INNOVATIONS

A SERIES OF ARTICLES WHICH EXPLORES SOME OF THE COMPLEXITIES OF EMERGING TECHNOLOGIES

DIGITAL COMPRESSION—EVOLUTION OF A STANDARD

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The *Broadcasting Services Act 1992* (section 94) provides for a digital compression standard for a full digital transmission system to be agreed to by both pay TV licensees A and B. (See box for description of digital compression.) The Act provides for the Minister to declare,by notice in the *Gazette,* that the standard must be used by all satellite subscription television broadcasting licensees. There was a proviso that the Minister should consult with Optus in regard to the efficient use of the satellite. In addition, section 94 provides that if licensees A and B did not agree by 1 March 1994, the Minister must declare a standard chosen by the Minister.

When the Act was drafted it was envisaged that licences A and B would be allocated sometime in the middle of 1993. Licence B was not allocated until December 1993 and licence A in February 1994. This meant two months of frenetic activity by licensee B and the expected holders of licence A to develop a standard in record time.

The key issues facing the licensees were:

- availability of reception equipment capable of being manufactured in Australia;
- cost effective reception equipment;
- the evolving international standards in the area;
- efficient use of the satellite; and
- the need to fit all 10 services (from licensees A, B and C) into two Optus transponders.

The situation was complicated by the fact that the relevant international standards bodies, the International Electro-Technical Committee and the International Standardisation Organisation had released only a committee draft version of the standard commonly known as 'MPEG 2' (see insert). In addition, the European Launch Group (ELG) for the Digital Video Broadcasting (DVB) was also in committee stage and had not agreed a final standard. Both licensees were keen to ensure a practical standard that could be delivered as early as possible and this quickly led to a two phase approach to a full digital transmission system.

The licensees recognised that ultimately the aim was to get to a fully open systems architecture, based on the committee draft ISO 13818 or MPEG 2. The major problem was that a chipset to implement MPEG 2 was unlikely to be available to manufacturers until the fourth quarter of 1994. This meant working with a number of manufacturers who had an interim solution (probably based on MPEG 1) to allow the fastest rollout of satellite subscription television broadcasting.

In order to provide some boundary to the problem, the following decisions were made:

- that the interim solution be in production now;
- that both the interim and final solutions had to have the control led access capabilities that were likely to be required by the Senate inquiry into the provision of R rated material in subscription television programs;
- that the minimum total bit rates for broadcasting be as follows - sport: 8Mb/s - general programming: 6Mb/s - movies: 5.2Mb/s;
- that the subscriber installation fee be reasonable.

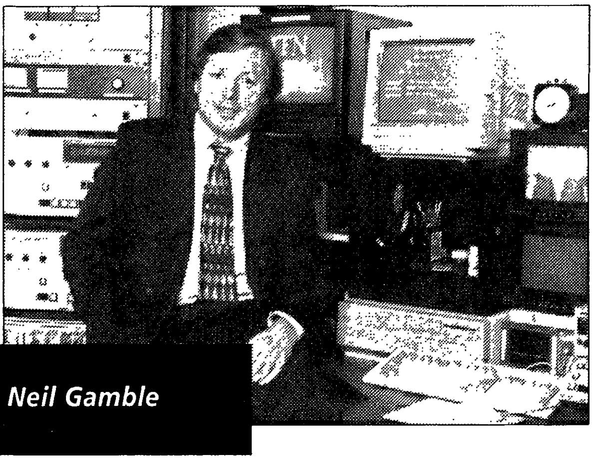
THE MPEG STANDARD

The standards for video compression worldwide were derived from early work on compressed still picture information performed by the Joint Picture Expert Group (JPEG). This committee approach was adopted by the Moving Picture Experts Group (MPEG) with support from bodies across the world including the International Telecommunications Union, the American National Standards Institute and Standards Australia. The original standard for compressed digital video was designed to operate on 'closed' systems. it was envisaged that digital compressed video would be used mainly in personal computers and graphics work stations. This meant that although the standards would find the techniques to be used in compression including discreet cosine transform and variable length in coding, there was no anticipation that the compressed video would be sent over a transmission path and therefore no transmission standard. The standard established by this MPEG group, commonly known as MPEG 1, is optimised for bit rates of between 400 kilobytes per second and 1.5 megabytes per second. The 1.5 megabytes per second rate represents the primary telephony bit rate in the US. MPEG 1 encoding also allowed for full stereo CD quality audio to be associated with the video image. MPEG 1 had no pretensions about quality, merely aiming for near VCR quality.

