

Local Area Data Transport Service Overview

By M. N. RANSOM*

(Manuscript received October 25, 1983)

A new packet data communication service known as Local Area Data Transport (LADT) has been recently introduced. Combining new loop electronics technology with packet switching, LADT provides customers with low-cost data communications within local access and transport areas, as well as access to interexchange data communications networks. This paper describes the need for LADT, its goals, architecture, and services, and also serves as an introduction to the following paper on LADT system hardware and software.

I. THE NEED FOR A LOCAL PACKET-SWITCHING NETWORK

1.1 *Data communications applications*

The communications industry is currently experiencing a large growth in new data services. Examples are extensive. On-line credit-checking terminals are commonplace. Entrepreneurs have set up specialized information databases providing their subscribers with electronic access to economic forecasts and stock market information. Home information services, such as videotex, are beginning on a national and international scale.¹ The trend for corporate communications is to bring more users “on-line” by providing terminals for immediate access to corporate databases and to automate current paper-flow processes.² The current growth in personal computing also is expected to require data communications for the exchange of electronic mail and the transfer of software.³ Current centrex customers are demanding new data communications capabilities to handle their needs more effectively.

* AT&T Bell Laboratories.

Copyright © 1984 AT&T. Photo reproduction for noncommercial use is permitted without payment of royalty provided that each reproduction is done without alteration and that the Journal reference and copyright notice are included on the first page. The title and abstract, but no other portions, of this paper may be copied or distributed royalty free by computer-based and other information-service systems without further permission. Permission to reproduce or republish any other portion of this paper must be obtained from the Editor.

Consider some specific examples of information services already in place:

1. The *Viewtron** service, provided jointly by Knight-Ridder Newspapers, Southern Bell, and AT&T Consumer Products. This system provides videotex services in South Florida.⁴

2. The *Pronto*† home banking service, provided by Chemical Bank in the New York City area.⁵

3. The *Extravision*‡ service, provided by CBS, AT&T Consumer Products, and New Jersey Bell, to supply home information services.⁶

4. The *Source*¶ owned by Reader's Digest, which provides news and specialized information to its subscribers.

5. *Dow Jones News/Retrieval Service*,** which provides business news and financial data to subscribers in an on-line fashion.⁷

6. The Mead Corporation, which provides bibliographical and on-line text retrieval services.

The exact nature of future applications is uncertain, but what we can expect are more applications by more information providers and, with them, a dramatic growth in data communications.⁸ One common element these services will share is a need for an effective data communications network. The characteristics of data traffic are so significantly different from those of voice that use of the voice switching network is a poor match to this need. On the other hand, the cost of providing a separate data network for each type of service would be prohibitive.

Possible solutions to this problem include the use of two-way cable systems, hybrid cable and telephone systems, and use of other local distribution systems such as radio. The telephone operating companies, because of their in-place loop plant, have a unique opportunity to serve this market. LADT takes advantage of this opportunity by adding data capabilities over existing loop facilities through the addition of new loop technology. LADT is planned as part of the overall evolution of the telephone network, and is oriented toward interactive, packet-switching applications.

1.2 Data communications characteristics

As contrasted with voice, data communications has several differentiating characteristics:

1. The fundamental information content is digital in nature.

* Service mark of Viewdata Corporation of America Inc.

† Service mark of Chemical Bank of New York.

‡ Service mark of CBS Inc.

¶ Service mark of The Source Telecomputing.

** Service mark of Dow Jones & Co., Inc.

2. Data communications is very sensitive to errors in this digital information.

3. Precisely defined rules and procedures are required in the form of protocols because of the machine-to-machine nature of the communications.

4. A very wide range of data traffic is typical, ranging from message sizes of a single bit, as in sensor applications, to megabits, as in facsimile or file transfers. Holding times for these types of calls can range from less than a second for a meter-reading application, to over an hour for some business applications.

5. Interactive data applications are usually characterized by bursty data traffic—long holding time calls with an average data rate a small fraction of their peak data rate.

1.3 Technical approaches to data communications: status quo

One of the early technical approaches to data communications was to treat information as if it were voice. This approach led to the development of modems (e.g., *DATAPHONE** II data sets⁹). In fact, this approach has a number of advantages. It produced an immediate, ubiquitous network for switched- and private-line applications. Data communications equipment can be placed selectively in the network, allowing data networks to be built with relatively low start-up costs. Finally, the technique is transparent to data content and format. This approach, however, has limitations. Transmission rates are limited to bit rates that can be reliably transmitted over a voiceband channel. With current technology, transmission rates are typically up to 1.2 kb/s full duplex over the switched network and up to 9.6 kb/s over four-wire private lines. Customers who opt for private-line service have the additional disadvantage of homing a particular terminal to a single-host computer. Source and destination data equipment must operate at the same transmission rate. Central computing sites that must communicate with many remote locations require a proliferation of computer front-end ports, modems, and lines. Use of a voice line for data precludes its simultaneous use for voice. This is undesirable because of the long holding time of data calls and because some applications (e.g., security) must be able to transmit data at any time. Finally, and perhaps most importantly to the telephone operating companies, many applications make inefficient use of the public switched telephone network because of very long or very short holding times and because of the long idle periods occurring in interactive data calls.

* Trademark of AT&T Technologies, Inc.

1.4 The local area data networking opportunity

Over the last ten years, a number of specialized value-added networks have emerged to address this data communications market.^{10,11} Access to customers of these networks is usually provided through the local telephone network. This approach has proven attractive from a customer cost point of view because telephone operating companies have typically charged on a flat-rate basis for local calls. As measured usage is introduced, however, the cost of using this local network for data will become visible to customers.

The telephone operating companies, because of their extensive investment in the local-distribution network, are in a good position to provide effective, low-cost access to these interexchange data networks. By augmenting local loops with electronics, simultaneous voice and data service can be provided to subscribers. By combining this loop technology with packet-switching technology,¹² subscribers can not only be provided access to multiple interexchange data networks, but can also be provided access to a variety of intra-LATA (Local Access and Transport Area) data services. Such an arrangement achieves a more cost-effective way of handling bursty data applications, can eliminate the problems of speed matching the source and destination, and can provide a multiplexed access to central-site computing centers. The essential decision is whether to integrate these functions into existing voice-switching machines or to augment the existing network with new, separate components. The concept of a *packet overlay* network has been chosen to allow the telephone operating companies to initiate new data services independent of the particular voice switches currently in place. These technologies and this approach are the basis for LADT.

