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IEEE P1003.0 Draft 14 – November 1991

4.3 Network Services

Responsibility: Charles Severance

4.3.1 Overview and Rationale

This clause describes the network services component of the application platform. It also describes the services provided to application programs and users, and it describes current and emerging standards that are standardizing these services.

Applications gain direct access to network services via the POSIX API. The network is just another system resource (albeit an important one) allocated among the competing processes.

4.3.2 Scope

Network services cover the areas of file transfer, namespace and directory services, electronic mail services, services in support of distributed environments such as remote procedure call, distributed time management, transparent file access, and data representation services. The application programs using these services should be able to access them via a high-level, context-insensitive or low-level, context-dependent interface.

In the open systems and distributed system environments, interoperability is of equal or greater importance than portability. The network protocols defined for both Open Systems Interconnect (OSI) and Internet Protocol Suite (IPS) for TCP/IP should provide the basis for the open networking interfaces; however, these interfaces should not preclude the use of some subsequent networking protocol in the future. The interfaces provided by the network services must be network protocol independent and provide for this level of interoperability.

It is important for an open system to interoperate with more systems than just other open systems. Many open systems users will have requirements to interoperate with non-OSI networks for the near future.

4.3.3 Reference Model

This subclause identifies the entities and interfaces specific to the construction of an POSIX Network Environment. This environment is consistent with and extends the environment of Section 3.

As illustrated in Figure 4-3, the components of a network architecture that require standardization are divided into two groups called external environment interfaces (EEI) and application program interfaces (API).

There may be some correspondence between services offered to the application across the API and the interfaces available at the EEI. It is quite possible for an API service to have no corresponding effect at the EEI. A good example of this is an interapplication communication service provided by the Network API between

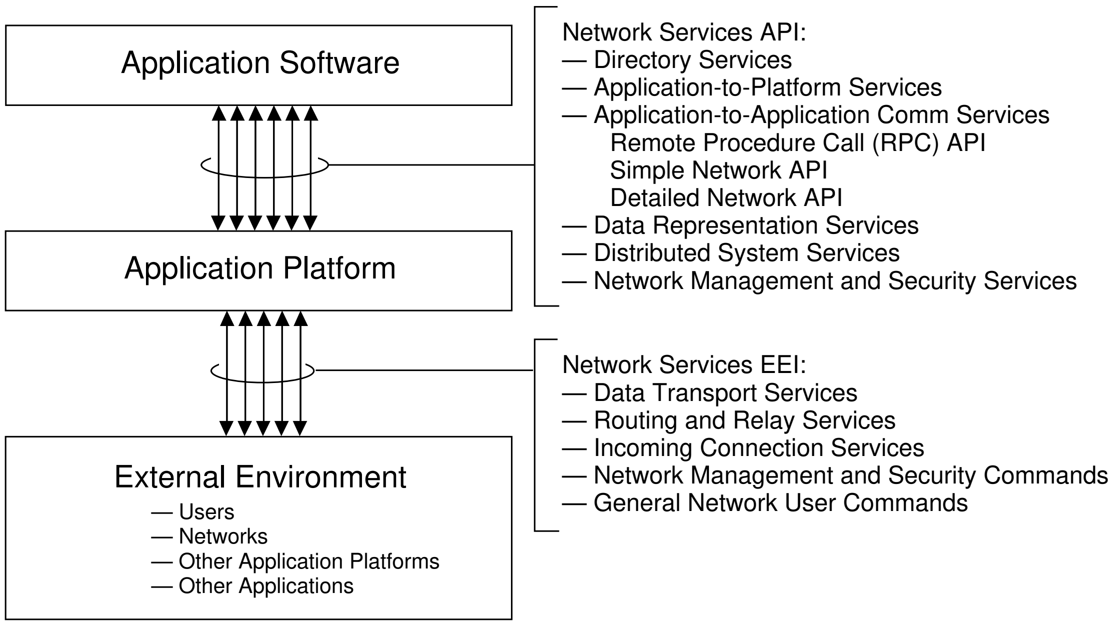

Figure 4-3 – POSIX Networking Reference Model

two applications on the same application platform. There may also be services available at the EEI provided by the Application Platform that are not available at the API such as remote login services.

4.3.3.1 Network Application Program Interface (API) Services

The API is concerned with the interfaces and associated standards that apply to the interface between the application and the application platform.

The services available at the API are:

— Directory Services

— Application to Platform Services

— Application to Application Communication Services

— Data Representation Services Services

— Distributed System Services

— Network Management and Security Services

Directory Services are those services associated with identifying and naming network elements.

Application to Platform Services provide an application with a very high level interface to networking capabilities. This interface provides applications with capabilities such as ‘‘mail this file to this address’’ or ‘‘transfer user xxx file from host yyy to the local host.'' These services do not require the application to be aware of any of the low level network details.

Application to Application Services are the services provided by the Application Platform that allow an application to communicate with another application to exchange information. These interfaces support applications that range from having extremely simple networking requirements to the most complicated applications that must make full use of every possible network capability.

Data Representation Services provide the application with network oriented data representation services to insure the application can interchange information with other entities in the proper format.

Distributed system services provide the application with the ability to make use of multiple physical computer systems resources.

Network management and security services allow the application to control and configure the network resources.

4.3.3.2 External Environment Interface Elements

4.3.3.2.1 User Interface EEI Elements

The User interface EEI elements include the commands that users can use to perform network functions such as:

— File transfer

— Electronic mail

— Remote printing

These commands are considered to be beyond the scope of this clause and will be covered in 4.10.

