Adaptive Coding and Modulation

Technology Whitepaper

7 August 2009

Background

Variable Coding and Modulation (VCM) and Adaptive Coding and Modulation (ACM) are techniques that are strongly associated with the DVB-S2 standard (EN 302 307). VCM can be used to provide different levels of error protection to different components within the service. It does this by allowing different combinations of modulation and FEC rate to be applied to different parts of the data stream. ACM extends VCM by providing a feedback path from the receiver to the transmitter to allow the level of error protection to be varied dynamically in accordance with varying propagation conditions. Claims of performance improvements exceeding 100% have been made for ACM in terms of satellite capacity gain.

What is less well known is that the DVB-S2 VCM and ACM concepts can be applied to traditional Single Channel Per Carrier (SCPC) types of services and can offer similar benefits. This whitepaper gives an overview of how these concepts can be used outside of DVB-S2 satellite services.

DVB-S2 itself is offered by Paradise in SCPC modems and can be used in both SCPC and Multiple Channels Per Carrier (MCPC) modes. However, it is convenient to use a term that can be used to refer specifically to non-DVB-S2 SCPC satellite services and the terms 'SCPC' and 'traditional SCPC' are used in this whitepaper for that purpose (even although traditional SCPC systems have themselves evolved to have an MCPC capability).

For the avoidance of doubt, the traditional SCPC services (i.e. all services offered by Paradise SCPC modems) that are being referred to include, but are not limited to the following: IBS and IDR framed satellite services, Closed Network services, Engineering Service Channel (ESC), Automatic Uplink Power Control (AUPC), Drop and Insert, TPC, Viterbi, Reed-Solomon, TCM, LDPC (including the low-latency variety), all traditional modulations (including 8QAM and 16QAM), multiplexing of data from multiple terrestrial interfaces onto a single carrier, MIL-STD-188-165A/B, etc. – all using a variety of terrestrial interface types including IP, EIA530, LVDS, G.703 and HSSI.

SCPC VCM

VCM can be used to extend traditional SCPC services in a similar manner to how it is used in DVB-S2.

A quasi-error free quality target is set for each remote terminal as normal. The choice of modulation and FEC rate, which determines the strength of the error correction, will be determined by a number of factors including the position of the remote terminal within the satellite footprint.

The DVB-S2 concept of a frame can be applied to SCPC links along with all of the other DVB-S2 concepts including, but not limited to, mode adaptation, stream adaptation, baseband frames, mapping, pilots, dummy frames, scrambling, bit interleaving, constellation bit mapping, slots, generic continuous and generic packetized streams, stream synchronisation, FEC frames and Physical Layer framing. When applied to traditional SCPC services, these DVB-S2 concepts perform similar functions and provide similar benefits to those documented for DVB-S2.

At its simplest, the user data (whether packetized or continuous) is put into baseband frames (possibly with padding), FEC information is added and then a Physical Layer (PL) header is prefixed prior to transmission to create the satellite frame for transmission.

The size of the baseband frames is dependent on the particular FEC scheme being used. For block based FECs such as LDPC and TPC, the baseband frame size is related to the block size of the FEC.

Mode adaptation and stream adaptation deal with the issues of single and multiple stream inputs and merging and slicing of these streams into a sequence of satellite frames.

A particular frame, PL header apart (see overleaf), is always transmitted in a homogeneous manner using a single modulation and FEC rate.

(continued →)

Paradise Datacom LLC
328 Innovation Blvd.
State College, PA 16803 USA
Tel: 1 (814) 238-3450
Fax: 1 (814) 238-3829

www.paradisedata.com

Paradise Datacom Ltd.
1 Wheaton Road, Witham
Essex CM8 3UJ England
Tel: +44(0) 1376 515636
Fax: +44(0) 1376 533764

SCPC VCM (continued)

As with DVB-S2, particular information can be conveyed in the baseband header to help with decoding at the receiver, including:

- Data format (packetized/continuous)
- Single/multiple stream indicator
- CCM/VCM/ACM indicator
- Stream synchronisation information
- Roll-off factor.

Also as with DVB-S2, particular information can be conveyed in the PL header to help with receiver synchronization and demodulation of the frame, including:

- Frame identification information
- Details of the FEC type, modulation and FEC rate used to encode the remainder of the frame
- Indication of the FEC frame length.

All of the baseband and PL header fields can easily be extended to accommodate non-DVB-S2 pertinent data that is required for use of these techniques with traditional SCPC services (such as the use of alternative FECs to those specified in DVB-S2).

A key point is that the PL header is always transmitted using a particular robust modulation (BPSK is used in the DVB-S2 standard) and strong FEC rate. This helps the receiver lock onto the signal and it provides the information required to demodulate the remainder of the frame. When not receiving a signal, the receiver is automatically configured to detect any PL header, requiring just a centre frequency and symbol rate to have been set.

Note that the DVB-S2 concept of pilots (unmodulated symbols) can also be applied to make traditional SCPC services more robust.

SCPC ACM

ACM can be used to extend traditional SCPC services in a similar manner to how it is used in DVB-S2. The benefits include greater satellite throughput, reduced link margins and higher service availability.

SCPC ACM is applicable to both point-to-point and point-to-multipoint systems. In terms of a return channel, both a direct return channel over satellite and an indirect return channel via a terrestrial network can be used. Even over satellite, multiple separate SCPC return channels are possible using receive-only modems at the hub, where the return information can be passed on to the transmit modem to allow it to optimise the strength of error correction for each stream as applicable to the channel conditions.

The concept of the DVB-S2 ACM command can equally be applied to traditional SCPC systems and for the same purpose.

Signalling of reception quality via the return channel can be supported in SCPC systems, in particular continuous feedback of the carrier to noise plus interference ratio at the receiver along with other potential reception quality parameters (e.g. Eb/No, Modulation Error Rate (MER), Error Vector Magnitude (EVM) and suchlike).

SCPC ACM is particularly well suited for use in IP networks because mechanisms readily exist in terms of IP protocols such as Quality of Service provisioning, traffic shaping and TCP to feedback changes in data rate to the terrestrial network, allowing dynamic changes in satellite bandwidth due to varying reception conditions to be quickly reflected in the data stream to optimise use of the link.

In summary, the flexibility, robustness and efficiency of DVB-S2 VCM and ACM multistreaming features can now be used to extend traditional SCPC services, bringing the same benefits to all applications including cellular backhaul, ISP trunking and backbones, broadcast, teleports, government, military and SNG.