
Draft for Development

Token ring local area networks

Part 2. Guidance for implementors

Contents

	Page		Page
National foreword	Inside front cover	C. Token monitoring	33
Committees responsible	Back cover	Introduction	33
		Distributed control	33
Draft for Development		Timers	35
Preface	3	D. Token ring network management	37
Introduction	5	Problem determination	37
Background	5	Ring fault detection	37
OSI reference model in relation to IEEE 802.5	6	Ring fault isolation and reconfiguration	38
Overview of IEEE 802.5 operation	8	Other network management consideration	41
Token-passing ring	10	E. Definitions and abbreviations	42
The physical control layer	11		
How a station attaches to a token-passing ring network	11	Figures	
Station insertion and removal	11	1. The family of IEEE 802 Local Area Network Standards	3
Use of differential Manchester encoding	13	2. Relation of OSI Reference Model to LAN Model	7
The media access control sublayer (ring access method)	14	3. Token-Passing Ring Configuration	8
Ring operation	17	4. Ring station attachment to the ring medium	12
Reliable token operation	19	5. Differential Manchester Code	13
Service specifications	20	6. Token Structure	14
Notes to implementors	21	7. Frame structure	15
General requirements	21	8. IEEE 802.5 Finite State Machines	17
Configuring a ring network	22	9. Service Specifications	20
Trunk Coupling Units (TCUs)	23	10. Wiring topology and components of a token-passing ring	22
Bridges	23	11. Multiple-bridge LAN with ring backbone	24
Gateway function	25	12. Multiple-bridge LAN with broadband backbone	25
Basic wiring in a ring LAN	26	13. Source and destination addresses, and their position within a frame	28
		14. Priority scheme with uniform access	32
Appendices		15. IEEE 802.5 Timer descriptions and recommended values	36
A. Addressing	27	16. Ring reconfiguration after wrapping	40
Multiplexing	27		
The destination and source addresses	27		
Routing	29		
B. Priority scheme	30		

This publication is not to be regarded as a British Standard.

It is being issued in the Draft for Development series of publications and is of a provisional nature because the application of standardization to LAN technology is rapidly advancing and not yet sufficiently stable, pending the outcome of deliberations in the International Standards Committee (ISO/TC 97/SC 6 Data Transmission).

It should be applied on this provisional basis, so that information and experience of its practical application may be obtained.

A review of this Draft for Development will be carried out not later than two years after its publication. Notification of the start of the review period, with a request for the submission of comments from users of this Draft for Development, will be made in an announcement in the appropriate issue of *BSI News*. Observations which it is felt should receive attention before the official call for comments will be welcomed.

According to the replies received, the responsible BSI Committee will judge whether the Draft for Development can be converted into a British Standard or what other action should be taken.

National foreword

This Draft for Development has been prepared under the direction of the Office and Information Standards Committee.

This Draft for Development complements DD 136 : Part 1 by giving guidance to implementors, and is identical to the Technical Guide on token ring LANS which was previously available from the Department of Trade and Industry as TG 101/4.

Information on related standards and Drafts for Development is given in the introduction to DD 136 : Part 1.

A brochure giving details of existing and projected British Standard publications for Open Systems Interconnection (OSI) may be obtained from the Sales Department, BSI, Linford Wood, Milton Keynes MK14 6LE.

Terminology and conventions. The text of Technical Guide TG 101/4 has been approved as suitable for publication as a Draft for Development without deviation. Some terminology and certain conventions are not identical with those used in Drafts for Development; attention is drawn especially to the following.

Wherever the words 'IEEE Standard 802.5' appear they should be read as 'DD 136 : Part 1'.

PREFACE

The Institute of Electrical and Electronic Engineers standard 802 (IEEE 802) is a family of standards for local area networks (hereinafter referred to as LANs). Various definitions exist, but essentially a LAN is a data communications network in a limited geographic area with the following major characteristics:

- * high-speed data transmission, most often in excess of 1 Mbps (1 million bits per second)
- * privately-owned transmission media wholly on the premises of the owner (ie not crossing a public-right-of-way)
- * providing access to a heterogeneous mix of data processing machines including (personal) computers, office systems and word processors, cluster controllers and terminal devices.

