Digital Terrestrial Broadcasting in Japan (ISDB-T System)
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   Part 2; Portable reception- One seg
   Part 3; HDTV Mobile Reception
1. Outline of Digital Broadcasting in Japan
Japan's Profile

- Population 127 million
- Number of households 48 million
- Area of Japan 378,000 km²
- TV receivers 100 million

- Terrestrial TV networks
  - 3-9 stations/region with many relay stations (including 2 channels by public broadcaster, NHK)
  - NHK: reception license fee based, nation wide network
  - Private broadcasters: regional based (30 regions in Japan)
  - 5 major networks + independent stations
The Merits of Digital Broadcasting

- HDTV
- Multiple programs
- Data broadcasting
- Mobility
- Advanced caption etc.
- Interactive TV
Implementation Schedule of Digital Terrestrial Television Broadcasting in Japan

1994
- MPT asked to Council for technical requirement

1998
- Issue of Digital Broadcasting Study Group Report

1999
- MPT established technical standard

Apr. 2003
- Provisional licenses were awarded

Feb. 2003
- Start of Analog channel relocation

Sep. 2002
- MPHPT established license conditions and requirements

1999-2003
- Real Scale Experiment Broadcasting

Apr. 1st 2006
- Start of 1-Segment Broadcasting

Oct. 2006
- Start of DTTB (main city of the whole country)

Dec. 1st 2003
- Start of DTTB ! (Tokyo, Nagoya, Osaka)

2007
- Start of Server-type Broadcasting

2006
- Start of 1-Segment Broadcasting

2003
- Start of DTTB (main city of the whole country)

2007
- Start of Server-type Broadcasting
Expansion Schedule for DTTB in Japan

In the seat of Prefectural Government,
DTTB . . .

- Already Begun
- Will begin by Oct. 2006
- Will begin by Dec. 2006
Targets on Diffusion and Shipment Volume of Digital Terrestrial TV Receivers

As of Dec, 2004
3,162 kset

As of July, 2005
5,431 kset

As of June, 2006
11,902 kset
The Cumulative shipments of DTTB Receivers

Source: JEITA
Licensing Policy for Digital Terrestrial Television Broadcasting

- Over 2/3 simultaneous broadcasting of analog programs per day
- HDTV program time quota of more than 50% for all Digital terrestrial television broadcasters
- Broadcasting using subtitles and commentary
Strategy to Promote Digital Terrestrial Television Broadcasting

- End of Analog Broadcasting; July 2011 mandated by Radio Law
- Promote Digital terrestrial television broadcasting receivers
- DTV as integrated home information terminal
- Need of collaborative work among government, broadcasters and industry
2. What is ISDB-T?
ISDB-T is ----

- ISDB-T system was developed by the Association of Radio Industries and Businesses (ARIB) in Japan.
- ISDB (Integrated Digital Services Digital Broadcasting) is a new type of digital broadcasting intended to provide audio, video, and multimedia services. T is Terrestrial.
- ISDB-T is one of ISDB family.
- ISDB-T uses a modulation method referred to as Band Segmented Transmission (BST) OFDM
Requirements for Digitalization

- Multimedia-service
- High-Quality TV/ Multi-Channels
- Flexible/Versatile
- Effective frequency utilization
- Mobile and handheld service (ground wave)
- Commonality of receiver

At first, the requirement of digital broadcasting should be established. The requirements described above are for digitalization in Japan.
Multimedia-Service
High-Quality, Multi-Channels
- HDTV 1CH or SDTV 3CH within 6MHz band.
- Robustness against multi-path

Multimedia-Service
- Integrated Service (Video/Audio/Data)
- High quality Data Service
- Bi-directional Service (Inter-operability)

Flexible/Versatile
- Efficient Spectrum utilization
- Single Frequency Network (SFN)

Mobile and handheld service (ground wave)
- Robustness against mobile/portable reception
- Both fixed/mobile service within same band → Layer Transmission Technology

Commonality of receiver
- Commonality for BS/Cable/Terrestrial Broadcasting.
Features of ISDB-T Transmission System

Japanese Requirements for DTTB
- Robustness, SFN
- Extensible, Partial Reception
- Mobile Reception, Indoor Reception
- Flexible, Versatile

Technical Specification
- OFDM
- Segment Structure
- Time Interleaving
- TMCC
What is Segmented OFDM with time interleave?