The User interface EEI elements that will be covered in this section are the commands that are used to perform network management and security functions.

4.3.3.2.2 Communication EEI Elements

The primary focus of the network EEI is the network protocols and supporting formats for network communication.

The entities in the external environment may be other application platforms or user interface equipment connected to the network using the open networking protocols. The standards at the EEI will be in several areas including:

— Physical connections

— Network protocols and formats

— Distributed systems services

The standards at the EEI will impact system interoperability but also may have an effect on application portability because certain applications may require particular types of network access to operate.

4.3.3.3 Implementation Aspects

The POSIX OSE Network reference model focuses on the requirements of application portability and system interoperability. As such, the model does not represent how systems are actually put together.

In the network area, there is much effort dedicated to the design of network standards to allow network components to be re-usable. This subclause shows how some of these network standards are related within the POSIX Network Reference Model.

Other network models are also related to the POSIX OSE Network Reference models. None of these other models are in conflict with the POSIX OSE Network Reference model. These models show much more detail in the area of how different standards work together.

4.3.3.3.1 Relationship Between the OSI Reference Model and the POSIX OSE Network Reference Model

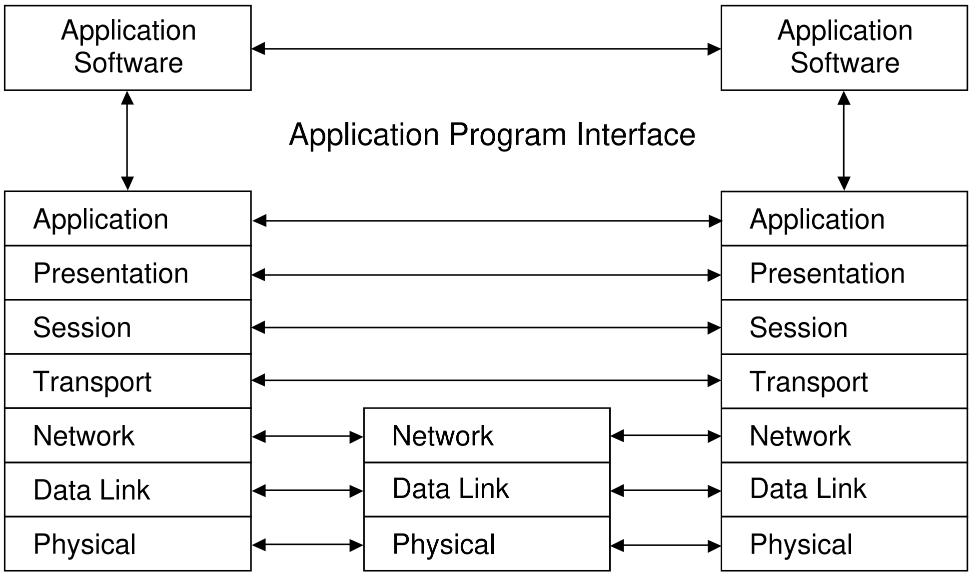

Figure 4-4 – OSI Reference Model

Figure 4-4 shows the OSI reference model for networking as standardized by ISO. E

There are many aspects of network architecture that are specified by the OSI E
reference model: E

— The number of layers in the model and the roles for each layer.

— An indication of which layers are logically end to end and which layers are simply to the next physical network node.

— The services between the layers and the protocols between the peers within the same layer. This has an impact on the actual format of the information transferred between nodes at the physical layer.

In addition, this model specifies how networks of computer systems can be assembled using the routing capabilities of intermediate nodes.

The POSIX OSE Network Reference Model has a much more limited scope than the OSI reference model. The POSIX OSE reference model only looks at two interfaces to an application platform: the interface between application software and the application platform (API) and the interface between the application Platform and the External Environment (EEI). At both the API and EEI, the POSIX OSE network model describes the services that are provided to the application or external environment at the interface.

Figure 4-5 shows an example of how an application platform made up of a single computer system would provide services at the API and EEI. It is important to note that the POSIX OSE application platform actually may be made up of multiple physical computer systems, as shown in Figure 3-5. In Figure 3-5, each computer system making up the distributed system would be running a complete OSI stack for networking.

Because the OSI portions of the Application Platform External Environment Interface depend on the format, protocol, and services of what is produced at the physical level of the OSI reference model, the EEI technically depends on all seven layers the OSI model plus the services added on top of the application layer such as platform provided services or network management services.

Figure 4-6 shows an API interface to only layer seven of the OSI Network interface, which is intended to be the primary API for accessing network services. It is possible to define APIs that interact directly with any of the seven layers. There are a number of pragmatic reasons to provide APIs that access layers below layer 7. The cost of using one of these lower layer APIs is that the applications may sacrifice portability and/or interoperability.

It is important to note that while these APIs are represented as a part of a layered network architecture, from the point of view of the application interacting with the application platform, this layering is not critical to the use of the services. From the application perspective, there are simply three different types of network services, each with a different set of capabilities and requirements. Whether or not there is any actual layering or code common to the three services is implementation dependent.

4.3.3.3.2 POSIX Network Standards Efforts

The current POSIX approach to networking focuses on producing Application Program Interface (API) specifications. Most of the network connectivity specifications at the External Environment Interface are well covered on other standardization areas such as ISO (OSI networking) and the MIL-STD process (TCP/IP).

