New digital transmission services for the business community

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Summary For many years digital transmission equipment has been installed in telephone networks, yet has not been extended to customers' premises to provide improved data services. This article describes the Marconi equipment that has been designed in conjunction with British Telecom to bring all the advantages of digital transmission to the customer with data transmission needs. British Telecom is using this equipment to provide a digital leased-line service in the UK called 'Kilostream', which will be of particular benefit to the business community.

In essence, the system consists of a digital local-line system operating at up to 64kbit/s feeding a 2Mbit/s multiplexer with 64kbit/s timeslot access on 31 channels. This enables data terminals operating at 2·4, 4·8, 9·6, 48 and 64kbit/s to transmit to remote sites, using the digital trunk telephone network as a bearer.

The demand for such a service is discussed, together with the availability of suitable transmission plant. Also the customer interface is described, and the method of routing and of synchronization, as well as the powerful supervisory and alarm system. Lastly, the scope for further development is explored.

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Introduction

Data transmission is at a point of change. Since the 1960s, modem designs have evolved to become today's complex and sophisticated devices, providing up to 16kbit/s transmission over an analogue voice bandwidth telephone channel, and 168kbit/s over a group bandwidth channel. These modems, together with the use of intelligent multiplexers and centralized network control equipment, have been used to set up very elaborate private networks, which in many cases form a fundamental part of the management and operations of major organizations.

It would be ridiculous to suggest that all this is suddenly going to change. However, there is now a growing realization that digital transmission facilities can be made available today which offer improved performance and much higher bit-rate transmission at a lower inherent cost. The reason for this is the steady investment that has been made by PTTs around the world over the last twenty years in digital transmission equipment for the telephone service. In the next few years many countries will be able to offer to subscribers fully digital services operating at 64kbit/s and 2Mbit/s (or higher) using plant which has been installed essentially for the telephone service. The impact of these transmission services on today's and tomorrow's data networks will be considerable, and the following paragraphs discuss the demand for, and the evolution of these services. The Marconi equipment which will be in production shortly to provide them is also introduced. Later articles will describe the equipment in more detail.

Growth in data transmission

In the last ten years data forecasts have tended to underestimate the growth that has occurred in data transmission. This can be seen in the various studies undertaken for the European PTTs. The latest report – Eurodata 79 – sponsored by the Eurodata Foundation on behalf of 18 European PTTs, indicates that in 1979 revenues from data services had reached 5% of total PTT revenues. It also forecasts that by 1987 the number of network connections for data applications will increase fourfold and the volume of data traffic about sevenfold. Clearly, the situation is very buoyant, with the United Kingdom (UK) remaining the largest user of data communications in Europe.

The report states that, in 1979, 59% of connections were on analogue leased lines carrying 92% of all transactions; 38% of connections were on the switched telephone network, and a small proportion were on the new data networks currently being established. The report forecasts that, by 1987, 30% of data connections will be on public data networks, and person-to-person communications and information retrieval will provide the most significant growth. General management use of data communications will continue to be the leading application.

A major conclusion in the report is that the most important task that PTTs can carry out in the next few years is the provision of public data networks and digital leased-line services. The data networks referred to

