WORLDWIDE IMPLEMENTATION OF OPEN SYSTEMS INTERCONNECTION (OSI) STANDARDS

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SUMMARY

Open Systems Interconnection (OSI) is the world standardization program in the area of computer communications. This paper gives an overview of some of the principal activities currently underway in the implementation of the program.

INTRODUCTION

Open Systems Interconnection (OSI) is the name given to the worldwide standardization program in computer communications being undertaken collaboratively by the International Organization for Standardization (ISO) and the Consultative Committee for International Telephone and Telegraph (CCITT). The OSI program is based on the jointly developed and standardized architecture of computer communications described in the Reference Model of OSI (ISO 7498, CCITT X.200). This architectural reference model specifies how seven layers of communication services and protocols fit together to provide end-to-end exchange of information between application processes (Figure 1).

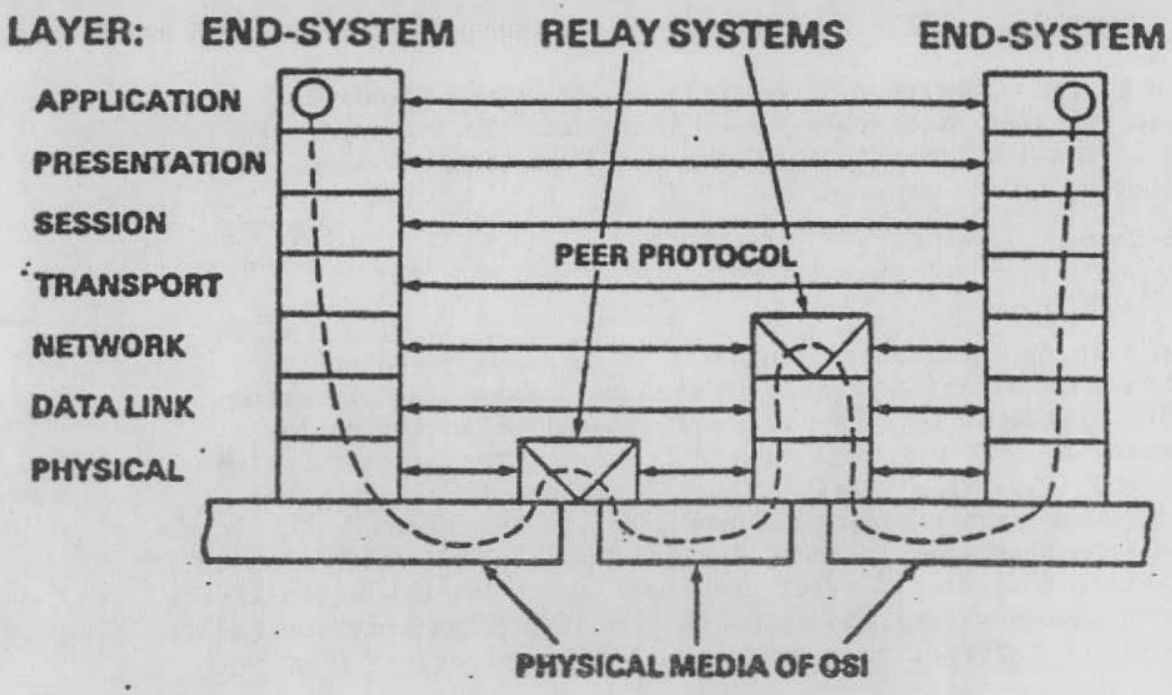
Application processes using OSI may provide any information processing services and may be implemented by any configuration of hardware and software. The OSI standards specify the manner by which information output from one user application process is transmitted transparently to any other user application process, using any combination of public data networks and other OSI compatible networks (Figure 2).

OSI applies to the exchange of information between any user application processes, no matter how they are implemented, just so long as they obey the OSI international standard protocols. For example, a user application process could be a person at a terminal, a program in a computer, or a microprocessor automated tool in a factory (Figure 3).

