"FINE-TUNING THE OSI MODEL: LAYER FUNCTIONS AND SERVICES"

MARK D. PARDUE

THE BDM CORPORATION

ABSTRACT

This paper examines some aspects of the Open Systems Interconnection (OSI) Reference Model, which provides the framework for most current international data communications standardization efforts. General theorems are developed and architectural breakouts of the layers of the Reference Model are analyzed to address minor inconsistencies in layer services and functions presently specified in OSI documents.

INTRODUCTION

Background

The Open Systems Interconnection (OSI) Reference Model was developed in 1979 to help in data communications standardization efforts. The OSI Reference Model was developed by knowledgeable persons in the data communications field and was the first effort of its kind. The Reference Model is an extremely useful architectural framework for the development of data communications standards.[27][41][59][62][69] As OSI standards are developed, the Reference Model will evolve toward greater detail.[41] The Reference Model was initially developed to cover basic requirements on which a consensus could be quickly reached, and it was intended to be extended later to meet new requirements.[37]

One of the most important objectives of the model is to standardize services and functions at layer interfaces.[16][23][41][44] Faced with a lack of standards, vendors develop their own standards, none of which are usually compatible.[27][57][59]

By the nature of the development effort for the Reference Model, and the fact that the model had to be developed in subcommittee fashion (one or two layers developed by separate groups of people), there are minor omissions and inconsistencies. These are further promulgated by the fact that the service definitions are also developed in the same subcommittee fashion. In all cases, these discrepancies are minor in nature and should be addressed as the OSI Reference Model evolves.

Purpose of this Paper

This paper identifies some of the minor discrepancies and inconsistencies in the OSI Reference Model in the areas of basic services provided by each layer and basic functions performed by each layer. General theorems applicable to OSI are developed and several layer breakouts of the OSI architecture are examined to help address these discrepancies and inconsistencies.

This paper does not address every service and function presently included in the Reference Model, but rather discusses some of the basic services and functions already included as a part of the Reference Model. The aspects of security, connectionless operation, special applications services, application management, and systems management are not addressed in this paper. Nor does this paper discuss every service that should eventually be included in the Reference Model because the model should evolve, as discussed above.

The work on the OSI Reference Model has been complex and extensive, and has been performed in an extremely able manner by those involved in its development. This has allowed this author the opportunity to take a systems perspective of the Reference Model. The theorems and concepts developed in this paper should be of use in the further evolution of the OSI Reference Model and the development of other OSI standards. The services and functions listed below point out the minor omissions in the OSI documentation that should be added in the appropriate OSI documents as they evolve to correct these omissions.

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GENERAL LAYER SERVICES AND FUNCTIONS

The following theorem addresses general layer services and functions:

(1) There are some services and functions common to all layers because they are basic to the idea of layering no matter what the unique characteristics of the layer.

General Layer Functions

The concept of layering requires certain basic functions to be performed. Layer management is one example of a function that must be performed in each layer no matter what the peculiarities of the layer.[35][39][48] This function is specified in the Reference Model for several of the layers, but not for all layers. This is an obvious omission, and the layer management function should be specified for all layers. Basic functions common to all layers should at least include:

(a) Connection establishment
(b) Connection release
(c) Connection identification
(d) ID and parameter exchange
(e) Service-data-unit transfer (normal data transfer)
(f) Expedited service-data-unit transfer (expedited data transfer)
(g) Layer management
(h) (N)-address to (N-1)-address mapping
(i) Service-data-unit mapping to protocol-data-unit mapping

General Layer Services

It is a well-documented principle of the OSI architecture that the services provided by the (N-1)-layer are passed upward as services to the next higher layer, the (N)-layer, which adds value to these services and then passes them upward as services to the next higher layer, the (N+1)-layer.[2][35][37][69] The only exceptions to this are services that are transparently passed through a layer. These are called "pass-through" services or directly-mapped services. This situation occurs only for services initiated within the Session Layer.[34][39][43][86] Functions add the value to the services and provide the services initially.[31][37][40][51][53][60][69]

This leads to the following theorem:

(2) For a service to be provided by a layer, there must be a corresponding function(s) performed by the layer that allows that service to be provided. The exceptions to this are "pass-through" services that are actually provided/generated at lower layers and passed through layers transparently to be provided to an upper layer.

Thus, any general layer services provided by all layers because of the layering process must be descended from general layer functions.

Table 1 shows the general layer functions and services associated with establishing peer-to-peer connections within a layer. It can be seen from the entries in the table that many of the OSI standards do not address these functions and services. This is also the case with the other general layer functions and services listed above.

