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ATM is your next HiFi

Modern communications protocols could determine the shape of home electronic entertainment

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Abstract
The expansion of options for home entertainment and the adaptation of technologies from the information technology offer new possibilities for home electronic equipment. The increasing catalogues of programe and the wider diversity of services are being promoted through a larger number of delivery methods. The possibility is that the technological leak from the combination of telecommunications and information technology equipments could have an impact on the implementation of domestic entertainment equipment design. This arises from the sheer volume of the compnents used to achieve very complex functions. One of the most interesting technologies which is on the horizon is that based on Asynchronous Transfer Mode (ATM). This is being talked up in a wide number of forums including Video on Demand (VOD), interactive services and plain delivery of sound services to the home. Systems dedicated to HiFi audio only will still survive perhaps a little more successfully than dinosaurs did. We may note that vinyl has yet to die entirely and live concerts are still attended but they are examples of programme sources and these are increasing. This paper looks at the technology and its potential to rise to the need.

Introduction

The options for home entertainment have expanded greatly in the past five years. Within the UK there has been a general growth in the cable, celestial and terrestrial sources of programme material. These services are developing value added options in ways which reflect an increase in the potential for user choice and interactivity. The explosion in the sales of information technology equipment (ITE) for home use and the high popularity of CDROM and multimedia systems is creating a generation of users who handle readily the complexities of operating the equipment. A third force is the expansion of interest of the PTTs beyond the straight provision of communication services for commerce through the recognition of the benefit of being a value added service provider by using the existing contact with the private residences.

The confluence of these strands brings together three powerful market drivers each of which is discovering that its delivery mechanisms and protocols has much in common. The Intel 486 or Pentium chip used in the PC at home is the same one

which is used in the PC which is found in businesses. The large volume and commonality of chips and protocols leads to an impressively low cost of computing power and of the cost of access to service providers. This alone will drive down the costs of implementing design but it is the use of these same components to provide access for home entertainment which offers the interesting future.

The most dramatically introduced technology seems to be that based on Asynchronous Transfer Mode (ATM). Its design was spawned by PTTs (01) but it has been shown to be an impressive bearer of television and radio services (02). Its use within ITE has been extensively promoted partly because modern IT installations are great consumers of bandwidth but also because there is growing pressure to provide video and audio to the desktop whether from an internal office PC or via an Internet connection. The home entertainment systems have been traditionally built on individual equipments providing access to separate functions with the plain audio only HiFi providing the clearest examples of this practice. This has its origins in the history of HiFi where traditionally quite significant amounts of circuitry were required to achieve simple functions. Assuming that signals are available in digital form quite complex processing can be carried out on the signal in remarkable small space.

Conventional HiFi equipment places a single function in each box. Thus one unit handles the CD player, another the pre-amplifier, another the radio, another the graphic equaliser, another the power amplifier, another the surround sound processing and so on. Each such unit repeats the audio or video signal interface processing before passing the signal onwards. One of the major problems facing users with multiple equipments is their interconnection. Though it may be a dream, a single simple cable which connected the units together whether they were video, audio data or telecommunications might give rise to some simplicity. The simplicity would also be noticed at the man machine interface (MMI) where the trend towards automatic initialisation would be made available. Thus the physical MMI now becomes the real home entertainment equipment and it supplants the front panbel controls on the large number of individual equipments. This control may be a well styled remote control interface or an emulation program running on a PC.

The separation can be readily achieved if the signals are carried outside of an equipment in effectively the same signal format. This is quite sensible if the programme is a digital signal. This in turn recognises that there is no distinction between an audio, video or data signal. The data rates might be different but this is an aspect which could readily be handled if the communication hardware handled slow audio data with the same ease with which high speed video data could be handled. In order to assist with this operation all of the tools of bit rate reduction could be quite cheaply deployed.