OSI application protocols allow for the exchange of a wide variety of types of information. As one example, any two user application processes able to create and display electronic messages may exchange them using the OSI X.400 series of protocols. As another example, any user application process able to query a local ISO standard relational database would be able to query any remote relational database using the OSI remote database access protocol now under development.

FIGURE 1.

SEVEN-LAYER REFERENCE MODEL OF OSI



- APPLICATION LAYER — PERFORMS MECHANICS OF INFORMATION EXCHANGE ON BEHALF OF SOURCE/SINK USER APPLICATION-PROCESSES.
- PRESENTATION LAYER — MANAGES AND TRANSFORMS SYNTAX OF STRUCTURED DATA OBJECTS BEING EXCHANGED.
- SESSION LAYER — ESTABLISHES AND MANAGES COMMUNICATION DIALOGS WHICH EXCHANGE BIT-STRINGS.
- TRANSPORT LAYER — PROVIDES FULL-DUPLEX TRANSPARENT PIPES FOR RELIABLE END-TO-END EXCHANGE OF BIT-STRINGS.
- NETWORK LAYER — ACCOMPLISHES ROUTING AND SWITCHING OF DATA BETWEEN ANY TWO SYSTEMS ACROSS MULTIPLE LINKS AND NETWORKS.
- DATA LINK LAYER — ACHIEVES RELIABLE TRANSFER OF BLOCKS OF DATA ACROSS A PHYSICAL LINK.
- PHYSICAL LAYER — ACHIEVES TRANSMISSION OF DATA BITS ACROSS PHYSICAL MEDIA.

FIGURE 2.

OSI ENVIRONMENT

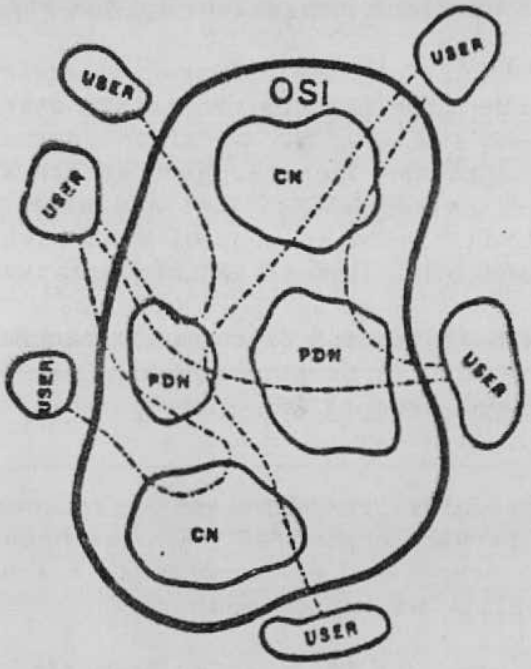
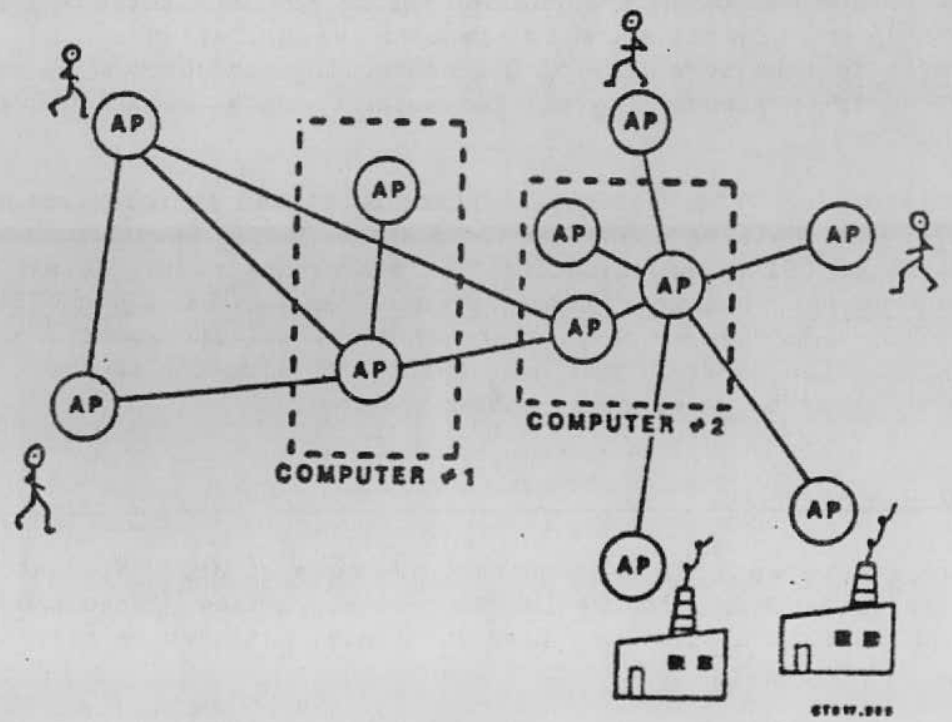