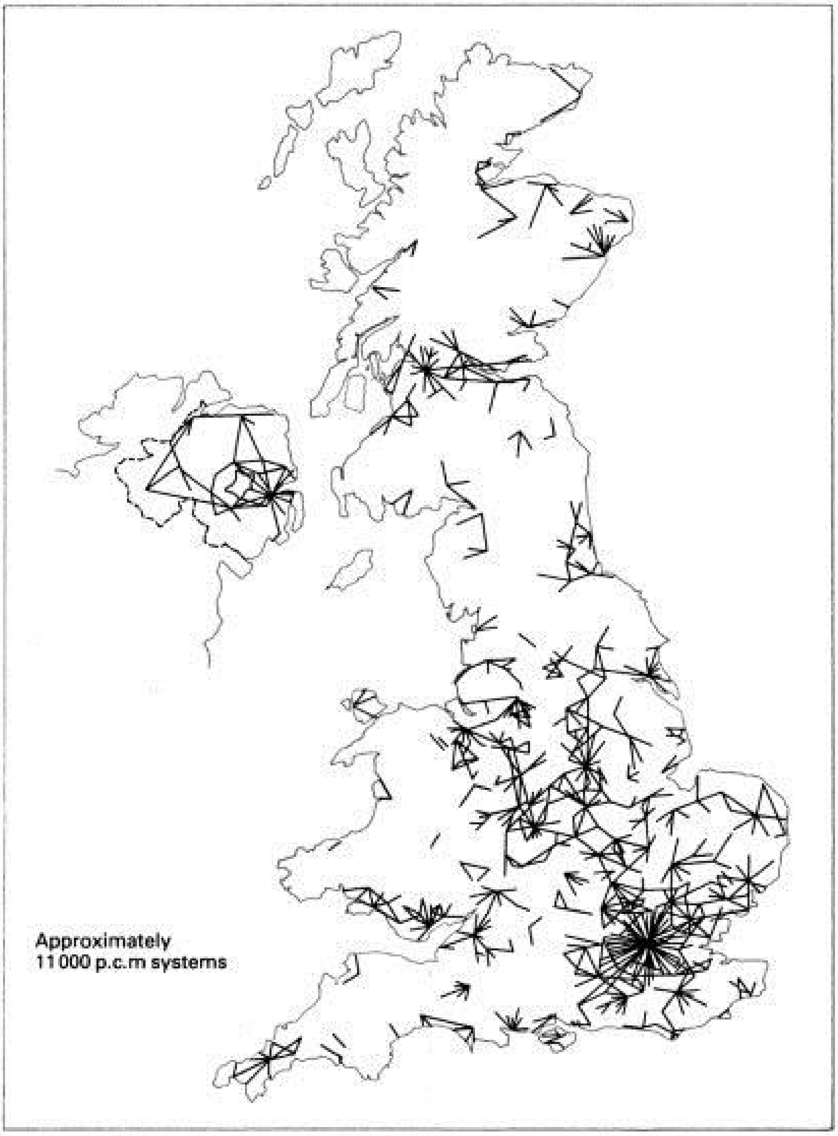

Fig. 1. Digital junction systems – April 1981

are able to offer substantial advantages over the use of the switched telephone network. These include rapid response, error control, automatic re-routing, speed independence and multiplexing. However, tariffs tend to be high at present due, in no small part, to the use of analogue transmission techniques for local access and trunk transmission. It is clearly most important that digital transmission is introduced at the earliest possible time. Its introduction will also enable higher data rates to become economically attractive.

Growth in digital telephony

The last twenty years has seen the steady introduction of digital telephony transmission systems into junction and trunk telephone networks. Initially this was done to increase capacity between telephone exchanges utilizing existing cables and ducts, but the trend towards digital working as a means of creating a more flexible and economical telephone network has escalated the levels of digital procurement. As an example of the penetration of this equipment, figure 1 shows the current provision of digital junction circuits in the UK. In addition, by September 1983, digital trunk systems operating at 8Mbit/s, 120Mbit/s and 140Mbit/s will have connected together the main business centres of the UK (figure 2) using copper cable, fibre optic cable and microwave radio bearers. Thus the benefits of fully digital data transmission can be brought to a great many subscribers in this timescale, by installing suitable multiplex equipment in local telephone exchanges and providing appropriate line (or radio) systems to the subscribers' premises.

Digital telephony can be seen as evolving in a number of stages:
Stage 1. An expedient used to expand point-to-point capacity.
Stage 2. The integration of digital transmission and time-division switching, leading to a considerable reduction in overall costs and an increase in operational flexibility, i.e the concept of IDN – The Integrated Digital Network.
Stage 3. The evolution of this to provide a single network to cover the needs of all likely new customer services whether voice, data or video, i.e the concept of ISDN – The Integrated Services Digital Network.

The creation of an IDN in the UK is well under way using System X exchanges, interconnected by digital transmission equipment. Currently, considerable resources are being employed in determining the facilities that need to be provided to create an ISDN. However, there is much to define, and a long road ahead, before international agreements are reached. In particular, recommendations on new subscriber interfaces and signalling systems are likely to require protracted discussion. In the meantime, the digital transmission capability is available, particularly in and between business communities, and existing customer interfaces and data rates can be used. In addition, the liberalization of the PTT monopoly in the UK, which may well be followed in other countries, is likely to hasten developments and to enable many new services to be introduced making use of digital leased lines.

The realization of a digital data transmission service

The previous paragraphs have indicated the demand for improved data transmission services and the availability of suitable digital bearers. The following paragraphs discuss the requirements for subscriber access and multiplexing in the local exchange, in order to be able to provide a digital data service.

As it is not a practical proposition at present to introduce regenerators into existing local cables, the provision to the subscriber of 2Mbit/s (or higher) services inevitably means the installation of special cable (copper or optical

