Digital TV and Mobile TV Backhauling Over IP

IP continues to replace TDM technologies on its way to becoming the universal transmission platform. When correctly engineered and complemented by the right error protection mechanisms, it can be used to provide reliable content distribution to TV transmitter networks.

IP Carriage of TV Distribution Services

Digital TV content distribution, or backhauling, has traditionally been done using ASI services over TDM circuits. Those natively used the TV multiplex's MPEG framing. When carried over IP, the MPEG stream needs to be encapsulated in IP according to the Pro-MPEG COP3 (or equivalently SMPTE 2002-2) open standard: the MPEG multiplex is partitioned into consecutive groups of up to seven MPEG packets; each such group is encapsulated in an IP packet; and, finally, the resulting IP packets are carried over a unidirectional RTP stream.

Traffic Engineering for TV Distribution

When traffic-engineering an IP network for Digital TV or mobile TV distribution, the following considerations need to be taken into account:

Bit rate: A TV backhaul stream will typically be Constant Bit Rate (CBR) in a Single Frequency Network (SFN) and moderately Variable Bit Rate (VBR) in a Multi-Frequency Network (MFN). While it is fairly tolerant to delay and jitter (see below), the necessary capacity for the stream needs to be available over any averaging interval that is longer than a few tens of milliseconds. So, for example, bandwidth sharing with volume applications such as FTP is not desirable unless proper bandwidth management mechanisms are in place: otherwise, the FTP stream might occasionally crowd out RTP for a period that is long enough to cause underflow of the TV transmitter's input buffer.

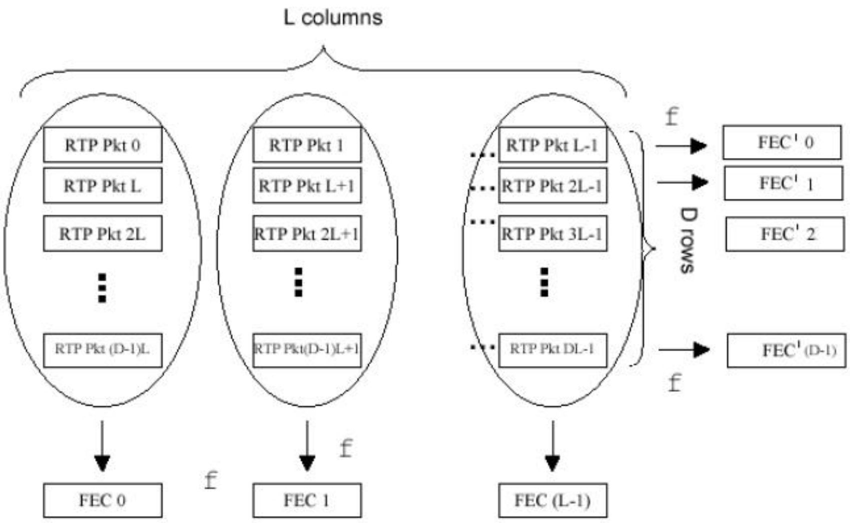
Delay and jitter: TV backhauling is fairly tolerant to delay and jitter. While video encoding and decoding are real-time in nature, the fact that the service is unidirectional means network delay is not critical and buffering can be employed to combat jitter. For MFNs, Channelot's Channelot 10X transmitters include a deep buffer that can accommodate jitter of hundreds of milliseconds. In SFNs, transmitters in general and Channelot 10X in particular need to include a worst-case delay plus peak jitter buffer of 1 second.

Packet loss: TV backhauling is sensitive to packet loss: the loss of a packet is likely to be noticeable to the viewer as a momentary distortion in the picture or soundtrack. Furthermore, in an SFN the loss of a packet may cause misalignment of the transmitter's output for an extended duration, causing a longer service disruption: in DVB-T/H, the remainder of the mega-frame will be out of sync with the SFN, while in CMMB the loss of a service-description packet will result in the loss of an entire transmission slot. Since completely avoiding packet loss in packet networks is difficult, a more effective approach is to utilize the end-to-end packet-level error correction scheme we'll now describe.

IP Packet-Level Error Correction

Recognizing the vulnerability of TV distribution services to packet loss, COP3 (or equivalently SMPTE 2002-1) specifies an optional packet-level error correction mechanism for MPEG-carrying IP streams. This calls for the sender to add to the stream redundant packets, which enable the receiver to re-create packets that have been lost en route and re-insert them at the correct location in the stream, thereby avoiding service interruptions. This is achieved using the following mechanism:

A COP3 / SMPTE 2002-1 compliant sender conceptually divides the MPEG-carrying packet stream into fixed length groups of packets. Each such group is then organized into a two-dimensional matrix with a pre-determined size of *L* columns by *D* rows (the product of which equals the size of the group). The sender then internally generates one additional row of *L* packets and one additional column of *D* packets, the content of which is computed as follows: the payload of each of the *L* packets in the new row is computed by bit-wise XORing all *D* packet payloads in the corresponding column, and similarly, the payload of each of the *D* packets in the new column equals the bit-wise XOR of the *L* packet payloads in the corresponding row, as illustrated below:



The sender now tags the packets with numbers specifying their location in the matrix. It then transmits the $L \cdot D + D + L$ packets in a pre-determined order, adding signaling that informs the receiver of the parameters used, group start locations etc.

The receiver starts its own processing by arranging each group of packets in the same two-dimensional order of original and redundant packets. While doing this, the receiver uses the numbering information supplied by the sender to identify packets that were lost and are missing from the group. The receiver is now able to re-create the payload of up to one missing packet per column (or row) by bit-wise XORing the remaining D (or L) out of $D + 1$ (or $L + 1$) original and redundant packet payloads that were received correctly.

The standard allows a range of values for D and L, providing flexibility in trading-off overhead, delay and error-correcting capability. As a minimum, senders and receivers should support a Column count of up to 20 and a row count of between 4 and 20, with $L \cdot D$ ranging up to 100.

By way of parameter choice examples, if *L* and *D* are chosen to equal 10 the error-correction overhead is 20% and 10 lost packets can be recovered per group (10%). The delay added in this configuration is 52.6 ms at a multiplex rate of 20 Mbps. If *L* and *D* are chosen to equal 5 the overhead increases to 40% and up to 20% of packets in a group can be recovered; the delay at 20 Mbps is then 13.2 ms.

Conclusions

With the aid of end-point packet-level error protection, properly engineered IP networks can reliably and cost-effectively serve TV content distribution to transmitters. With their comprehensive selection of IP network interfaces and built-in support of COP3 error correction, Channelot 100, 101 and 102 are ideally suited for operation with such IP-based distribution networks.