II. LADT SYSTEM CHARACTERISTICS

2.1 Network architecture

With the basic ingredients of subscriber loop multiplexing and packet switching, a basic network architectural plan for LADT was conceived. This architecture is depicted in Fig. 1. Two methods are provided for accessing LADT: direct access and dial-up access. The direct-access method allows voice and data service to be provided simultaneously over a single pair of wires to the subscriber. This pair of wires terminates on a Local Data Concentrator which demultiplexes the voice and data. Voice is sent in standard voice frequency format to the voice switch, while the subscriber's data are sent to a packet switch. Figure 2 shows the direct-access technique used in LADT in more detail. Data and voice are multiplexed together at Network Circuit Terminating Equipment (NCTE) at the customer premises.

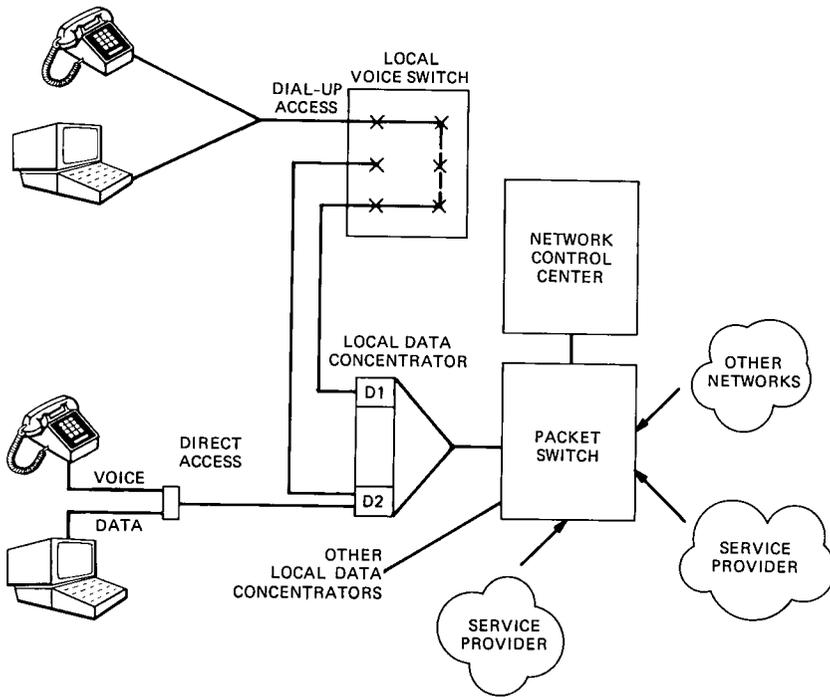
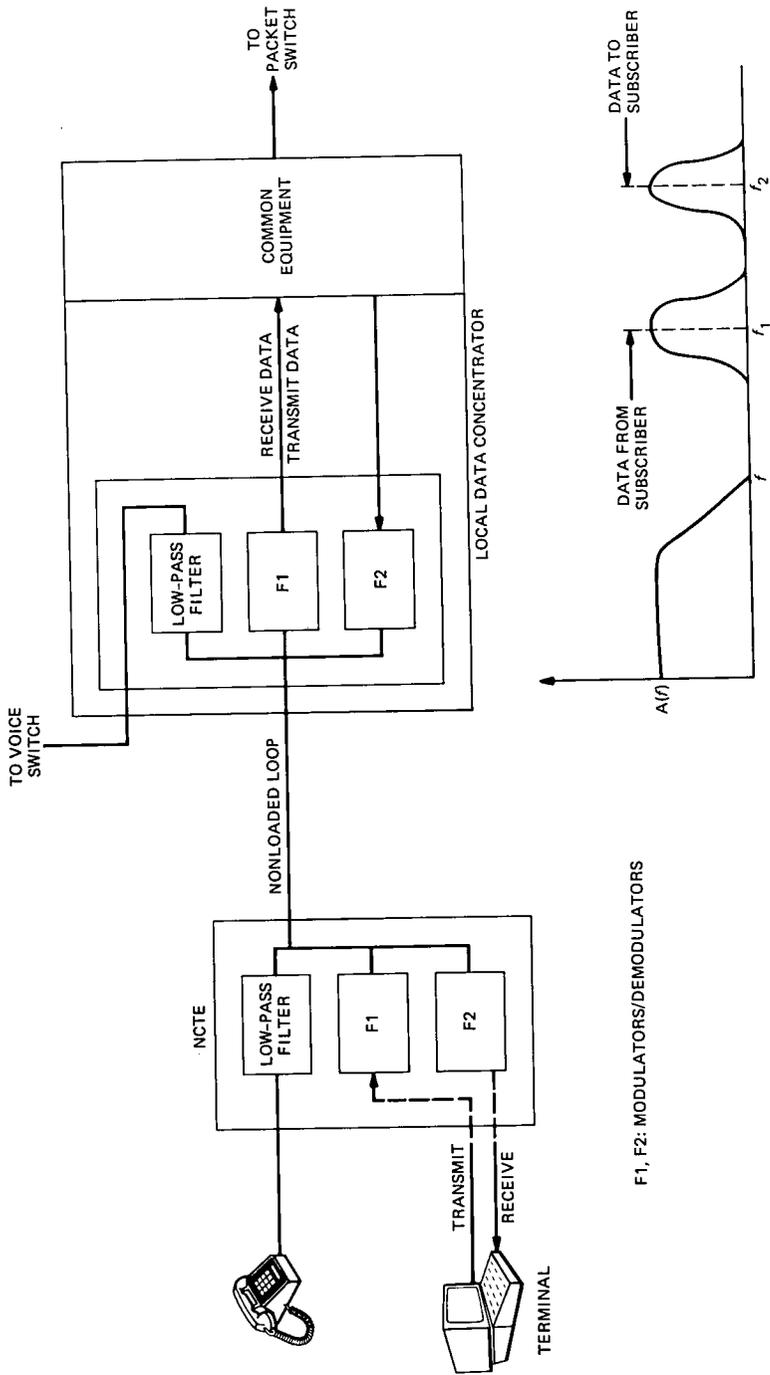


Fig. 1—LADT network architecture.