The relationship among the IEEE 802 family members is as shown below:

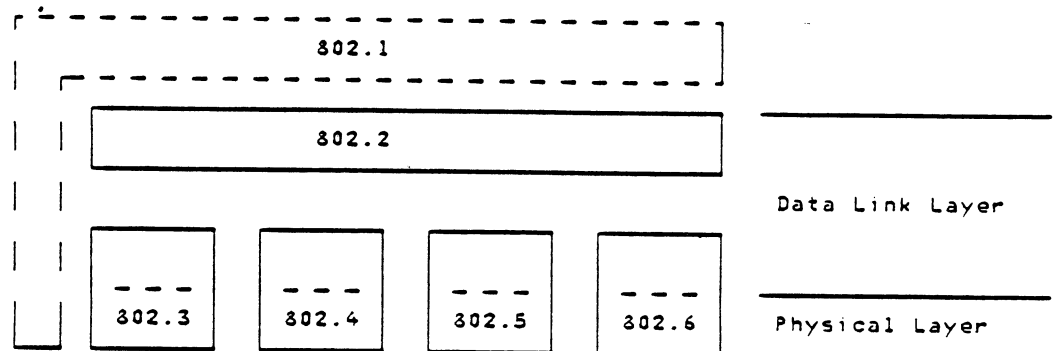


Figure 1. The family of IEEE 802 Local Area Network Standards

The IEEE 802 family of standards is directed at the Physical and Data link layers as defined by the International Standards Organisation (ISO) in their Open System Interconnect Reference Model (OSI RM). It should be understood that for communications between business machines to be meaningful, equivalent function to that specified in all the layers of the OSI RM must also be supplied. This is more fully explained in the introduction. As the figure shows, the IEEE 802 Standard defines four types of medium access technique with their associated physical media, each appropriate for particular applications or system cost objectives. These four standards are:

- * IEEE Standard 802.3, a bus using the Carrier-Sense Multiple-Access with Collision Detect (CSMA/CD) media access technique
- * IEEE Standard 802.4, a bus using the token passing media access technique
- * IEEE Standard 802.5, a ring using the token passing media access technique
- * IEEE Standard 802.6, a metropolitan area network.

The common Logical Link Control Standard (LLC), IEEE 802.2, is intended to be used in conjunction with the four medium access standards.

A companion document, IEEE 802.1, describes the relationship among these standards and their relationship to the ISO OSI RM in more detail. It also explains the relation of the IEEE 802 Standards to higher layer protocols, and discusses internetworking and network management issues.

INTRODUCTION

Before launching into a description of IEEE 802.5, it is as well to understand the business and technological drives which have aroused such an interest in local area networks. Also presented in this section is a brief overview of standards activity in other areas of systems interconnection.

BACKGROUND

The present trend towards distributed data processing, and office automation, together with a decrease in the cost of component parts, has created a need for greater flexibility in the attachment and interconnection of data processing and office equipment. In a recent American survey, the majority of office managers and executives reported the need for a multifunction, automated office-type workstation. The survey revealed that the most sought-after features of this workstation are:-

- * Ability to communicate with other devices
- * Easy attachment of peripheral devices
- * Easy access to multiple databases
- * Standalone processing ability

The devices would typically be supplied by a variety of different vendors, and would encompass data, text, image etc, and include devices for filing and indexing of information as well as its transmission.

Other surveys have suggested that in many organisations, over 80% of the information generated within an establishment stays within it, and only 20% is transmitted outside. All this has led to an interest in LANs for the connectivity and high speed transmission they promise.

Certainly high speed transmission is achievable; connectivity, depending on how it is interpreted, could prove more troublesome.

A LAN is defined by the IEEE Project 802 as follows:-

A LAN is distinguished from other types of data networks in that the communication is usually confined to a moderate-sized geographic area such as a single office building, a warehouse, or a campus, and can depend on a physical communications channel of moderate to high data rate which has a consistently low error rate.

The geographical constraint, by eliminating the need for common-carrier facilities, enables very high transmission speeds (in excess of 1 million bits per sec) to be reached at a reasonable cost.

Today's technology allows data transmission at speeds of up to about 12 Mbps on coaxial cable as long as the distance between stations or repeaters is small (in the order of hundreds of

metres).