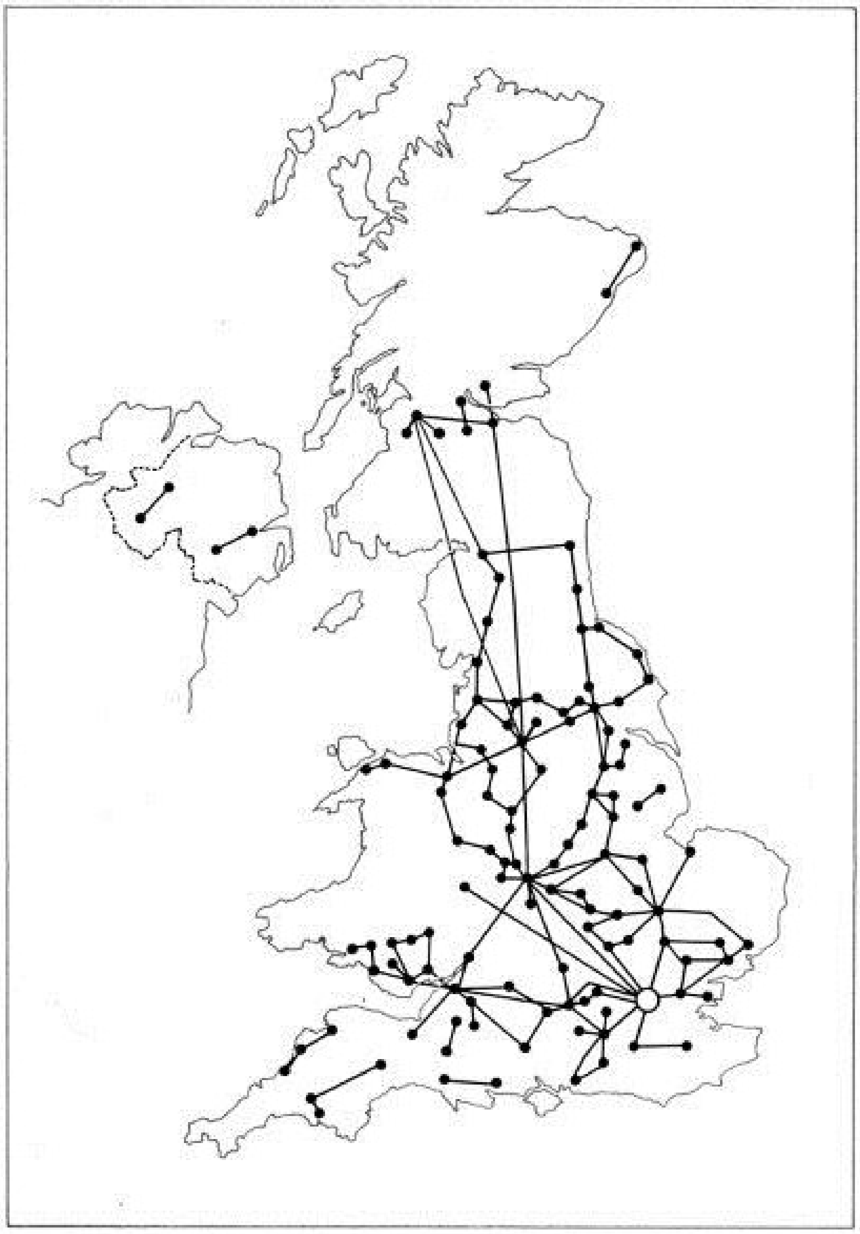

Fig. 2. Digital trunk systems – September 1983

fibre) or radio between the subscribers' premises and the local telephone exchange. However, at 64kbit/s a simple baseband transmission system can be used on existing cables without the use of regenerators. This gives a good digital performance within the existing telephone planning limits for local connections, i.e a maximum attenuation of 10dB at 1600Hz when terminated in 600Ω. The actual maximum distance will be dependent upon the size and type of existing cable, but typically would be about 5km. Also, moderately higher data transmission rates can be transmitted over shorter distances.

At the local telephone exchange, 64kbit/s signals need to be multiplexed together to provide a standard 2Mbit/s signal for onward transmission on existing digital line systems. This can be achieved in three ways:

a) a 2Mbit/s line system can be intercepted by a device which provides access to a limited number of 64kbit/s timeslots in the frame format of the existing system. This is an inelegant, expensive and inflexible solution;

b) a new generation p.c.m multiplex can be installed which has 64kbit/s timeslot access facilities built-in. These tend to be limited to about six channels, a restriction which creates problems of channel flexibility;

c) the Marconi solution is the provision of a dedicated data multiplex. This is basically a time-division multiplex using the same frame structure as standard p.c.m but without the complexity of speech encoding and speech signalling. This means that the p.c.m signalling channel – Timeslot 16 – is available for subscriber use as a normal 64kbit/s timeslot, and therefore the multiplex provides 31 subscriber channels of 64kbit/s. Timeslot 0 is used for framing and network management in the normal way. As this is a new device it is possible to build into the design an '$n\times64$kbit/s' capability, where n is any integer up to 30. For example, a possible subscriber rate of 640kbit/s ($n=10$) can be accommodated.

Subscriber interface and signalling methods

The universally accepted subscriber interfaces for conventional data applications are covered by the CCITT V-Series Recommendations for data transmission over the telephone network. In particular V24 and V28 cover the functional and electrical characteristics of the interface between the data terminal or computer (called the data terminal equipment or DTE in CCITT parlance) and the modem (called the data circuit terminating equipment or DCE). The procedural aspects of the interface are covered by the respective modem recommendations, e.g V21, V22, V23, V26, etc. V35 and V36 cover all aspects of 48kbit/s transmission.

However, a new set of recommendations covers interconnection on Public Data Networks, and these are in the X-Series. X24 covers function and describes a simplified set of interconnection wires (figure 3) when compared with V24. X26 and X27 (equivalent to V10 and V11) cover the electrical characteristics and provide an improved performance over V28 requirements. X21 defines a general-purpose interface for synchronous operation on public data networks, and is intended to be the basic interface for circuit-switched, packet-switched and leased-line services.

Data transmission over the switched telephone network makes use of telephone signalling techniques for setting up, maintaining and clearing a call, and modem generated tones for controlling the flow of data. As data transmission often occurs in short, fast bursts, it is necessary to have signalling and control methods which match this requirement, and this is the basis of the X21 procedures. Also, current

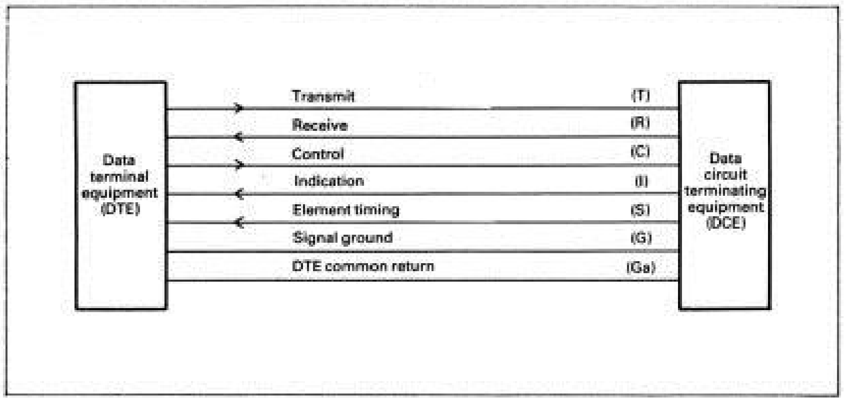

Fig. 3. X21 DTE/DCE interface

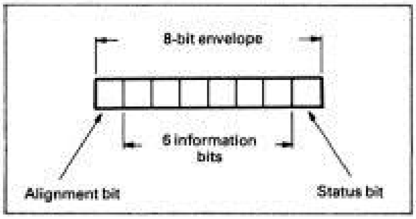

Fig. 4. 6+2 envelope format

analogue telephone exchanges and signalling techniques will not be part of dedicated data networks, making it essential to define new methods.