FIGURE 3.

COOPERATING APPLICATION PROCESSES



The OSI protocols, as international standards under the active technical and programmatic cognizance of ISO and CCITT, will form the world infrastructure for computer communications by the end of the decade.

Supporting ISO and CCITT in the OSI program are many national and regional groups including: the national voluntary standardization bodies in each country (e.g., in the USA, the American National Standards Institute (ANSI)); the European Computer Manufacturers Association (ECMA); and the national telecommunications administration in each country (e.g., in the USA, the Department of State, which organizes the deregulated carriers and other interested organizations) (Figure 4).

In the USA, a new organization of computer manufacturers and interested users, the nonprofit Corporation for Open Systems (COS), has been formed to develop and promote OSI interoperability specifications and testing (Figure 5).

In Europe, the Standards Promotion and Acceptance Group (SPAG) and its nonprofit testing service arm, SPAG S.A., has been formed to develop and promote European "norms" -- i.e., functional standards -- for OSI, and assure interoperability among its members.

In Japan, a group known as POSI -- for Promotion of OSI -- plays a role similar to that of COS and SPAG.

All three of these groups -- COS, SPAG and POSI -- are cooperating with ISO and CCITT and with other user groups to develop interoperability standards and tests to assure worldwide compatibility of OSI products.

Clearly, the worldwide information technology industries and users should develop and promote standard computer communications architectures to take advantage of OSI conforming product designs now offered or under development by all the major computer manufacturers and network providers.

In this paper, we do not repeat other published articles about OSI. For example, see "Helping Computers Communicate," IEEE Spectrum, March 1986; "Status of OSI Standardization," R. desJardins and J. Foley, J.Telecomm.Networks, December 1984; Special Issue on OSI, Proc.IEEE, December 1983. Instead, we concentrate on a few salient aspects of the OSI standardization program that have special application to the worldwide integration of computer communications.

LOCAL AREA NETWORKS

Local area network (LAN) standards have come of age. Standards are available in all speeds. In the 100 Mbps range, a fiber optic LAN standard (ANSI Fiber Distributed Data Interface) has been developed in

FIGURE 4.

