objectives, information technology standards must be recognized worldwide. International acceptance of standards allows applications to be used by multinational organizations and encourages their use internationally.

Generally, standards are developed in a voluntary, consensus process and are usually not mandatory. Except for compliance with national laws and regulations, for example those pertaining to product safety, ergonomics, etc., the decision whether or not to conform to a standard remains with the manufacturer and is based on its business assessment. IBM has found that many standards do meet the user's requirements and that market requirements make conformance to such standards desirable. As a result, IBM products have a very good record of conformance to standards.

IBM and OSI standards. IBM believes that the current direction of developing one set of internationally agreed-to OSI standards is the best approach. Of particular note is the excellent cooperation between ISO and CCITT, which has resulted in both organizations adopting the same OSI standards.

IBM supports the current ISO-OSI direction for the development of one set of international test criteria and test suites. IBM also believes that the OSI standards should allow for functional growth without creating obsolescence and for the use of new techniques and technologies.

IBM's support of OSI. IBM recognizes the widespread interest on the part of information-technology users in interconnecting systems of different communication architectures, and supports the development of OSI as a set of internationally accepted standards for system-to-system communication.

IBM has participated in the OSI standards development since its inception to help ensure that standardization efforts meet the requirements of manufacturers and users. As part of this process, in 1980 IBM submitted to ECMA comprehensive documentation on SNA as an example of an implementation of a layered architecture. IBM continues to support the OSI standards development through contributions by its technical experts in many national standards bodies as well as international organizations such as ISO, IEC, and CCITT.

IBM has products available today supporting various OSI-related standards in the Physical, Data Link, and Network layers, such as X.21, X.25, and HDLC. Also, in several countries where market conditions warrant, IBM has announced products supporting selected functions of the OSI Network, Transport, and Session layer standards. Announced in Europe in September 1985 and called OTSS for Open Systems Transport and Session Support, this software product for System/370 provides many of the Transport and Session layer functions. With additional programs developed by the user, it can be used to connect to existing applications, or new user-developed applications can be written directly on the OTSS Layer 5 interface. OTSS interfaces on the network side with Open Systems Network Series (OSNS), previously announced, which connects to the System/370 X.25 interface.

As the OSI standards for layers 6 and 7 are finalized over the next few years, IBM will develop products incorporating these standards based on user requirements.

IBM has participated in projects such as the General Motors MAP that demonstrate the feasibility of using OSI as the basis for system interconnection, and IBM expects to participate in additional demonstration projects in the future.

IBM operates a European Networking Center in Heidelberg, West Germany, to perform open research into OSI. The role of the Center will be to experiment with the OSI protocols in the upper layers that are still under development. The Center is open to members of nonprofit European research organizations. Results of the project will be published and shared with the related standards organizations.

Also operational is the Telecommunications Technical Center at IBM La Gaude in France, which provides OSI information and expertise support to users.

Relationship of SNA and OSI. OSI will provide solutions for many user requirements, but it will not replace the need for vendor architectures, at least in the foreseeable future. Vendor architectures have the ability to respond quickly to new and unique user requirements. SNA, for example, continues to be developed and functionally enriched as new user requirements are identified.

SNA and OSI are designed for different objectives and are implemented differently.

Although both SNA and OSI are layered architectures which may overlap in certain areas, they are designed for different objectives and are implemented differently. SNA is a total system architecture, with provisions for host CPUs, controllers, and terminals. It also has facilities for sophisticated flow control and many system and network management facilities. OSI is a set of standards for peer-to-peer communication among independent, self-sustaining systems that rely on communication facilities such as X.25 that are provided by PTTs or common carriers.

The initial concept of OSI was to provide for the interconnection of systems containing different architectures; this is still one of its capabilities. As the intelligence of smaller devices, such as the personal computer, has increased over time, it is now possible for a single unit to operate as a system, e.g., be able to stand alone and operate with sophisticated protocols. OSI systems such as those described by MAP and TOP are becoming a reality.

OSI and SNA therefore should be seen as complementary architectures, each meeting specific needs. OSI is being addressed by IBM as an increasingly important business need, and thereby requires functional definition, technical perspective, and product solutions.

SNA/OSI interconnection. Some vendors of information processing equipment have designed their products so that they may be attached to, or used with, IBM's SNA. IBM makes information on SNA publicly available so that others can design their systems and products to attach to an SNA network.

One of the major objectives of the IBM standards program is to strive for functional compatibility between IBM and OSI where appropriate. It is not technically possible for all of the formats and protocols to be identical with SNA or other vendor architectures. However, if functional compatibility is achieved, a conversion or gateway approach can be utilized so that interfacing an SNA system with another system via the OSI standards could be done at an OSI connection point in the SNA system without impacting the other products in the SNA system. Nothing prevents systems and products from being designed so as to be consistent with and complementary to both SNA and OSI.

OSI standards—some pros and cons. Some of the advantages of standards are the following:

- No single entity can change the technical content without the agreement of all standards bodies.
- Often there are many technical contributions to choose from; thus, a highly advanced solution may be attainable.
- Standards have strong government support and are often part of procurement requirements.
- Because of government support, conformance tests may be required and thus be available.
- Users can select products from multiple vendors with expectations of compatibility.

Some of the disadvantages of standards are the following:

- The organizational structure of standards groups, the many parallel meetings, the many technical inputs, and the consensus process dictate that a standard cannot normally be developed and approved in less than four to six years.
- Once the initial standard is completed, there is a tendency for the contributors to move on to new projects rather than concentrating on enhancements.

- It is not always clear that anyone is responsible for continued enhancement, maintenance, or interpretation.
- There is no thoroughly defined, efficient process for determining whether errors exist in the standards, for correcting any errors, and for notifying users and vendors of their existence, symptoms, and corrective measures.

In the past, most standards efforts were self-reliant. OSI is a complex interaction among many standards, and the various related standards committees need close coordination.

Summary

Open Systems Interconnection has moved from the conceptual state to reality. Although some items such as OSI management still have to be resolved, a sufficient number of OSI standards have been approved, and implementation has begun.

The momentum of OSI continues to gain strength because of the increasing number of approved OSI standards, as shown in the "wedge" chart (Figure 2), and the involvement of several important international standards organizations whose cooperation and dedication to expeditious handling of the standards have materially increased the velocity of the process in this complex subject area.

OSI has received substantial government support from the onset. User groups have formed to give the ramifications serious consideration, and manufacturers along with PTTs and common carriers are beginning to address the subject with products and service offerings.

Possibly the most difficult challenge of all befalls the development standards organizations, which have the awesome task of ensuring that the OSI standards are completed on schedule, are technically sound, and have procedures and people in place to enhance, maintain, and effectively correct any fault conditions. They must coordinate the evergrowing OSI standards subjects, many of which can create technical complications and changes, and they must retrofit to other standards already completed and implemented.

The continued heavy involvement and support of the manufacturers, governments, users, and PTTs and common carriers will be required if OSI is to take its place in the world of telecommunications and information processing.

OSI has the potential to advance significantly the use of heterogeneous system solutions by offering interesting alternatives and/or supplemental approaches to those solutions already available to users. This potential includes not only large complex systems but also the emerging small personal computer and workstation applications. As a result, the telecommunications and information processing community can benefit from the OSI work.

General references

ISO 7498, Information Processing Systems–Open Systems Interconnection–Basic Reference Model, International Organization for Standardization, 1 rue de Varembe, Geneva, Switzerland.

IBM and OSI, An Interconnected Future, IBM Europe, Tour Pascal, 22 Route de la Demi Lune, 92075, Paris, France.

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