MPEG 2 was seen to being a unifying standard across a number of different market requirements. The first, as a basic video compression system which could be agreed by CCITT. The Americans saw MPEG 2 as being the basis for high definition television (HDTV) and 'the Grand Alliance' provided a great deal of input to the MPEG committee. MPEG 2 is a standard which includes elements of transmission and multiplexing and specifically has a transmission standard that is compatible for the next generation of switching systems—Asynchronous Transfer Mode (ATM).

The video compression portion of the MPEG 2 Draft International Standard was finalised at the Sydney meeting of MPEG in early 1993. However the transmission standards were only finally agreed at the last meeting of the MPEG committee.

This shortened the list of potential suppliers quite substantially and also started to influence the dish size to be used and the performance of the low noise converter that converts the high performance signals (about 12 GHz) down to the more manageable 950-1450MHz, which is the standard input on most satellite set-top converters. At the same time research showed that a target dish size of 65cm. diameter was probably the most acceptable for the vast majority of Australians.



Neil Gamble

Availability

Having made these decisions, the licensees then approached Optus to consult on the optimum use of the satellite. Optus provided tremendous assistance in coming up with an optimal solution which would lead to a service availability greater than 99.9% of the time in the worst rain affected month. This concept of availability is key in that it determines both dish size and quality of picture. The fact that the system is digital means that consumers see either a perfect picture or no picture at all. This is analogous to the cellular phone industry. With traditional analog phones, one can hear when fading is about to occur, whereas with digital phones there is a complete dropout. With the assistance of Optus a solution was determined which provides for a large rain fade margin in the worst rain month. It is mainly due to the variable gain mode of the Optus B series satellite that uplink rain fade margin could almost be eliminated. This mode of satellite operation is unique to Australia.

Consultations with the Department of Communications and the Arts started in early February, after several drafts had been completed. The licensees received assistance from the Department's Communications Laboratory, in further refining the approach and ensuring that the key elements, conditional access and forward error correction, were correctly defined.

The final draft was submitted to the Minister's office on the last Friday in February. Between then and gazettal, the Department went through a rigorous due diligence process, to ensure that the standard met all the requirements of the Act. The standard was finally gazetted in the second week of May 1994.

What is Video Compression?

Basics

Digital Video Compression is a transmission technique that can transform a conventional television signal into digital information. This dramatically reduces the amount of frequency bandwidth needed to broadcast the signal. This technology makes it possible for satellite operators and local broadcasters to transmit multiple television signals within the amount of frequency spectrum now used to relay a single television channel.

By using digital video compression, for example, a single satellite transponder can accommodate the simultaneous transmission of up to ten video program services. Indeed, the same compression technology could be used to transmit up to four channels within the six or seven megahertz band width now used relay a conventional broadcast or MDS television channel.

Digital video compression can also appear to improve the quality of both broadcast pictures and television sound. Because the signal is composed of digital data rather than conventional analog wave forms, the picture and sound quality are not subject to 'ghosting', poor colour quality or other degradations that occur during the transmission of conventional television signals. Furthermore, digital video compression also uses advance techniques to produce a superior video image. Another feature is that compact disc quality sound is delivered by digital video compression systems.

How Digital Video Compression Works

A singal frame of 625 line PAL video is composed of almost 200 000 pixels. Since video operates at a rate of 25 frames per second, more than 4 million pixels are being displayed on a television screen every second.

To compress this astronomical amount of information into a more compact package, the luminance and chrominance components of the video signal must be converted into a digital format. The pixels contained in each television frame are encoded into blocks of binary digital bits.

Before compression a single digitalised colour television signal require a data stream of about 140 million bits per second (140 Mbit/s), a rate that requires a fibre optic or three satellite transponders. With compression, each digitalised block of pixels is first analysed or 'encoded' to determine which blocks within the frame actually need to be sent.

It is necessary to resend a block of pixels in which no picture elements have changed. In this case, the encoder can economise by sending a signal to the satellite receiver, and instructing it to recall the unchanged blocks of pixels from the last frame and reinsert them into the next frame.

Using a technique called 'motion compensation' the direction and speed of any moving object within a particular frame is computed and then a signal is transmitted which instructs the receiver to recall the affected blocks of pixels from the previous frame and then shift those same blocks to an adjacent portion of the picture during the next frame. Whenever a major scene change occurs the encoder must transmit an entire set of new blocks and instruct the receiver to drop all of the blocks comprising the previous frame which have been stored in memory.

Once the video encoding has been completed the next step in the compression process is to reorganise digital blocks of pixels into an even more compact format. The most common algorithm to achieve this is discrete cosine transform (DCT). The output digital data stream is maintained at a constant bit rate by throwing away information when there is too much to handle or by sending more information than is needed to maintain a constant bit rate.