AN INTRODUCTION TI CCITT RECOMMENDATION X.21

BILL BADDELEY

B. BADDELEY
HEWLETT PACKARD
COMMERCIAL SYSTEMS PINEWOOD
308-314 KINGS ROAD, READING
BERKSHIRE, RG1 4ES

Bill Baddeley
Hewlett Packard
Commercial Systems Pinewood

This paper is an introduction to CCITT Recommendation X.21. The recommendation specifies a new data communications interface which you will probably encounter soon if you haven't already.

At the present time, most data communications among remote terminals and computer systems are carried over the public switched telephone network or over leased telephone circuits. The telephone network has evolved over many years and is an excellent medium for voice transmission. When people started connecting computers and terminals over long distances, the telephone network provided a readily availble, though not an optimal, connection medium for digital signalling. Computer systems and terminal equipment are typically connected to the public switched telephone network or leased telephone lines through an interface which is referred to by the label RS-232 or V.24. This interface type has been around for quite some time and is commonly available on modem and terminal equipment.

An organization of devoted to international cooperation in telecommunications, the CCITT, is an international advisory body which deals with telephone and telegraph communications. The CCITT issues recommendations for services and implementation of services. There is a series of CCITT recommendations (the "V-series" recommendations) for the connection of data terminal equipment or DTE (the category DTE includes terminals and computer systems) to the telephone network through a modem. The connection point to the telephone network is called the data circuit terminating equipment, or DCE. The standard connection between terminals or systems and the telephone network is described in CCITT recommendation V.24 and the EIA (the U.S. Electronic Industry Association) RS-232. The 25-pin connector which you may have seen on your terminal cable or computer system is the standard connector for this interface. The V.24 or RS232 connection carries signals between the terminal or computer and the modem. These signals include the transmitted and received data signals, timing information and control signals which constitute a dialog between the modem and the computer concerning the state of the connection. For leased telephone circuits, the V.24/RS-232 connection carries all of the information needed between the modem and the system or terminal. The V.24 recommendation specifies the function of each of the data and control circuits in the interface, and the dialog between the terminal/system and the modem/DCE. For switched telephone connections, some PTTs offer automatic calling units. CCITT

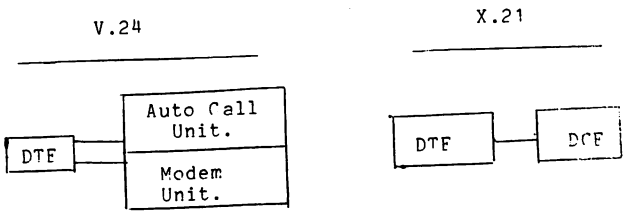
recommendation V.24 also describes the standard interface between a system or terminal and the automatic calling unit (the EIA specification is RS-366). This interface uses the same 25-pin connector as the V.24 modem interface with redefined signal lines. The V.24 recommendation specifies the dialog between the system/terminal and the automatic calling unit for establishing connections.

The telephone network is being replaced for some classes of data communications traffic by public data networks. There is a lot of information in the computer press these days about the new public data networks and the new international standards for these data networks. Depending on where you are located, you may have heard of either X.25 or X.21 or both. The CCITT has issued a series of recommendations (the X series) which deal with data communications networks. The X series of recommendations deal with services on networks which are specifically designed for data communications. There are quite a few public data networks now in operation, and more services are planned for introduction within the next few years.

These networks can be broken into two principal categories according to the type of service which they offer. One type is Circuit-Switched, where the connection between two systems or terminals is equivalent to a hardwired connection once it has been established through the network. Examples of circuit switched networks are the Nordic Public Data Network in Denmark, Finland, Norway and Sweden and the DATEX-L network in the Federal Republic of Germany. The other type of network is Packet-Switched. Packet switched networks support multiple virtual connections through the network over a single DTE/DCE connection.

The CCITT X.21 recommendation describes an interface between Data Terminal Equipment (terminals and systems) and Data Circuit-terminating Equipment for synchronous operation on public data networks. This interface replaces the two-connector, multiple signal interface of V.24 with a simpler set of signals, a smaller connector, and improved electrical characteristics (fig. 1).

Comparison of CCITT Recommendations V.24 and X.21



	V.24	X.21
Distance:	< 20 Metres	> 1000 Metres
Speed:	< 20 Kbit/sec.	> 100 Kbit/sec.
Signals:	<= 31 signals	<= 7 signals
Connectors:	1-2 25-pin	1 15-pin

The X.21 interface is better able to meet the requirements of current systems for data communications than is V.24 in terms of speed and distance between the system and the network port interface. The speeds of service in public data networks under the CCITT X recommendations are easily met by the X.21 interface, the fastest being 48 kbits/sec. For this reason, X.21 is gradually replacing the V.24 interface.

The CCITT X.25 recommendation, which covers packet-switched data networks, specifies the X.21 interface as the electrical and mechanical interface between the DTE and DCE. The X.25 recommendation will be covered in more detail later in this session.

In addition to the electrical and logical definition of the X.21 interface, the CCITT recommendation describes logical procedures for the operation of the interface in a circuit-switched network and in leased-circuit applications.

The circuit-switched network procedures are broken into four phases: the quiescent phase, when no connection exists between the local station and any remote station; the call establishment phase, when either the DTE starts a call or the DCE signals an incoming call; the data transfer phase, and; the call clearing phase. The circuit-switched network procedures are very much like the procedures one uses with the switched telephone network.

