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Computer Communications and Networking

X.25 EXPLAINED
protocols for packet switching networks

R. J. Deasington

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To my parents

Preface

When computer communications was in its infancy, in the mid- to late 1960s, the accepted strategy for the interconnection of computer systems was to create specialised modules to handle different functions. No overall scheme was used: each type of connection produced its own problems, for which specific solutions were developed. The areas addressed by these systems provided for the remote connection of terminals and remote job entry stations. This reflected the centralised view of data processing mainly held at that time. Computing resources were still very expensive and had to be shared among many, possibly geographically dispersed, user communities. The 1970s saw the creation by several major computer manufacturers of complete networking strategies designed to make use of common components in the systems design to allow the movement of computer communications systems away from the specialised to the generalised. Two typical systems of this type are the DECnet product from Digital Equipment Corporation, and Systems Network Architecture (SNA) from International Business Machines. These differ from previous communications systems in that they are both sets of standards for systems interconnection, rather than actual products themselves. They were, and are, used as corporate standards for the interconnection of systems and terminals for all the types of hardware and operating software produced by these companies. Thus if the purchaser of a networked system only used software and hardware supplied by a single manufacturer he could be sure to achieve the required connectivity. Owing to IBM's dominant market position the SNA protocols are widely emulated by other manufacturers to provide connectivity between their systems and those of

IBM. In 1977 the International Standards Organisation (ISO) set up a sub-committee to examine the development of a non-manufacturer-specific set of communications protocols to cover the range of requirements, from the link level protocols used on the communications line to detect and correct errors right up to the application level where the ISO determined to define a standard set of functions for file access, job transfer, terminal control etc. These could be implemented by all manufacturers to provide the buyer of a system supporting these protocols with the ready ability to set up heterogeneous networks of computers. At the present time almost all manufacturers are committed to the development of software to implement the ISO protocols for Open Systems Interconnection (OSI) as each new layer is finalised. At the time of writing the lower four layers of the seven layer model for open systems interconnection developed by the ISO are completely defined, the upper three layers are generally very close to completion. The OSI protocols have recently become of some political importance since in the UK British Telecom (the privatised common carrier in the UK) and IBM attempted to set up a national Value Added Network making use of SNA protocols. The government has refused to licence this operation since it was considered that the public interest was not being served by the non-use of existent OSI protocols by such a powerful combination of companies.

The purpose of this book is to introduce the ISO seven layer model for Open Systems Interconnection in general, and specifically to cover the lower four layers which can be considered to provide the communications subsystem, the upper three layers being increasingly oriented towards applications. The first chapter gives details of the OSI layerings and the present state of their development; subsequent chapters proceed up through the bottom four layers until the Transport layer is reached (layer 4). At this layer we describe not only the ISO Transport Service but also some other Transport protocols at this level which are in widespread use. In the final chapter we cover another set of protocols which also reside at the fourth level, but which were defined prior to the main ISO work and are widely used for connecting terminals to host computer systems. This set of protocols, generally known as 'Triple X' has been included because of its popularity, even though it is not a true OSI protocol.

Finally I should like to thank my friends and past colleagues in the University of Strathclyde Computer Centre, and those in other establishments, for their help and encouragement in the development of the open system of communications in the UK academic community which was the inspiration for this book; and my wife Kate

who has been the nidus of my motivation when it seemed that the standards were changing as fast as I could digest them.

R.J.D.

January 1985

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Introduction to the ISO seven layer model

1.1 INTRODUCTION

The intention of this book is to introduce the reader to the protocols which form the bottom four layers of the ISO seven layer model. We also cover some other non-ISO protocols which are in wide use since they form *de facto* standards in themselves. In the past couple of years almost all the major computer manufacturers have adopted some form of layered architecture. Some attempt to describe their existing networking products in terms of the ISO layered model with varying degrees of success. The two major manufacturer specific architectures which predate the Open Systems Interconnection (OSI) model for data transmission are Digital Equipment Corporation and International Business Machines with their DECnet and SNA systems respectively. Both are now able to make some use of X.25 networks to form links in their proprietary networking systems, but not in a particularly well-integrated manner. The function provided by the X.25 network is ignored and the DECnet or SNA protocols are carried by the X.25 virtual circuits almost as if they were another physical medium with a different Link level protocol to provide the error-free characteristic required by the higher levels in the architecture. Many European manufacturers would like to break the IBM monopoly on communications protocols and are actively taking the OSI line towards a set of networking protocols which will allow the interconnection of any heterogeneous set of machines. In the United Kingdom the academic community have been largely responsible for the development of networking software for Open System

Interconnection by insisting that all computers purchased for academic computer services must have software and hardware for connection to a national Joint Academic Network (Janet). This network is based on the X.25 protocol together with several higher level protocols for Transport Service and several standard functions such as terminal access, file transfer, electronic mail and remote job submission. Since the higher levels of OSI are not yet standardised these protocols are temporary intermediate standards applicable only to the UK and a few other users. But they do however provide valuable experience in the practical implementation of such software which can be fed back into the standardisation process.