Many devices currently attach to tele-communications media using one of the many physical layer standards currently defined. The ubiquitous CCITT V24 interface standard can be cited as an example. By providing an adapter with a V24 interface on one side and some form of multiplexing the high-speed cable on the other, (eg CSMA/CD - Carrier Sense Multiple Access/Collision Detection) we could boast high-speed any-to-any connectivity. Certainly we are providing a method of sharing a piece of cable, however, if we need to exchange data between the devices, then we are a long way short of this goal. Behind the device's V24 interface is an implementation of a data link layer (often referred to as DLC, 'data link control') such as BSC (Binary Synchronous Communications) or HDLC (High-level Data Link Control), and behind DLC, higher-level protocols for network routing, for controlling end-to-end flow, for synchronisation/checkpointing facilities, for presentation services etc. Without matching higher-level protocols, communication is impossible.

The lower-level protocols, whilst necessary, are not themselves sufficient. A useful analogy is the international telephone network allowing connections between countries. Although it is possible for an English subscriber to dial and connect to a subscriber in Japan, intelligent communication is impossible without a higher-level common protocol, in this case a common language.

What a LAN can do, by providing common access to a common high-speed cable, is to enable a building to be pre-wired for the needs of data communications devices over the life of the building in much the same way as is done for telephones today. Anyone involved in installing cable to accommodate an extra terminal will fully recognise the advantages that pre-wiring can bring. (It is worth noting that some studies have shown that in the case of incremental installations, the cost of pulling cable can sometimes exceed the cost of the terminal itself).

The trend towards office automation requires the inter-connection of a wide variety of terminal and communication device types, often from different vendors. Technology trends suggest that such devices will in future need to encompass data, text, image, graphics, voice and video. These requirements motivate LAN designers to provide methods of local high-speed communications, whilst ensuring the continued interest of the standards authorities.

OSI REFERENCE MODEL IN RELATION TO IEEE 802.5

All communications, whether local or remote, whether high-speed or slow, need functions such as controlling the flow of data, ensuring that messages are received in the proper sequence, interpreting the data etcetera. It is not possible to describe in depth all of the functions needed when communication between data processing machines is desired in a document such as this. There are many books and papers available dedicated to computer network communications, the reader is referred to [1] as a recent example. Since there are bodies already at work attempting to standardize

these functions, we should understand how IEEE 802 relates. A large body of reference work already exists defining these functions, [1] is a recent example. The International Standards Organisation (ISO) has sponsored the definition of an 'Open Systems Interconnection-Basic Reference Model' [2] to facilitate communications between systems which have been independently designed and implemented, and several computer manufacturers have their own 'standards' for communications of which IBM's Systems Network Architecture (SNA) [3] is an example.

It is not the purpose of this document to describe the whole communications process in detail, suffice it to say that a LAN essentially has the same communications needs as a traditional wide-area network, differing only in how the physical connection is managed. The relationship between the IEEE 802 LAN architecture and the ISO OSI-RM is depicted in figure 2. IEEE 802 specifies formats and protocols equivalent to those specified in the OSI Reference Model at the physical and data link layers.

References

- 1 Tanenbaum, A S, Computer Networks, Prentice Hall Inc., 1982.
- 2 International Standards Organization, ISO/TC97: IS7498 Open Systems Interconnection - Basic Reference Model
- 3 IBM Corporation, Systems Network Architecture-Concepts and Products, GC20-3072.