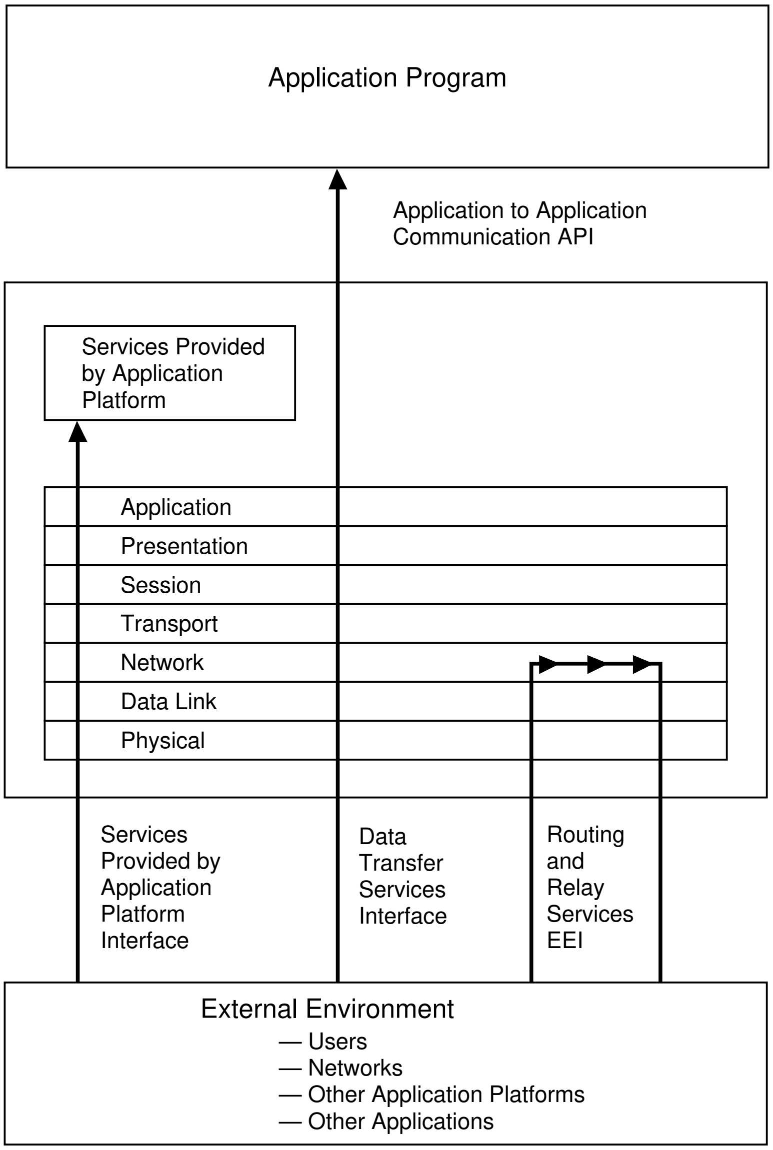

Figure 4-5 – Relationship of OSI and POSIX OSE Network Reference Models

One important aspect of the POSIX networking approach is that it is not focusing solely on producing standard APIs for OSI Network services. The POSIX Simple Network Interface (P1003.12 SNI) is explicitly designed so to be implemented transparently on a wide variety of networks. At the current time the possible list includes:

— OSI Application Layer

— OSI Transport Layer

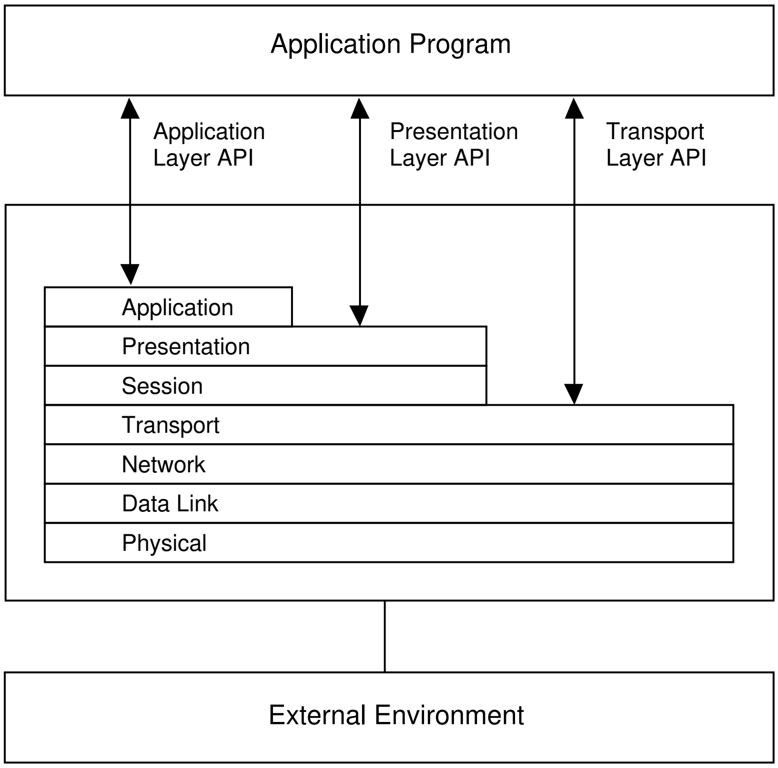

Figure 4-6 – Multiple POSIX OSE APIs to Different OSI Layers

— Internet Protocol Suite (IPS) E

— Other networks, including proprietary networks

The current POSIX API standardization efforts include:

P1003.12	Simple Network API
P1003.12	Detailed Network API
P1003.17	Directory Services API
P1224	X.400 Electronic Mail Services API E
P1224.1	OSI Object Management API E
P1238.0	OSI Application Layer API (ASCE)
P1238.1	OSI Application Layer API (FTAM)