DATA COMMUNICATIONS STANDARDS ORGANIZATIONS

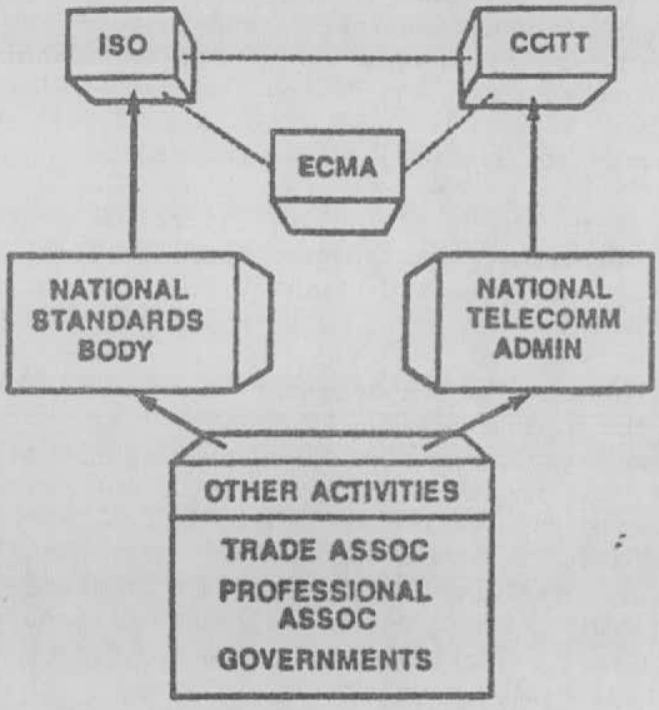


FIGURE 5.

CORPORATION FOR OPEN SYSTEMS

- AT&T
- AMDAHL
- BELLCORE
- BURROUGHS
- CDC
- CONVERGENT TECH
- DEC
- HARRIS
- HEWLETT-PACKARD
- HONEYWELL
- IBM
- INTEL
- NCR
- NATIONAL ADVANCED SYSTEMS
- NORTHERN TELECOM
- PRIME
- SPERRY
- TANDEM
- TELEX COMPUTER PRODUCTS
- WANG
- XEROX

... AND MORE TO COME!

the USA and is being submitted internationally. In the 10 Mbps range, the key standards are the baseband "Ethernet" standard based on carrier sense multiple access with collision detection (CSMA/CD) (IEEE 802.3, ISO 8802/3, adopted by the Technical and Office Protocols (TOP) program), and the broadband token bus (IEEE 802.4, ISO 8802/4, adopted by the Manufacturing Automation Protocol (MAP) program).

There are also low cost, low speed LAN specifications available. For example, the 1 Mbps unshielded twisted-pair CSMA/CD "Starlan" specification has recently been approved by the IEEE 802.3 committee, and is being submitted to ISO.

Another example of lowering LAN implementation costs is the MAP token bus. MAP started out with expensive RF broadband as its only defined medium, but is now testing carrier-based subnets for cell-level (cluster) control. This will reduce significantly the unit cost of network attachments. Single-chip carrier-band modems are being developed by several companies for delivery in 1987. MAP has also defined "collapsed architectures", called Extended Performance Architecture (EPA) and MiniMAP, which eliminate Layers 3 through 6 of OSI and allow direct application-to-LAN address binding for high-speed responses in localized application clusters.

WIDE AREA NETWORKS AND INTERNETWORKING

The big interest in wide area networks (WAN) is the interconnection of networks through both connection-oriented and connectionless architectures. End-to-end digital connections based on direct digital links from 9600 bps to T1 (1.544 Mbps), low speed (1200/2400/4800 bps) CCITT X.25 virtual circuits, and the forthcoming Integrated Services Digital Network (ISDN) 2B+D digital channels (64+64+16 Kbps), are either already available or will be in place by the end of the decade.

For example, the European Parliament recently approved an ambitious plan for implementation of standard ISDN services in all of its 12 member countries. The plan sets a number of deadlines, the most important of which is end of 1988, by which time all countries are to provide an ISDN B-channel transparent to user traffic. In addition, four basic applications, or "teleservices", are to be accessible through and supported by this channel: voice grade telephony, Teletex, Group IV facsimile, and mixed-mode Teletex and facsimile. Adapters for existing analog, X.21, and X.25 customer terminal equipment are also required by the same deadline.

The ISO connectionless internetwork protocol (ISO 8473) serves to interconnect LANs across these WAN services. Mix-and-match architectural solutions are being defined and standardized (e.g., ISO 8881 for providing X.25 on LANs, various proposals for interconnecting connection-oriented and connectionless subnetworks). See "What the New Internetworking Standards Provide," A. Weissberger and J. Israel, Data Communications, February 1987.

INTERMEDIATE LAYERS

Spanning the networks are the OSI end-to-end protocols: Transport (ISO 8073), Session (ISO 8327), Presentation (ISO 8823), and Application Association Control (ISO 8650 Part 2). These standards are either approved (the Transport and Session standards were approved in October 1984 and are being widely implemented) or are in the final Draft International Standard stage.

