Next-Generation Digital Television Terrestrial Broadcasting Systems

Author: Eng. Ernesto Fontes Pupo.
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Mail: fontes@lacetel.cu
Outline

• Introduction
• Brief review of the first-generation DTTB standards
• Current status of the second-generation DTTB systems
• Technical challenges at 2013
• State of the Art - Technological Advances
• Next-Generation: NGB-W (China)/ ATSC 3.0 (USA)
• Conclusions
Introduction

“The future of television is to stop thinking of television as television.”

- 1985
Nicholas Negroponte
Introduction

Internet

TVD

+ 20 year of evolution

Technological Evolution

5G

4G LTE

Wi-Fi

Super Wi-Fi
Evolution of the DTTB standards

First-generation
- 1995: ATSC
- 1997: DVB-T
- 1999: ISDB-T
- 2006: DTMB

Second-generation
- 2009: DVB-T2
- 2010: ATSC-M/H
- 2015: ISDB-Tmm
- 2015: DTMB-A

Next-generation
World Distribution

- **DVB-T**
- **DVB-T2**
- **ATSC**
- **ISDB-T**
- **DTMB**
## Technical challenges at 2013

<table>
<thead>
<tr>
<th>OFDM-Based tx</th>
<th>Mod. &amp; CH coding</th>
<th>MIMO</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-OFDM</td>
<td>• higher order mod. Schemes (QAM)</td>
<td>• large-scale MIMO</td>
</tr>
<tr>
<td>TDS-OFDM</td>
<td>– UW-OFDM</td>
<td>• low-complexity implementation algorithms</td>
</tr>
<tr>
<td></td>
<td>– DPN-OFDM</td>
<td>– Ant. placement</td>
</tr>
<tr>
<td></td>
<td>– TFT-OFDM</td>
<td>– Signal detection algorithms</td>
</tr>
<tr>
<td></td>
<td>➢ PAPR reduction</td>
<td>– channel estimation</td>
</tr>
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</tr>
</tbody>
</table>
## Technical challenges at 2013

<table>
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<tr>
<th>Return Channel</th>
<th>Wireless localization</th>
<th>Multi-service</th>
</tr>
</thead>
</table>
| • DVB-RCT (60 km)  
  − OFDMA (↑PARP)  
  − SC-FDMA (↓PARP)  
  − TDS-FDMA  
  • WLAN or 2G/3G | • GNSS, GPS  
  − accuracy: 3–10m  
  • DTTB-based  
  − accuracy: ↓1m  
  ➢ Rx is located near one particular Tx  
  ➢ non-line-of-sight  
  • Convergence of GPS- and DTTB | • Fixed and mobile Rx  
  − Power consumption  
  • T/FDM (DVB-T2)  
  • BST-OFDM (ISDB-Tmm)  
  • layered super-frame structure/TDM (DTMB) |
What about now?
Non-Uniform Constellation (NUC)

1 Dimension

- more than 1 dB gain respect to a system which uses UC.

2 Dimension

64 condensed points
Layered Division Multiplexing (LDM)

QPSK

UL

LL

LDM

Multilayer Signal (Upper + Lower Layers)

Upper Layer (UL)

Lower Layer (LL)

Injection Level

Noise

NUC 256 QAM
**Channel Capacity (6MHz)**

- **Next-Gen.**
  - Capacity: $C = 1.98$ Mbps
  - SNR: $-6$ dB C/N
  - Efficiency: $1.56$ Mbps

- **DVB-T2**
  - Capacity: $C = 66$ Mbps
  - SNR: $33$ dB C/N
  - Efficiency: $62.19$ Mbps

**Low Capacity, Robust**

**High Capacity, Less Robust**
Next-Generation DTTB Systems

NGB-W (China)