Figure 4-7 shows how the basic network services can be related. The Simple Network Services API is designed so that a Simple Network Services Implementation can be done using the services available using the Detailed Network Interface API. An application can use the Detailed Network Interface to access multiple network transports but there may be differences between networks visible at the

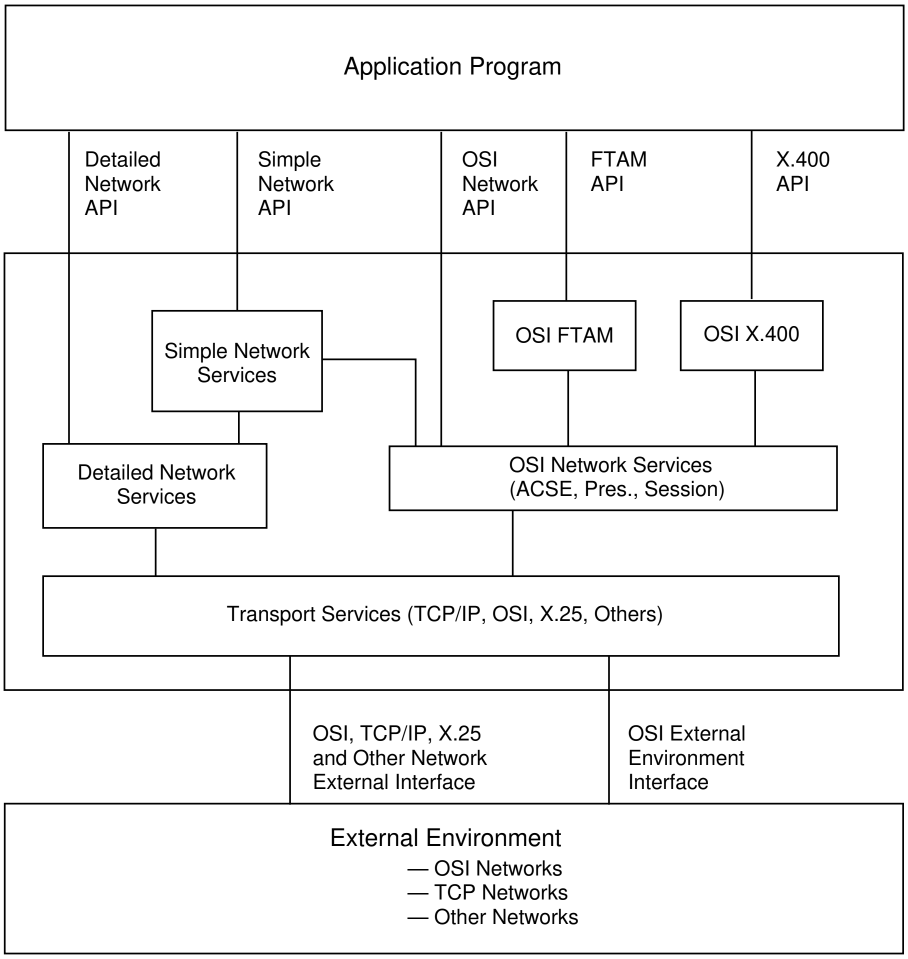

Figure 4-7 – POSIX Network Services Model

API. Applications that need to be portable across different types of network transports should be written using the Simple Networking Interface.

It is important to note that while the SNI API and DNI API standards have been designed so that the SNI Services can make use of the DNI API to access transport services, it is not a requirement that every implementation of SNI Services be written using the DNI API to access transport services. From the point of view of the application program, it is only important that the application platform provide an API for both the SNI and DNI services. This interface between the SNI Services and the Transport Services is an example of a Systems Internal Interface, as described in 3.6.

Another example of a System Internal Interface that is the subject of discussion in the POSIX Network area is the interface between the OSI Network Services and the transport services. This may or may not be required to be the DNI API. This is an example of an interface that should have no impact on user application portability but may have great impact on the ability to procure the different types of network services from different vendors.

The area of Directory Services (P1003.17) is also specified so to be able to make use of different types of Directory Services including:

— X.500 Directory Services

— TCP/IP Directory Services

— IEEE P1003.7 System Administration and Management Services

Figure 4-8 shows how the Directory Services are related to the other network services. All of the APIs and SIIs from the previous figure have been eliminated to reduce the number of interfaces shown on the figure.

4.3.4 Service Requirements

The service requirements for the network component of an open system are very wide ranging. Many of the other components of the application platform make implicit or explicit use of network services.

Much standardization effort has gone into the aspects of networking that are available at the external environment interface. Effective networking standards at the external interface are fundamental to providing system interoperability.

The service requirements for both the API and EEI are described in this section.

4.3.4.1 Application Program Interface Services

4.3.4.1.1 Directory Services

Directory services allow an application to find the names and addresses of objects and services available to the application. These services include the ability to:

— Look up the name to be used to access a particular service

— Look up the address of a named object

4.3.4.1.2 Application to System Services

These are the services requested by the application that are performed by the Application Platform on behalf of the application without the application actually communicating directly with another application. Many of these services may actually connect to some remote application but the details of the connection are left up to the application platform.

