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Introduction

The merging of technologies—coupled with increasing demands for the efficient collection, processing and dissemination of information—is leading to the development of integrated systems that transmit and process all types of information. The ultimate goal of this evolution in communications is called the Integrated Services Digital Network (ISDN).

The ISDN will eventually be a worldwide public telecommunications network which will deliver a wide variety of services. The ISDN will be defined by the standardisation of user interfaces, and will be implemented as a network of digital switches and transmission paths which support a broad range of traffic types and provide value-added processing services.

The impact of ISDN on both users and suppliers will be most profound. To control this evolution and impact on communications infrastructures, a massive effort at worldwide standardisation is under way.

The evolution of the existing telecommunications networks, specialised carrier facilities, and value-added data communications networks from the separate entities which exist today into the ISDN of the future is based on two technological developments: digital transmission and digital switching. Both of these developments are today well established with a first digital carrier system being introduced into commercial service in the early 1960s

Apart from the benefits of both of these two technologies, a major revolution was seen by the combining of transmission and switching to form an integrated digital network (IDN). This concept which was proposed in the late 1950s is today well advanced and is being implemented worldwide.

The conversion of telecommunications networks to digital transmission and digital switching is well under way. However, much less well developed is the provision of digital service to the end user. Telephones still send analogue data to and from the end user which must be digitised before transmission over the network. Lower-speed (up to 64 Kbit/s) digital services are commonly available via leased lines and higher-speed leased services (up to 2 Mbit/s) are being introduced.

Economic pressures and advances in semiconductor technology have led to the increasing use of digital techniques in public telephone networks. Today digital techniques are being used not only in inter-exchange transmission but also in subscriber loops by incorporating analogue-to-digital converters into telephone handsets. It is expected that the public telephone networks of today will evolve into the end-to-end digital networks of tomorrow. In practice, pulse code modulation (PCM) techniques are being used to convert analogue telephone channels into digital channels with a bit rate of 64 Kbit/s.

However, end-to-end digitisation allows the standard 64 Kbit/s channels employed throughout digital telephone networks to be used not only for PCM encoded speech but also for a wide range of new and existing non-voice services. The further evolution of the IDN will combine the coverage supplied by the geographically extensive telephone network with the data carrying capacity of digital data networks. This leads to the concept of the Integrated Services Digital Network (ISDN). Integrated referring to the simultaneous handling of digitised voice and a variety of data traffic on the same digital links and by the same digital exchanges. The key to ISDN is the small additional cost for offering data services on the digital telephone

network, whilst incurring no cost or performance penalty for the voice services already carried on the IDN.

The concept established for the basic user access to the ISDN is shown in Figure 1.1 which illustrates the functional structure and the related interfaces at the user's premises and at the digital local exchange. Due to the larger data rates which result from the use of digital technology, a time division multiplexed-channel structure of two B-channels and one D-channel is made available at the ISDN user-network interface by existing two-wire subscriber links.

As shown in the figure, B designates one of two independent circuit switched 64 Kbit/s user information channels which can be used simultaneously to different addresses. The standard bit rate of 64 Kbit/s derives from the situation where digital transmission and switching systems are based on 64 Kbit/s PCM channels as described in CCITT Recommendation G703. The B-channels are characterised by end-to-end transparency and, as well as carrying out their original task of transporting PCM encoded digital voice, can also be used for transport of data information, or other types of non-voice information such as text, facsimile, video, etc.

D designates a separate signalling channel which is shared in multiple-terminal installations by the set of terminals which may be attached to the particular ISDN network. Although the access configuration is shown typically in the figure as star connected, both bus and ring intra-site distribution networks can be envisaged. The D-channel is message interleaved, being primarily designed to carry the signalling information which controls the handling of the B-channels through the ISDN. Enhanced signalling capabilities are offered to the ISDN services because the transfer of user and network signalling information does not interfere with the transport of user data on the B-channels. In addition to carrying signalling information, the D-channel might optionally be used for transport of slow-speed data and for telemetry information.