TABLE 1. AN EXAMPLE OF GENERAL LAYER SERVICES AND FUNCTIONS

LAYER	SERVICE	IDENT	FUNCTION	IDENT
APPLICATION	APPLICATION CONNECTION ESTABLISHMENT	RM SD	APPLICATION CONNECTION ESTABLISHMENT	RM PS
PRESENTATION	PRESENTATION CONNECTION ESTABLISHMENT	RM SD X	PRESENTATION CONNECTION ESTABLISHMENT	RM PS X
SESSION	SESSION CONNECTION ESTABLISHMENT	RM X SD X	SESSION CONNECTION ESTABLISHMENT	RM PS X
TRANSPORT	TRANSPORT CONNECTION ESTABLISHMENT	RM X SD X	TRANSPORT CONNECTION ESTABLISHMENT	RM X PS X
NETWORK	NETWORK CONNECTION ESTABLISHMENT	RM - SD X	NETWORK CONNECTION ESTABLISHMENT	RM PS X
DATA LINK	DATA LINK CONNECTION ESTABLISHMENT	RM - SD X	DATA LINK CONNECTION ESTABLISHMENT	RM X PS -
PHYSICAL	PHYSICAL CONNECTION ACTIVATION	RM SD X	PHYSICAL CONNECTION ACTIVATION	RM X PS -

RM - OSI REFERENCE MODEL
PS - OSI LAYER PROTOCOL SPECIFICATION
SD - OSI LAYER SERVICE DEFINITION
X - SERVICE/FUNCTION EXPLICITLY IDENTIFIED
\- - SERVICE/FUNCTION IMPLICITLY IDENTIFIED

Not all functions performed in a layer manifest themselves in the form of services provided to the next upper layer, however. Only capabilities that can be seen from the (N+1)-layer are services of the (N)-layer.[35][69] This discussion leads to the following theorem:

(3) While Theorem (2) states that a service must have an underlying function(s), the converse is not true. A function in a layer does not always manifest itself directly as a service provided by that layer.

Looking at the general layer functions listed above, and in light of Theorem (3), the following functions can be seen to not result in layer services:

(a) Layer management
(b) ID and parameter exchange
(c) (N)-address to (N-1)-address mapping
(d) Service-data-unit to protocol-data-unit mapping

VALUE-ADDED SERVICES

As stated previously, one of the basic principles of layering in the OSI Reference Model is that services are passed upward layer by layer with value added in each layer (except for pass-through services in the Presentation Layer) until the final service is presented to the user. An good example of this principle can be seen in the error notification/exception reporting services shown in Table 2. The Physical Layer provides the fault condition notification service to the Data Link Layer. This service is supported by the fault condition monitoring function in the Physical Layer, according to Theorem (3). By the fault condition notification service, the Data Link Layer is notified of fault conditions detected within the Physical Layer that may interrupt or prevent transfer of data. The Data Link Layer uses the fault condition notification service of the Physical Layer, and along with its own error detection function provides the error notification service to the Network Layer. Unrecoverable errors detected by the Transport Layer are reported to the Session Layer through the Transport Layer error notification service. This in turn is used by the Session Layer function of exception condition monitoring. The exception reporting service is supported by the exception condition monitoring function. This continues upward through the layers. This discussion leads to the following theorem:

(4) All services are passed upward through the layers of the Reference Model with value added in each layer (with the exception of pass-through services) until they are presented in their final state to the direct user.

TABLE 2. AN EXAMPLE OF SERVICES AND FUNCTIONS THAT EVOLVE THROUGH THE LAYERS

LAYER	SERVICE	IDENT	FUNCTION	IDENT
APPLICATION	EXCEPTION REPORTING	RM SD	EXCEPTION CONDITION MONITORING	RM PS
PRESENTATION	EXCEPTION REPORTING	RM SD X	EXCEPTION CONDITION MONITORING	RM PS X
SESSION	EXCEPTION REPORTING	RM X SD X	EXCEPTION CONDITION MONITORING	RM - PS
TRANSPORT	END-TO-END ERROR NOTICATION	RM SD	END-TO-END ERROR DETECTION, END-TO-END ERROR RECOVERY	RM X PS X
NETWORK	ERROR NOTIFICATION	RM X SD	ERROR DETECTION ERROR RECOVERY	RM X PS X
DATA LINK	ERROR NOTIFICATION	RM X SD X	ERROR DETECTION ERROR RECOVERY AND NOTIFICATION	RM X PS X
PHYSICAL	FALUT CONDITION NOTIFICATION	RM X SD -	FAULT CONDITION MONITORING	RM PS -

RM - OSI REFERENCE MODEL
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It can be seen from the entries in Table 2 that some of the error notification/exception reporting services and their supporting functions are not specified for all layers be either the OSI Reference Model or the other OSI standards.