These services will be provided by a relatively simple high level API. These services include:

(1) File transfer

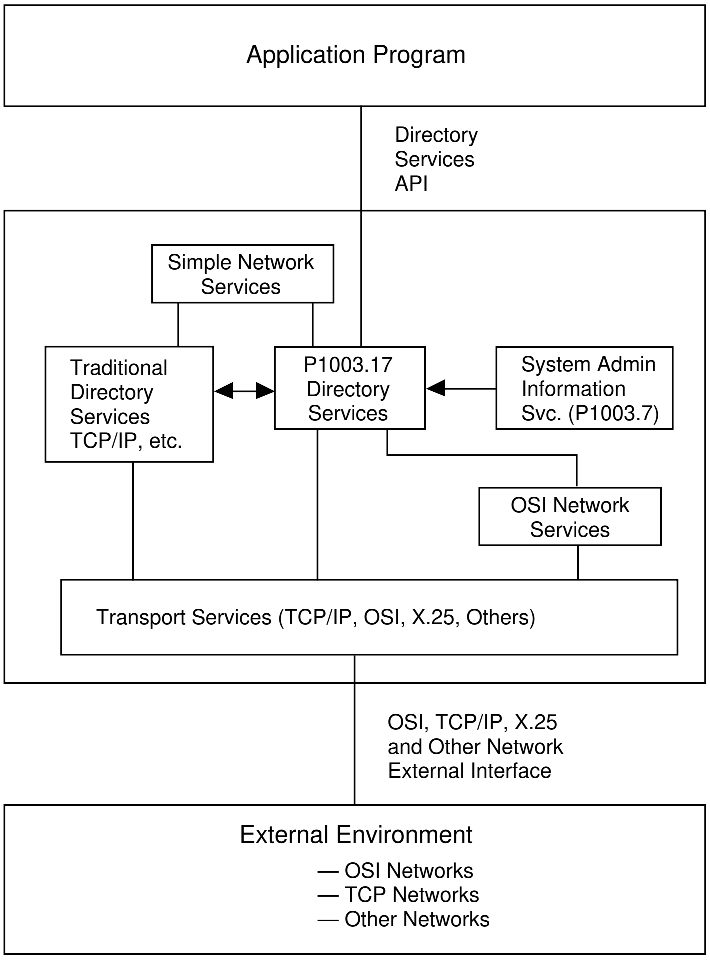

Figure 4-8 – Directory Services Architecture

(2) Remote execution of commands

(3) Electronic mail E

(4) Remote login

(5) Remote printer access

(6) Network status

— The ability to access remote or local systems using remote procedure calls (RPC). When this type of access is provided, nearly all of the details of the network connection and interaction are masked from the application.

4.3.4.1.3 Application to Application Service

There are three areas of application to application service requirements:

— RPC Services

— Simple Network Services

— Detailed Network Services

The RPC services allow an application to register with the network application platform as the provider for a particular RPC Service. Once the service has been properly registered, other applications can transparently request services using a subroutine call. The details of communicating the service request to the application that is registered to provide the service and the return of the response to the requesting application are handled transparently by the Application Platform.

Applications making use of RPC services may not even be aware that the service are being provided via an RPC mechanism.

The Simple Network Services are application to application services provided using a simple set of interface routines. These will allow a wide variety of networking applications to be written that do not need to exercise control their network access at a very complex level of detail.

In addition, these services should be provided over a wide variety of network transport mechanisms. Applications written exclusively using the simple services should be portable across a wide variety of networking environments.

Applications written using the simple network services may not be able to make use of unique advantages of a particular physical networking scheme. To make use of these network-specific features the Detailed Network Services must be used.

The service requirements for the simple network services are intended to be the minimum requirements to write a large subset of network applications.

The Simple Network Services sacrifice the capability to control every detail of the network services in the interest of portability across networking environments and applications simplicity.

The Detailed Network Services API allows the application to control over much more detail of the network services. In addition, using the Detailed Network Services an application may be able to make use of unique networking capabilities available in particular networking environments.

4.3.4.1.3.1 RPC Services

These service requirements include the ability:

— To register as an RPC service provider

— To wait for incoming requests

— For an application using RPC services to control parameters such as timeout

4.3.4.1.3.2 Simple Network Services

The services provided at the simple network interface are:

(1) Name resolution

(2) Connection oriented services

- — The ability to indicate willingness to accept incoming connections
- — Establishing and destroying connections
- — Data transfer over connections
  - Read
  - Read with timeout
  - Write
  - Write with timeout
- — Simple error handling
  - Connection dropped notification
  - Connection read failure
  - Connection write failure
- — The ability to close a connection
  - Unconditionally
  - Only after all data has been received

(3) Connectionless services

- — The ability to indicate willingness to accept incoming requests
- — The ability to send requests
  - With acknowledgment
  - Without acknowledgment
  - Specified timeout
- — The ability to receive requests
  - Wait unconditionally
  - Wait with timeout
- — The ability to query as to whether any requests are available
- — Simple event notification
  - Lost request
  - Request acknowledgment

- — Simple error handling
  - General network failure

(4) Support for server applications

- — The ability to register as the provider for a service

(5) Simple status inquiry

- — General network availability

4.3.4.1.3.3 Detailed Network Service Requirements

The services provided at the Detailed Networking Interface include all of the service requirements in the Simple Network Service Requirements plus the following abilities:

(1) Query the network services to get detailed information about network configuration and status

(2) Specify performance metrics

(3) Control routing

(4) Select between different network protocols

(5) Negotiate capabilities

- — Required capabilities
- — Optional capabilities
- — Determine the results of the negotiation

(6) Information with different priorities

(7) Request and process extended event notification

(8) Request and process extended error recovery including allowing the application to completely control error recovery.

(9) Make full use of network resources for performance critical applications

This should provide the application with the ability to completely control connection oriented services and connectionless services.

4.3.4.1.4 Data Representation Services

- — The ability to access all of the data representation and format conversion services to allow an application to communicate with a wide variety of computer systems.

