Digital Multiplexed Interface: 
Architecture and specifications

by JAMES L. NEIGH
AT&T Information Systems
Lincroft, New Jersey

ABSTRACT

The Digital Multiplexed Interface provides cost-effective data connectivity between PBX-based terminals and host computers. DMI uses high-speed digital transmission facilities, common channel signaling, and four data transport modes to provide data connectivity at rates up to 64 Kbps for 23 (30 in the European version) data channels over a single 4-wire interface. DMI is consistent with both the existing and evolving standards for the Integrated Services Digital Network and is probably the first practical example of implementation of an ISDN interface. Since DMI was initially announced in November 1983, over 60 companies have licensed the right to build DMI, and many host and PBX vendors are currently implementing the interface. DMI licensees are aided in their implementations through participation in the DMI Users Group. The Users Group includes detailed information and discussion on DMI implementation, in addition to information on standards activity related to DMI and discussions of plans for continued DMI evolution. DMI's capabilities were demonstrated between an AT&T Information Systems PBX and a Hewlett-Packard 3000 host computer at Interface '85 in Atlanta. PBX and host equipment with DMI interfaces will begin being shipped to customer locations in the second half of 1985.
INTRODUCTION

The Digital Multiplexed Interface (DMI) was defined to provide cost-effective, high-speed interconnection between terminals and host computers in a PBX environment. The DMI definition maintains a balance between maximum use of existing technologies to facilitate early implementations and compatibility with emerging international standards for the Integrated Services Digital Network. DMI takes advantage of existing high-speed digital carrier systems (1.544 Mbps in North America and Japan; 2.048 Mbps in Europe) to provide multiple (23 or 30) 64-Kbps data communications channels over a single physical interface. To provide a smooth evolution to ISDN, DMI uses existing AT&T Information Systems algorithms for data transport over a 64-Kbps channel and confines signaling to a single common channel.

The initial public announcement of support for DMI was made jointly by AT&T Information Systems, Hewlett-Packard Company, and Wang Laboratories in October 1983. Since that time many additional vendors have licensed for the right to develop DMI on their products. This group of licensees includes most of the significant vendors in today's voice/data communications marketplace.

PRE-DMI DATA CONNECTIVITY

Without a DMI-like interface, data communication between a PBX and host computer is limited in several respects. The most common arrangement requires separate wire pairs, a physical termination, and a pair of modems for each data channel. In addition to the obvious cost burdens of this arrangement, functionality is limited by a maximum data rate of 19.2 Kbps.

The economic burden can be eased in some applications through the use of statistical multiplexers to achieve more efficient use of the physical connections. The maximum data rates can be increased through the use of product specific data modules rather than modems. However, none of the existing arrangements provide an efficient means for high-speed multiplexed data transport between a PBX and a host.

Figure 1 shows three alternatives for data transport between a PBX and host: (1) the use of modems on a per-channel basis, (2) product-specific data modules that provide two 64-Kbps data channels per termination, and (3) DMI. Figure 2 shows a relative cost comparison for one example of an intrapremise implementation of each of the three alternatives. As shown in the figure, DMI is more cost-effective than the 2-channel digital interface when three or more data channels are required. Similarly, when compared to the per-channel data modem alternative, DMI is economically attractive when five or more data channels are required. Thus, DMI is an attractive solution even when relatively modest levels of data connectivity are required between PBX-based terminals and the host.

DMI DESCRIPTION

Overview

The North American version of DMI is based on use of the standard DS1 (T-carrier) interface. The DS1 interface is 4-wire and supports a 1.544-Mbps digital signal. The 1.544-Mbps signal is channelized into 24 64-Kbps channels plus one 8-Kbps channel for framing. Channels 1 through 23 are used as information channels; channel 24 is a common signaling channel. Each of the information channels can support standard data rates up to 64 Kbps. In initial applications, the common signaling channel will make use of multiplexed A-bits to indicate on and off hook and dial pulse information. Present plans call for implementation of a message-oriented signaling protocol, which is a subset of the protocol defined by the CCITT for customer access to the Integrated Services Digital Network approximately one year after the initial release of DMI.
The European version of DMI is based on the CEPT standard 2.048-Mbps digital interface. This interface is divided into 32 64-Kbps channels: 30 information channels, a common signaling channel, and a framing channel. Data transport formats are identical for European and North American versions of DMI. The common signaling channel in initial implementations uses the CEPT standard for multiplexed A-bits in channel 16. Later versions will use the CCITT standard message-oriented signaling.

