# EXPERIMENTAL BROADBAND IN-HOME NETWORK


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THE BROADBAND INTEGRATED SERVICES DIGITAL NETWORK (B-ISDN) IS BEING STANDARDIZED BY CCITT. THUS, B-ISDN WILL BE ABLE TO OFFER ALL EXISTING SERVICES AND ANY THAT MAY BECOME AVAILABLE IN FUTURE. WITH B-ISDN, INFORMATION CAN BE PROVIDED BY THE PUBLIC NETWORK TO A CUSTOMER VIA AN OPTICAL FIBRE AT A RATE OF 622 MBIT/S. THE CUSTOMER IN HIS TURN CAN OFFER UP TO 155 MBIT/S OF INFORMATION TO THE PUBLIC B-ISDN. THE QUESTION ARISES AS TO WHETHER CONNECTION TO SUCH AN ADVANCED NETWORK WOULD BE OF INTEREST TO A DOMESTIC CUSTOMER. WHAT TYPES OF SERVICES WOULD JUSTIFY SUCH A CONNECTION AND WHAT SORT OF EQUIPMENT WILL BE NEEDED AT HOME? IN ORDER TO BE ABLE TO ANSWER THESE KINDS OF QUESTIONS, A DEMONSTRATION NETWORK, CALLED THE "EXPERIMENTAL BROADBAND IN-HOME NETWORK" (EBIN), HAS BEEN REALIZED AT PTT RESEARCH. EBIN USES B-ISDN TECHNOLOGY AND IS DESIGNED TO OFFER MANY EXISTING AND NEW SERVICES. DIFFERENT ASPECTS OF EBIN WILL BE HIGHLIGHTED WHILE DESCRIBING THE DEMONSTRATION SET-UP IN THIS SECTION.

## The demonstration set-up

EBIN is located in a room which has been divided in three parts. First, the living room, with two sofas and a living room cabinet. The latter contains a high- resolution screen, a camera and a CD player. Two loudspeakers are placed at the other side of the living room, each of which is equipped with its own amplifier. Furthermore, there is a microphone on a small table near the sofas and a remote control with an integrated trackerball. Each piece of equipment in the living room is connected to the in-home network via its own interface. Thus, video, audio and data can be presented by and offered to the in-home network. The screen and the remote control constitute the user interface and, as such, fulfil a central role in the system. They allow the user to select any of the facilities or services offered by the network.

The second room in the demonstration set-up is the study. This contains a desk and a bookcase. Located on the desk are a personal computer with a mouse, as well as a microphone, a camera and two loudspeakers. All this equipment, which is connected to the in-home network via a single interface, acts as a single multimedia terminal, which can handle audio, video and data. The screen, keyboard and mouse of the personal computer constitute a second user interface, identical to the one in the living room. Thus, two people can use the in-home network and its services simultaneously. To demonstrate this, the interior of the study is fully visible from the living room.

The final part of the demonstration set-up is partitioned off from the living room by a curtain. A home switch and two terminals, which are situated behind the curtain, serve to demonstrate the technology used in EBIN.

## The user interface and the services

Limited use is made of in-home networks today. Simple networks are currently in use to transmit radio and television signals, to interconnect the audio and video equipment and to support the telephony service at home. Sometimes an intercom system is installed or cabling to remotely open the front door, or even a complete security network. In the future existing applications can be improved or new applications can be offered, when these in-home networks are interconnected. It will then, for example, be possible to see on the television screen who is at the front door or to keep the home comfortably warm while cutting heating bills. One could also search for a secondhand car in an electronic database which also contains pictures of the cars on offer.

The greater the range of features offered by in-home networks, the more difficult it will be to control the network and the services. It is therefore of the utmost importance that extensive research be conducted into the system's user interface. Not only should any user be able to operate the system without difficulty, but it should also be fun to use the services offered.