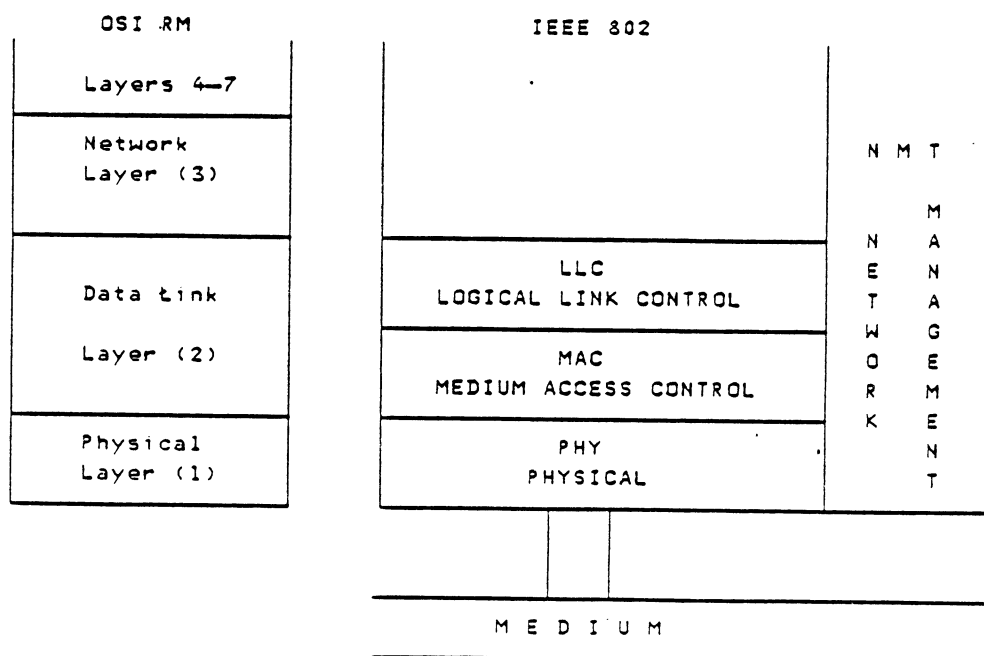


Figure 2. Relation of OSI Reference Model to LAN Model

OVERVIEW OF IEEE 802.5 OPERATION

The IEEE 802.5 Draft Standard employs a high-speed ring configuration as illustrated in figure 3.

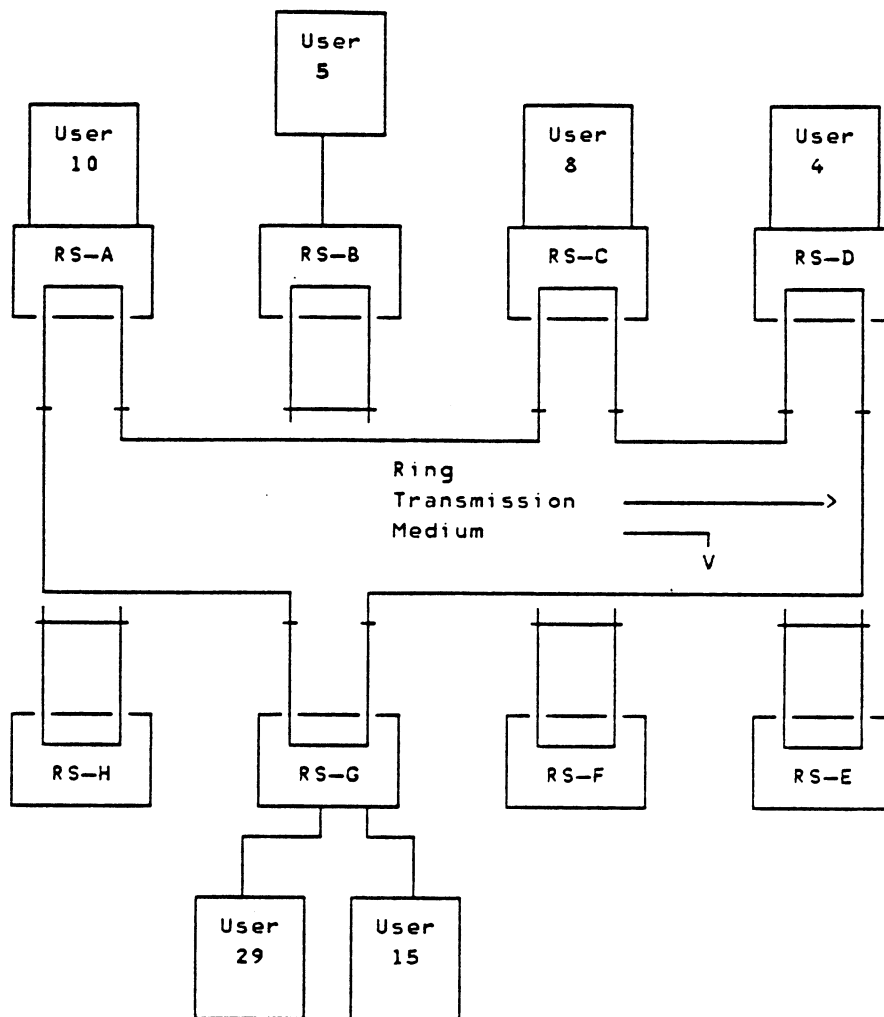


Figure 3. Token-Passing Ring Configuration: Eight ring stations are shown, 4 of which are active (or 'inserted' into the the ring) and 4 are inactive (or 'bypassed'). Ring station G is shown with 2 users (there is no upper limit to the number of users a ring station can have), and ring stations A, C and D are shown with integral user stations.