The procedures defined in X21 make use of two control wires (actually pairs) on the DTE/DCE interface, one called 'control' and the other 'indication' (figure 3). These indicate the status of the transmit and receive information respectively, as determined by the associated DTEs, i.e whether signalling/control information or data is being transferred. These status conditions are transmitted across the network by adding additional bits to the data stream in each direction. One, called the alignment bit, is used to create a frame or envelope, and the other, the status bit, is used to transfer the status condition in each direction (figure 4).

Two envelope formatting standards exist, one having a total of 6+2 bits (figure 4) and the other 8+2 bits. These are described in Recommendations X50 and X51 which define multiplexing schemes having a bearer bit-rate of 64kbit/s. X50 also describes how the two formatting schemes may be interconnected, for example at international boundaries. In the UK, British Telecom have chosen 6+2, whereas in the Nordic countries, for example, 8+2 is used. Thus, if a user data rate is 48kbit/s, the bearer rate is 64kbit/s due to 6+2 formatting. This signalling and control capability of 16kbit/s within a 64kbit/s timeslot is clearly very powerful, and is aimed primarily at providing a fast response on circuit-switched networks. Arguably, it is a heavy overhead on leased-line services, and on packet switching bearers where much of the signalling and control information is already formatted in the data stream. Nevertheless, it is prudent to have a standard interface for all services, and the signalling capability is particularly useful for diagnostic and maintenance purposes and may well be vital in a mixed circuit and packet-switched environment, or to provide enhanced or additional services.

Recognizing that it will be some time before DTEs meeting the above requirements are widely in use, the CCITT have defined transitional recommendations which will enable DTEs with V-Series interfaces to be connected to public data networks. In particular X21bis defines the connection for synchronous data transmission. Basically circuit 105 (Request to Send) controls the condition of the outgoing status bit and circuit 109 (Data Channel Received Line Signal Detector) is controlled by the incoming status condition, i.e the status bit replaces the carrier signal in analogue transmission. As well as translating the basic modem procedures, diagnostic procedures such as local and remote looping can also be provided.

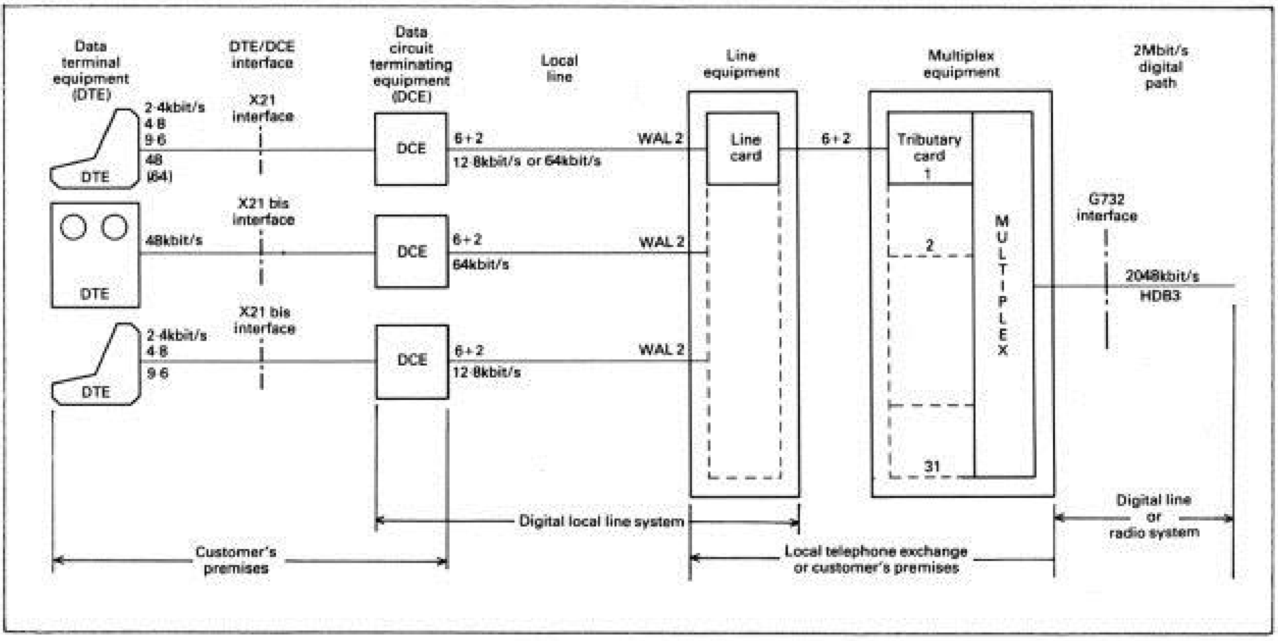

Fig. 5. Basic system configuration

The Marconi system (U3000 Series equipment)

The basic system configuration is shown in figure 5. This system allows the transmission of synchronous duplex data at 2·4, 4·8, 9·6, 48 and 64kbit/s from subscriber premises to subscriber premises using 64kbit/s timeslots on the digital telephone network. The basic components of the system are the local-line system, consisting of the DCE and the line card, and the 31-channel multiplex equipment. The local-line system makes use of normal, unconditioned telephone pairs, taken two at a time to give a four-wire connection, using planning rules similar to those used for the standard telephone connection. Normally the DCE is co-sited with the DTE, and the line card and multiplex equipment are situated at the local telephone exchange. However, for organizations with a large amount of data traffic it may be worthwhile to site the multiplex at the subscriber's premises and to use a 2Mbit/s line or radio system into the digital telephone network.