ATSC 3.0 (USA)
<table>
<thead>
<tr>
<th>Feature</th>
<th>Details</th>
</tr>
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<tbody>
<tr>
<td>FEC</td>
<td>BCH/LDPC</td>
</tr>
<tr>
<td>BICM</td>
<td>YES</td>
</tr>
<tr>
<td>Constellation</td>
<td>QPSK; <strong>NUC</strong> 16QAM, 64QAM, 256QAM, 1024QAM</td>
</tr>
<tr>
<td>Transmission Mode</td>
<td>SISO/MISO/MIMO</td>
</tr>
<tr>
<td>FFT size</td>
<td>4K, 8K, 16K, 32K (with PAPR)</td>
</tr>
<tr>
<td>Frame Duration (ms)</td>
<td>≤ 250</td>
</tr>
<tr>
<td>PLP</td>
<td>YES</td>
</tr>
<tr>
<td>Dedicate Return Ch.</td>
<td>YES</td>
</tr>
<tr>
<td>Bitrate Max. (8 MHz)</td>
<td>62 Mbps (SISO), 122 Mbps (MIMO)</td>
</tr>
</tbody>
</table>
## NGB-W vs DVB-T2 (Channel Capacity)

<table>
<thead>
<tr>
<th>Performance index (BW = 8 MHz)</th>
<th>NGB-W</th>
<th>DVB-T2</th>
</tr>
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<tbody>
<tr>
<td>Maximal Transmission bitrate (Mbps)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SISO pattern</td>
<td>62</td>
<td>50.2</td>
</tr>
<tr>
<td>MISO pattern</td>
<td>122</td>
<td>NA</td>
</tr>
<tr>
<td>Maximal translational speed (km/h)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>329.6</td>
<td>301.3</td>
</tr>
<tr>
<td>Maximal single frequency network radius (km)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>184.3</td>
<td>159.6</td>
</tr>
<tr>
<td><strong>Physical overview</strong></td>
<td></td>
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<tr>
<td>----------------------</td>
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<tr>
<td><strong>FEC</strong></td>
<td>BCH; CRC + LDPC</td>
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<td>QPSK; NUC 16, 64, 256, 1024, 4096 QAM</td>
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<td><strong>Transmission Mode</strong></td>
<td>SISO/MISO/MIMO and Channel Bonding</td>
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<tr>
<td><strong>FFT size</strong></td>
<td>8K, 16K, 32K (with PAPR)</td>
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</tr>
<tr>
<td><strong>PLP number</strong></td>
<td>from 1 up to 64</td>
<td></td>
</tr>
<tr>
<td><strong>PLP multiplex</strong></td>
<td>TDM, FDM, TFDM, LDM</td>
<td></td>
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<tr>
<td><strong>Dedicate Return Ch.</strong></td>
<td>YES</td>
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</tr>
<tr>
<td><strong>Bitrate Max. (6/8 MHz)</strong></td>
<td>57/78.5 Mbps (SISO), 114/157 Mbps (MIMO)</td>
<td></td>
</tr>
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</table>
Conclusions

• These Technological advances will revolve the actual DTV

• These Technological advances transcend the DTV limits.

• Are we in conditions to be alien to these Technological evolution?
Thank You!
First-generation DTTB standards

- **1995**
  - **ATSC**
    - Single-Carrier
    - Outdoor fixed Rx
    - 6 MHz
    - 19.39 Mb/s

- **1997**
  - **DVB-T**
    - C-OFDM
    - Out/Indoor, Mobile Portable Rx
    - 6, 7, 8 MHz
    - 4.98-31.67 Mb/s

- **1999**
  - **ISDB-T**
    - BST-OFDM
    - Out/Indoor, Mobile Portable Rx
    - 6, 7, 8 MHz
    - 3.65–23.23 Mb/s

- **2006**
  - **DTMB**
    - BST-OFDM
    - Out/Indoor, Mobile Portable Rx
    - 6, 7, 8 MHz
    - 4.81–32.49 Mb/s

- **2011**
  - **ITU**
    - TDS-OFDM
    - LDPC-BCH
    - Out/Indoor, Mobile Portable Rx
    - 6, 7, 8 MHz
    - 4.81–32.49 Mb/s
Second-generation DTTB systems

- **DVB-T2 (2009)**
  - LDPC-BCH
  - BICM
  - ▲30% Spectral efficiency
  - Constell. rotation
  - PAPR reduction
  - PLP

- **ATSC-M/H (2010)**
  - Backward compatibility
  - Out/Indoor, Mobile portable Rx
  - Wireless localization

- **ISDB-Tmm (2010)**
  - Compatible with ISDB-T
  - Multi-media materials
  - Variable tx BW (13-33 segments)
  - partial reception

- **DTMB-A (2015)**
  - Gray-APSK
  - BICM
  - Signal Space Diversity (SSD)
  - Multi-service
  - Wireless localization
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