Full-duplex 4.8-kb/s data are sent above the voice spectrum over the subscriber's loop. This technique allows use of existing nonloaded loop plant up to 18 kft in length, achieves cost reductions relative to use of separate access lines with modems, and allows simultaneous use of voice and data services.

Dial-up access for low-volume users is also shown in Fig. 1. Such users access the LADT network through the current telephone network. While this results in data traffic being passed through voice switches, the number of voice switches in the transmission path is reduced relative to current value-added networks through the deployment of Local Data Concentrators. Nonetheless, customers using dial-up access cannot make normal use of their line at the same time they are using their line for data and are also limited to 1.2-kb/s service. Since this method of access may involve a longer path to the LADT network than for direct access, a more robust modulation technique is needed. Because of the widespread acceptance of the modulation technique used in the 212A data set,¹³ this modem technology is used for dial-up access.

Two functions performed by the local data concentrator have just been noted: separating voice and data for direct-access subscribers,



F1, F2: MODULATORS/DEMODULATORS

Fig. 2—Data over voice technique.

and terminating calls from dial-up access subscribers. The local data concentrator performs a number of other functions. It checks data received from subscribers for transmission errors and, if necessary, requests retransmission. To reduce transmission costs, data from many customers are concentrated by the Local Data Concentrator onto a 56-kb/s data facility to a packet switch. This greatly reduces costs relative to providing individual data facilities to the packet switch for each data call. The local data concentrator also provides a number of per call administrative functions, such as billing, traffic, and error measurements, relieving the packet switch of some of these functions.

The packet switch performs a number of important functions for subscribers and hosts. From the subscriber's point of view, the packet switch allows data calls to be connected to a large number of hosts. From a service-provider point of view, the packet switch provides a second level of subscriber concentration, allowing a single data link to the host to be accessed from subscribers throughout the LATA. The multiplexed network interface to the host allows up to 511 active terminals to be served by a single 56-kb/s *DATAPHONE* Digital Service (DDS) channel.¹⁴ This eliminates the need for a separate modem and front-end processor port for each active line. It is expected that most LATAs will be served by a single packet switch, although large LATAs may eventually be served by multiple-packet switches.

In addition to direct connection to hosts, LADT will provide connections to inter-LATA data networks, thereby allowing subscribers to access hosts throughout the nation and, eventually, through international data networks.

A Network Control Center (NCC) will provide a centralized point for monitoring and controlling the operation of LADT throughout the LATA. It consists of a set of operations, administrative, and maintenance functions which are best located centrally in a LATA rather than distributed to each local data concentrator. In some implementations of LADT, the NCC may be combined into the packet switch.

2.2 Protocol standardization

LADT has been designed to use existing international protocol standards where available. This allows compatibility with data equipment being marketed internationally and allows internetwork and inter-LATA communications to be easily supported in the future. Current standardization activities are focused on the Open Systems Interconnect (OSI) model¹⁵ written by the International Organization for Standardization and on the X.25 protocol¹⁶ written by the International Telegraph and Telephone Consultative Committee (CCITT). X.25 implements the first three levels of the OSI model. LADT has chosen to support the X.25 protocol. At the terminal interface, the

link level of X.25 is supported with ASCII text call progress messages. At the host interface, all three levels of X.25 are supported. Details of the LADT terminal and host interfaces are described in Sections III and IV, respectively.

2.3 Uniform numbering plan

International standards organizations, in particular the CCITT, have provided standards for data-network numbering to facilitate internetwork communications and addressing. The primary goal of the numbering plan standards is to specify the structure and coding of the international numbering plans for data networks. To do this, standard X.121 has been developed.¹⁷ This standard specifies a numbering structure that allows a maximum of 14 digits for data-network numbering. The first four digits are termed a Data Network Identification Code (DNIC). DNICs identify the country and data network within the country. Number assignment of DNICs is administered by CCITT.

The remaining digits of the data-network number are termed a Network Terminal Number (NTN). The NTN is required to be numeric and to be at most 10 digits in length.

The LADT service has been assigned a single DNIC by the U.S. State Department/CCITT. This means that the structuring of the 10-digit NTN must allow routing to the appropriate LATA. This has two primary effects. The first is that the interexchange carriers must be aware of the NTN structure of LADT to handle inter-LATA calls. The second is that the individual telephone operating companies must use a standard NTN structure to support network-wide communications.

The LADT service has been designed to allow data communications worldwide. A 10-digit LADT numbering plan will be used, similar in structure to the today's telephone numbering plan, although independent of it. LADT NTN numbers have the following structure:

$$\text{NPA-NXX-XXXX,}$$

where NPA denotes the Numbering Plan Area codes used in the public switched telephone network, N is an digit from 2 to 9, and X any digit from 0 to 9.

2.4 Performance objectives

A number of performance objectives have been set for LADT, assuring customers satisfactory service for a wide variety of data applications. LADT is to provide 24-hour-a-day, 7-day-a-week service without scheduled downtime. It is to be highly reliable with the service available to a given subscriber 99.6 percent of the time. The probability

of a subscriber's request for service being denied because of lack of system resources during the busy hour is to be less than 1 percent except during the 10 busiest days of the year. The probability of an error being introduced into customer's data by the network is to be less than 1 in 10^8 packets sent. LADT introduces very little delay into the connection between the subscriber and host. The delay between the time LADT receives a packet from the subscriber and the time that packet is placed in the output queue for transmission to the host is to be less than 200 ms. This delay is defined as the time interval from the receipt of the last character of information from the source until the first character of that packet is ready for delivery to the destination. This definition eliminates from the performance objective the effects of customer choice of access line speeds and traffic loading per host X.25 line.