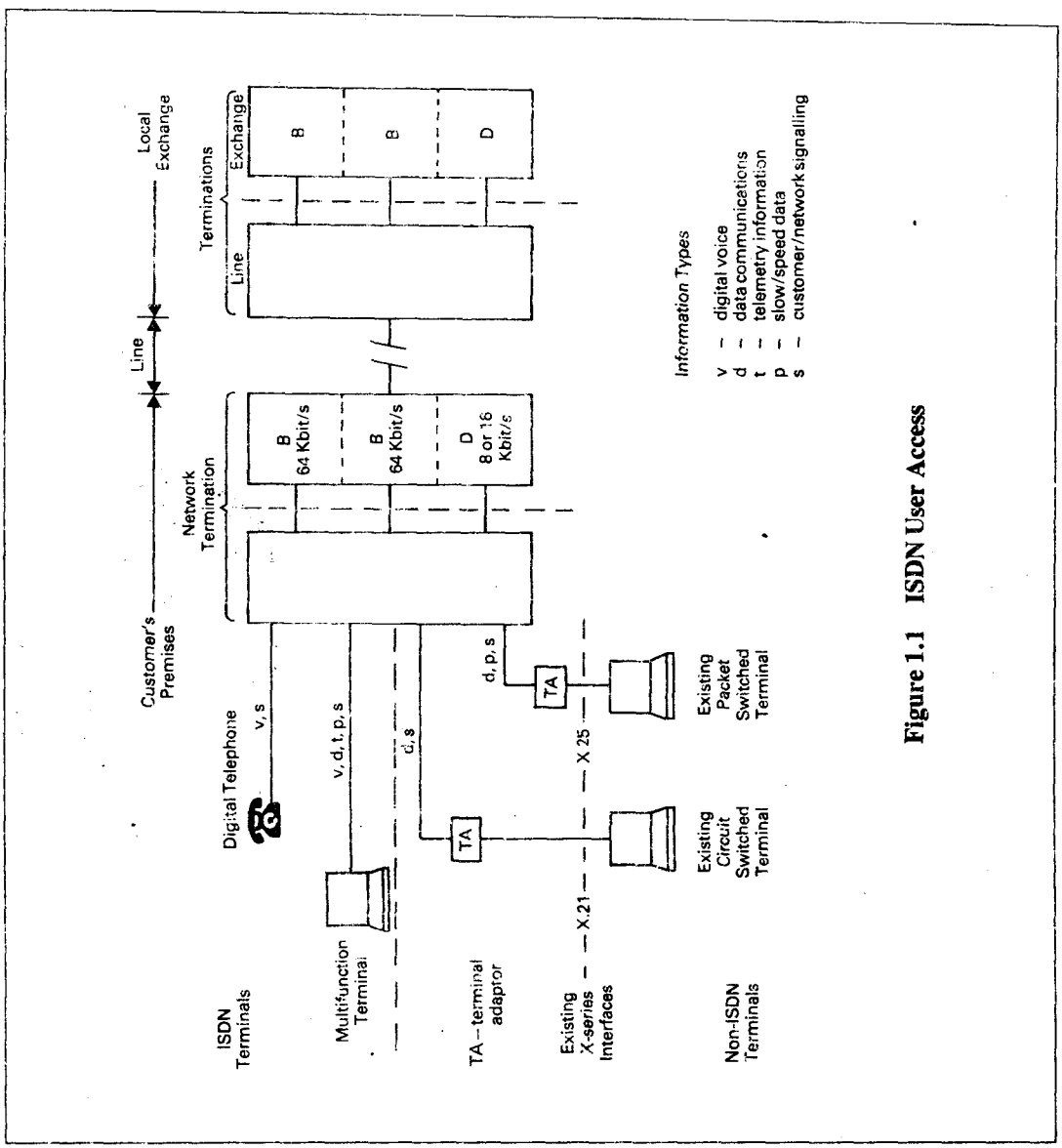

Figure 1.1 ISDN User Access

From a user's point of view, access to the ISDN can be seen as a local interface to a digital pipe of a certain bit rate. Pipes of various sizes will be available to satisfy different needs. For example, a residential customer may require only enough capacity to handle a telephone and a simple viewdata terminal; whereas an office user will undoubtedly wish to connect to the ISDN via an on-site digital PBX, and as such will require a much higher capacity pipe.

Whilst the pipe to the user's premises has a fixed capacity, the traffic on the pipe may be a variable mix of traffic and services up to a given capacity limit. Thus a user may access circuit switched, packet switched, and other services in a dynamic mix of signal types and bit rates.

New ISDN terminals will use a new universal interface which is designed to the ISDN channel structure and which employs common channel signalling. In effect this interface can be regarded as a service-independent ISDN-type interface to which voice terminals as well as non-voice terminals can be directly connected. A call control procedure is used which is common to all circuit switched ISDN services, that is digital telephony and circuit switched data communications. ISDN terminals will be offered with multi-function and multi-service capabilities to exploit the full range of features provided by the ISDN.

An important aspect of the interface is that users can, at any time, employ less than the maximum capacity of the pipe, and be charged according to the capacity used rather than for the connect time. This should significantly diminish the value of current network designs in which circuit use is optimised through the provision of concentrators, multiplexers, private packet switching devices and other line sharing arrangements.

With the current availability of both circuit and packet switched services on dedicated data networks in accordance with the adopted X-series CCITT recommendations, provision has to be made for the connection of existing

text and data terminal equipment to the ISDN. This requires existing X-series interfaces, such as X.21 and X.25, corresponding to circuit and packet switch services respectively, at bit rates lower than 64 Kbit/s according to recommendation X.1. Terminals with interfaces X.21 or X.25 will be connected to the ISDN network by means of suitable data rate adaptors which primarily adapt the X.1 user rates to the 64 Kbit/s bearer rate of the B-channel.