The DCE

The functions performed by the DCE are control of the interface, envelope encoding and line encoding, plus the reciprocal decoding functions. The envelope encoding structures the user data into a 6+2 format to provide an associated signalling and control path, and thereby increases the user data rates, referred to in the previous paragraph, to 3·2kbit/s, 6·4kbit/s, 12·8kbit/s and 64kbit/s respectively. The user rate of 64kbit/s does not have envelope encoding applied. The signal transmitted to line is 12·8kbit/s for the lowest three rates, or 64kbit/s. In order to transmit the lowest two rates the signal is reiterated (i.e repeated) to give a 12·8kbit/s signal.

The line encoding is introduced to ensure that there is no d.c content in the line signal, allowing isolation of the electronic circuitry from the line, and to provide sufficient transitions in the signal to enable timing to be recovered at the far end. The particular encoding technique used is known as WAL2, and has the advantage that the signal energy is moved into the linear part of the amplitude/frequency characteristic of the telephone line, thereby removing the need for equalization. This is a baseband modulation system, which is essentially simple and produces a digital line signal. It should not be confused with the complex analogue modulation techniques used in data modems to convert digital data into audio bandwidth tones.

The DCE is a small, simple device, contained on a single printed-circuit board measuring 330mm by 203mm, yet which is able to support transmission up to 64kbit/s. The board is powered by low-voltage a.c, and may either be housed in a small, low-profile case (figure 6), or rack mounted in a 19in shelf, with associated mains transformers. Three types of DCE are provided according to the data rate and interface used by the data terminal. The DCE with the X21 interface transmits user data at all the possible envelope-encoded rates, which are plug-selectable on the board. Also, it is possible to strap out the envelope encoding function, providing a user rate of 64kbit/s. However, no independent signalling path is then available, and the interface provided is a non-standard version of X21, i.e the control and indication signals are not available on the interface. The X21bis DCEs, which are designed to interface with existing data terminals using V-Series interfaces, come in two forms; one supporting 48kbit/s transmission from a V35 terminal, and the other supporting all the lower rates from a V24 terminal.

Fig. 6. Data circuit terminating equipment – DCE

The line card

The line card equipment is co-sited with the multiplex equipment and performs the line encoding and decoding functions, but not, of course, envelope formatting. Only one design is required to cover all the data rates, which are plug-selectable. The design is contained on one printed-circuit board, 222mm×194mm, which is rack-mounted in accordance with the British Telecom transmission equipment practice, TEP–1(E), and powered from 50V exchange battery.

The multiplex

The multiplex equipment contains 31 tributary cards which reiterate the data received from the line cards in order to produce 64kbit/s signals. These are then time-division multiplexed into a frame structure which is identical to that used in CCITT Recommendation G732 for the 30-channel p.c.m speech multiplex, except that Timeslot 16 is made available for data transmission. Timeslot 0 is used for framing and supervision in the normal way, resulting in a frame structure of 32 64kbit/s timeslots, giving an output signal of 2048kbit/s (2Mbit/s approximately) which is HDB3 encoded for onward transmission into the digital telephone network. The multiplex equipment is housed in one 8VU-high shelf and two 4VU-high shelves of TEP–1(E), the latter two containing the tributary cards. The equipment is powered from 50V exchange battery.

The tributary card

The tributary card takes the envelope encoded signal from the line card, reiterates it to 64kbit/s if needed, and by recognition of the envelope alignment bit pattern (alternate 0 and 1 in consecutive envelopes), aligns the envelope structure with the 2Mbit/s

