DVB-T2 Update
Standardisation, Performance, Service Plans

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BBC Research & Innovation
Introduction

- UK are committed to starting T2-based HD service by end 2009
  - T2 chosen because of potential capacity increase over DVB-T

- Other countries (e.g. Finland, Sweden, Italy) also showing strong early interest in T2

- More than 40 companies and 70 people have actively participated in development of T2 specification
  - Many meetings; many tens of telecons; thousands of emails

- T2 specification
  - Frozen: March 2008
  - Published by DVB: June 2008
  - ETSI standardisation under way
Key Commercial Requirements for T2

- Must be able to use existing domestic receive antenna and existing transmitter infrastructure
  - Intended primarily for services to fixed and portable receiver

- Should provide minimum of 30% capacity increase over DVB-T
  - Within same planning constraints as DVB-T

- Should provide for improved SFN performance

- Should have mechanism for providing service-specific robustness

- Should provide for bandwidth and frequency flexibility

- Should provide means to reduce peak-to-average power ratio
Summary of Techniques (1)

- S2 Low Density Parity Check (LDPC)
  - (Rates: $\frac{1}{2}$, $\frac{3}{5}$, $\frac{2}{3}$, $\frac{3}{4}$, $\frac{4}{5}$, $\frac{5}{6}$)

- Compatible S2 system layer (Baseband Frames)

- Classical GI-OFDM
  - FFT sizes: 1K, 2K, 4K, 8K, 16K, 32K
  - GI sizes: 1/128, 1/32, 1/16, 19/256, 1/8, 19/128, $\frac{1}{4}$
  - Bandwidths 1.7, 5, 6, 7, 8, 10 MHz

- 8 Scattered Pilot patterns

- Continual pilots for common phase error rejection and fine frequency control

- Three main levels of interleaving
  - Bit interleaving, Time interleaving and Freq. interleaving
Summary of Techniques (2)

- **Time slicing at physical layer**
  - Different Physical Layer Pipes can have different levels of robustness
  - Enables power saving

- **Sub-slicing within frame**
  - Increases time diversity/interleaving depth without increasing de-interleaver memory
P1 symbol for frame sync. and for rapid T2 signal detection

P2 symbol carrying frame construction data and PSI/SI information
Summary of Techniques (4)

- Rotated constellations

- MISO capability (Alamouti-based transmit diversity)
Summary of Techniques (5)

- Peak-to-average-power reduction via tone reservation and constellation distortion
- Future Expansion Frames
- Signalling and compatibility with future implementations of Time Frequency Slicing
- Low-level transmitter-identification signalling
Specification Documentation

- **Physical-Layer Specification**
  - DVB Blue Book: June 2008
  - ETSI EN 302 755: April 2009

- **PSI/SI Elements Specification**
  - Extension to DVB-T SI Spec
  - ETSI EN 300 468

- **Implementation Guidelines**
  - DVB Blue Book: Feb 09
  - ETSI TR 102 831

- **Modulator Interface Spec.**
  - DVB Blue Book: Feb 09
  - ETSI TS tbd

- **Transmitter Identification**
  - Work in progress

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## T2 Capacity estimate (untested)

<table>
<thead>
<tr>
<th></th>
<th>Current UK mode</th>
<th>T2</th>
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</thead>
<tbody>
<tr>
<td>Modulation</td>
<td>64QAM</td>
<td>256QAM</td>
</tr>
<tr>
<td>FFT size</td>
<td>2K</td>
<td>32K</td>
</tr>
<tr>
<td>Guard Interval</td>
<td>1/32</td>
<td>1/128</td>
</tr>
<tr>
<td>FEC</td>
<td>2/3 CC + RS (8%)</td>
<td>3/5 LDPC + BCH (0.3%)</td>
</tr>
<tr>
<td>Scattered Pilots</td>
<td>8.3%</td>
<td>1.0%</td>
</tr>
<tr>
<td>Continual Pilots</td>
<td>2.0%</td>
<td>0.53%</td>
</tr>
<tr>
<td>Frame structure overhead</td>
<td>1.0%</td>
<td>0.53%</td>
</tr>
<tr>
<td>Bandwidth</td>
<td>Normal</td>
<td>Extended</td>
</tr>
<tr>
<td>Capacity</td>
<td>24.1 Mbit/s</td>
<td>36.1 Mbit/s</td>
</tr>
</tbody>
</table>