**Connectivity**

The use of standard digital interfaces permits almost unlimited flexibility in the distances over which DMI can be used. For local applications, DMI can operate at distances up to 1300 feet between the PBX and host computer without signal regeneration. For distances greater than 1300 feet, DMI makes use of the standard T-carrier repeater line, or a fiber optic option. The T-carrier facility might be installed on a private basis or leased from a communications provider for long-haul applications. Thus, DMI could be used to link a PBX and host located as close as the same equipment room or as far as opposite coasts of the United States.

In addition to the essentially unlimited distance capability of DMI, the use of standard 64-Kbps channels permits the additional flexibility of switching the individual data channels from one interface to another within a digital PBX. Thus, for PBXs interconnected by DSI facilities, a DMI host at one location can establish a direct 64-Kbps path through its PBX to a terminal or host at a different location. An example configuration is shown in Figure 3. In this example, if the terminals and hosts support common DMI data transport modes and the PBXs support common channel signaling on the inter-PBX links, full connectivity between any pair of terminals and hosts is possible with no intermediate protocol conversions required.

**Physical Interface**

The DMI physical interface is based completely on North American, European, and CCITT standards for the use of digital transmission facilities at 1.544 and 2.048 Mbps. Implementation of the physical interface is identical to implementations on existing digital switching equipment.

Key characteristics of the physical interface are listed in Table 1. Also shown is the identification of the CCITT recommendation which defines each of the characteristics.

**Signaling**

To facilitate early implementations, DMI will support two types of common channel signaling. For initial implementations, and situations in which a sophisticated signaling capability is not required, bit-oriented signaling (BOS) will be used. With BOS, a single bit (A-bit) is assigned to each data channel. The A-bit is used to indicate the state (on hook, A = 0; off hook, A = 1) of its corresponding data channel, and to convey address information. The A-bits are multiplexed in the common channel by assigning the A-bits for consecutive channels to successive frames of the digital signal. In the simplest application of the North American interface, the A-bits for each channel are updated once every 24 frames.

In order to support increased functionality and to establish a clear evolution to ISDN, the initial release of DMI will be closely followed by a version with Message Oriented Signaling (MOS). DMI's message-oriented signaling is a fully compatible subset of CCITT recommendations 1.440/921 and 1.450/931. These recommendations define the Layer-2 and -3 signaling protocols for customer access to ISDN. A few examples of enhancements provided by message oriented signaling are faster call setup, calling number identification, and the ability to send user-to-user information.

**Data Transport**

Four modes, 0, 1, 2, and 3, have been defined for data transport on DMI. Mode 0 is for clear 64-Kbps data transport; in this case, the end user defines the higher layers of the data transport protocols. When defining mode-0 protocols for applications which may include transmission over North American T-carrier facilities, care must be taken to ensure that the data channels meet T-carrier 1's density constraints.

Mode 1 defines unconstrained use of a 56-Kbps data channel. Mode 1 is included in DMI to provide compatibility with Digital Data Service facilities.

Mode 2 is defined to provide transport of synchronous and asynchronous data at standard rates up to 19.2 Kbps. Mode 2's principal application is support of existing terminal equip-

<table>
<thead>
<tr>
<th><strong>Table 1—DMI Physical Interface</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RATE</strong></td>
</tr>
<tr>
<td><strong>NUMBER DATA CHANNELS</strong></td>
</tr>
<tr>
<td><strong>FRAMING</strong></td>
</tr>
<tr>
<td><strong>ELECTRICAL CHARACTERISTICS</strong></td>
</tr>
<tr>
<td><strong>CLEAR CHANNEL</strong></td>
</tr>
</tbody>
</table>

![Figure 3—DMI application example](image-url)
ment using RS232- or V.24-type interfaces. Mode 2 uses an HDLC-based frame approach to rate-adapt the existing data rates to 64 Kbps. The Mode 2 definition also includes a hand-shaking procedure at call initiation to establish various parameters such as speed, full/half duplex, and timing options. Mode 2 also includes an update message which indicates the status of the interface control leads at the remote interface.