4.3.4.1.5 Distributed System Services

The services provided in this area include the ability to:

— Identify available resources in a distributed system

— Dynamically make use of the resources in a distributed system.

— Access files regardless of the physical location of the files.

— Have reliable time services across all of the resources of the distributed system.

4.3.4.1.6 Network Management Services

The services provided at the Network Management API are abilities to:

(1) Manage

- — Network objects
- — Network relationships
- — Network security

(2) Monitor and report on

- — Network events
- — Network service alarms
- — Network security alarms

(3) Log

- — Network events
- — Network availability
- — Network load
- — Network performance

(4) Test network performance and reliability

4.3.4.2 External Environment Interface Services

At the external interface, there are several types of services that are provided. These include:

— Data transfer and connectivity

— Routing and relay services

— Services provided by the application platform directly to an incoming connection

— Network management and security services provided to other networks and other nodes within a network

— Network management user interface

This clause does not address the user interface to the general network services such as file transfer or mail sending. That is covered by the command interface clause, 4.10. As stated above, this clause covers the network management user interface.

In addition, there are a number of other areas of external interface requirements that are not covered in this guide. They include:

- Physical network interface connections
- Electrical specifications for network connections
- Specifications for physical network construction

4.3.4.2.1 Data Transfer and Connectivity

Services required at the EEI in the area of data transfer and connectivity include the ability to:

- Connect and interoperate with other standards-based systems using standards-based protocols including X.25 and OSI.
- Connect and interoperate with systems using de facto networking standards such as TCP/IP and UUCP.
- Connect and interoperate with personal computer and workstation networks.
- Interoperate with industry leading networking interfaces.

4.3.4.2.2 Routing and Relay Services

Services required at the EEI in the area of routing and relay capabilities include the ability to:

(1) Relay information through a system between like networks.

(2) Gateway information through a system between unlike networks at a data transfer level. Examples of this type of gateway include:

- Local Area Network (LAN) to LAN
- LAN to Wide Area Network (WAN)
- WAN to Global Area Network (GAN)
- Networks to point-to-point connections
- Point-to-point connections to networks

(3) Convert information from one format to another when transferring between unlike computer systems or networks. Information that may need to be converted includes:

- Mail messages
- File contents

— Printer file contents

The primary requirement for the routing and gateway services is to make any necessary relays and gateways transparent to the applications and systems using the network. This requires complete gateways and relays.

4.3.4.2.3 Services Provided by the Application Platform at the EEI

These EEI services are those provided to incoming connections that are not directed to an end-user application or server. These incoming connections are directed to standard services that can be provided by systems. These services include:

- — Remote logon and terminal emulation
- — Remote execution of commands
- — File transfer services
- — Remote authentication
- — Remote data access
- — Remote status information
- — Mail delivery services
- — Directory services

To access these services each user does not need to provide an application on the remote host. Simply by connecting to the service, the application platform will provide the service.

4.3.5 Standards, Specifications, and Gaps

4.3.5.1 Current Standards

Table 4-4 lists standards that address the services outlined in this clause. This table includes international standards, emerging standards coming from national and international bodies, and other current standards that meet gaps in the service requirements. Public specifications are cited to fill gaps only when there are no existing or emerging standards to meet the service requirements.

ISO Protocol Stack Standards

Figure 4-9 describes how the ISO protocol standards cited in this guide fit together.

4.3.5.2 Emerging Standards

Table 4-4 – Networking Standards

Service	Type	Specification	Subclause	
Directory Services	S	X.500	4.3.5.1	E
	E	IEEE P1003.17 X.500 API	4.3.5.2	E
Message Handling	S	ISO 10021 X.400	4.3.5.1	E
	E	IEEE P1224 X.400 API	4.3.5.2	E
File Transfer	S	ISO 857, ISO 8613, ISO 10026, ISO 8650, ISO 8652, ISO 8653, ISO 9735, ISO 9594	4.3.5.1	E
	E	IEEE P1238 FTAM API	4.3.5.2	E
Print Services	E	X3H3	4.3.5.2	E
Application Services				E
Connectionless	S	ISO 8649-2, ISO 8650-1	4.3.5.1	E
Connection Oriented	S	ISO 10040, ISO 10164, ISO 10165, ISO 9595, ISO 9596, ISO 9579	4.3.5.1	E
	E	IEEE P1238.1 ASCE API	4.3.5.2	E
Data Representation	S	ISO 8823 Presentation Protocol	4.3.5.1	E
	S	ISO 9576, ISO 8824, ISO 8825 ASN.1	4.3.5.1	E
Protocols				E
Session	S	ISO 8327, ISO 9548	4.3.5.1	E
Transport	S	CCITT X.214, X.224 (TP0)	4.3.5.1	E
	S	ISO 8072, ISO 8602 (TP4)	4.3.5.1	E
	E	IEEE P1003.12 Transport API ??	4.3.5.2	E
Network	S	CCITT X.25 PLP, ISO 8208	4.3.5.1	E
	S	ISO 8348 AD1, ISO 8473	4.3.5.1	E
Data Link	S	ISO 7776 HDLC/LAPB	4.3.5.1	E
	S	ISO 8802-2 Logical Link Control	4.3.5.1	E
Physical	S	EIA RS-232	4.3.5.1	E
	G	MIL-STD-114A	4.3.5.3	E
	S	ISO 8802-3 (CSMA/CD) ISO 8802-4 (Token Bus), ISO 8802-5 (Token Ring)	4.3.5.1	E

Table 4-4 – Networking Standards (*concluded*)