2.5 Administrative capabilities

It is the goal of LADT that the entire network, both local data concentrators and packet switch, be administered from a single location. Initially, billing information for dial-in subscribers, dedicated subscribers, and hosts will be collected through separate mechanisms. The collection of billing information for dial-in subscribers will not be done by LADT equipment. Instead, dial-in subscribers are billed according to the number of calls placed and holding time using standard automatic message accounting records. Billing information for direct-access subscribers is collected by the local data concentrators and sent to the NCC after each call. Billing information for hosts is collected by the packet switch. The eventual goal of LADT is for this billing information to be sent by a data link to the operating company revenue accounting office. In the initial implementation of LADT, this billing information is transferred by magnetic tape.

Traffic reports generated at the NCC allow operations personnel to monitor the functioning of the system and to engineer the system for the prevailing traffic load. Capabilities are also to be provided at the NCC to allow operations personnel to change such system data as equipment configuration data, customer profile data, and routing tables.

III. LADT TERMINAL INTERFACE

The OSI model, referred to in Section 2.2, provides a convenient and useful model for defining the interface between data equipment. It defines this interface in seven protocol layers or levels, each built on the previous level (see Fig. 3). Public networks, such as LADT, generally implement the first three levels of this model: the physical,

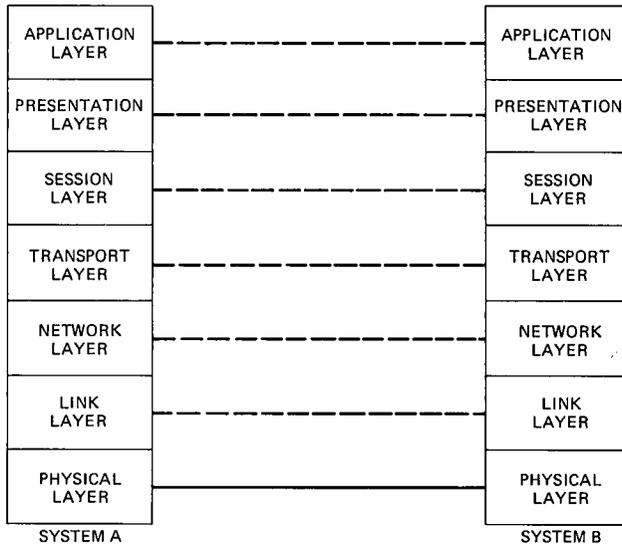


Fig. 3—Open systems interconnect model.

link, and network levels. Both the terminal and host interface to LADT¹⁸ will be described according to this model.

3.1 Physical-level interface

The physical level defines the electrical, mechanical, and procedural control characteristics of the transmission facilities that provide access to customers. As we discussed earlier, both direct- and dial-access interfaces to LADT are provided. Two physical-level protocols are therefore supported. For direct-access subscribers, the NCTE is provided at the customer premises. This device forms the customer's interface to the network. The NCTE is depicted in Fig. 4. The NCTE voice interface is a tip and ring connection. A data interface has been chosen to be compatible with the *DATAPHONE* Digital Service and the circuit switched digital capability. This interface is provided with an 8-pin connector. The data interface provides full-duplex 4.8-kb/s synchronous transmission. Of the eight pins provided in the data connector, four are currently assigned. Two leads provide balanced transmit data and two leads provide balanced receive data. Baseband bipolar return-to-zero signaling (50-percent duty cycle) is used for transmission of data to and from the NCTE and is described by the following coding rules: A binary 0 is transmitted as 0.0 volt. A binary 1 is transmitted as either a positive or negative pulse, opposite in polarity to the previous pulse. This is the alternate polarity rule. An example of bipolar signaling is shown in Fig. 5.