The ring itself consists of a number of ring stations serially connected by a transmission medium. Data is transferred serially, bit by bit from station to station. A station contains the necessary hardware and software to attach to the transmission medium, transfer, repeat and/or receive data in accordance with IEEE 802.5 specifications, and provide attachment for the ring user. The ring user must provide an interface to the ring station for the purpose of data transfer, as well as provide the necessary programming for higher-level communications functions (eg the logical link layer as specified in IEEE 802.2). In this sense, a ring user is a combination of a data processing device, computer (personal or otherwise), workstation etc, and data communications software.

A station transfers data from one of its users to the transmission medium where the data circulates from station to station. When regenerating and repeating a received bit stream, each active station must introduce a fixed delay which is a minimum of 1 bit but which can be in excess of this. This delay is speed independent, and allows a station to modify certain bits in the incoming stream before retransmitting them (see 'Entering repeat state' under Ring Operation, for example). Thus the time taken for a bit to traverse the whole ring is the sum of all the delays of all the active station plus the ring propagation delay. This time is known as the ring latency.

The addressed station (or stations in the case of a group or broadcast transmission) copies the data into a buffer as the data passes. Upon arriving back at its originating station the data is removed from the ring. This function is known as 'stripping' and is explained under Ring Operation.

Ring configurations are not new: the basic circular data path was originally used in loops [1]. Access to the use of loops is most often controlled centrally, with one station acting as a 'primary' and polling all other stations. In practice the 'primary' station was a controller or host computer, while the other 'secondary' stations were terminals with limited processing capacity. Communications between terminals was only possible by using the facilities of the 'primary' station.

In ring systems today, stations require to be able to communicate directly, without the need of an intermediate station. One of the motivations for this was to avoid the potential reliability problem of a single station controlling all communications.

Various methods of allowing peer use of rings have been proposed among them, slotted-ring as used in The Cambridge Digital Communication Ring [2], and register-insertion [3]. The token-passing access method at the heart of IEEE 802.5, when compared to other access methods, has superior delay-throughput characteristics [4]. Delay is defined as the time interval from packet generation at the source station, until its reception at the destination station.

TOKEN-PASSING RING

On a token-passing ring, permission to transmit is controlled by a token. The token is a unique signalling sequence which circulates around the ring between data transmissions. A field within the token indicates the current ring priority. A station with data to transmit, first waits for a token with the appropriate priority. When the token arrives, it is 'captured', and in its place a frame containing the data is transmitted. This is accomplished by modifying the appropriate control and status fields in the token and appending source and destination addresses, an information field and frame check sequence. The frame thus transmitted, eventually returns to the originating station where it is removed and a new token transmission initiated.

The maximum time between token capture and the initiation of a new token transmission is controlled by a token holding timer.

Since stations are denied access until they acquire an appropriate token, adequate detection and recovery mechanisms are provided to ensure that the token is protected from transmission errors and electrical noise (such as occurs when a station is inserted or removed from the ring). This is accomplished by a monitor function (see Appendix C 'Token Monitoring') residing in a single station with back-up capability in all other active stations.

References

- 1 Hippaert, R O, IBM 2790 Digital Transmission Loop, IBM Journal of Research and Development, Vol 14, No 6, November 1980, pp 662-667.
- 2 Wilkes, M V and Wheeler, D J, The Cambridge Digital Communication Ring, Proceedings of the Local Area Communications Network Symposium, Boston, May 1979.
- 3 Liu, M T and Reames, C C, Message Communication Protocol and operating system design for the distributed loop computer network (DLCN), Proceedings of the 4th Annual Symposium on Computer Architecture, March 1977, pp 193-200.
- 4 Bux, W, Local-Area Subnetworks: A Performance Comparison, IEEE Transactions on Communications, Vol COM-29, No 10, October 1981, pp 1465-1473.