DMI Mode 3 provides for statistical multiplexing of multiple data channels onto a single 64-Kbps channel. In addition, each of the multiplexed channels provides reliable data transmission because link layer procedures for sequencing, retransmission, and flow control have been defined. Mode 3 is based on CCITT recommendation I.440/Q.921, which was defined to provide link layer multiplexing of signaling and low-speed data on the ISDN signaling (D) channel.

**DMI SPECIFICATION**

The DMI specification contains a detailed description of the interface. The specification is separated into four basic parts: (1) an overview/introduction, (2) the physical interface description, (3) the common channel signaling protocols, and (4) the data transport formats. Issue 1.0 of the specification was made available to the general public at the March 13, 1984, meeting of the Electronic Industries Association TR41.1. Issue 1.0 was incomplete in that the message-oriented signaling protocols were not fully specified and the Mode 3 data transport format had not yet been introduced. Since the release of Issue 1.0, the DMI specification has been significantly enhanced through the introduction of new technical material and the addition of clarifying text. The present issue of the specification, Issue 3.0, presents a mature view of the interface. No significant changes to the existing sections of Issue 3.0 are anticipated. However, additions to the specification may be made to introduce enhancements which are a natural part of any evolving interface.

**IMPLEMENTATION SUPPORT**

DMI licensees are supported in their development of the interface by the availability of devices for DMI implementation and by membership in the DMI users group. Both Rockwell International and AT&T Technologies provide devices for implementation of the DS1 physical interface, and for the per-channel HDLC handling that is required for implementation of Mode 2 and Mode 3 data transport. The Rockwell DS1 devices are part of their standard DS1 chip set and are currently available. The Rockwell per-channel HDLC device, called the Highly Integrated HDLC Interface (HIHI), is under development. HIHI will provide 24 or 30 HDLC interfaces on a single chip. It is being developed specifically for DMI implementation. Initial availability is expected by the end of 1985.

The AT&T Technologies DS1 chip set is also currently available for DMI implementation. The AT&T Technologies HDLC device is called the Spyder. It is a general-purpose HDLC device with eight channels per chip. First availability of Spyder is also expected by the end of 1985.

The DMI user group was initiated to aid licensees in their implementation of DMI. A typical user group meeting will provide licensees with a status report regarding latest developments on the interface, explain technical details of the DMI specification, discuss implementation issues ranging from devices to certification testing, and answer any licensee questions. User group meetings have been held approximately every 4 months and have received a very favorable reaction from the licensees.

**ISDN STANDARDS**

DMI has been proposed as an industry standard for PBX to host data communication. In defining DMI, care was taken to ensure that DMI is consistent with the evolving standards for the Integrated Services Digital Network. The first set of formal recommendations for ISDN were approved at the CCITT Plenary Assembly in October 1984. The aspects of ISDN included in DMI are the primary interface rate, the DS1 physical interface, message-oriented common channel signaling, and the support of 64-Kbps clear channels. As such, DMI is a member of the ISDN interface family, and implementation of DMI is both consistent and compatible with the support of ISDN interfaces to both public and private networks.

In addition to adopting appropriate CCITT Recommendations in DMI, various aspects of the interface have been discussed within the Electronic Industries Association and the European Computer Manufacturers Association. Examples of ongoing activity of significance to DMI includes an ECMA effort to establish ISDN-based standards for interfaces between Data Processing Equipment and Private Circuit Switched Networks and CCITT efforts to establish a packet-oriented data transport protocol for use on ISDN bearer channels. The ECMA draft standard for a Q.931-based signaling interface is essentially equivalent to Message Oriented Signaling on DMI. Because of its outgrowth from the ISDN D-channel protocol (LAPD), one candidate for packet mode transport on ISDN bearer channels is a generalization of DMI Mode 3.

**SUMMARY**

DMI provides a cost-effective interface for multiplexed PBX to host data communication. Because it is based on the use of standard T-carrier facilities and 64-Kbps transmission and switching, applications of DMI can provide data connectivity over geographically dispersed private networks. DMI has been defined to provide an implementable interface for today’s applications and to be consistent with the evolving standards for the Integrated Services Digital Network.

Many major suppliers in the voice/data communications marketplace have licensed DMI and are building the interface on their forward-looking products. Implementation support is provided to these vendors by encouraging the availability of appropriate devices and through formation of the DMI Users Group. Implementation of DMI is an opportunity to provide a cost-effective interface providing a clear path for product evolution toward ISDN.