**Capacity = DVB-T + 50%**
Validation and Verification

Purpose:
- To verify clarity of specification through testing interoperability of independent implementations (software and hardware)
- To validate T2 performance through lab tests
- Generation of test bitstreams and waveforms - to aid demodulator developments

Progress to date
- 8 independent implementations being tested and compared
- 13 different modes tested with full agreement
- 83 final output streams shown to match
- Hardware plug fest planned for March
On-going T2 activities within DVB

- Simulation
  - Purpose
    - To simulate the expected performance of T2 across a range of transmission channels
    - To create an open Common Simulation Platform which can act as a ‘reference implementation’
  - Progress
    - Many results included in Implementation Guidelines document
Capacity limits for simple Gaussian noise channel
- With LDPC can get close to theoretical limit

Typically 30% gain in capacity compared with DVB-T codes.
In a Single Frequency Network must ensure that all modulators generate identical T2 frames

T2 infrastructure includes a ‘T2 Gateway’
- Constructs T2 frames at central location
- T2 frames distributed (via ASI or IP networks) to modulators at transmitters

Specification to be published in Feb 09
Transmitter Identification

- Requirements for professional monitoring receiver
  - Identify if Tx within SFN has incorrect timing
  - Identify if Tx within SFN has incorrect frequency
  - Monitor channel to check for anomalous propagation

- Technique being investigated
  - Addition of low-level signal that does not disturb reception of main signal

- Timetable:
  - Spec. to be completed by June 09
Early T2 Implementations

- **Software simulation platforms**
  - Common Simulation Platform
  - Several independent company implementations

- **FPGA prototypes**
  - Modulator: Some companies already demonstrating modulators at IBC
    - BBC, Screen Services, ..
  - Demodulator: Two T2-compliant demodulators demonstrated at IBC
    - BBC, SIDSA

- **VLSI**
  - Several large VLSI companies have started developing T2 demodulator chips
  - VLSI design is in critical path
  - Timetable is very tight to meet 2009 launch
Early T2 Implementations

- BBC has had T2 signals on-air since June 2008
UK regulator, Ofcom, has recommended UK launch should start in November 2009
- Starting in North West of UK as part of Switch Over
- Additional frequency consultations on-going - to enable simultaneous launch in other areas
  - e.g. London

Single public-service MUX to be used for HD services
- Starting with 3 HD services
  - BBC, ITV, Ch4
- Eventual capacity: 4 services?
UK Planning for HD services

- Ofcom coordinating UK-HD Pilot planning project
  - Participants include HD broadcasters, Arqiva, TV/STB manufacturers
  - First phase: Lab trials starting late 2008 and field trials starting early 2009
  - Technical goals:
    - To verify performance using real hardware (in comparison with simulations)
    - To verify planning parameters and choice of mode for UK HD services (particularly modulation mode and FEC overhead)
    - To provide test bed with real signals to assist manufacturer developments

- Lab & Field tests to include
  - Tests of rotated constellations, different FFT sizes, phase noise performance, ...
  - Field trials to confirm coverage expectations are met in real-world channels
    - Including indoor and outdoor channels
Technical pilot is only one strand of many in implementation programme for terrestrial HD services. Other strands include:

- Planning for transmit-side infrastructure
- Regulatory aspects
- Contractual and business issues
- Service offering
Conclusions

- T2 specification and documentation process approaching completion
- Validation & Verification activities making very good progress
- FPGA-based hardware prototypes already demonstrated
- VLSI design started
- Lab tests and field trials imminent
- Intense planning activity in UK - leading up to launch of T2-based HD services in November next year.