THE PHYSICAL CONTROL LAYER

HOW A STATION ATTACHES TO A TOKEN-PASSING RING NETWORK

A ring station connects to the ring medium by means of a medium interface cable. In order to facilitate ring station insertion and removal, a Medium Interface Connector (MIC) is defined.

Figure 4 shows the relative positions of the ring station, the MIC and the Trunk Coupling Unit (TCU). The MIC is an hermaphroditic (mates with itself and thus is both a plug and a socket) connector and may be sited anywhere from the ring station itself to the TCU. The MIC specifications can be found in IEEE 802.5 Appendix B; but essentially it connects the ring station to the ring medium. An example of how this can be implemented can be found in 'Notes to Implementers'. The MIC is the connector at which all transmitted and received signals are specified.

Both the PHY/MIC and the TCU/MIC cable are shielded cable containing two balanced 150 +/- 15 ohm twisted copper pairs.

Station Insertion and Removal

As conveyed in figure 4, the TCU contains the necessary electronics (bypass relays for example) for ring station insertion and removal.

The ring station itself initiates its own insertion into the ring by sending a DC (direct current) voltage on the medium interface cable. The DC voltage is transparent to the passage of transmitted symbols and hence is also known as a 'phantom' voltage. The TCU reacts to the phantom voltage by switching the ring station serially into the ring. Similarly, as soon as the TCU detects no phantom voltage, the ring station is bypassed and put into its own loop (see figure 3, RS-E for example). The phantom voltage circuit is designed in such a way as to detect open-wire and short-circuit faults in the medium interface cable (the transmit and receive pair both have phantom voltage circuits, and therefore a DC imbalance may be detected). In this manner, faults in the medium interface cable, and some ring station faults automatically cause the faulty ring station to be bypassed, thus optimising ring availability and providing a large measure of automatic fault insulation.

