AN INTRODUCTION TO DIGITAL CABLE TV
PART I

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A two part article introduces the reader to the basics of Digital CATV. Part I of this 2 part article provides a primer on the reasons for a transition to digital, and the basic technologies used. Next month, Part 2 will look at a Digital cable TV Headend & the advanced services that a Digital CATV system can deliver. Cable TV is transforming into Broadband services putting greater demands on the type and the quality and it is time the operators re-evalute themselves to meet these demands. Networks in India generally carry almost 60 Channels of Analog Video today and with the need for delivering Internet services and possibly Telephony in future is bound to apply greater pressures on the BW of the network.
How many Channels?

In analog format the maximum Video channels that can be carried over a 750 Mhz network is 84 which puts heavy demands on the active elements of the network to maintain the quality of services. But if other services have to be accommodated it has to be at the expense Analog video services. If other premium channels have to be delivered, more Bandwidth (BW) is consumed. A futuristic Broadband network will have to deliver the following services

Analog Video services

Analog scrambled Pay Per View

Digital Video services

Data (Internet) services

Interactive services including games

Video on Demand

Telephony

High speed data

Of course, all these would have to be simultaneously delivered through the same cable network.It is not possible to deliver all of them unless

- The network is of 860 MHz BW
- Two way capable robust network
- Quality end of line performance
- Controlled Noise performance
- Monitoring and control

While each point mentioned above could be dealt at length, we focus on Digital TV technology in this article.

What is the way out?

First and foremost is to reduce the occupancy of BW for Video services and the second is to deal with the return path issues for interactive applications. In fact there are other valid reasons to go digital in the cable system. What makes digital television so special? A digital image isn't inherently better than an analog image, and in some cases it can be worse. A digital TV transmission picture doesn't have to be digital either; Japanese HDTV is broadcast over an analog signal. But it occupies a lot more band width than the analog TV signal. There has to be another

reason why we are choosing to go through the pain of switching from analog to digital and that is conservation of Bandwidth.

In fact, there are several good reasons to go digital, including: how much data it can transmit, how consistent the data stays over distance, and what type of data the signal can carry. For the same amount of bandwidth, you can stuff a lot more information into a digital signal than an analog signal. A digital signal doesn't produce the same problems with the picture we see on a distant analog television, either. And television in the digital age won't be limited to video and audio; our televisions will become truly interactive. Combined with HDTV and digital sound, this means a better picture, better sound, and digital data. But how are we going to fit all this into the same amount of frequency?

DIGITAL VS ANALOG

Digitizing an analog signal is done by sampling the analog signal at a defined rate and assigning a value for each sample. It is evident that wider analog (higher BW) signal require higher sampling rate (more frequently to be sampled). Voice (telephone) channel require 64 Kbps Digitized video (with out compression) require 108 Mbps.

Is it not strange that now we have increased the BW requirement but still say digital has advantages? The secret lies in compression. An advantage digital has over analog is that analog signals can't be compressed as well as a digital signal can. To transmit an image on analog television, every pixel is included in the signal. A standard TV screen includes over 300000 pixels per frame. That's a lot, but it fits into the 6MHz bandwidth of a television channel. To transmit an HDTV picture, the pixels increase more than five times which means more BW requirement to transmit in conventional way. Somehow, more than five times as much information will need to squeeze into the same bandwidth of 6Mhz. So how are they going to do that? The same way the compression software on your computer squeezes your files.
Well, almost the same way…….. believe this.

COMPRESSION

Video on digital TV will be compressed using a scheme called MPEG-2. It takes advantage of how the eye perceives color variations and motion. Inside each frame, an MPEG-2 encoder records just enough detail to make it look like nothing is missing. The encoder also compares adjacent frames and only records the sections of the picture that have moved or changed. If only a small section of the picture changes, the MPEG-2 encoder only changes that area and leaves the rest of the picture unchanged. On the next frame in the video, only that section of the picture is changed.
In the above example, the change is the man running towards the house. This principle is called Spatial compression which is based on redundnat information from picture to picture. As a next step, if we are able to predict the moving object position in the next frame, and transmit only the difference between the actual and predicted. This type of compression is called Temporal compression.