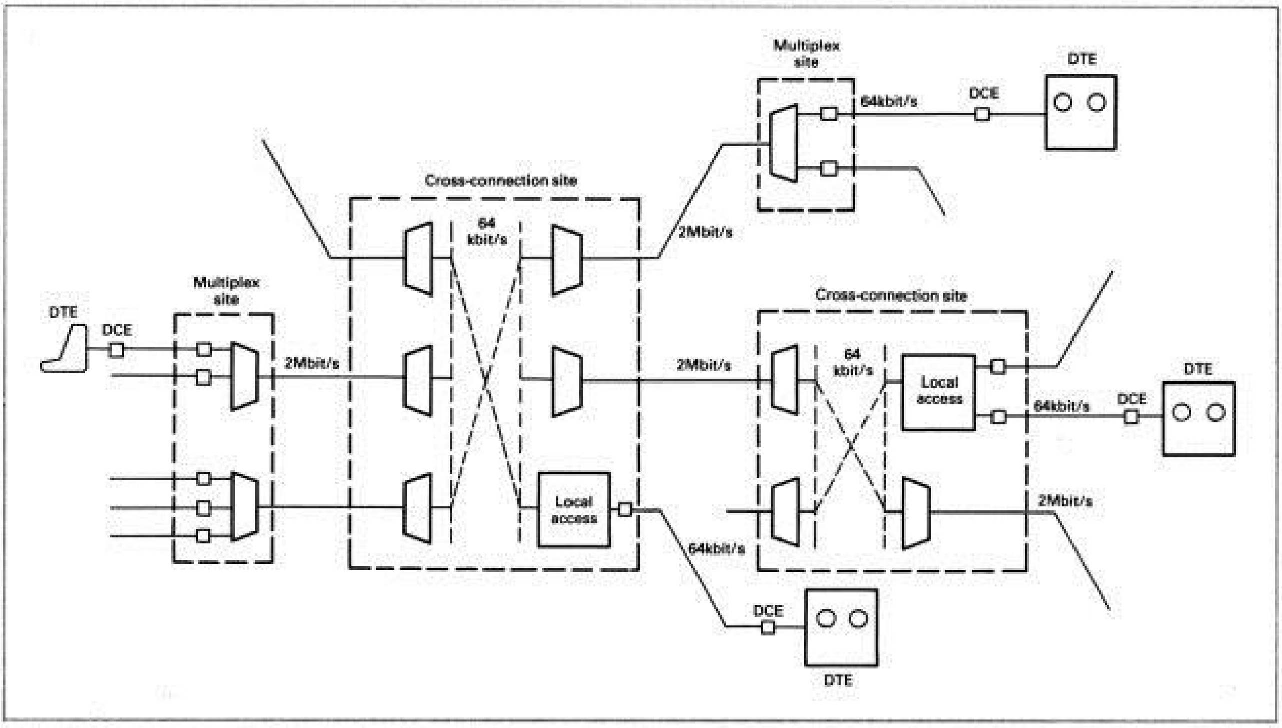

Fig. 7. Network routing

bearer frame structure. It then transmits the signal in 2Mbit/s bursts into the bearer frame under control from the multiplex common equipment. Four types of card are available as follows:

a) as described above;

b) a 64kbit/s co-directional interface is used in place of the line-card interface. This is a common interface used by telecommunications equipment in an exchange environment, and is used at the cross-connection site, mentioned later;

c) the tributary signal is unstructured 64kbit/s, i.e no 6+2 formatting has been introduced at the DCE;

d) an $n \times 64$kbit/s capability is provided for handling higher bit-rate tributary rates in multiples of 64kbit/s.

Leased-line routing

The equipment described so far enables a point-to-point connection to be set up, but routing methods have not been discussed. As the initial market is seen to be for a leased-line service rather than circuit switched, the Marconi system makes use of digital distribution frames situated within the digital telephone network at cross-connection sites (figure 7). At these sites, 2Mbit/s paths are demultiplexed using 31-channel multiplex equipment fitted with 64kbit/s co-directional tributary cards. Subscriber routing is achieved by cross connection on the distribution frames at the timeslot level. Also at these sites a synchronizing facility, suitably protected, is introduced to provide synchronizing signals to all the local multiplex equipment and thereby to all the equipment remotely connected. Also at the cross-connection site, provision is made for local data access such that locally generated user data is not multiplexed up to 2Mbit/s unnecessarily, but is presented directly to the distribution frame at the 64kbit/s level.

Supervisory and alarm facilities

The supervisory and alarm facilities are extremely comprehensive, and will enable a very high grade of service to be achieved. From the point of view of the data terminal operator, fault indications and local and remote looping facilities are available at the DCE. For the network controller, comprehensive status information is centrally available on all aspects of the network.

Three types of loop are available at the DCE (figure 8). Local loop 'c' is set by means of a front panel push-button, or by the terminal equipment via the DTE/DCE interface, and enables the data terminal to check itself through the interface circuitry. Remote loop 'b' is set in the same way but operates a loop back in the remote DCE, which enables network connections to be checked. This remote looping is achieved by using the signalling capability provided by envelope encoding, i.e a special bit pattern is sent in the information field with the status bit indicating a supervisory condition. Care has been taken to ensure that accidental operation of a looping but-

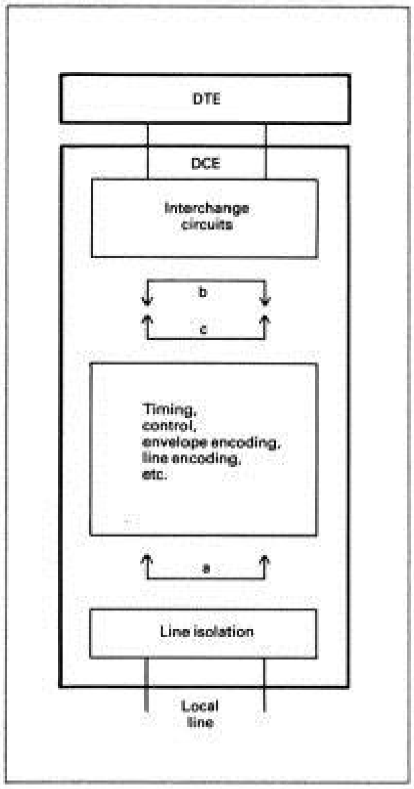

Fig. 8. Local and remote looping in the DCE

ton does not disrupt traffic, and when applied to a quiet channel, out-of-service signals are sent to the terminal equipment. An additional local loop 'a' is provided within the equipment to check the operation of the local DCE, and a test box is available to perform error measurements and X21 procedural tests off-line.

If the line signal received at the DCE is low or non-existent, or it is impossible to achieve envelope alignment, alarm conditions are sent back to the multiplex site causing the appropriate central alarms to be raised. To monitor the local line, a low-level d.c current (5 to 10mA wetting-current) is sent from the line card to the DCE and back again, and if this is lost then a line fault is indicated. This wetting-current is also used to indicate to the multiplex site if the DCE power is switched off, and this is achieved by a reversal in the direction of current flow in one of the pairs from the DCE.

At the multiplex site, the line-card monitors the level of the line signal and the presence and direction of the wetting-current, and sends appropriate indications to the alarm unit in the multiplex equipment. Similarly the multiplex tributary card monitors for loss of envelope alignment, or loss of input signal for those tributary cards that do not perform envelope alignment.