2
Background to ISDN

As the term ISDN implies, the integration of telecommunications services presupposes the existence of a digital telecommunications network. Basically any telecommunications network can be used for this purpose; however, as data networks are mainly used for business purposes and are thus tailored to specific requirements they are less suitable for integration of all telecommunications services including those used by private customers. Moreover, the fact that data networks are usually small and do not cover the whole country, makes them less attractive for this purpose.

A modern telephone network, on the other hand, does not suffer from these disadvantages. This explains why, as mentioned earlier, at the time digital telephone transmission was introduced into the existing analogue telephone networks, the establishment of ISDN was envisaged as a long-term objective based on the telephone network. Accordingly, in early 1972 two definitions were formulated by CCITT which described the development of an analogue into a digital telephone network and its further evolution into an ISDN, as follows:

> "an integrated digital network (IDN) is a network in which connections established by digital switching are used for the transmission of digital signals."

> "an integrated services digital network (ISDN) is an integrated

digital network (IDN) in which the same digital switches and digital paths are used to establish connections for different services."

These definitions, which were included in CCITT recommendation G702, remained untouched for some time. It was not until 1980, following a greater awareness of the potential of ISDN and growing international discussion of its role, that recommendation G705 was established to supersede the old definition of ISDN in G702.

The recommendation G705 set out for the first time the conceptual principles for the evolution of ISDN. The basic principles of an ISDN and of its evolution according to these concepts can be summarised as follows:

"The ISDN will be based on and evolved from the telephony IDN by progressively incorporating additional functions and network features including those of any other dedicated networks so as to provide for existing and new services.

New services introduced into the ISDN should be arranged to be compatible with 64 Kbit/s switched digital connections.

The transition from the existing networks to a comprehensive ISDN may require a period of time extending over 1 or 2 decades.

During the transition period arrangements must be developed for the interworking of services on ISDNs and services on other networks.

The ISDN will contain intelligence for the purpose of providing service features, maintenance and network management functions.

A layered functional set of protocols is desirable for the various

access arrangements to the ISDN. Access from the customer to the ISDN resources may vary depending upon the service required and the status of the evolution of national ISDNs."

Of these principles, agreed in 1980, two were of particular significance; namely, that the ISDN would evolve from the telephony IDN and as a result of adopting this principle, 64 Kbit/s would be the integrating standard bit rate in the ISDN which would be respected by all other services.

Recommendation G705 was adopted by the plenary assembly of the CCITT in 1980 but with growing worldwide interest in ISDN a short time later (at a meeting of Study Group XVIII) these two principles of dominant telephony service and the standard 64 Kbit/s bearer channel were questioned. It was considered that for a full digital network like ISDN bit rates less than 64 Kbit/s for voice services should not be excluded from the ISDN studies whereas, on the other hand, with the rapid evolution of wideband services there would be a call for the provision of bit rates of multiples of the 64 Kbit/s standard in the ISDN. Proposals have, therefore, been made to modify recommendation G705 to reflect this new approach.

The following recommendation is now proposed:

"the evolving ISDN may also include at later stages switched connections at bit rates higher and lower than 64 Kbit/s. Switched connections include both circuit switched and packet switched connections and their concatenations."

Summarising the conceptual principles, as proposed in the recommendation G705, plus the enhanced views as described above, the original definition of ISDN is revised as follows:

"a network evolved from the telephone IDN that provides end-to-

> end digital connections to support a wide range of services, including voice and non-voice services, to which users have access by a limited set of standard multi-purpose customer interfaces."

It is interesting to note in this latest definition that ISDN will provide for end-to-end digital connectivity but how this connectivity is being established is left open on purpose. In other words, there is no direct reference to a certain bit rate. Secondly, both voice and non-voice services are regarded to be on the same footing not withstanding the assumption that the ISDN will evolve from the digital telephone network. Thirdly, users will have access by a limited set of standard multi-purpose customer interfaces. In this definition, users does not only apply to persons such as business or residential users or subscribers; a user could also be a database, a PABX or even another network. These interfaces should be for all possible applications, ie multi-purpose, but restricted in their number, ie limited set, in order to avoid the growth of all sorts of interfaces which would increase both the cost and the complexity and restrict the free use of interconnectivity.

Evolution of ISDN

Taking these CCITT definitions as a guideline, the three following evolution phases of ISDN have been defined.

The first phase will be the digital telephone network. This will evolve from the analogue telephone network by progressively implementing digital transmission and digital switching. This phase is now under way and is being realised in many countries as they change from the analogue telephone network into a digital network. Apart from realising the economic, technical, and operational benefits for telephony, such a digital network provides one very important prerequisite for the ISDN, that is the 64 Kbit/s connectivity.

In the second phase of evolution, the ISDN evolves from the 64 Kbit/s