During the quiescent phase, the telephone is on-hook. In the X.21 case, the system/terminal and the network signal their respective states of readiness to establish a connection through the network.

The call establishment phase, in the case of the telephone conversation, begins when one lifts the receiver and dials a number or when the telephone rings, signalling an incoming call. In the X.21 network, the terminal/system signals to the DCE that it is preparing to issue selection signals; the DCE responds by signalling "proceed to select", and then the DTE issues a selection signal sequence specifying a remote station and/or network services. An incoming call is announced by the DCE to the DTE/system/terminal. All cases of call collision (incoming and outgoing calls at the same time) are resolved in favor of the outgoing call. If one dials a busy station or mis-dial a number, you receive in response a tone or tone sequence, or perhaps a recorded message. In the case of an X.21 network, the calling DTE receives call progress signals (figure) which indicate why a call is delayed or why it has failed. These call progress signals are useful in determining a reasonable next action. In additon to call progress signals, the X.21 recommendation describes optional facilities for transferring information such as called line identification to the calling DTE and calling line identificaiton to the called DTE as part of the call setup procedure.

X.21 Call Progress Signals

Group	Code	Meaning
0	01	Terminal Called
	02	Redirected Call
	03	Connect When Free
2	20	No Connection
	21	Number Busy
	22	Selection Signals Procedure Error
	23	Selection Signals Transmission Error
4,5	41	Access Barred
	42	Changed Number
	43	Not Obtainable
	44	Out Of Order
	45	Controlled Not Ready
	46	Uncontrolled Not Ready
	47	DCE Power Off
	48	Invalid Facility Request
	49	Network Fault in Local Loop
	51	Call Information Service
	52	Incompatible User Class of Service
6	61	Network Congestion (short term)
7	71	Long-term Network Congestion
8	81	Registration/Cancellation Confirmed
	82	Redirection Activated
	83	Redirection Deactivated

Group 0 signals are delay conditions without call clearing
Group 2 signals indicate short-term conditions
Group 4 and 5 signals indicate long-term conditions
Group 6 signals are short-term network related conditions
Group 7 signals are long-term network related conditions
Group 8 signals are confirmation signals (with call clearing)

Once the call setup is complete, the connection between the calling and the called DTEs is transparent. The network transfers the states of each station's transmit data line bit-for-bit exactly as it appears at the DCE interface. The data phase continues until one of the DTEs signals a clear request. This is analogous to the conversation part of a telephone call.

Call clearing is signalled by either end and transferred to the opposite end. Following call clearing, the DTE and DCE re-enter the quiescent phase.

The circuit switched public data network has several advantages over the public telephone network, having been designed expressly for data communications. One clear advantage is automatic call establishment (no operator dialling).

The X-series recommendations include recommendations for a uniform international node numbering scheme which is analogous to the international telephone numbering scheme. For example, each Nordic network connection has a 6-digit network number, which is unique within the country. International calls include an international prefix, a network/nation code, and a network node identification number. Within the Nordic Public Data Network, calls are possible among the nations of Denmark, Finland, Norway and Sweden.

Another feature of the new public data networks is fast call establishment and high reliability. For example, the Nordic Public Data Network specifications state that all calls will be set up within 2 seconds, 99% will be set up within 0.5 seconds and 90% of all calls will be set up within 0.1 seconds. Similarly all call clearing operations will take under 0.2 seconds, with 90% under 0.05 seconds. This is clearly an improvement over the performance of the switched telephone network.

The X.21 call progress signals, described previously, provide a clear indication of the status of a given call attempt along with information about the probable success of a retry.

Additional facilities allow the subscriber to simplify the call process by using short-form addresses for commonly called remote nodes. Access restrictions can be placed on a given node by specifying optional facilities to bar incoming or outgoing calls. A group number facility allows several ports to be accessed from the network by a common node address; a central computer can be equipped with several ports which, in addition to their unique addresses are also accessed via a common national network number. This facility is also referred to as "multiple lines at the same address". The Closed User Group facility allows the creation of private networks within the larger public data network. If a company has several systems at different geographical locations, and has no need to connect them to systems outside of the particular set, then the specification of closed user group

membership for each of them eliminates access from computers outside the network. The facility can also be used in such a way as to restrict the connections from any node in the group to only other group members. It is also possible for a particular node to belong to several closed user groups, one of which is the default or preferential one. In order to switch from the preferential to an alternate closed user group, the selection signal sequence is prefixed with a facility request code specifying which alternate group is to be used for the call setup, followed by the address of the node within that group.

A call queueing facility allows incoming calls to be held in a first in first out queue with a specified number of positions. The caller receives a call progress signal indicating that the call is queued at the remote end. The call redirection facility allows one node to temporarily transfer its address to another node; for the period during which this facility is activated, all calls for the node are redirected automatically to the alternate node. A call progress signal informs callers that the call has been redirected. The Calling and Called Line identification facilities provide for verification and monitoring of connections made through the network. A node specifying the Charge Transfer facility is charged for all incoming calls (which are normally charged to the caller). The charge advice facility allows a node to be informed, following disconnection, of the charges for a call.

Circuit-switched X.21 networks are currently offered in Denmark, Finland, Norway, Sweden, F.R. Germany, and Japan. Several other European nations have X.21 networks in their future plans. Further information about the specification and the network services is available from the implementing PTTs, and from the CCITT (Union Internationale Des Telecommunications, Place des Nations, CH-1211 GENEVE 20, SUISSE).