Given the state of the art of today's technology, PTT Research decided to develop a high-quality graphical user interface on EBIN, which can be presented on any high-resolution screen in the home. The user can issue his commands by using a remote control or a mouse. The user interface screen has two menu bars, one at the top and one at the bottom of the screen. The upper menu bar is used to select a service. Services are grouped into six sets or types of services. Videotelephony, for example, can be found within the group of communication services, while the controls of the lighting and the heating system are part of the housekeeping services. Simultaneous use of more than one service is possible on one screen because every service is offered within a different window. For example, watching television in one window whilst looking at the person with whom you are conducting a videotelephony conversation in another.

The second menu bar at the bottom of the screen gives access to a number of utilities, such as an diary and an address book. It also contains "the butler", through which the in-home network itself can be accessed and controlled, as can any equipment which is connected to it. By selecting the butler, a user can ask for a layout of his home in which the equipment is represented by icons. Once a new piece of equipment has been installed, its icon will automatically pop up on screen. The user can then drag the new icon to the correct position on the screen. Furthermore, the user can indicate how the different pieces of equipment should be interconnected. He can also gain control of the equipment by selecting its icon. This will open a window in which all of the available control functions of the equipment are displayed.

The applications of EBIN have been selected in such a way that every feature of future in-home networks is displayed, with one or more examples of:

- local communication as well as telecommunication,
- distributive and interactive services,
- broadband and narrowband services,
- control of the in-home network and the connected equipment,
- home automation and security,
- information retrieval, processing and storing and
- transport of audio and video via separate connections.

Two users can simultaneously:

- watch television,
- listen to the music of the CD player in any room,
- observe a picture of another room or listen to sound from this room,
- open or close the curtains,
- set up the necessary connections for sound and image transfer and
- add or move equipment.

Conflicts may occur when multiple users are able to control all the equipment from different rooms in the home. To solve this problem, simple rules can be used by the home system, such as "first come first go", or "dad has the last word". In EBIN, a user can claim a piece of equipment for a certain period of time during which it is not possible to control that piece of equipment from another user interface.

## The higher network layers

The B-ISDN is standardized to offer all types of services. However, in the future new services may arise which cannot yet be foreseen. The higher network layers should offer a very high degree of flexibility in order to be able to offer these services also. Therefore CCITT proposes a control system for the B-ISDN using a network layer in which call control (for supporting the services) is clearly distinct from connection control (for controlling network resources). Introducing a new service then means that protocol software for the higher OSI layers has to be installed within the terminals and a software module has to be added to the call control of the network.

Call control and connection control have been separated in EBIN, too. However, for reasons of simplicity the call control has been combined with the software of the higher OSI layers. These higher layers contain a description of the network in terms of physical and logical objects which can be manipulated. The connected equipment is described as physical objects, which can be claimed and switched on or off by a user. Examples of logical objects are services like video distribution, stereo pairs of loudspeakers and the logical connections between the connected equipment or between a service object and a terminal.

The objects can be arranged in a hierarchical relationship to each other. An object for video distribution, for example, uses a logical video connection to a screen and a logical audio connection to a stereo loudspeaker pair. The loudspeaker pair object in turn controls two different physical loudspeaker objects. This architecture facilitates the use of existing equipment or objects within any service. By enabling one service to make temporary use of an object which was already in use by another service, this also allows two services to interact with greater flexibility. When, for example, a loudspeaker pair is used by the video distribution service and a request comes in for a telephony call, the logical connections to the loudspeaker pair can be deactivated. The loudspeaker pair can then be used to support the telephony call. After this call is completed, the original logical audio connection for video distribution can be activated again. The higher layers of EBIN work in such a way that the in-home network, together with the connected equipment, operates as a single distributed multimedia terminal.

The connection control has also been modified in order to support the flexible manipulation of logical connections by the call control. The most important difference to the existing protocols for ISDN is the capability of using one network element to set up a physical connection between two other network elements. A connection between a microphone and a loudspeaker can then be set up, for example, from a graphical user interface. A second difference is the ability to set up a physical point to multipoint connection. A camera can simultaneously be connected to one or more screens. This is accomplished by first setting up a point to point connection between the camera and the first screen. A branch is then fitted between this connection and the next screen. This facility saves network resources. Finally, it is important that different connections be used for the transfer of sound and images within EBIN. Thus, it is possible to change a telephony call into a videotelephony call at any time by setting up an additional video connection. In this way it is possible for a service to use the equipment which has already been installed and this allows for a faster introduction of new services.