APPLICATION PROTOCOLS

The OSI program will provide most of the basic application protocols required for information systems interworking, leaving the individual industry groups such as banking (ISO TC 46) and manufacturing (ISO TC 184) to develop specialized protocols for their unique data exchange and systems management requirements.

OSI currently provides International Standards or Draft International Standards in electronic message handling (CCITT X.400, ISO 8883); document architecture and interchange (ISO 8613); file transfer, access and management (ISO 8571); X.25 network virtual terminal (CCITT X.3/X.28/X.29) and basic class application virtual terminal (ISO 9041); job transfer and manipulation (ISO 8832); computer graphics file transfer (ISO 8632); relational database (ISO 9075); and network database (ISO 8907). Standards are currently in draft stages of development for systems directories, remote database access, interactive computer graphics, information resources dictionary, and systems management information.

The list of open systems application standards now available or under development is impressive by any measure. With minor qualifications, all the standards listed enjoy an excellent base of support.

DATA EXCHANGE

Important activities in the data exchange area are firmly established. ANSI Committee X.12 and ISO Technical Committee TC 154 have developed approved and draft international standards for business data interchange. A new ANSI Committee X3T2 has been formed to develop standards for general data interchange between heterogeneous systems based on the OSI standard abstract syntax notation and encoding (ISO 8824 and 8825). In the Technical and Office Protocols (TOP) program, activities are underway to define standards for the exchange of product data among heterogeneous computer environments.

SECURITY

In most computer communications applications, data security and access control are essential requirements. OSI has developed a draft addendum to the Reference Model covering the OSI Security Architecture. This addendum identifies a reference architecture for security services and mechanisms and identifies corresponding requirements for international standards for achieving "commercial" levels (not "national security" levels) of security in computer communications networks.

Mechanisms and standards for providing peer entity authentication, access control, data confidentiality, data integrity, data origin authentication, and non-repudiation, are identified in the addendum, and ISO is beginning to develop the encryption and access control protocols corresponding to the security mechanisms required. These will cover the use of both the well-known private key encryption techniques (such as the ANSI DES algorithm) as well as the newer and very attractive public key encryption techniques (such as the proprietary RSA algorithm).

SYSTEMS MANAGEMENT

Systems management provides for the smooth operation of all systems involved in a computer communications configuration, including both OSI end-systems that are performing the information processing for the application and OSI intermediate systems that are performing relay and routing functions.

Systems management provides visibility into the overall system configuration and provides mechanisms for its control. This includes the ability to query directories for network and process addresses and parameters, and to set up and modify the system configuration (i.e., provide for the downline loading of software and the setting of control variables). In addition, systems management must be able to monitor the performance of the system; receive and respond to error events; isolate and analyze failures and unexpected loads; and assign data flows and proceses to alternate links, gateways and processors, and modify their operating parameters. Finally, for analysis purposes, systems management must maintain logs of its operation and present all the necessary management information displays to the operators.

OSI systems management activities are very actively developing an OSI directory standard and OSI common management information standards. Rudimentary standards based on draft versions of the OSI standards have been defined by MAP, and more complete directory and network management standards are due in the MAP Version 3.0 forthcoming in early 1987.

MAP AND TOP

Manufacturing Automation Protocol (MAP) and Technical and Office Protocols (TOP) are OSI "functional standardization" programs. That is, they are programs that begin with OSI standards and then select specific standards classes, subsets, and parameters that define an industry configuration for carrying out a specific function such as providing the OSI Transport Service over a specified collection of LANs, or providing a specified application service over the transport service.

MAP and TOP are compatible families of standards, and differ in their physical environments and application emphases. In the middle layers, Network to Presentation (Layers 3 to 6), MAP and TOP are identical. The MAP architecture is shown in Figure 6.

Particular note should be taken of the MAP token bus LAN for deterministic process control, the TOP contention-based ("Ethernet") LAN for the office automation environment, the MAP Manufacturing Message Service (EIA RS-511) for interactive process control applications, and the TOP data exchange standards for documents, spreadsheets, graphics, and product data definitions.