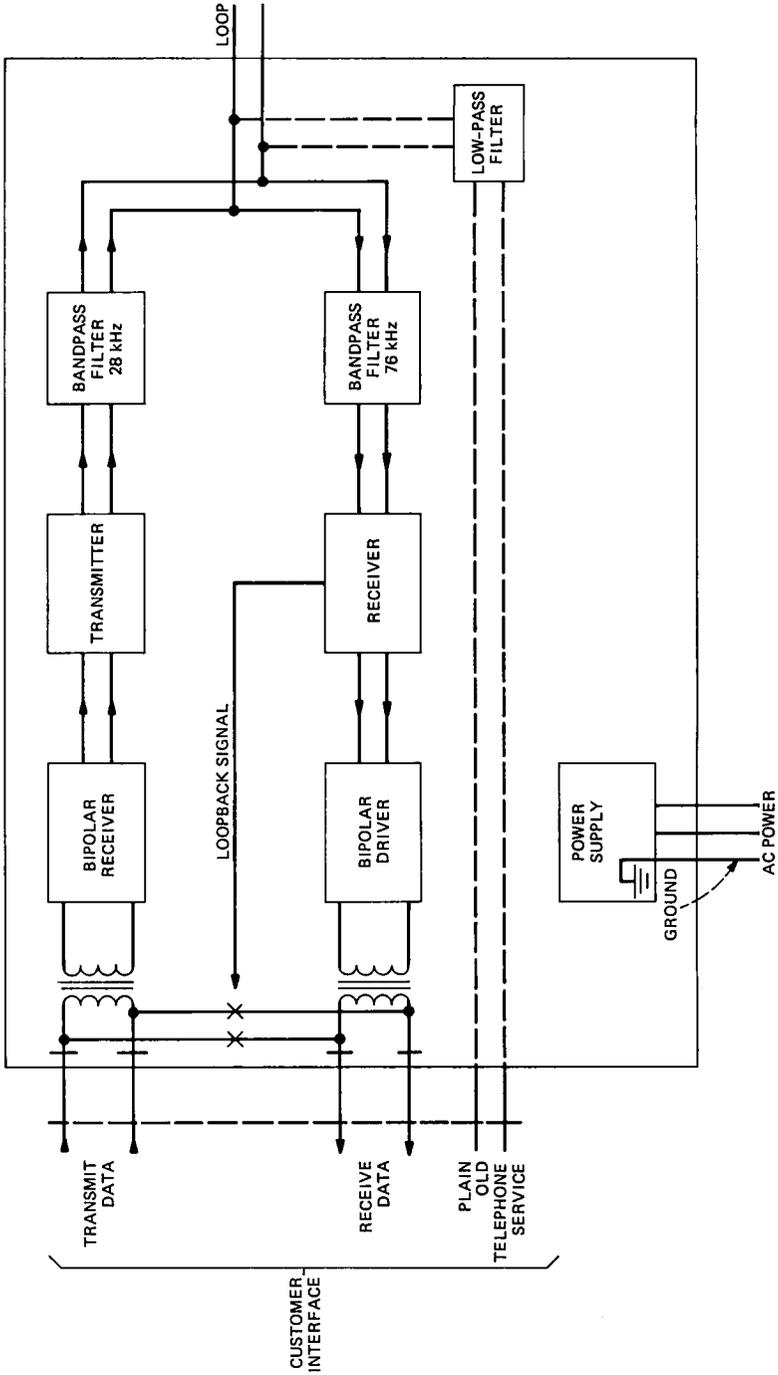


Fig. 4—LADT network circuit terminating equipment.

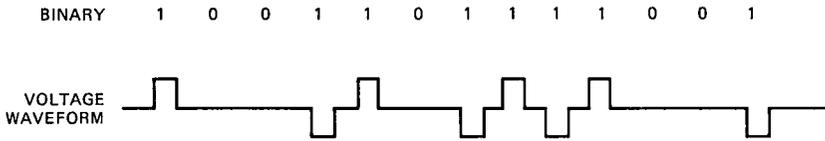


Fig. 5—Bipolar signaling.

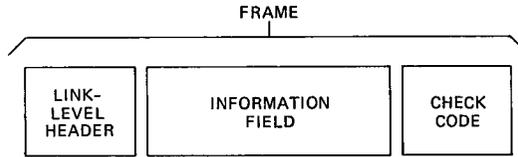


Fig. 6—LAPB frame structure.

When connected to the direct-access interface, the terminal equipment must perform the timing recovery and coding and decoding of data. Timing recovery is required to enable the terminal equipment to sample correctly the incoming synchronous data and to clock the terminal equipment's transmit data to the NCTE. Coding and decoding data involve using the bipolar coding rules.

Dial access to LADT is supported via a 212A compatible interface. Full-duplex 1.2-kb/s bit-synchronous transmission is supported. The dial-access port of LADT automatically answers incoming calls. Answer tone is provided to notify the user that a port has been connected.

3.2 Link-/network-level interface

The link- and network-level interface protocols supported by LADT are the same for direct and dial-up subscribers. The link-level protocol used in LADT is the X.25 Link Access Procedure B (LAPB) protocol. LAPB provides the subscriber an essentially error-free data channel through the use of error detection and retransmission. This is important for applications such as electronic funds transfer. Both information and control are transferred across the access link in information units called frames. The link level forms information frames, as shown in Fig. 6. A header in the frame contains such information as what type of frame it is (an information frame or a control frame). It also contains a sequence number so that lost frames can be detected. The header also contains acknowledgment information for frames received from the other end. A 16-bit cyclic redundancy code is added to each frame to detect transmission errors.

The values of the link-level parameters in the network implementation are as follows:

1. The link-level window size, LAPB parameter k , is two frames. This allows both the network and the terminal to send a second frame without having to wait for the first one to be acknowledged.

2. The acknowledgment timer, parameter $T1$, is 5.0 seconds. This is how long the network will wait for an acknowledgment before assuming the frame was lost and initiating recovery action. Timer $T1$ is started at the end of the transmission of a frame. Therefore, the terminal should not delay the response to a frame by more than $T1$ minus $T2$, where $T2$ is total of the round-trip propagation delay of the access line plus any processing time required by the network. The value of $T2$ for the network will not exceed 0.3 second. In addition, the network will not delay the response to a received frame by more than 0.3 second, including round-trip propagation delay for an access line.

3. The maximum number of attempts to obtain an appropriate response to a transmitted frame, parameter $N2$, is 4. After $N2$ unsuccessful attempts, the network will initiate the appropriate link-level recovery, as specified in X.25. Also, if the link cannot be restored in $N2$ attempts, the network will clear the virtual call on the link, if one exists.

4. The maximum number of bits in an information frame (excluding flags and 0 bits inserted for transparency), parameter $N1$, is 2080 bits (260 octets). The information field must contain an integral number of octets. If the terminal transmits an information frame whose information field exceeds this length, the network will transmit a frame reject response. If the terminal transmits an information frame whose information field is not an integral number of octets in length, the network will discard the frame without acknowledging it.

The LADT network-level access protocol provides the interface procedures required to set up, maintain (i.e., control the transfer of data), and clear virtual calls. To reduce the level of complexity of terminal protocol software, and because X.25 does not currently support dial-up protocols, LADT provides simple network-level messages in the ASCII code set. A single logical channel is supported to the subscriber. Data are transferred across this interface using information frames. Control information is transferred across the interface using several types of link-level frames.

Network-level signaling consists of signaling from the network to the terminal using signaling messages and signaling from the terminal to the network using a destination address. An information frame can contain one or two signaling messages. All signaling messages and destination addresses are coded using the ASCII code set complying with ANSI X3.4.¹⁹ The network sets the value of the most significant (parity) bit to 0 when transmitting a signaling message to the terminal.

The terminal may set the value of the most significant (parity) bit to either 0 or 1 when transmitting the destination address to the network; the network ignores the parity bit.

Figure 7 shows an example of the signaling message which prompts for the called number and shows the ASCII coding. An example of how these signaling messages are used to set up data calls in LADT is given in Section V.

IV. LADT HOST INTERFACE

As we stated earlier, LADT will support all three levels of the X.25 protocol at the host interface. Reference 20 gives specifications of this interface.

