Chapter 6
Network and Internetwork Communication Services

6.1. VIRTUAL CIRCUIT AND DATAGRAM SERVICES

We consider peer protocols in the network layer or internetwork layer that provide packet-transport services. (See Figures 1-24 to 1-26.) The end users may be attached to the same network or to different networks.

As discussed in Section 1.5.2, a packet-transport protocol may provide a virtual circuit or a datagram service. A virtual circuit service is provided by networks that support the X.25 network access protocol. For a description of X.25, see the articles by Rybczynski et al. [RYBC 76, RYBC 80a, RYBC 80b]; we reprint [RYBC 80a] below. Folts described a datagram service and a fast select capability for the X.25 virtual circuit service that were later added to the X.25 standard [FOLT 80]. A detailed X.25 specification appeared in [CCIT 80].

The DOD Internet Protocol (IP) standard is probably the most widely used protocol that provides a datagram service [POST 80a, POST 81]. Protocol software to implement an IP-to-X.25-interface for the CSNET was described in [COME 83].

6.2. INTERNETWORKING ISSUES

Sunshine [SUNS 77], and Cerf and Kirstein [CERF 78] provided excellent tutorials on the issues and problems of interconnecting different networks. ([CERF 78] is reprinted below.) The specific issue of fragmentation is covered in detail in an article by Shoch [SHOC 79]. The interrelated issues of naming, addressing and routing were also treated by Shoch [SHOC 78]. Both articles by Shoch are reprinted below. A specific implementation proposal to use 48-bit absolute addresses was made by Dalal and Printis [DALA 81]. Sunshine discussed some difficult problems in designing, naming and addressing techniques for multi-network systems [SUNS 82].

6.3. INTERNETWORKING APPROACHES

Excellent tutorials on internetworking approaches can be found in the article of Cerf and Kirstein [CERF 78], reprinted below, and one by Postel [POST 80c]. The two main internetworking approaches that have been implemented were introduced in Section 1.5.3. (See Figures 1-25 and 1-26.) The encapsulation approach was adopted in the DARPA Internet Protocol [POST 80a, POST 81], and in Xerox's Pup internetwork architecture [BOGG 80]. ([POST 81] is reprinted below.) See also the article of Shoch, Cohen and Taft [SHOC 81] on the concept of mutual encapsulation. A draft standard of the ISO Internetwork Protocol can be found in [ISO 84].

The common network access interface approach is the basis of public data networks that implement X.25/X.75 protocols. Descriptions of X.75 implementations can be found in [WEIR 80, RYBC 80c, BLEV 80, UNSO 81]. The article by Unsoy and Shanahan describing an implementation of the X.75 interface between Datapac and Transpac is reprinted below.

6.4. THE DESIGN OF HOST-TO-HOST PROTOCOLS

Host-to-host protocols that provide a reliable transport service between user processes in host computers were of significant interest dating back to the early days of ARPANET. DARPA's

Transmission Control Protocol (TCP) is probably the best known example around. Cerf and Kahn [CERF 74] described the early proposal that led to the current TCP [POST 80b]. Garlick et al. [GARL 77] described various issues and problems in the design and implementation of host-to-host protocols. Both [CERF 74] and [GARL 77] are reprinted below.

A specific problem that makes host-to-host protocols difficult to design is the many different types of errors that they must deal with. A packet-switching network not only will damage or lose packets, but it may also duplicate packets and deliver them out of order. What is worse is that a packet may reside in the network for a random and indefinite amount of time before getting to its destination. Such behavior makes the use of sequence numbers to uniquely identify packets a very difficult design problem. Discussions of these issues and some solutions can be found in the articles by Tomlinson [TOML 75], Dalal [DALA 75], and Sunshine and Dalal [SUNS 78]. This last article is reprinted below.

A slightly different approach to solve the above problem is to introduce mechanisms in the packet-switching network to enforce bounds on packet lifetimes [SLOA 83]. Given bounded packet lifetimes, the host-to-host protocols can be made simpler [WATS 81]. In fact, it is obvious from our work on protocol modeling and verification [SHAN 82, SHAN 83] that it is extremely difficult, if at all possible, to design a correct host-to-host protocol without bounded packet lifetimes.

6.5. SECURITY KEY DISTRIBUTION PROTOCOLS

Network security is a vast subject much of which is beyond the scope of this text. But protocols for key distribution and for obtaining current authentication of communicants are important constituents of any networking protocol hierarchy for secure communications (either one-way or interactive). Such protocols are needed whether conventional or public-key encryption algorithms are employed. We reprint below the article by Needham and Schroeder [NEED 78] on this topic. Improvements to the protocols of Needham and Schroeder were published by Denning and Sacco [DENN 81] and by Bauer et al. [BAUE 83]. See also the survey article by Denning [DENN 83]. Survey articles on the general subject of network security can be found in [POPE 79, VOYD 83].

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