Service	Type	Specification	Subclause	E
Network Management	S	ISO 9596	4.3.5.1	E
	S	ISO 9593	4.3.5.1	E
	S	ISO/NMF	4.3.5.1	E
Network Security	S	ISO 803.10	4.3.5.1	E
	E	X3T4	4.3.5.2	E
	E	SIRS 233	4.3.5.2	E
Distributed System Services	S	ISO DP	4.3.5.1	E
	E	IEEE P1003.8 TFA API	4.3.5.2	E
Remote Procedure Call (RPC)	E	ECMA 127	4.3.5.2	E
	E	ISO 10148	4.3.5.2	E
	E	IEEE P1237 API	4.3.5.2	E
Protocol-Independent Network Interface	E	IEEE P1003.12 SNI API	4.3.5.2	E
Interoperable Networking Directory Services	G	RFC-1034 Domain Naming	4.3.5.3	E
	E	IEEE P1003.17 Directory Services API	4.3.5.2	E
File Transfer	G	MIL-STD-1780 (TCP/IP FTP)	4.3.5.3	E
Message Handling	G	MIL-STD-1781 (TCP/IP SMTP)	4.3.5.3	E
Virtual Terminal	G	MIL-STD-1782 (TCP/IP Telnet)	4.3.5.3	E
Protocols	G	MIL-STD-1777 (IP)	4.3.5.3	E
	G	MIL-STD-1778 (TCP)	4.3.5.3	E
	E	IEEE P1003.12 API	4.3.5.2	E
Mainframe Networking	E	IEEE P1003.12 API	4.3.5.2	E
	G	X/Open CPIC	4.3.5.3	E
PC Networking	G	X/Open PCI:SMB	4.3.5.3	E

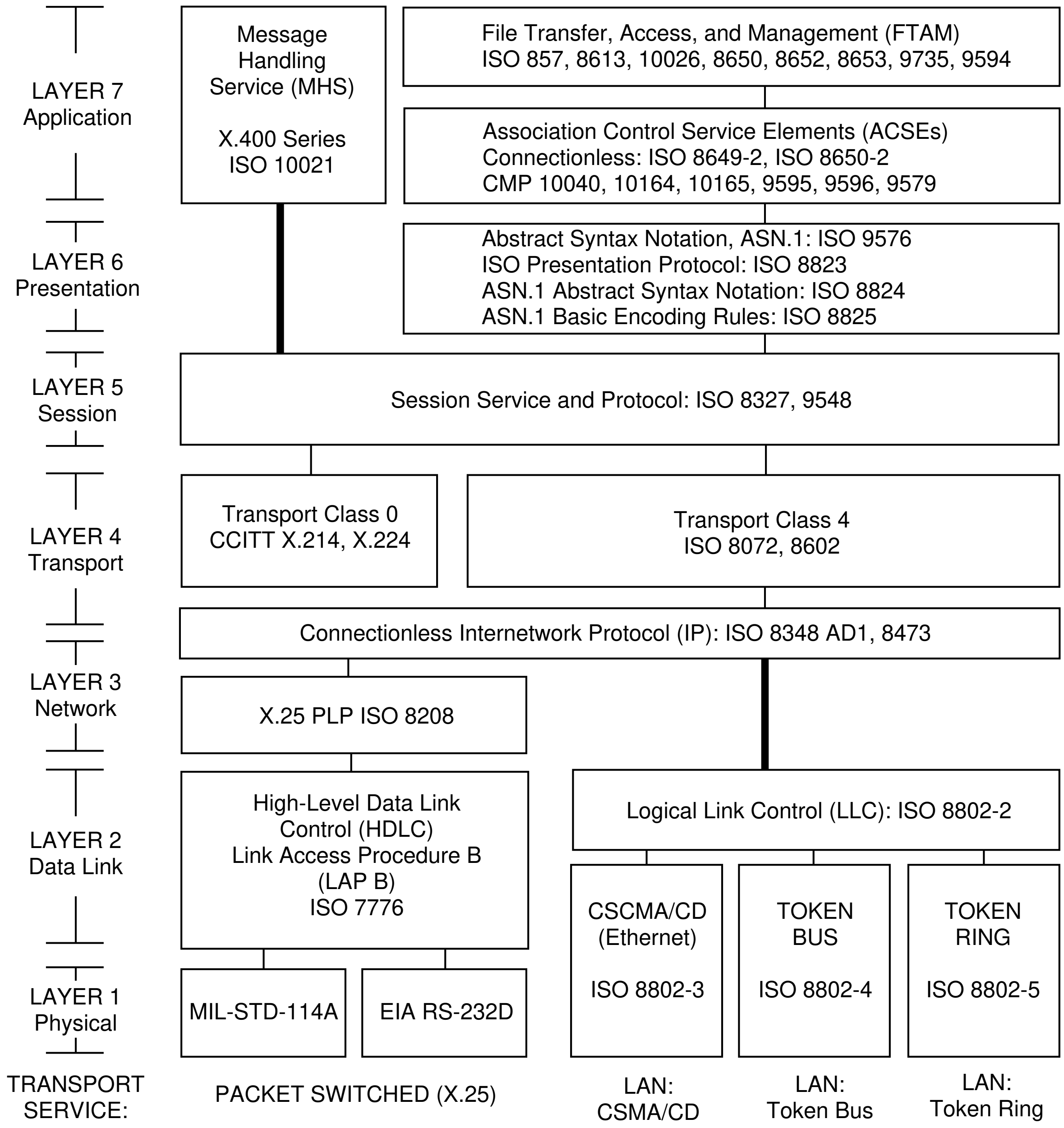

Figure 4-9 – OSI Network Services Standards

IEEE P1003.12

This group is developing a standard that provides networking application program interfaces. P1003.12 contains the specification for a Simple Network Interface (SNI) and a Detailed Network Interface (DNI). The Simple Network Interface is designed to usable on a number of different transport services, ranging from ISO networks to completely proprietary networks, without requiring application changes. To do this, the SNI has a very limited set of services with minimal parameters. The Detailed Network Interface is also designed to be implementable across a wide variety of network protocols. However, DNI allows applications to access the low-level details of each of the different network protocols. As a result, programs written using DNI may be portable between environments that use the same underlying network protocols.