Feature of Japan’s Digital Broadcasting system
(1) Flexibility of service: Interface between source coding and Multiplex is common interface (Transport Stream interface), so, any contents based on TS can be available.
(2) Flexibility of transmission media: Optimized to each transmission media.
(3) Terrestrial transmission system; For any reception type, such as fixed/mobile/handheld, adopt Segmented OFDM with time interleave (see next page)

• Segmented OFDM; Possible to support fixed/mobile/handheld reception service

• Time interleave; reduce impulse noise and reduce the degradation caused by fading (tested in Brazil by Mackenzie and TV GLOBO)
Service Image of ISDB-T in Japan

10110...

Digital Broadcasting

Broadcaster

Multiplexing to One Channel

HDTV  Portable  HDTV

12 Segment
Compressed by MPEG2

1 Segment
Compressed by H.264

Original Image

10110...

Sports

For large Screen Television

High Definition Picture

High Quality Sound

For Portable Terminal

At home

Disaster

News

Anytime

Anywhere

In the Bus

While walking

In the train

For Portable Terminal

In the train

While walking

In the Bus
3. Comparison of 3 DTTB Systems

-Comparison of 3 DTTV systems
-Results of comparison test in Brazil
-Summary of comparison
## Broadcasting Services

<table>
<thead>
<tr>
<th>Item</th>
<th>ATSC</th>
<th>DVB-T</th>
<th>ISDB-T</th>
</tr>
</thead>
<tbody>
<tr>
<td>HDTV/ SDTV</td>
<td>☺</td>
<td>☺</td>
<td>☺</td>
</tr>
<tr>
<td>Fixed reception</td>
<td>☺</td>
<td>☺</td>
<td>☺</td>
</tr>
<tr>
<td>Data broadcasting</td>
<td>☺</td>
<td>☺</td>
<td>☺</td>
</tr>
<tr>
<td>SFN</td>
<td>×</td>
<td>☺</td>
<td>☺</td>
</tr>
<tr>
<td>HDTV Mobile reception</td>
<td>×</td>
<td>☺</td>
<td>(☺ SDTV)</td>
</tr>
<tr>
<td>Portable reception with cellular phone</td>
<td>×</td>
<td>⬇️</td>
<td>☺</td>
</tr>
<tr>
<td>Internet access</td>
<td>×</td>
<td>☺</td>
<td>☺</td>
</tr>
</tbody>
</table>
Effect of Time Interleaving

• As the experimental result, time interleaving improve required CN ratio about 7 dB in mobile environment on 16QAM.
• Diversity system improve about 7dB on 16QAM.
• Time interleaving (time diversity) work independently from space diversity.
• That is the reason for advantage of ISDB-T in mobile environment.
• Time interleaving improve robustness against impulse noise interference that come from power line and motor cycle engine.
Results of Brazilian Tests

• Comparison testing of three DTTB systems
  – ATSC, DVB-T, ISDB-T
• Carried out from Aug. 1999 to April 2000
• Laboratories tests
  – AWGN, impulse noise, multipath interference
• Field tests
  – Coverage, indoor reception
Impulse Noise

- Better performance of the ISDB-T system, by introducing time interleaving

(From the presentation of the Brazilian SET/ABERT study group at NAB2000)
Static Multipath

Carrier to noise ratio as a function of carrier to echo ratio
Comparison at post-echo = 8us

(From the presentation of the Brazilian SET/ABERT study group at NAB2000)
Outdoor: Coverage

Success on Receiving - Cumulative Function
Criterion: Number of Errors < 5

(From the presentation of the Brazilian SET/ABERT study group at NAB2000)
Any improvement of digital receiver was not considered to make the table below.

<table>
<thead>
<tr>
<th>Requirements</th>
<th>System conform to requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum bit rate under Gaussian noise environment</td>
<td>ATSC</td>
</tr>
<tr>
<td>Robustness against multi-path distortion</td>
<td>DVB-T, ISDB-T</td>
</tr>
<tr>
<td>Robustness against impulse noise</td>
<td>ISDB-T</td>
</tr>
<tr>
<td>Wide area single frequency network (SFN) operation</td>
<td>DVB-T, ISDB-T</td>
</tr>
</tbody>
</table>
Any improvement of digital receiver was not considered to make the table below.