In common with the other architectures mentioned, the OSI protocols define what the interfaces are to be between various pieces of software or hardware, they do not specify how the internals of the software or hardware must be built. For example at the Physical level the V.24 interface specifies, directly and by reference to other standards documents, what voltages must appear on what pins of a particular layout of connector at what times and for how long in order to convey binary digits of data from a data terminal to a modem. It does not suggest how the voltages should be generated, or recommend a particular type of integrated circuit to be used. However, if the data terminal manufacturer and the modem manufacturers both correctly interpret the specification, then there should be no problems with the intercommunications of the two devices. This example, however, raises several problems. The fact that two disconnected groups of people will have have to work from a single document created by a committee made up of yet further unconnected people highlights the requirement for absolute accuracy and unambiguity. Whereas for an intra-company project the two groups could sort out between them what the specificiation ought to be, who is to be the arbitrator in this new situation? Even if two independently developed systems can interwork this does not in itself prove that they conform to the intention of the standard. What is required is the provision of an independent tester of protocols for conformity with the standard. Some work is being progressed on this in the UK but it is a non-trivial task.

The Department of Trade and Industry in the United Kingdom is sponsoring work to develop tests for the conformity of data communications protocols. However, the construction of a test environment by which the required sequences of messages can be generated is in practice often a greater problem. This is due to the very nature of. the protocols in that they describe external manifestations of the protocols rather than the internal operation. Thus is it nearly impossible to create a transportable set of test routines since the interfaces to the different implementations of the same protocol layer are likely to be different in ways which depend on the nature of the operating system which is supporting the communications system.

1.2 A BRIEF INTRODUCTION TO OPEN SYSTEMS INTERCONNECTION

The International Standards Organisation (ISO) set up a new sub-committee in 1977 to develop standards for the interconnection of a heterogeneous set of computers. This is known as Sub-Committee 16, often referred to as SC16 in the literature. The objective of SC16 was the creation of a set of communications protocols which would allow different manufacturers' systems to interconnect and interwork provided they adhere to a set of standardised protocols required for 'Open Systems Interconnection'. The highest priority was given to the development of the overall architecture which would allow the construction of a set of layered protocols which could be easily expanded or altered to cope with future developments in technology in this area. The initial 'Reference Model of Open Systems Interconnection' was completed in 1979 and is widely known as the 'seven layer model'. Each layer is known as the Nth layer, the layers below and above being known as the $N-1$th and $N+1$th layers respectively. Each higher layer in the hierarchy is intended to provide value added over the more primitive operations provided by the layers beneath. Each layer will only communicate with the layers directly above and below it in the seven layer model, there will be no communications arbitrarily from one layer to another. The interfaces will be clean between each layer, the interface is defined by the protocol definitions of OSI, but not the internal functioning of the layer, except where it relates the input of one layer to its output at another. The interface is only detailed in so far as the data which must be passed is specified, not the exact mechanism for handling the interlayer interfaces. It may well be that in some implementations the operating system supporting the system will provide convenient message-passing mechanisms and interlayer communications may make use of this. Often, however, the operating system is less helpful and the interfaces may be either of an *ad hoc* nature or non-existent with no boundaries between layers visible from outside the software implementing the protocols. The ISO determined a number of principles to arrive at a sensible layering of the functions which are needed by an all-encompassing set of communications protocols. In somewhat abbreviated terms they are as follows: there should not be so many layers that it is difficult to describe or integrate them; the layers should handle functions which are basically similar; the boundaries should be at points where experience has shown them to be correct, or where the descriptions of the services provided are small so that the amount of information to be passed is minimised, or where it may seem that the layer may provide some useful function in isolation in the future; the layering should allow for a change within a layer in future without having to disrupt other layers should a technology advance make such a change useful.

1.3 OVERVIEW OF THE SEVEN LAYERS

The Physical layer: This layer provides the electrical, mechanical and low level protocol for the establishment, maintenance and release of communications circuits to transmit binary digits of information from higher levels from one end of the link to another. Examples are V.24, V.35, and X.21. The level one definitions of OSI take these established physical layer standards and describe their exact use in an OSI environment.

The Link layer: Building on the communications function at the bit level provided by the Physical level this layer provides an error-free virtual channel over the error-prone layer beneath. The ISO has already defined standards in this area, HDLC in particular. The seven layer model expects that a subset of HDLC will be used as the Link layer for communications, but the possibility of using a character mode protocol is not excluded. As well as providing an error-free virtual channel by means of error detection and retransmission where errors have occurred, the link level also provides low level flow control so that the receiver is able to control the rate of sending of data, thus preventing flooding of the receiver.

The Network layer: The basis for all present work in this area is the CCITT defined X.25 packet-switching protocol. This is being enhanced to provide a more generalised addressing system which will allow for the possibility of interconnected networks in a 1984 revision. It is at this level that the basic multiplexing of data occurs. Many different virtual circuits may be operated over one link layer handling one physical connection between the network host and the local packet-switching exchange. The Network layer is also the level at which routing occurs between the communicating network hosts. Each intermediate node between the source and destination