The alarm unit in the multiplex equipment monitors the common multiplex functions and the tributary functions. These are scanned under microprocessor control, displayed locally, and multiplexed for onward transmission on the 2Mbit/s line system using the spare signalling capacity in Timeslot 0. Alternatively, if the multiplex is at the control centre for the network, the status or fault conditions are fed to an alarm concentrator. This also receives similar information from all the local multiplex equipments, and thereby monitors the status of all remote equipment. The network control centre is therefore able to monitor the status of the entire network, and to display the conditions existing on any multiplex equipment or tributary channel in the network.

In addition, test equipment is available for use at a multiplex site which can extract any timeslot from a 2Mbit/s signal, or can be used at the tributary channel test access points. This equipment can remotely loop DCEs and carry out various error

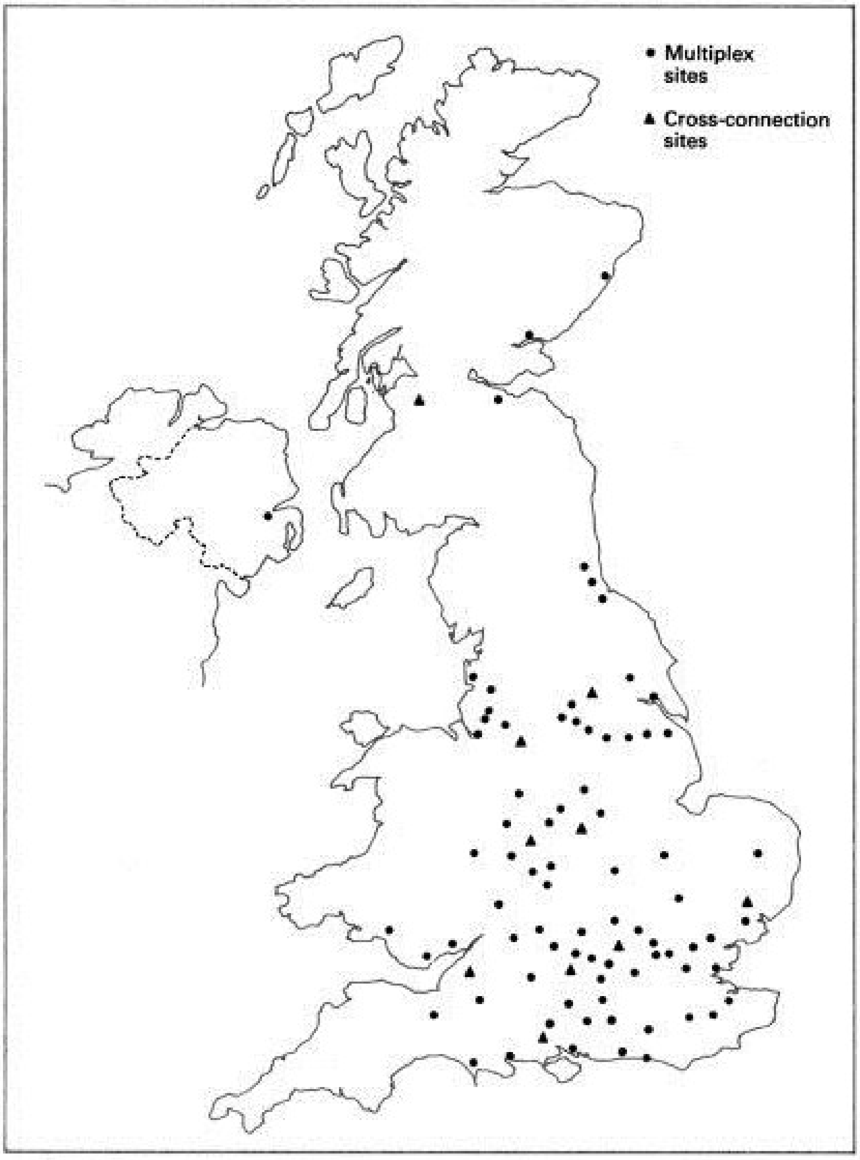

Fig. 9. Kilostream coverage (excluding the London region)

measurements. Also, by monitoring the envelope alignment bit pattern, error measurements can be made without disrupting traffic.

The British Telecom 'Kilostream' service

The equipment described so far has been designed in conjunction with British Telecom, and is being used by them to establish a major data service in the UK called 'Kilostream'. This will offer a digital leased-line service aimed particularly at meeting the needs of the business community. The extent of the initial production contract will result in UK coverage as shown in figure 9, with approximately one half of the equipment being provided in the London area. The initial service will start in late 1982, and will be built up rapidly to provide approximately 1100 multiplex equipments with associated tributary line systems and network terminating equipments (DCEs).

Not only will the Kilostream service enable business users to introduce much-improved internal communications but it will be used by British Telecom to enhance many existing services such as telex, packet switching and Prestel (videotex) by providing digital trunk connections or improved subscriber access. Also it will be used to provide out-of-area connections to System X digital telephone exchanges, bringing forward the benefits of these exchanges to a wider community. In addition, Kilostream equipment will be used as a distribution network for satellite business earth terminals.

Kilostream heralds the Integrated Services Digital Network (ISDN) of the future, and will provide the economical high bit-rate transmission for private network users that will be the norm for all users in future years. It will be the catalyst for the merging of today's separate speech and data networks; for the provision of entirely new services, not economically feasible on today's analogue networks, and for the dynamic allocation of capacity between many dissimilar functions which at the present time need different methods of transmission.