<table>
<thead>
<tr>
<th>Requirements</th>
<th>System conform to requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobility and Portability</td>
<td>ISDB-T &gt;&gt; DVB-T</td>
</tr>
<tr>
<td>Hierarchical transmission (Multiple modulation systems simultaneously in the same channel is possible)</td>
<td>ISDB-T &gt;&gt; DVB-T</td>
</tr>
<tr>
<td>System commonality with digital terrestrial sound broadcasting (One segment receiver is available)</td>
<td>ISDB-T</td>
</tr>
</tbody>
</table>
4. Structure of ISDB-T Standard
Structure of Japan’s Digital Broadcasting system

Source coding
(any of service are available)

Common interface (Transport Stream interface)

Multiplex
Common interface (Framed Transport Stream interface)

Transmission coding

MPEG-2 Video coding
MPEG-AAC Audio coding
Data coding (note)
H.264 video coding

Multiplex (Based on MPEG-2 systems)

Single carrier 8-PSK/PSK
Single carrier 64QAM
Segmented OFDM QAM/DQPSK With time interleaved

(satellite) (cable) (terrestrial)

(note) both BML and MHP are available, But in Japan now BML is only service in.
## ARIB Standards for Digital Broadcasting

<table>
<thead>
<tr>
<th></th>
<th>Digital Television</th>
<th>Digital Sound</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BS / wCS</td>
<td>Terrestrial</td>
</tr>
<tr>
<td>System</td>
<td>STD-B20</td>
<td>STD-B31</td>
</tr>
<tr>
<td>Multiplex</td>
<td>Coding &amp; Multiplexing</td>
<td></td>
</tr>
<tr>
<td>Service Information</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Source coding</td>
<td>Coding &amp; Multiplexing</td>
<td></td>
</tr>
<tr>
<td>Data Broadcasting</td>
<td>Presentation Engine (BML)</td>
<td>STD-B24</td>
</tr>
<tr>
<td></td>
<td>Execution Engine (GEM-based)</td>
<td>STD-B23</td>
</tr>
<tr>
<td>CAS</td>
<td>Conditional Access</td>
<td></td>
</tr>
<tr>
<td>Home servers</td>
<td>System based on Home Servers</td>
<td>STD-B38</td>
</tr>
<tr>
<td>Receivers</td>
<td>STD-B21</td>
<td>STD-B30</td>
</tr>
<tr>
<td>Operational Guidelines</td>
<td>TR-B15</td>
<td>TR-B14</td>
</tr>
</tbody>
</table>
Digital broadcasting & Multiplex system

Structure of Digital broadcasting

Service

- TV service
  - Audio service
  - Video coding (STD-B32)
  - Data coding (STD-B24)
  - Data service
  - EPG service

Common for transmission media

- Scramble system (STD-B25)
- Multiplex system (STD-B32, ISO/IEC 13818-1)

Different for each media

- Digital terrestrial audio broadcasting (STD-B29)
- Digital terrestrial TV broadcasting (STD-B31)
- BS/wideband CS digital broadcasting (STD-B20)

Transmission

- Terrestrial digital audio broadcasting
- Terrestrial digital TV broadcasting
- BS
- Wideband CS
4.2 ISDB-T transmission system

• Features of transmission system

1. Efficient frequency utilization
   (1) Adopt OFDM transmission system; SFN operation
   (2) Adopt hierarchical transmission; service for different type of reception in one frequency channel

2. Mobile/ handheld service in one transmission standard
   (1) Time interleave; Improve mobile reception quality
   (2) Partial reception; handheld service in same channel

3. Robustness against interference
   (1) Adopt concatenated error correction with plural interleave
   (2) Time interleave; very effective for impulse noise (urban noise)