Host subscribers interface with LADT directly to the packet switch using one or more channels. The *DDS* channels are supported at 2.4-, 4.8-, 9.6-, and 56-kb/s transmission speeds. The lower-speed interfaces may be adequate for situations where only a small number of simultaneous sessions are required. However, for interactive data applications such as videotex, the information database is typically provided on a large processor and the traffic load per active subscriber is relatively low. Therefore, there may be hundreds or even thousands of simultaneous sessions per information provider. For this kind of situation, the high-speed 56-kb/s interface would be used.

LADT supports at the host interface the same balanced LAPB supported on the terminal interface. Unlike the network-level protocol at the terminal interface, which provides only a single logical channel, the network level of X.25 at the host interface allows multiple, independent logical channels to be provided on a single physical link. This is illustrated in Fig. 8. This multiple logical channel capability allows customers to replace many individual front-end processor ports and modems with a single higher-speed digital channel and interface port

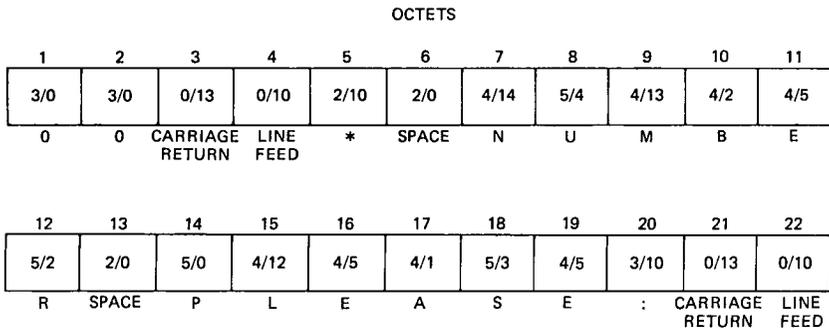


Fig. 7—Signaling message to prompt subscriber for called number.

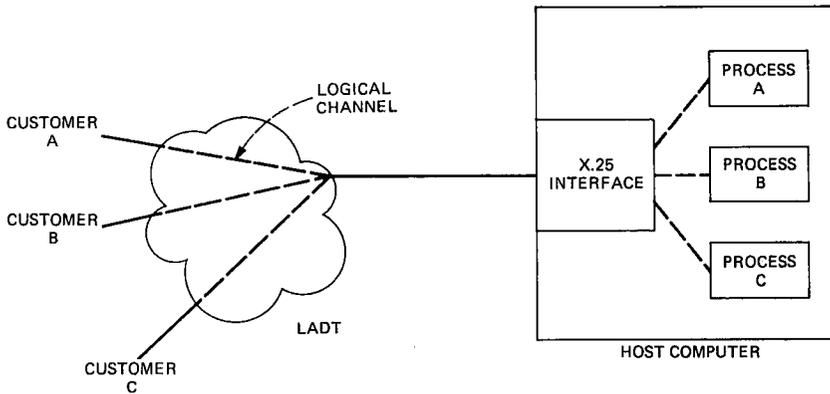


Fig. 8—Multiple logical channels on one host link.

to the host. LADT supports up to 511 logical channels over a single 56-kb/s access line.

The X.25 interface allows the customer to use these logical channels statically as permanent virtual circuits or dynamically as virtual calls. The permanent virtual-circuit interface is meant to emulate a point-to-point private line for applications that do not require switching. Virtual calls are used when the user wishes to use logical channels dynamically. A combination of permanent virtual circuits and virtual calls may be served over a single physical interface.

The LADT host interface allows customers to choose several packet-level facilities to meet particular application needs. The remainder of this section describes some of these facilities.

4.1 Hunt groups

Even though LADT allows many data calls to be set up on a single data link to a host, for very large hosts many data links will be needed to handle the volume of data traffic. For these situations LADT provides a hunt-group capability. A data network number is assigned to the data links making up the hunt group. Incoming calls are assigned to links by LADT in such a way as to try to have equal numbers of data calls on each link.

4.2 Conditional removal of data links

There may be times when a host may want to remove a data link from service but only after all existing data calls have terminated. To do so, LADT provides a conditional removal capability. When requested to conditionally remove a data link from service, LADT will then allow existing calls to remain on the link but will not allow new incoming calls to be established.

4.3 Packet size selection

Packet-switching services like LADT require network resources on a per-packet basis. The amount of processing required to switch a packet is relatively independent of the actual number of bits in the packet. Thus, users who must send large amounts of data can most efficiently transfer their data by using large-size packets. LADT allows users to select a maximum packet size of 128 octets or 256 octets of user data. Given equal cost per packet, the user with large amounts of data to send can more effectively use the switch by selecting a 256-octet maximum.

4.4 Throughput and flow control

Virtual-circuit throughput is an important measure of packet-switching service. Because the switches and trunks are statistically shared, brief storage of data from a particular virtual circuit is needed. Thus, packet buffers are allocated for this purpose. However, the system must protect itself from individual users taking an excessive share of these packet buffers. LADT does this by requiring that when an individual virtual circuit has used all of its share of packet buffers, it is prohibited from sending any additional packets until the destination accepts at least the first in sequence. The LADT X.25 interface allows users to select packet-level window sizes of two or three packets. This allows a virtual-circuit throughput of up to 9.6 kb/s.

4.5 Closed user groups

Closed user groups are supported on the X.25 interface to provide security. By means of this feature, only calls from certain locations are allowed to terminate on a host.

Closed user groups are implemented with a mechanism similar to a key and lock. The key, called a closed user group number, is sent with the call setup packet. If it matches the closed user group set allowed at the destination, the call setup packet is sent to the destination. If there is no match, the call is blocked.

4.6 Fast select

The fast-select facility is provided on the X.25 interface. It allows the customer to transmit data as the call is established or torn down. This is done by allowing up to 128 octets of user data to be sent along with a call request packet. Likewise, the called party may send up to 128 octets of data while issuing a request to clear the call.

4.7 Data connections between host and terminals

Using the LADT host interface, hosts can set up data calls not only to terminals, but to other hosts as well. When connected to another

host, all X.25 capabilities that the other host supports can be used. When connected to terminals, however, certain limitations apply. This is because LADT supports a simple network-level interface to terminals, and not all X.25 capabilities can be transferred across this interface. For instance, the X.25 qualifier bit loses its significance on such connections. Reference 21 describes host requirements when connected to terminals on LADT. These are summarized in Table I.