The system described so far is able to offer a service which is far superior to that provided by present-day analogue equipment. However, increasing use of the system is likely to lead to demand for greater efficiency in operation, requiring the use of sub-multiplexing in place of the reiteration stages. The higher concentrations of traffic created will lead in turn to the need for more protection equipment to be introduced. Work is in hand on all these aspects. In particular, an asynchronous telex/data multiplex with a bearer rate of 64kbit/s and a protected output will shortly be available, and will be described in a later article. This will be followed by other sub-multiplex equipment offering great flexibility and variety of input.

To cater for the business user who has sufficient demand to require a 2Mbit/s multiplex on his premises, a variety of new multiplex tributary cards will be available providing speech as well as data facilities. It follows from this that line and radio transmission systems able to carry 2Mbit/s services to the customers' premises will need to be introduced into the local network. Further, noting that Local Area Networks such as Cambridge Ring and Ethernet are gaining acceptance as a means of connecting on-site terminals and computers together, it is likely that a 'gateway' facility will need to be introduced in order to transmit to remote sites across Kilostream.

Acknowledgement is made of the help received from many colleagues within The Marconi Company and British Telecom who have assisted in the preparation of this article.

RÉSUMÉ

Depuis plusieurs années déjà on équipe les réseaux téléphoniques de systèmes de transmission numérique majs, jusqu'à présent, leur application n'avait pas été prévue dans les locaux des utilisateurs en vue d'améliorer la transmission des données. Cet article décrit l'équipement que Marconi a conçu conjointement avec British Telecom pour offrir tous les avantages de la transmission numérique aux utilisateurs qui sont raccordés à des systèmes de transmission de données. British Telecom utilise un tel équipement sur une liasion numérique spécialisée appelée 'Kilostream' qui sera mise à la disposition des entreprises en Grande-Bretagne.

Ce système se compose essentiellement d'une ligne locale numérique de 64bit/seconde maximum alimentant un multiplexeur de 2Mbit/seconde avec un créneau d'accès sur 31 circuits. Il permet à des terminaux de données fonctionnant à 2,4, 4,8 9,6, 48 et 64kbit/seconde d'émettre en utilisant comme porteur le réseau téléphonique numérique interurbain.

L'auteur examine ensuite la demande potentielle pour un tel service, recherche les équipements de transmission appropriés disponibles sur le marché, décrit l'interface-utilisateur, la méthode d'acheminement et de synchronisation des messages ainsi que le puissant système de surveillance et d'alarme. Enfin, il explore les possibilités de développement ultérieur de cet équipement.

ZUSAMMENFASSUNG

Digitale Übertragungsgeräte werden schon seit vielen Jahren in Telefonnetzen eingebaut, jedoch noch nicht beim Teilnehmer, um verbesserte Datenverarbeitungsmöglichkeiten zur Verfügung zu stellen. Dieser Artikel beschreibt die Marconi-Geräte, die in Zusammenarbeit mit der englischen Telefongesellschaft 'British Telecom' konstruiert wurden, um dem Kunden mit Datenübertragungs-Anforderungen die Vorteile digitaler Übertragung zur Verfügung zu stellen. 'British Telecom' benutzt diese Geräte bei der Erstellung in Großbritannien von Mietsleitungen, die unter dem Namen 'kilostream' bekannt und für die Geschäftswelt besonders vorteilhaft sind.

Im wesentlichen handelt es sich dabei im ein digitales Ortsleitungssystem mit einer Betriebsgeschwindigkeit bis zu 64kbit/s zur Speisung eines 2Mbit/s-Multiplexers mit Zeitspalten-Zugriff auf 31 Kanälen. Auf diese Wiese können mit 2,4, 4,8, 9,6, 48 bzw. 64kbit/s arbeitende Datenendgeräte an eine Fernstation übertragen, wobei das digitale Telefon-Fernnetz als Träger funktioniert.

Die Nachfrage nach einem solchen Dienst wird erwogen, sowie die Verfügbarkeit geeigneter Übertragungsanlagen. Weiterhin wird die Kunden-Schnittstelle sowie die Leit- und Synchronisiermethode und außerdem das leistungsstarke Überwachungs- und Alarmsystem beschrieben. Die Möglichkeiten für weitere Entwicklung werden zum Schluß auch betrachtet.

RESUMEN

Durante muchos años el equipo de transmisión ha sido instalado en redes telefónicas, y sin embargo no se ha extendido al establecimiento del cliente para proporcionar servicios de datos perfeccionados. Este artículo describe el equipo Marconi que ha sido diseñado en conjunción con la British Telecom para traer todas las ventajas de transmisión digital al cliente con las necesidades de transmisión de datos. La British Telecom está empleando este equipo para proveer un servicio de línea arrendada digital en el Reino Unido llamado 'Kilostream', que será de beneficio particular a la comunidad de negocios.

En esencia al sistema consiste en un sistema de línea local digital que opera a hasta 64kbit/s alimentando un multiplexor de 2Mbit/s con acceso de ranura de tiempo en 31 canales. Esto permite que datos terminales funcionando a 2,4, 4,8, 9,6, 48 y 64kbit/s transmitan a un sitio remoto empleando la red telefónica de enlaces digitales como apoyo.

Se discute la demanda de este servicio, junto con la disponibilidad de instalación adecuada de transmisión. También se describe entrecaras del cliente, y el método del recorrido y de sincronización, lo mismo que el poderoso sistema de supervisión y alarma. Finalmente, se explora la actividad de futoros desarrollos.