4. Flexibility for several type of service/ reception style

5. Commonality of TV/audio transmission standard

6. Auxiliary (AC) channel can be used for transmission network management
## Parameters of ISDB-T (6MHz Bandwidth)

<table>
<thead>
<tr>
<th>ISDB-T mode</th>
<th>Mode 1 (2k)</th>
<th>Mode 2 (4k)</th>
<th>Mode 3 (8k)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of OFDM segment</td>
<td>13</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Useful bandwidth</td>
<td>5.575MHz</td>
<td>5.573MHz</td>
<td>5.572MHz</td>
</tr>
<tr>
<td>Carrier spacing</td>
<td>3.968kHz</td>
<td>1.984kHz</td>
<td>0.992kHz</td>
</tr>
<tr>
<td>Total carriers</td>
<td>1405</td>
<td>2809</td>
<td>4992</td>
</tr>
<tr>
<td>Modulation</td>
<td>QPSK, 16QAM, 64QAM, DQPSK</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of symbols / frame</td>
<td>204</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Active symbol duration</td>
<td>252 μs</td>
<td>504 μs</td>
<td>1.008ms</td>
</tr>
<tr>
<td>Guard interval duration</td>
<td>1/4, 1/8, 1/16, 1/32 of active symbol duration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inner code</td>
<td>Convolutional code (1/2, 2/3, 3/4, 5/6, 7/8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outer code</td>
<td>RS (204,188)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time interleave</td>
<td>0 -- 0.5s</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Useful bit rate</td>
<td>3.651Mbps -- 23.234Mbps</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
5. Current Service of ISDB-T in Japan
(part 1; Total Image)
Unique Features of Japan’s Digital Broadcast

**HDTV**
- High quality image and sound service.

**Data broadcasting**
- Simple program searching and retrieval of information at any time.

**Mobile reception**
- Stable reception service

**Multi-channel service**
- Realization of multiple channels

**Interactive TV**
- Communication services and linked TV service
HDTV

High Definition Broadcast

- Most powerful application
- The quality images on the wide, 16:9 aspect ratio screen and CD-quality sound make you feel as if you were there.
- European broadcasters have opted for “multi-channel” strategy, however Japan’s broadcasters have chosen the advantages of “high definition” pictures.

Pure HDTV : 16x9 1080i
Multi channel SDTV

- The bandwidth of a single digital channel can be used to transmit two or three programs with standard definition simultaneously.
- Multi-channel approach is presently positioned as an “experimental”.
Data broadcasting (1)

Data broadcasting is now on service.

- Weather information
- Anytime news
- Result of sports game
- Information associated TV program

Players list

Ongoing games

A example of soccer game

Other games result

Other information
Data broadcasting (2)

Current programme screen

Player’s list

Games schedule

Other games results

Top menu of soccer game Data
Data broadcasting (3)

- **Description language is BML format**
- **Features**
  - Easy creation of contents
  - Affinity for internet

Based on XHTML

BML

Functions for Broadcasting

XHTML

Additional capability
EPG

EPG (Electronic Program Guide)

An electronic programme guide (EPG) is a on-screen guide to scheduled broadcast television programs, allowing a viewer to navigate, select and discover content by time, title, channel, genre, etc, using their remote control.
5. Current Service of ISDB-T in Japan
(part 2; Portable Reception – One Seg)
One-Seg service (1)

- One segment service launched from April 1st, 2006.
- One-Seg is abbreviation of one segment service.
- Common logo was designed as shown below.
One-Seg service (2)

The One-Seg service sends images to mobile phones, car TV's, personal computers etc. so that you can enjoy digital terrestrial television broadcasting program anytime anywhere.

Merits

- Stable reception in a mobile environment.
- High quality of video & audio in a mobile environment.
- Robust to noise and multi-pass.
### One-Seg service (3)

#### Comparison between ISDB-T and other systems

<table>
<thead>
<tr>
<th></th>
<th>ISDB-T</th>
<th>Other Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Transmission method</strong></td>
<td>ISDB-T One-seg service</td>
<td>T-DMB (KOR) DVB-H (mainly EU) Media FLO (US)</td>
</tr>
<tr>
<td><strong>Service application</strong></td>
<td>Video / Audio / Data</td>
<td>Video / Audio / Data</td>
</tr>
<tr>
<td><strong>Assignment of new spectrum</strong></td>
<td>Not necessary</td>
<td>Necessary</td>
</tr>
<tr>
<td><strong>Additional license</strong></td>
<td>Not necessary</td>
<td>Necessary</td>
</tr>
<tr>
<td><strong>Service provider</strong></td>
<td>Broadcaster</td>
<td>Broadcaster / Carrier / Other company</td>
</tr>
</tbody>
</table>
**One-Seg service (4)**

- **ISDB-T** has a capability of segmentation in a channel and one seg TV uses only one segment as partial reception.
One-Seg service (5)

Data rate

Video (H.264)
approx. 180-256 kbps

Audio (AAC-SBR)
approx. 32-64 kbps

Data-cast (BML)
approx. 20-80 kbps
One-Seg service (6)

Fusion of communication and broadcasting

Jump to internet site!
5. Current Service of ISDB-T in Japan
(part 3; Mobile HDTV Reception)
Difference between fixed and mobile reception environments

Mobile reception
- Antenna height 1.5---3 m
  - decrease field strength
  - increase multi-path
  - increase fading interference

Fixed reception
- Antenna height 10 m

1) Antenna height difference (Clearance)
2) Receiving antenna difference (Antenna gain)
3) Field strength fluctuations (Multipath fading)
Why is mobile reception available? What kinds of technologies are used?