## The lower network layers

EBIN makes use of the Asynchronous Transfer Mode (ATM), which was standardized by CCITT for use as the transfer mode of B-ISDN. ATM is a time division technique, where all information is transferred in digital form in short packets of fixed size, called cells. Each cell has a header which contains the number of the channel to which the cell belongs. This header is large enough to multiplex thousands of channels on one physical link. The gross link capacity is divided in a flexible way between the active channels by allocating a different number of cells per second to each channel.

EBIN demonstrates that the use of ATM offers many advantages. The same hardware switches, multiplexes and transmits all video, audio and data traffic as a single bitstream over one fibre. In ATM it is no problem to set up different connections for the transfer of video, audio and data, because of the large number of available channels. For this reason ATM is very well suited to support multimedia services. Another important advantage is that the bandwidth needed by, for example, a video terminal can be selected by the terminal itself. A video terminal may thus request less and less bandwidth as videocoding techniques improve. This is demonstrated in EBIN by using a simple scheme for analog to digital conversion of the video signal, where it is possible to select two different qualities for video transfer without this having any impact on the ATM network itself.

One of the most distinctive aspects of EBIN is its topology. Bidirectional ATM transmission is performed at 155 Mbit/s on a passive optical tree and branch network. The tree was selected because of the flexibility it offers to the user when it comes to extending the network. When a user redecorates a room or buys a new terminal, he can increase the number of network outlets by adding an extension box which only contains one or more passive optical splitters. Moreover, since it is completely passive, the cabling is relatively insensitive to failure. A tree topology will always possess a central point, i.e. the root. Here, a home switch will be connected which, in turn, can be connected to the public B-ISDN. An important advantage of having a central point in the topology is that the total system cost can be reduced. This is because technical problems only have to be solved once (at the switch) rather than many times (at every terminal).

Terminals requiring to transmit an ATM cell are allowed to do so after they have been polled by the home switch. A terminal with many cells to transmit will be polled more often by the switch than will a terminal with only a few cells to transmit. However, a polling mechanism does not exclude the possibility of cells transmitted by different terminals colliding on the optical tree. The propagation speed of light in a silica optical fibre is 5 ns/m and the different branches of the tree may have different lengths. A nearby terminal may thus be connected to the home switch by as little as 10 metres of fibre, while the length of optical fibre between the home switch and a more distant terminal may well be one hundred metres. A cell from a distant terminal will therefore arrive at the switch after a relatively long time and a cell transmitted from a nearby terminal will arrive there within a short time, when both terminals are polled directly one after the other. The result of this will be a collision, in spite of the polling. This collision could have been avoided if the nearby terminal had delayed its response to the polling message. When the total sum of the optical propagation delay and the additional electrical delay inserted in a terminal is equal for all terminals, then transmission from the terminals to the home switch will be both highly efficient and free of collisions. In EBIN, an automatic protocol has been implemented to meet this requirement.

## Conclusion

The Experimental Broadband In-home Network is a demonstration network developed at PTT Research to study the application of B-ISDN services and techniques in the domestic environment. The most important demand was to design a user-friendly system. An advanced user interface has been developed through which the network and all services can be controlled by the user. EBIN can be used to demonstrate a number of services which will be characteristic of a future B-ISDN in particular and of future in-home networks in general. The software has been designed in such a way that it is easy to introduce new services by describing the relationship between currently available service components, using an object-oriented approach. This architecture allows for a flexible allocation of equipment and network resources to a service or to a set of interacting services. EBIN furthermore demonstrates the use of bidirectional ATM transmission at 155 Mbit/s on a passive optical tree and branch network.

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