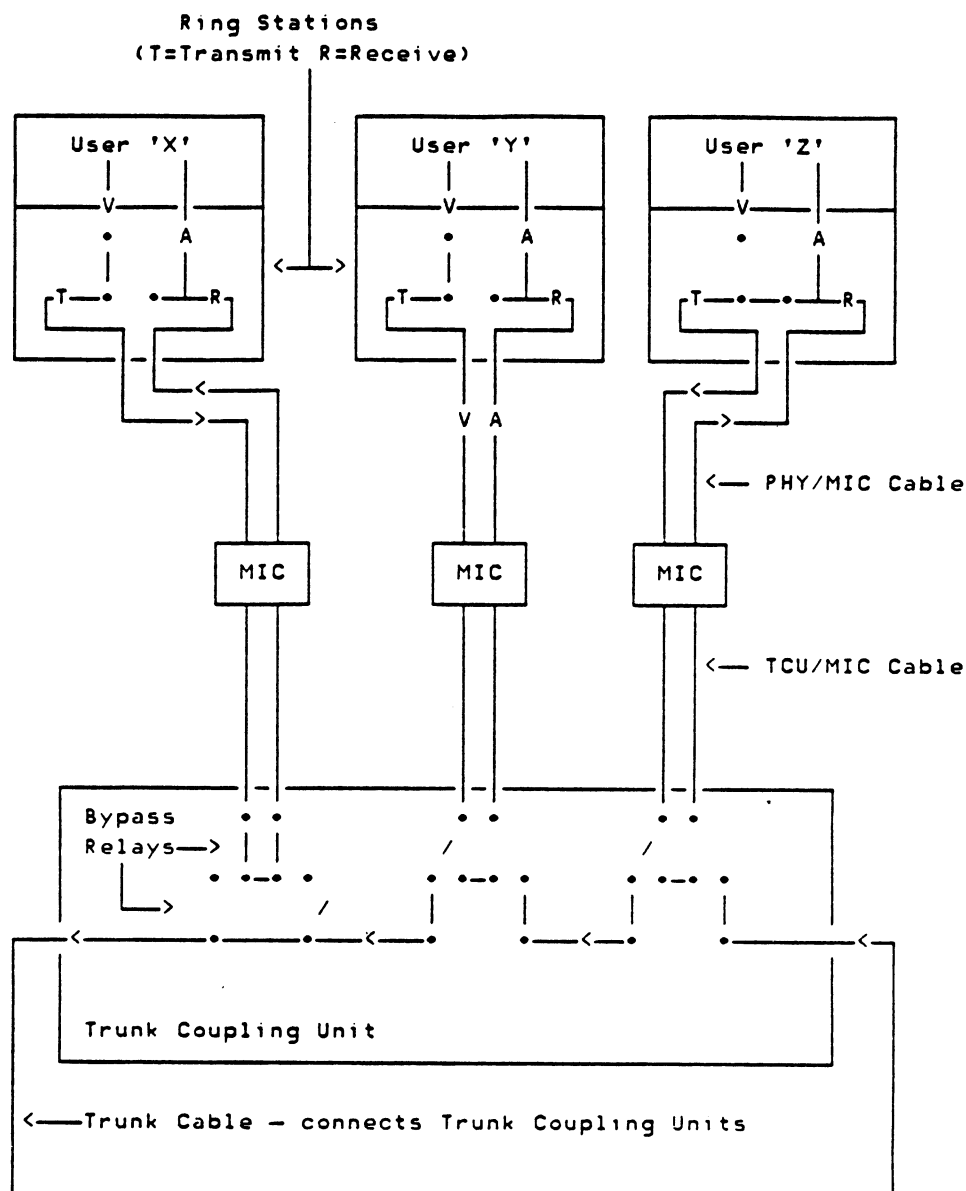


Figure 4. Ring station attachment to the ring medium: The figure shows only one user per station, in practice, there may be more. User X is shown to be bypassed, User Y is transmitting, while User Z both receives and repeats onwards and back to User Y.

USE OF DIFFERENTIAL MANCHESTER ENCODING

IEEE 802.5 uses a differential Manchester code to convert binary data (bits) into signal elements. Manchester encoding was chosen because the receiver can derive clocking pulses from the encoded signal.

The code consists of two signal elements of opposite polarity for each bit of data. This technique maintains the DC balance in each bit, and guarantees a transition so that clocking pulses can be recovered. A bit is determined as being a '0' or '1' by comparing the first signal element of the bit with the last signal element of the previous bit. If the signal elements have the opposite polarity (ie a transition has occurred at the bit boundary), then the bit is a '0', otherwise it's a '1' bit. This is illustrated in Figure 5.

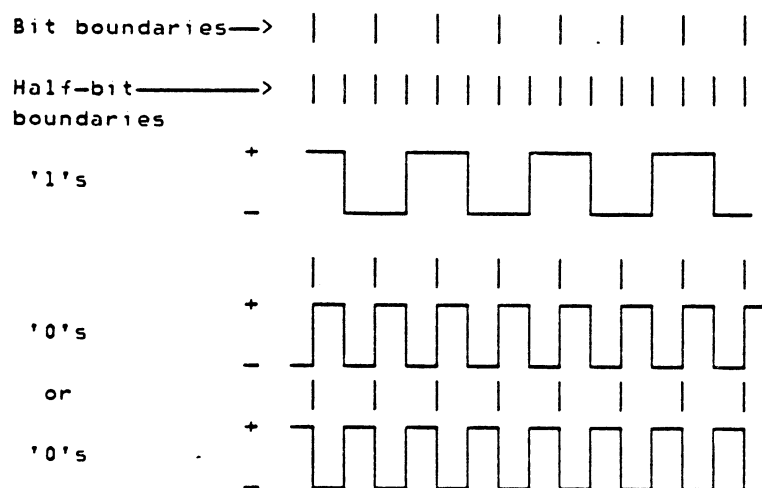


Figure 5. Differential Manchester Code

The polarity (positive or negative) of the signal element does not effect the decoding of the bits, only the transition - or lack of one - at the bit boundary is used in decoding.

Of course it is possible that no transition occurs at the bit midpoint, and therefore neither a '0' or '1' is encoded; these 'non-data' codes are used as frame delimiters, and thus enable all data to be transmitted and received transparently. (Compare this to the encoding used in HDLC for example, where six consecutive '1' bits delimit a frame, and thus any data containing five consecutive '1' bits must be modified before transmission and after receipt). The transmission of only one 'non-data' symbol introduces a DC component into the ring, and so to avoid accumulating DC components, 'non-data' symbols are usually transmitted in pairs, one of each polarity. A 'non-data' symbol is called a 'non-data-k' if a transition occurs at the symbol boundary, and a 'non-data-j' if no such transition occurs.