1. Feature of transmission system
   - Time interleave (see next page)

2. Adopt new technology for reception
   - Space diversity reception

Space diversity reception technology for OFDM signal; Very unique technology is used, that is, “maximum ratio combining for each OFDM subcarriers”. This technology is very effective against frequency-selective fading.
Prototype 4-branch space diversity for HDTV mobile reception

- NHK’s prototype diversity reception system for HDTV mobile reception
  - Signal: 6MHz BW 64QAM-OFDM (ISDB-T)
  - Application: HDTV (14 Mbps) in a mobile car
  - Diversity: 4-branch space diversity

- Implementation and performance evaluation
  - Laboratory test
    - Maximum Doppler frequency in fading environment
  - Field trial in Nagoya wide-service area
Block diagram of diversity reception system

Maximal Ratio Combining with carrier by carrier of OFDM signal

- Tuner → FFT
- Tuner → FFT
- Tuner → FFT
- Tuner → FFT

Diversity combine

Channel estimate → Weight

Stable output signal
Comparison of receiving areas by branch numbers

4-branch: good
2-branch: bad
1-branch: bad
Correct reception rate vs. received field strength (total)

\[
CRR = \frac{Ncd(Ei)}{Nsd(Ei)} = \frac{N\{(E+1) > E_i \geq E \text{ and } \text{PER} = 0\}}{N[(E+1) > E_i \geq E]}
\]
6. Digital Receivers on Market
Fixed Reception type Digital Receiver

(Plasma type)

(LCD type)

(CRT type)

(Rear Projection type)
SET TOP BOX

SONY DST-TX1

PANASONIC TU-MHD500

SHARP TU-HD200
Cellular Phones for ONE-SEG Broadcasting
PCs with DTTB tuners

Sony

One-seg

Sony

Tuner

Fujitsu
DTTV Receivers for Car-Navigation Systems

Tuners
One-seg /12seg

Car-Navigation Systems with DTTB tuner

Panasonic
One-seg /12seg

SANYO
One-seg

ALPINE

MITSUBISHI

Pioneer

NISSAN
DVD Player and Audio Player

Portable DVD/SD/CD Player with one-seg receiver

HDD Audio Player with one-seg receiver

127 hours programs recordable

Panasonic

TOSHIBA
Conclusion

1. ISDB-T is the only one system which enable fixed/mobile/portable reception service in one channel!
   (1) Save frequency resource (not necessary for portable reception service separately
   (2) Save the broadcaster’s infrastructure cost (Only one transmitter for different service)

2. ISDB-T uses OFDM technology for transmission system
   (1) Save the frequency resource by using SFN technology

3. ISDB-T adopt Segment transmission system with time interleave
   (1) Enable portable reception service (One seg) in same channel
   (2) Enable the HDTV mobile reception (receive same signal as fixed reception)
   (3) Enable indoor reception service because of the robustness against signal level fluctuation

4. Enable service flexibility by using MPEG systems for multiplex
   (1) Any type of TV service are available; HDTV, Muliti-channel SDTV, One-seg LDTV, Data service and interactive service
   (2) Future development is also available to include into digital TV service
Conclusion

5. Support any type of multi-media service

   (1) ISDB-T includes 2 types of multi-media service, one is presentation engine type (BML), which is defined in ARIB STD-B24, other is the execution engine type, which is defined in ARIB STD-B24

   (2) Presentation engine type service data-casting is now in service in Japan and very popular.

5. Current market

   (1) More than 12 million digital receivers were sold in Japanese market

   (2) More than 1 million portable receivers were sold in 5 month!

   (3) Various type receiver are now in market, also STB is available.

6. Bandwidth

   (1) Prepare the standard for 6.7,8 MHz system. 6MHz system is most popular (Japan and Brazil). The market of 6MHz system is very big!
Thank You for Your Attention!