The bulk of the effort so far in industry has been on the use and growth of ATM technology as ther transport for B-ISDN signalling. Though the costs of installing

B-ISDN is high in the UK this can be confidently expected to fall. Interestingly enough ISDN is more widepspread and at a much lower cost both to install and to operate in some other European countries. If the provision reaches the level at which the pricing no longer has to be determined by the need to choke demand then the costing of its use will move to concentrate on the value of the services which it can bear. In the next half decade it is possible to envisage that domestic access to B-ISDN terminal ports will be widespread. The full realisation of potential will not arrive until the bandwidth of the incoming signal aproaches that of the direct cable, satellite and digital terrestrial television carriers (Ref 07 and Ref 08). There is a will for the PTTs to compete on this ground as they wish to have parity with the cable operators, for example, who have the right to bring the telephone connection into the home.

More input for change comes from companies with a sizeable investment and interest in both consumer equipment and in the programme material or software. Companies such Sony are not passive observers of the developments in this area (Ref09).

This implies that a domestic residence may be fitted with a wideband port which can be used for outward communication and inward programme delivery - including any desired interactivity. The question might be whether this terminal adapter port can relate to anything else in the house. The answer may lie in the very low cost of ATM PC based chipsets. The cost is set to tumble as current press reports indicate, for example PCs will shortly come with the requisite ATM interface chip already attached to the mother board. Direct connection may be thus facilitated in much the same way as the modem modem and fax machine attach directly to the same voice grade line used for the current POTS (plain old telephone service).

Does ATM have to be the only technology in the home? The answer is not necessarily. Proposals (Ref 04) such as the Universal Serial Bus (USB) and Firewire (also known as P1389) have been made. But these are intended to support activity over short distances principally for local ITE. The USB, which runs at 12MHz, is intended to replace the parallel and serial ports presently found attached to a PC and is limited to a 5m length. One feature of ATM is that even Cat 3 cable could be driven satisfactorily by some hardware. Access to the house entertainment bus becomes one of accessing the nearest telephone style socket - call it the multimedia socket - which happens to carry an ATM signal from the main switching hub in the house. Part of the development of the future may depend a little on the development of the electronics industry and on the role of the conventional manufacturers of high end equipment. What is becoming clear is that the PC is gaining facilities which will allow it to carry out high quality changes to both sound and picture data in real time (Ref 05). This was the essence behind the Intel Native Signal Processor (NSP) proposal. The ATM link is essentially a two way link and it becomes possible to envisage the processing, selection and

switching for an entertainment source for the occupants of a house being located centrally whilst the point of control and experience is elsewhere. In principle there is no reason why, subject to adequate bandwidth being available, a number of unrelated services may travel the same internal wiring. The benefit comes if it is considered that the future use of externally provided programme or service facilities is much greater than it is at present. This requires us to imagine a number of gentle culture twists. In this regard the simple demonstration offered of real time decoding of an MPEG Layer III audio signal from a 28kBaud modem link to an Internet site (Ref 03) was demonstrated. The technology could be readily adapted to provide a music on demand service at CD quality levels.

What Is the ATM technology?

A full description of the technology fills books (Ref 06). ATM was chosen as the transfer mode for B-ISDN in 1988 and the choice of cell format was fixed in 1989. The growth is almost to ubiquity for professional ISDN users. The drivers and the stages in the growth of ATM are basically:

Digital switches replacing electromechanical switches

Optical transmission systems

Migration of digital communication towards the customer eg with ISDN

Rapid growth in mobile telephones

High speed data networks in LANs

The standard copy line remains the promise of one networking technology for all services and of flexible bandwidth on demand. ATM is so-called because information is transferred asynchronously with respect to its appearance at the input to the communications system. Information is received into a buffer which fills an ATM cell. When this is full the cell is despatched. At a multiplexing stage an ATM cell from a given stream of cells is transmitted as soon as there is an unused ATM cell available to carry it. If there is no information to be transmitted an unassigned cell is sent instead. This differs from packet switched networks in a number of ways:

The cells are shorter in order to reduce cell latency.

The overhead is minimised for high bit rates, for instance there is no error correction mechanism, it is left up to the application).

The cells are transported at regular intervals and there are no gaps between cells.

The order of cell arrival is guaranteed to be the same as the transmitted order.