PASS-THROUGH SERVICES

Theorems (2) and (4) note the existence of pass-through services. These services occur predominantly in the applications support operation of Layers 5, 6, and 7. This allows non-hierarchical relationships to exist between the Session Layer and the Presentation Layer, because the Application Layer may make use directly of services of both the Session Layer and the Presentation Layer.[34]

ARCHITECTURAL BREAKOUT OF SERVICES AND FUNCTIONS

The general principle of services being provided upward through the layers to the user is valid as presented in Theorem (4) above. However, application of this theorem requires an interpretation of who the direct user of these services is. The ultimate user of the Transport Service is the Application User. However, the direct user of the Transport Service is the Session Layer. Thus, it is possible for a service to be explicitly provided upward only up to the Session Layer, and then stop. The Application User does not make direct use of the service, nor does it need to. A similar situation exists with regard to Layers 1, 2, and 3. Together, these three layers comprise the Network Service. [49][55][69] The Transport Layer is the direct user of the Network Service, and services that are part of the Network Service are not explicitly passed upward above the Transport Layer. In summary, the Application User is the direct user of services that are passed upward through the Application Layer; the Session Layer is the direct user of services that are only part of the Transport Service; the Transport Layer is the direct user of services that are only part of the Network Service.

Figures 1 and 2 show the layer breakout used in this paper. Different breakouts of the layers have been advanced by other authors and additional layer interfaces could certainly be defined to describe other groupings of services (i.e., "Data Link Service"). But, this author feels that these two interfaces, Transport Layer/Session Layer and Network Layer/Transport Layer, are appropriate for the development of the framework for the definition of OSI services and functions. This breakout also has support from others knowledgeable in this field.[1] [30][34][55] The Transport Layer is the "liaison" between the Network Service (Layers 1 through 3) and the Applications Support (Layers 5 through 7).[34][69]

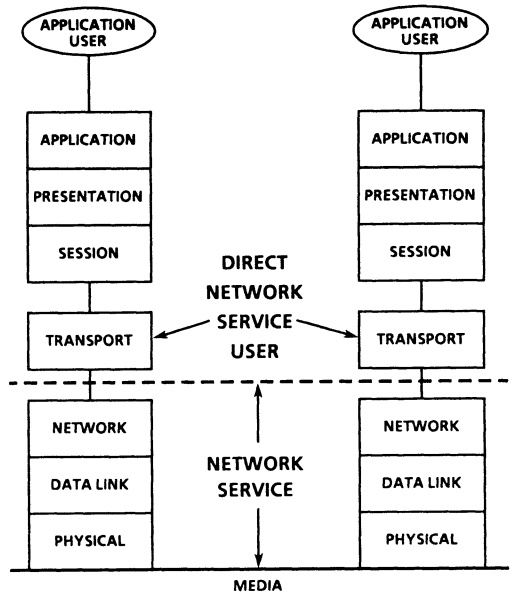

FIGURE 1. THE OSI ARCHITECTURE SHOWING THE NETWORK SERVICE

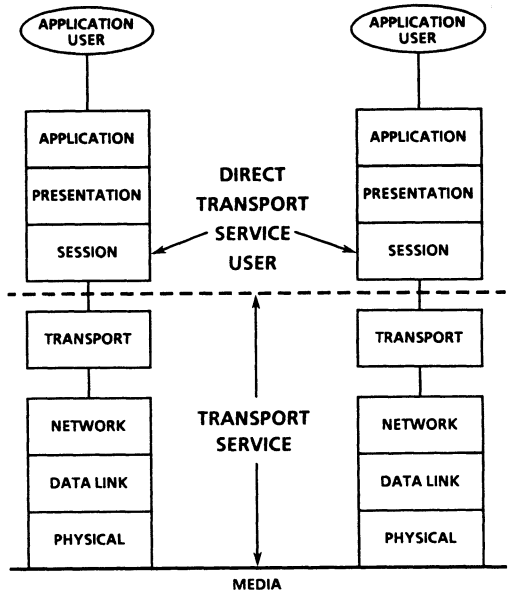

FIGURE 2. THE OSI ARCHITECTURE SHOWING THE TRANSPORT SERVICE

CONCLUSIONS

Understandably, minor inconsistencies are present in the OSI Reference Model, largely due to the subcommittee fashion in which it had to be developed. This paper has noted some of those inconsistencies in the areas of services provided by each layer and functions performed by each layer in the Reference Model. Theorems have been developed to help address these inconsistencies, and some sets of consistent services and functions have been presented.

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