Applications can be written using a combination of the SNI and DNI interfaces. The engineers designing the applications can make portability tradeoffs as the applications are developed.

IEEE P1003.17

This group is developing an API standard that will enable applications to access directory services. Backwards compatibility with existing name resolution services, such as TCP/IP, is included in the design of the P1003.17 interface. P1003.17 can also use the following directory services:

— X.500

— TCP/IP

— IEEE P1003.17 System Management Name Space

— Others

IEEE P1238

This group is developing an API for connection-oriented Application Layer services. It establishes a specification methodology and defines an API to:

— OSI Association Control Service Element (ACSE) services and

— common support functions for OSI connection-oriented protocol APIs.

The specification is operating system and language neutral; POSIX and C-language bindings are provided. Further, it is intended to be used as the basis for the connection management interface for the future Application Service Elements (ASE) such as the File Transfer, Access, and Management (FTAM) API.

IEEE P1238.1

This group is developing an API for interfacing with the FTAM application layer element. It is standardizing an X.400 API and a companion OSI Object Management API, based on the X.400 API and an OSI Management API developed by the X.400 API Association and X/Open. The X.400 API consists of two parts: an X.400 application API and an X.400 gateway API. These APIs were developed based on the 1988 CCITT X.400 series of recommendations. The X.400 API and Object Management API are separate documents.

The purpose of the X.400 API is to provide standard interfaces supporting the development of applications that are users of the message transfer system, and gateways that incorporate or use X.400 mail functionality; this includes gateways between X.400 mail networks and proprietary mail systems.

The purpose of the companion OSI Object Management API is to provide a standard interface supporting the manipulation of complex arguments and parameters used by the X.400 and Directory Services APIs. The scope of the OSI Object Management API is to define an ASN.1 Object Management API for use in conjunction with, but otherwise independent of, the X.400 and Directory Services APIs that are currently being standardized.

4.3.5.3 Gaps in Available Standards

This subclause describes the standards that are cited to satisfy identified service requirements that are not satisfied by any existing or emerging standard.

Interoperable Networking Standards

This set of protocol standards is the traditional TCP/IP suite of standards, which are currently widely available on many computer platforms and operating systems.

This group of specifications includes:

TCP/IP	MIL-STD-1777, MIL-STD-1778
TELNET	MIL-STD-1782
FTP	MIL-STD-1780
SMTP	MIL-STD-1781

While these protocols are not expected to be standardized at any higher level than the MIL-STD level shown, it will be necessary for open systems to interoperate with these standards in a backwards-compatibility mode for some time.

Low Cost Wide Area Networking

The UUCP (UNIX-to-UNIX Copy Protocol) services and commands, for electronic mail and file copying, which are traditionally included in UNIX and UNIX-like systems are not addressed by any standards effort. Among other reasons, UUCP is not currently being addressed because of the inability of the POSIX groups to decide whether the UUCP services and commands should be standardized in the POSIX.2 Group (since UUCP is a traditional UNIX service with traditional command interfaces) or in the networking groups (since UUCP is an electronic mail and file copying facility that works on networks).

4.3.6 OSE Cross-Category Services

These EEI Services allow remote systems to be managed and monitored. Network management services include the ability to:

- Get network status information
- Get network configuration information
- Test network functionality
- Make network configuration changes

The security services allow the system management to control access to system resources and system information. Security services include:

- Protect the system from intruders
- Provide selective access to sensitive system resources
- Manage the network security

See also 5.3.

4.3.7 Related Standards

ISO 8587, Distributed Transaction Services; see 4.6.

4.4 Database Services

Responsibility: Sandra Swearingen

4.4.1 Overview and Rationale

This subclause describes an overview of an architectural framework for discussing database management. It also describes the services provided to application programs and users, and it describes standards, current and emerging, that standardize those database services.

Database management is an important component of the POSIX Open System Environment; in a large class of application programs, especially those used in business, database access through a database management system plays a key role. For portability and interoperability, an application using a database must be isolated from the hardware and software retrieval methods as much as possible. Otherwise the application must have the data manipulation capability coded in its own programs. This might be done if performance is a key issue and the data is very unique. The cost is portability and interoperability.

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4.4.2 Scope

Included within the component of database management are various structured ‘‘data models,’’ including indexed files and network, relational, semantic, and object-oriented databases. Specifically excluded from consideration are services for accessing data that is not part of a database. This subclause discusses database management services from both the application program and user points of view.

Database services provided to application programs by this component, for example, include the ability to create, alter, or drop tables, records, and fields and the ability to insert, select, and update data included in the structures above.

Included within this component are also utility capabilities such as database administration services.

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4.4.3 Reference Model

4.4.3.1 Reference Model

In this subclause, the conventional view of Database Management is related to the POSIX reference model described earlier.

The application programmer’s view of the database model is introduced first. Quite simply, an application program, through a *Database API*, requests database