Of interest is the protocol reference model for B-ISDN. The model is a little more complex than the familiar Open Systems Interconnection (OSI) 7 layer model. Visualised as a cube, the front face carries the physical layer, ATM layer, ATM Adaptaion Layer (AAL) and the higher layers. These last are split into the control plane and the user plane. Behind these plans are the corresponding management planes. The physical layer contains the transmission convergence layer which handles cell rate decoupling, header error correction (HEC) generation and verification, cell delineation, transmission frame adaptation and transmission frame generation and recovery. The physical medium layer handles the bit timing and the interface the the physical medium itself. The ATM layer handles generic flow control, cell header generation and extraction, cel Virtual Channel Identifier (VCI) and Virtual Path Identifier (VPI) translation and the cell multiplex. The AAL contains the convergence and the segmentation and reassembly layers.

The basic transport unit, the ATM cell, has 53 bytes comprising a 5 byte header and a 48 byte payload. There are two formats: the User Network Interface (UNI) and the Network Node Interface (NNI). The UNI has a smaller range of VPI values because it allocates the first four header bits to the flow control function. The VPI and the VCI specify the sewitching path for each ATM cell. This label is overwritten at each ATM node according to the Nodes internal routing table. This table maps incoming and outgoing ports and changes the VCI and VPI labels accordingly. Other functions determined by certain VCI and VPI values determine the operation and maintenance (OAM) functions, the cell loss priority (CLP) bit and the HEC byte.

The physical layer applies to the transmission and reception of ATM cells across a physical medium such as twisted pair, coaxial cable or optical fiber. It consists of two layers the physical medium dependent sub layer and the transmission convergence sub layer. The first deals with the signalling and error performance of the link. The second maps the ATM cells into a transmission frame and adapts the input and output cell rate by inserting idle cells. The ATM Adapation Layer (AAL) maps the variable length frames of user data into the fixed size payload of an ATM cell. AAL1 is intended for constant bit rate services, while AAL2 handles variable bit rate services such as bit rate compressed video. AAL3/4 were intended to handle mapping for connection and connection-less oriented data services. AAL5 is a simpler way layer method which may be more efficient than AAL3/4 and may replace it in time. It is intended for non-isochronous data at a variable bit rate such as MPEG 2.

There is a wide variety of interfaces defined for ATM. Initially the synchronous optical network (SONET) and the synchronous digital heierarchy (SDH) were

envisioned as the transmission technology for B-ISDN thus giving rise the the basic data rates of 155MB/s, 622Mb/s and 2.488Gb/s. The ATM Forum is addressing the need for the very large number of systems where shielded twisted pair (STP) or unscreened twisted pair (UTP) are found and this will lead to desktop ATM rates of around 25Mb/s. It is this which the home user is likely to find in the entertainment interface. The interface is the Residential Broad Band (RBB) and the ATM Forum is in the process of specifying the home interface.

The service is what the customer pays for and this service, in terms of ever increasing bandwidth, is used to support an application. There is a spiral here. At present the business user may be considered a broadband user as demands on a 10Mb/s ethernet Local Area Network (LAN) system would show. Increasingly business users are driving the LAN into the wide area network (WAN) and this brings with it the need to provide for the wider bandwidth. The system is not yet integrated in the sense that separate circuits are required for baseband voice communication and this is where the concept of ATM enters. In 1993 experimental ATM switches existed and manufacturers were announcing pilot products. By 1995 a wide variety of ATM based products could be seen at major exhibitions of computer network equipment, broadcast equipment and telecommunications equipment.

Implementation and the future

Recent collaboration between AT&T Microelectronics and Broadband Technologies Inc in the USA has led to a set of chips which are intended to be used to link a set-top box to a street based fibre optic loop. This is intended to provide at each house, an incoming data rate of 51.84Mb/s and an associated interactive feedback data rate of 1.62Mb/s. (Ref 10). In this structure a local optical network unit receives digital video and other data in ATM cells from the network centre. The address of each cell is read and the packet is sent to the home on a short length of UTP after other local services, such as POTS and cable vision are combined. Inside the home the ATM traffic is split off and can be sent to suitable set top equipment or computer. Outline costs of the three chip set required for the set top equipment is around 25$ in quantity and AT&T envisage an interface card costing around 350$ in around one year. BT (Ref 11) have been investigating the technology for providing quality videophone signals via ISDN lines and they envisage a wider use than simply face to face conversation.