There are good descriptions of the MAP and TOP programs in the April 1986 issue of IEEE Spectrum: "Protocols for Communicating in the Factory," M. Kaminski; and "Communicating in the Technical Office," S. Farowich.

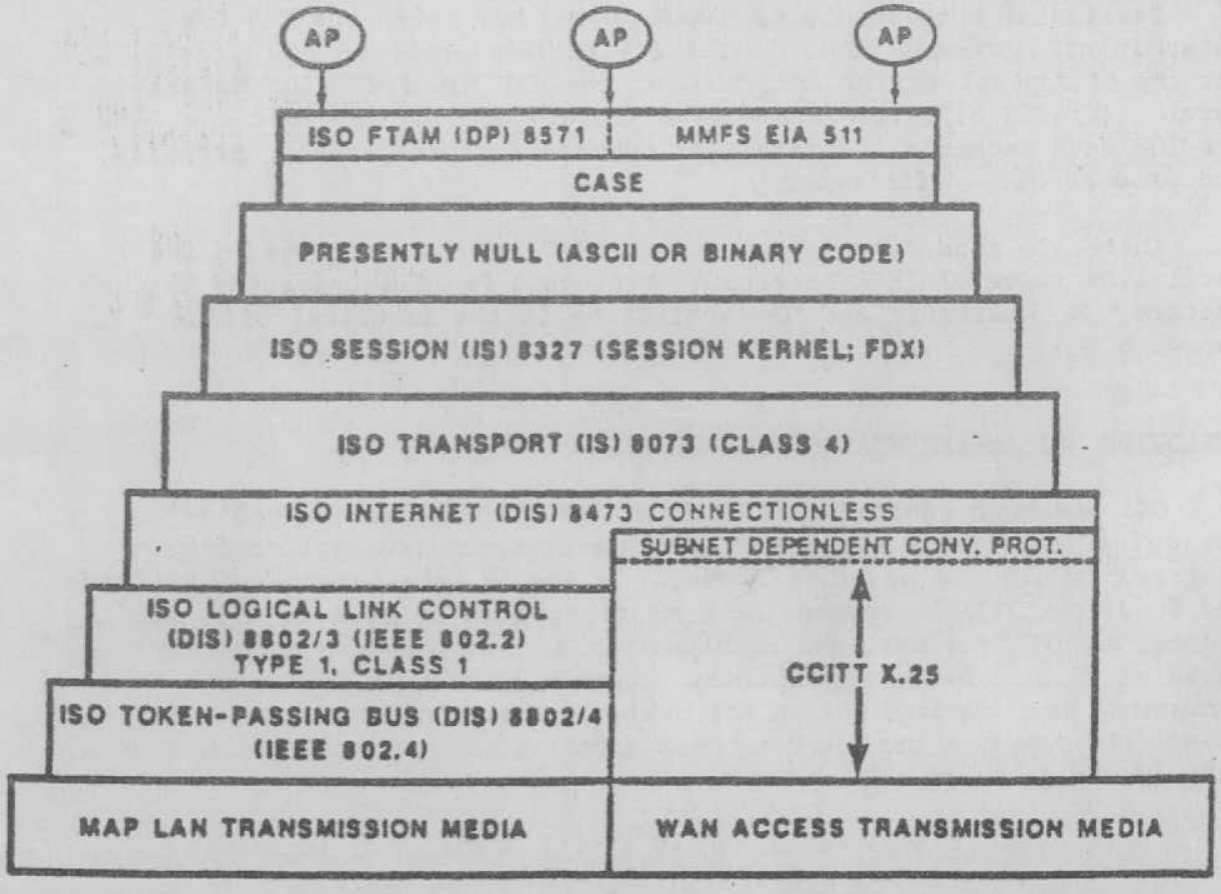
WORLDWIDE OSI IMPLEMENTATION ACTIVITIES

OSI has been adopted by all the major standardization bodies worldwide, and is the subject of government-sponsored application programs in all the major countries. In the UK, the Department of Trade and Industry (DTI) is sponsoring a major program to promote OSI. In France, ARCHITEL, a national architecture for information networking based on OSI, is being implemented. Both NATO and the European Community have adopted OSI as the basis of their information networking plans. In Japan, a national network architecture based on OSI has been defined and is being implemented.