V. CALL HANDLING

Let us now examine how data calls are handled in LADT. As an example we will describe a data call from a dial-up LADT subscriber to a host. This is illustrated in Fig. 9. A call from a subscriber with direct access occurs in the same manner except that the need for initially placing a telephone call is eliminated.

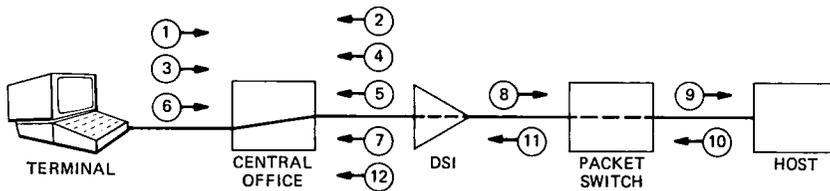
The subscriber begins by placing a telephone call to a special directory number associated with LADT. This will result in the call being routed to the nearest local data concentrator (quite likely one in the same central office as the subscriber). Upon detecting ringing, the local data concentrator answers the call and sends an answer tone to the subscriber. This tone is recognized by the subscriber's terminal (or data set), which responds by sending data carrier. This is detected by the local data concentrator, which then returns data carrier itself and begins establishing the X.25 LAPB protocol with the terminal. After this protocol is established, the local data concentrator sends the message

NUMBER PLEASE :

which is printed on the screen of the subscriber's terminal. The

Table I—Summary of use of services, facilities, and subscription items on host interface to provide compatibility with terminal interface

Service, Facility, or Subscription Item	Use
Specify the desired line transmission rate	Specify
Specify the desired number of logical channels and the range of logical channel numbers	Specify
Virtual-call Service	Mandatory
Flow-control parameter negotiation	Mandatory
Incoming calls barred	Precluded
Closed user group	Precluded
Multiple addresses on an access line	Optional
Multiple-line hunt group	Optional
One-way logical channel outgoing	Optional
Outgoing calls barred	Optional
Throughput class negotiation	Optional
Fast select	Optional
Fast select acceptance	Optional
Permanent virtual circuit service	Optional



- | | |
|---------|---------------------------------------|
| 1 | SUBSCRIBER DIALS LADT |
| 2 | DSI RETURNS ANSWER TONE |
| 3, 4 | DSI AND TERMINAL EXCHANGE CARRIER |
| 5 | DSI PROMPTS FOR CALLING NUMBER |
| 6 | CUSTOMER ENTERS CALLING NUMBER |
| 7 | DSI INDICATES CALL SETUP IN PROGRESS. |
| 8 TO 11 | DATA CALL SETUP TO HOST |
| 12 | DSI INDICATES CALL IS NOW SET UP |

Fig. 9—Call setup example.

subscriber responds by entering the data network number of the desired host. The local data concentrator does preliminary screening on the number entered to ensure that it appears reasonable (e.g., has the right number of digits) and sends the message

CALL BEING ATTEMPTED

to the subscriber. At the same time it takes the called number and formats it into an X.25 call request packet, which it sends to the packet switch. The packet switch translates the called number and sends an X.25 incoming call packet to the called host. If the host decides to accept the call it then sends an X.25 call accepted packet to packet switch, which responds by sending an X.25 call connected packet to the local data concentrator. The local data concentrator responds by sending the message

CALL CONNECTED

to be printed on the subscriber's terminal.

At this point a connection has been established between the subscriber's terminal and the host. Thereafter, all information frames received from the subscriber are sent transparently (without interpretation by LADT) to the host. If the call had been refused by the host, or if the local data concentrator or packet switch detected an error in the data network number, an appropriate message would have been sent to the subscriber.

The call can be cleared by either the subscriber or the host. The subscriber can clear the call by sending a LAPB disconnect frame or (in the case of a dial-up subscriber) by simply going on-hook. If the host clears the call (by sending an X.25 clear request packet to the packet switch) the message

is sent to the subscriber. At the end of the call, the local data concentrator will send billing information to the NCC. This information includes the number of packets sent and received, the time the call began, and its duration.

VI. SERVICE EVOLUTION

In the future additional capabilities will be added to LADT to provide expanded customer features, improve system economics, and further facilitate operations support. This section will summarize what features are currently available in LADT and what features are planned or are being considered.

6.1 Current services

The principal capabilities currently provided by LADT are the following:

1. Dial-up access at 1.2 kb/s
2. Direct access at 4.8 kb/s
3. Synchronous (LAPB of X.25) terminal access protocol
4. Billing via holding time for dial-up subscribers
5. Fixed monthly charges plus packet and holding time sensitive charging capabilities for direct access subscribers
6. All essential X.25 virtual call features on host links
7. Hunt group across host links
8. Conditional removal of host access lines.

6.2 Potential future services

A number of other capabilities are being considered for future inclusion in LADT, although no decision to include such capabilities has been made. Other access protocols may later be provided. For example, an asynchronous terminal interface capability may be added allowing asynchronous devices, including most home computers, to access LADT. Full X.25 protocol to terminals might be provided. This would permit subscribers to receive (as well as initiate) data calls and would allow the subscriber to set up multiple, simultaneous data calls. In the future, LADT customers may be able to place data calls to hosts in other LATAs. This would be accomplished using the CCITT X.75 gateway protocol²² between the LADT and various interexchange data networks. Other access arrangements to LADT might be introduced. New billing capabilities may be included along with support capabilities in various operations support systems.