The focus on reducing the cost of delivery of a wide bandwidth service is focusing on the cable drop into each home and there are competing approaches. Another approach, called Hybrid Fiber Coax (HFC), taps off the main fiber neighbourhood feeder to produce a multi-drop coax feed to each house in which the required wide bandwidth service is modulated on a carrier whose centre frequency may be as high as 550mhz. Whilst this is a minimum cost it does not provide for a wide

bandwidth for an interactive channel and for bandwidth hungry services and the approach which some PPTs in USA are taking is to provide switched digital video (SDV) solutions. In this case the provision of wider bandwidth will payoff because of the greater use of the better services which can be provided. The future is also being promoted in the UK (Ref 12) where, once more, the potential of linking the video, hifi and computer is recognised.

There are many more reports of work being carried out to interface ATM signals to more prosaic equipments. What is clear from the large amount of work which is being reported is that this is a technology which will become much more pervasive than even the humble Intel x86 style processors. The use of the ATM switching technology could have a radical effect on the way in which entertainment can be provided in the home. Partly through the sheer fact of its delivery in this mode, partly because of the ability to route around the house with ease but also because future entertainment equipments could come equipped with ATM ports as the preferred means of acquiring signals to process, display or to produce sound from.

References

01 The CCITT investigated the issue of B-ISDN and ATM in the 1985 - 1989 study period. At that time it agreed only that ATM would be the target transfer mode for implementing B-ISDN. The 1989 - 1992 study period resulted in a number of CCITT recommendations published in June 1990.

02 **Jacob and Parmar**, Reuters experience of vision over SDH or how comms and television got together and stepped into the future, Proc IBC 95, IEE

03 Fraunhofer Research Institute demonstrated ISO MPEG :Layer III real time decoding from a 28k8 Internet connection at IBC 95 Amsterdam. It can provide CD quality levels of music on demand in real time.

04 The Universal Serial Bus (USB) may impact as well. The current document is not finished but it is adequately long, try http://www.teleport.com/usb

05 **Taylor and Sanchez**, Audio Standards in Multimedia Computers, Proceeedings of AES UK Conference May 1994 Managing the Bit Budget. This may illustrate the growing importance of quality sound and pictures in PCs. It set out by noting that the IBM PC, first launched in 1980, always included audio and the facility to build on that existed. FM synthesis, wave table, MIDI coding, various forms of bit rate compression have been adapted. Whilst the target sources became the CDROM, telephony, games. The Multimedia PC Marketing Council set target standards in 1990 based on the data rates and perceived quality of CD audio.

06 **L Cuthbert and J-C Sapanel**, ATM The Broadband Telecommunications Solution, IEE London 1994.
This is a reference tome on the technology.

07 **C Coughlan**, Technological convergence, DEC, Proc SRS 94, Keele, IEE pub 402 pp112-117. The convergence is that of Media industry (films, music, publishing, associated marketing) Communications industry (telecoms, broadcasters, Internet, subscription service providers, NVOD) and ITE (CDROM - itself a crossover from audio though it was foreseen right from the outset - processing power, standardised MMI and program interfaces, initiatives such as OMF and AES3 help).

08 DAVIC issues draft MultiMedia specifications, Electronic Design Sept 5 1995 pp30, These standards are intended to support emerging technologies such as broadcasting, VOD, teleshopping and other interactive services. The specification defines all system components including set top box, server, physical layer through to application layer. It covers the modulation schemes for fiber, kerb side, satellite, UTP, use of MPEG2 and Remote Procedure Call, AAL5 for ATM and Q.2931 for ATM signalling. Information from Dr Ing Giancarlo Franzini, DAVIC secretary at +39 11 772 01 14 franzini@sia-av.it

09 **C Barraud**, The Impact of ATM on Television, IEE lecture to PGE14, 7 March 1995.

10 **L Goldberg**, Brains and Bandwidth: Fiber Service at Copper Prices, Electronic Design, 2 October 1995

11 **W Kembury, A R Murphy, D J Myers, C S Pitts**, K A Smith, Network Based Video Storage for Retrieval over the ISDN, Proc Storage and Recording Systems 1994, IEE publication 402

12 Electronics Times 13 April 1995 reports that SJ Electronics is planning on a low cost ATM switch which could be sold for around 50£.

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