ACM Evaluation Using SDR Channel Emulation

2014/2015 SCS Program – Basic Techniques Project
Team: Juan Pablo Cuadro, Adrien Gay
Supervisor: Laurent Franck
Introduction

DVB-S2

Adaptive Coding and Modulation (ACM)

Laboratory Setup
  - Modems
  - Channel Emulator
  - Network Model
  - Measurement Procedure

Results

Conclusions
Introduction

Project objectives:

- Demonstrate the use of channel emulation for satellite links using SDRs.
- Illustrate the advantages of ACM over CCM
DVB-S2 & ACM
DVB-S2

- High demands for new types of services (HD TV, VoIP, Internet access or interactive services) + improvement of technologies
  → called for an updated standard: **DVB-S2**

<table>
<thead>
<tr>
<th></th>
<th>DVB-S</th>
<th>DVB-S2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Usage</strong></td>
<td>Broadcast</td>
<td>Data Streams</td>
</tr>
<tr>
<td><strong>Mode</strong></td>
<td>CCM</td>
<td>CCM/ACM</td>
</tr>
<tr>
<td><strong>Modulation</strong></td>
<td>QPSK, 8PSK, 16QAM</td>
<td>QPSK, 8PSK, 16APSK, 32APSK</td>
</tr>
<tr>
<td><strong>FEC</strong></td>
<td>RS - Convolutional</td>
<td>LDPC-BCH</td>
</tr>
<tr>
<td><strong>Roll-off</strong></td>
<td>35%, 25%</td>
<td>35%, 25%, 20%</td>
</tr>
</tbody>
</table>

**DVB-S2:**
- More efficiency
- More flexibility
Constant Coding and Modulation (CCM):

- Fixed MODCOD for each user and all the time
- High margin in link budget (worst case propagation conditions)

Adaptive Coding and Modulation (ACM):

- Selection of the optimal MODCOD for each user according to the state of the propagation channel
Complex system as we need to have a return channel, a reliable estimation of CNIR and an ACM client/controller.
Selection of the optimal MODCOD is tricky as it has to take into account distortion of the signal. It is estimated by a proprietary algorithm, the NoDE (Noise and Distortion Estimator)

Optimal MODCOD: Compare Es/N0 with ( Threshold + Distortion + Margin )

Margin UP > Margin DOWN:

→ Create hysteresis to avoid spurious variations of MODCODs
Laboratory Setup & Measurements
Laboratory Setup

- Ethernet Switch
- Newtec EL470 Modems:
  - HUB
  - Station
- Vector Signal Transceivers
- R&S FSV Signal Analyzer
- Multiple Lab PCs
Laboratory Setup (cont’d)

Connection Diagram

- Ethernet
- Coaxial
- PXIe

Diagram showing the connection setup with various devices and their connections.
Modems: Newtec EL470

- State-of-the-art modem designed for transmission of IP data over satellite links. Maximum throughput of 133Mbps with strict DVB compliance.

- Available modcods:
  - QPSK: $\frac{1}{4}$, $\frac{1}{3}$, $\frac{2}{5}$, $\frac{3}{5}$, $\frac{2}{3}$, $\frac{3}{4}$, $\frac{4}{5}$, $\frac{5}{6}$, $\frac{8}{9}$, $\frac{9}{10}$
  - 8PSK: $\frac{3}{5}$, $\frac{2}{3}$, $\frac{3}{4}$, $\frac{5}{6}$, $\frac{8}{9}$, $\frac{9}{10}$
  - 16APSK: $\frac{2}{3}$, $\frac{3}{4}$, $\frac{4}{5}$, $\frac{5}{6}$, $\frac{8}{9}$, $\frac{9}{10}$

- Embedded point-to-point FlexACM controller (HUB) and client (Station). ACM only available in FW link.

- L-band outputs
Modems (cont’d)

16APSK
VSTs allow for real-time processing in LabVIEW by streaming IQ samples to and from lab PC

AWGN injection for Es/N0 setting. Phase noise injection is also available.

Es/N0 controlled either manually or by inputting a time series.
Modems are configured as L3 IP bridges.

Ethernet link is terminated at each modem.

Hosts at both ends are neighboring hosts.

Only IP traffic destined for remote site is transmitted.
Network Model (cont’d)
Measurement Procedure

- Es/N0 time series is fed into channel emulator software and emulation is started.

- At the same time UDP traffic is generated using Iperf by the HUB PC. In addition all Ethernet frames arriving to the Station PC’s Ethernet interface are captured using Tcpdump.

- ACM controller log (.csv) is extracted from modem.

- All this data is then passed on to a set of matlab and python scripts for parsing and processing.
Results & Conclusions
Results – Es/No Emulation

16 minute emulation

Es/N0 ranging from 25dB to 2dB.

0.5dB steps lasting each 10s.

Both curves overlap. There seems to be some underestimation as well as spurious values.
ACM adapts modulation and coding depending on link conditions to achieve QEF target (PER = $10^{-7}$).
Results – Throughput ACM vs CCM

Naturally, UDP throughput varies as modcod parameters vary. UDP throughput disappears quickly because of LDPC BER curve steepness.
Results highlight the importance of ACM-type schemes in current DVB-S2 systems as well as their potential for future satellite systems.

We achieve better spectral efficiency when favorable conditions occur.

Better availability with respect to CCM.

Work shows that SDR based channel emulation is a viable and reliable option which is cost-efficient in comparison with dedicated hardware.
Thank you.