VII. INITIAL EXPERIENCE WITH LADT

The LADT service was initiated by Southern Bell Telephone Co. in the southern Florida LATA on July 1, 1983, using equipment manu-



Fig. 10—The *Viewtron*™ service showing the *Sceptre*™ home terminal.

factured by Western Electric.²³ A local data concentrator called the data subscriber interface is being manufactured by AT&T Technologies, Inc. for LADT. The AT&T Technologies, Inc. packet switch available for LADT is the 1PSS packet switch²⁴ also used in the AT&T Communications basic packet-switching service. The initial application of LADT is the *Viewtron* service provided by Viewdata Corporation of America (see Fig. 10). Subscribers access this service using the *Sceptre** videotex terminal designed AT&T Technologies.²⁵ Twelve

* Trademark of AT&T Technologies, Inc.

southern Florida banks and over fifty information providers cooperate in providing the *Viewtron* service. With *Viewtron* subscribers can read up-to-the-minute news, order merchandise, post bulletin board messages, consult an electronic encyclopedia, play games, and pay bills. It is expected that by the end of 1984, 5000 subscribers will be regularly accessing this service over LADT.

VIII. SUMMARY

LADT represents an important step into the information age. By providing powerful and economic data transmission to homes and small businesses, LADT has opened the door to important new information services. Many new and varied information services may soon be provided over LADT. Our early experience with the service has shown strong customer acceptance. As a result we expect LADT service will become widely available.

REFERENCES

1. J. Tydeman, H. Lipinski, R. Adler, M. Nyhan, and L. Zwimpfer, *Teletext and Videotex in the United States*, New York: McGraw Hill, 1982.
2. H. L. Morgan, "The Interconnected Future: Data Processing, Office Automation, Personal Computing," VACN Symposium, May 1979, pp. 291-300.
3. N. Carruthers, "Personal Computers and Videotex," *Viewdata 82*, London October, 1982, (Middlesex: Online Conferences Limited, 1982), pp. 159-167.
4. The *Viewtron* Newsletter, Viewdata Corporation of America, Inc., Miami, Florida, 3 No. 2, (June 27, 1983).
5. W. B. Cornfield, "Electronic Banking: Why Its Time Has Finally Come," *Viewdata 82*, October, 1982, New York, New York, (Middlesex: Online Conferences Limited, 1982), pp. 343-7.
6. D. Shaider, "Taking Videotex to Market: The CBS Role In The Joint CBS/AT&T Ridgewood Trial," *Videotex 83*, New York, New York, June 27, 1983 (Middlesex: London Online Inc., 1983) pp. 93-8.
7. P. Sternberger, "Dow Jones News Retrieval Service, Videotex 81, Toronto, Ontario May, 1981, (Middlesex: London Online Inc. 1981), pp. 85-94.
8. I. Dorros, "Telephone Nets Go Digital," *IEEE Spectrum*, 20, No. 4 (April 1983), pp. 48-53.
9. F. J. Brophy, G. Herbert Honnold, and S. J. Thayer, "DATAPHONE® II Service—New Standard for Data Communications," *Bell Lab. Rec.*, 59, No. 8, October 1981.
10. L. Tymes, "TYMNET—A Terminal Oriented Communication Network," 1971 Spring Joint Computer Conf. AFIPS Conf. Proc., 38, pp. 211-6.
11. L. G. Roberts, "Telenet Principles and Practice," European Computing Conf. on Commun. Networks, London, England, 1975; pp. 315-29.
12. D. W. Davies, et al., "A Digital Communications Network for Computers Giving Rapid Response at Remote Terminals," ACM Symposium Operating Systems Problems, October 1967.
13. "Compatibility Criteria for Data Set 212A," USITA Technical Advisory No. 20—Revision No. 3, September 1977.
14. N. E. Snow and N. Knapp, Jr., "Digital Data System," *B.S.T.J.*, 54, No. 5 (May-June 1975), pp. 811-32.
15. H. Zimmermann, "OSI Reference Model—The ISO Model of Architecture for Open System Interconnection," *IEEE Trans. Commun.*, COM-28, No. 4 (April 1980), pp. 425-32.
16. CCITT, "Interface Between Data Terminal Equipment (DTE) and Data Circuit-Terminating Equipment (DCE) For Terminals Operating In The Packet Mode on Public Networks," *Public Data Networks, Yellow Book*, 8, Seventh Plenary Assembly, Int. Telecommunications Union, Geneva, Switzerland, November, 1980, pp. 100-89.

17. CCITT, "International Numbering Plan For Public Data Networks," *Public Data Networks, Yellow Book*, 8, Seventh Plenary Assembly, Int. Telecommunications Union, Geneva, Switzerland, November 1980, pp. 245-56.
18. "Local Area Data Transport Terminal Interface Specification," AT&T Preliminary Technical Reference, PUB 54200, June 1982.
19. American National Standard Code for Information Exchange, ANSI X3.4, Amer. Nat. Standards Inst., Inc., 1977.
20. "X.25 Interface Specifications," AT&T Preliminary Technical Reference, PUB 5400, August 1981.
21. "Local Area Data Transport Host Interface Specifications," AT&T Preliminary Technical Reference, PUB 54210, June 1982.
22. CCITT, "Terminal and Transit Call Control Procedures and Data Transfer System on International Circuits Between Packet-Switched Data Networks," *Public Data Networks, Yellow Book*, 8, Seventh Plenary Assembly, Int. Telecommunications Union, Geneva, Switzerland, November 1980, pp. 142-207.
23. H. J. Kafka, W. J. Paule, and D. J. Stelte, "AT&T Technologies Implementation of Local Area Data Transport—A Hardware and Software Overview," *Bell Lab. Tech. J.*, this issue.
24. J. C. Ehlinger and R. W. Stubblefield, "No. 1 PSS Service Capabilities and Architecture," ICC '83, Boston, Mass.
25. Videotex '83, New York City, New York, June 27, 1983.

AUTHOR

M. Niel Ransom, B.S.E.E., 1970, and M.S.E.E., 1971, Old Dominion University; Ph.D., 1973, University of Notre Dame; AT&T Bell Laboratories, 1973—. Mr. Ransom is currently Supervisor of the Switching Architecture Planning Group of the Exploratory Switching Networks Department of AT&T Bell Laboratories. His group is responsible for identifying network applications of emerging switching technology. Prior to this, he held various supervisory positions with applied research and had development responsibility for AT&T products that provide Local Area Data Transport service. As a Member of Technical Staff, he had various responsibilities in switching systems engineering, applied research in voice and data switching, and development of the 5ESS™ switching system.