In the USA, the National Bureau of Standards (NBS) is leading the Federal Government participation in OSI. In particular, NBS has organized the OSI Implementors Workshop, which enjoys the participation of all the major computer vendors and several major users. The Workshop is developing the agreed functional standards baseline for OSI in the USA, and is coordinating with similar activities in Europe. NBS has also sponsored the implementation of OSINET, a network for cooperative testing and demonstration of OSI products and services between implementors in the USA and also in other countries through international X.25 networking.

FIGURE 6.

MAP NETWORK ARCHITECTURE



All the computer manufacturers support the outputs of the Workshop, and many of them are already using OSINET for cooperative testing with each other. In addition, most major manufacturers have joined the Corporation for Open Systems, which will define and administer OSI conformance and interoperability testing for the industry as a whole.

In the UK, a similar network of OSI implementors has been established. A group of vendors including DEC, Unisys (the new name for the merger of Burroughs and Sperry), NCR and ICL has established the Implementor Group on OSI Network (IGOSINET). IGOSINET is mainly a testing network similar to the USA OSINET, but in addition, participants will be able to call up proprietary information from each other. Such information includes the address codes of vendors' operating systems, known as service access points (SAPs). SAPs are necessary to make intermediate layer connections into each other's internal OSI implementations.

Every major manufacturer has in place OSI programs and laboratories that are implementing and testing OSI products, and most manufacturers such as IBM, DEC, Honeywell, Burroughs, Sun Microsystems, and Intel, have product offerings on the market.

For example, IBM has established three OSI research and implementation centers in Europe -- Rome, La Gaude, and Heidelberg. IBM OSI products available in Europe include the X.25, Transport and Session protocols, and IBM has publicly demonstrated an X.400 capability as well. In La Gaude, France, IBM has established an OSI compatibility testing and certification facility. In Heidelberg, IBM is reputed to be implementing OSI Presentation, Association Control, and FTAM protocols as well as developing an X.400 product for introduction by the end of 1987.

As another example, during 1986, DEC introduced the VAX OSI Transport Service (VOTS), an X.400 message handling system product, an X.25 product, and an OSI Application Kernel implementing the Session protocol. By 1988, DEC plans to integrate the lower four layers of OSI into Decnet in a smooth evolutionary manner.

A major industry show to demonstrate OSI products in the USA is being organized for mid-1988.

The USA Department of Defense (DOD), under prodding from the National Academy of Sciences, has adopted transition to OSI as a policy, and has put in place a major program in cooperation with NBS to implement the transition. This program has defined the specifications for gateways to convert DOD application protocols to OSI application protocols.

Several Federal agencies have produced a joint draft specification for Government OSI Procurement (GOSIP). The Office of Management and Budget, again with the cooperation of NBS, is developing an OSI policy for the Federal Government.

Every major developed country has adopted specific policies or programs in support of OSI. Every year, representatives of the major western countries meet to share their experiences and plans. The fourth such conference, attended by over 200 representatives of governments, users and manufacturers from Belgium, Canada, West Germany, France, UK and USA, was held in January 1987 in Bonn. As at the previous conferences, the focus was on conformance testing and interoperability. These conferences are establishing the basis for agreed worldwide OSI interoperability based on three principal aspects: base standards developed by the international standardization organizations ISO, CCITT, and IEC; functional standards developed by regional manufacturer and user groups such as COS, SPAG, POSI, CEN/CENELEC, MAP/TOP; and conformance tests and certification capabilities being implemented by governments, PTTs, manufacturers, and third parties. The challenge will be to keep the various functional standards, tests and certification capabilities compatible with each other.

Clearly, OSI is coming along rapidly. OSI systems and operations will be routinely available in the developed countries by the end of the decade.