MPEG-2 has some problems, but it's a good compression scheme and it's already an industry standard for digital video for DVD-Videos and some satellite television services. One problem with MPEG-2 is that it's a "lossy"compression method. That means that a higher compression rate gives a poorer picture. There's some loss in picture quality between the digital video camera and what you'll see on your television. However, the quality is still a lot better than an average Analog image. And using these compression schemes, MPEG-2 can reduce the amount of bits by about 55 to 1. With that ratio, there's a lot of information that get's thrown away, but there's still enough to look like everything is still there.

MPEG-2 has lot of advantages mainly ; Robust to Errors, Low over head bits, Simple decoding process, Friendly for ATM (Telecom) links facilitates long distance transport.
Digital Television bit rates
Analog live Video - Digital format- 108 Mbps
Analog live Video - Compressed format - 6.0 Mbps

Video on Demand - Compressed format- 3.0 Mbps
Video Games - Compressed format - 1Mbps

SOUND

The human ear isn't as easy to fool like you can fool the eyes. It's much more sensitive to subtle changes in sound. Digital TV is going to improve the sound over today's television using advances in digital sound developed over the last two decades. When CD's appeared on the market, most people were skeptical about the silver discs, but the sound was great. Digital audio recordings on CD have a wider frequency range, finer sampling, and they won't wear down with age (it stays perfect until something like a scratch damages the data). Almost everyone can hear an obvious improvement. Eventually they have taken over the commercial music industry, but television is still low-range analog. Taking the next logical step, Digital TV will broadcast sound using the Dolby Digital/AC-3 audio encoding system. It's the same digital sound used in most movie theaters, DVDs, and many home theater systems since the early 1990's. It can include up to 5.1 channels of sound: three in front (left, center, and right), two in back (left and right), and a subwoofer bass for a sound you can feel. Sound on digital TV will be "CD quality" with a range of frequencies lower and higher than most of us can even hear.

TRANSMISSION

Remember the days before cable television when someone in the family would assume the job of antenna specialist to improve that picture to a viewable standard, they would skillfully adjust the alignment of the antenna to get the best possible picture. But sometimes the picture would still show a foggy double image or ghostly images from the next channel. All these problems are caused by the weak signals from distant or blocked transmitters as viewed by the receiving antenna.
A basic natural law that no technology can't overcome is the weakening of television signals as they travel away from the transmitter and around or through objects. Both analog and digital signals get weaker with distance. However, while the picture on an analog TV slowly gets worse for more distant receivers, a picture on a digital transmission will stay perfect until the signal becomes too weak for the receiver to pick it up. By perfect we mean the picture on the TV is exactly the same picture at the staring point.In a digital signal, a one is always a one and a zero is always a zero.

RF MODULATION AND BANDWIDTH

The compressed video is delivered to the home over the cable network over QAM (Quadrature Amplitude Modulation). In a simple statement, QAM is a form of Double side band modulation. The data stream is split in to two half rate streams. One of the streams modulates a sine wave RF carrier and the other stream modulates Cosine carrier. When they are added the resultant signal looks like a vestigial side band with no pilot carrier present. With QAM modulation in a 7 MHz RF channel we can transmit atleast 38 Mbps of information. The RF carrier is very similar to the Analog carrier hence all existing cables can carry this service. Infact, digital service can co exist with analog service in the cable plant.

Assuming 6 Mbps for one Video program we can confidently say that 6 Video programs can be delivered to homes in 7 Mhz BW which would have carried only one analog video had we not gone digital. Now you can appreciate the Digital better? Typically 8 programs are accommodated in a 7 Mhz channels by using multiplexers which will dynamically allot bit rates. We will not be getting into details in this article.

Some additional information on QAM:

- It is the most BW efficient modulation well suited for HFC networks
- QAM has fast carrier acquisition and will appeal well for interactive application and surfing applications
- Forward error correction bits are added in the data stream to allow for correction of transmission errors
- Additional Trellis and Reed-Solomon error correction are used to correct practically all errors thus requirement of C/N is only 25 dB (Remember a good analog picture require C/N of 45 dB).

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