Trend of Digital Broadcasting in Japan and Research and Development in NHK STRL

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1. Introduction of NHK STRL

Leading organization for future broadcasting world
NHK (Japan Broadcasting Cooperation)
- Established in 1925
- Non-profit public broadcasting organization
- 2 AM radio, 1 FM radio, 2 terrestrial TV, 3 satellite TV

NHK STRL (Science & Technical Research Labs.)
- Established in 1930
- (5 years later science radio broadcasting started)
- Research department of NHK
- Major research themes
  - Advanced television systems, Wireless systems, Advanced broadcasting devices, Program production and future broadcasting related systems and devices.
3rd generation research complex

- Opened in April 2002
  - 14 stories high
    (office tower)
  - 6 stories high
    (experiment building)
- STRL area
  - B2 – 5th floors
- STRL employees (’05, March)
  - 282 personnel
    (260 research engineers)
- Researches based on “Middle and long term research vision (MLRV) of STRL” are conducted
Organization of STRL (9 research labs.)

- **Wireless systems**
  - Terrestrial/satellite digital broadcasting, wireless LAN

- **Networked broadcasting systems**
  - Networked program production broadcasting systems and services

- **Advanced television systems**
  - Ultra high definition video (super hi-vision), 3D visual systems

- **Acoustics and audio signal processing**
  - High definition audio systems, acoustic signal analysis and coding

- **Visual information technologies**
  - Video compression and image expression

- **Intelligent information processing**
  - Metadata production and applications, image recognition, media processing

- **Human science**
  - Services for visual or hearing impaired, software agents, speech processing

- **Advanced broadcasting devices**
  - Ultrahigh-sensitivity imaging devices, ultrahigh-density recording

- **Materials science**
  - Materials for displays and recording devices
2. Digital broadcasting in Japan
Broadcasting systems in the digital era

**ISDB** (Integrated Services Digital Broadcasting)
ISDB family

MPEG-2

Video → Coding → Multiplexing

Audio → Coding

Data → Coding

Satellite
Error correction RS(204,188) → Modulation TC-8PSK

Cable
Error correction RS(204,188) → Modulation 64QAM

Terrestrial
Error correction RS(204,188) + Conv. code → Modulation Segmented OFDM

Package, communication, and other media (DVB and ATSC)

MPEG-2 TS
# Transmission parameters for ISDB family

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<th>ISDB-S</th>
<th>ISDB-C</th>
<th>ISDB-T</th>
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<tr>
<td><strong>Video coding</strong></td>
<td>MPEG-2 Video (ISO/IEC 13818-2)</td>
<td>MPEG-2 AAC (ISO/IEC 13818-7)</td>
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<td><strong>Audio coding</strong></td>
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<td><strong>Data broadcasting</strong></td>
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<td>BML (XHTML), ECMAScript</td>
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<td><strong>Multiplex</strong></td>
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<td>MPEG-2 Systems (ISO/IEC 13818-1)</td>
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<td><strong>Conditional access</strong></td>
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<td>Multi 2</td>
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<tr>
<td><strong>Error correction</strong></td>
<td>Outer: (204,188) Reed-Solomon code</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Inner: 2/3Trellis Code / Conv.code(1/2-7/8)</td>
<td>-</td>
<td>Conv.code(1/2-7/8)</td>
</tr>
<tr>
<td><strong>Modulation</strong></td>
<td>TC-8PSK, QPSK, BPSK</td>
<td>64QAM</td>
<td>Segmented OFDM (DQPSK,QPSK, 16QAM,64QAM)</td>
</tr>
<tr>
<td><strong>Information bit rate</strong></td>
<td>52.17 Mbit/s (Max)</td>
<td>28.6 Mbit/s</td>
<td>3.7 – 23.2 Mbit/s</td>
</tr>
<tr>
<td><strong>Channel bandwidth</strong></td>
<td>34.5 MHz (12GHz)</td>
<td>6 MHz (Cable)</td>
<td>6 MHz (VHF/UHF)</td>
</tr>
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</table>
Digital broadcasting services in Japan

- **High picture quality / sound quality**
  - HDTV and 5.1 surround stereo system

- **Multi-programs broadcasting**

- **High performance**
  - Electronic Program Guide (EPG)
  - Data broadcasting (program related data services, interactive data services)

- **Digital terrestrial TV broadcasting**
  Along with digital satellite broadcasting services,
  - Services for mobile reception terminals (1 segment broadcasts)
  - Regional broadcasts
  - NHK Data Online
    - New service using the Internet connection of digital broadcasting receivers
Schedule of digitalization of broadcasting media in Japan

- **Terrestrial TV**
  - Digital Terrestrial TV
    - Conventional Analog TV

- **Satellite TV**
  - BS Digital TV: Started on Dec. 1, 2000
  - BS Analog TV
  - BS Analog HDTV

- **CATV (re-transmission)**
  - BS Digital

**2000**

- **Launch** on Dec. 1, 2003
  - Tokyo, Nagoya, Osaka Metro Area
  - Reaching all of Japan

**2003**

- **Experimental Broadcasts** started in Oct. 2003 in Tokyo, Osaka Metro Area
- Switch-over in July 24, 2011

**2006**

- Other major capital cities (by Year 2006)

**2011**

- Closing by 2011 (expected)
- Closing by 2007 (expected)

**Fully digital**
3. New services for digital broadcasting
New services are coming!

- Conventional Analog TV
- Digital Terrestrial TV
- BS Digital TV
- BS Analog TV
- BS Analog HDTV
- BS Digital (expected)
- Digital Terrestrial Audio
- CATV (re-transmission)

**Timeline:**
- 2000: Started on Dec. 1, 2000
- 2006: Service for handheld terminals
- 2011: Broadcasting based on home server

**Areas:**
- Tokyo, Nagoya, Osaka Metro Area
- Other major capital cities (by Year 2006)

**Technologies:**
- Experimental Broadcasts started in Oct. 2003 in Tokyo, Osaka Metro Area
- Fully digital (expected)
- Switch over by July 24, 2011
- Closing by 2007 (expected)
- Closing by 2011 (expected)
Digital terrestrial broadcasting for handheld receivers
Segmented OFDM and services in ISDB-T

6-MHz TV channel (13 segments)

Example
Case 1
- 1 segment service
- 6-MHz TV channel (13 segments)

Case 2
- SDTV Video: 4.3 Mbps
- SDTV Video: 4.3 Mbps
- SDTV Video: 4.3 Mbps
- Data Broadcasting

Data Broadcasting

Transmission Data Rate: 310 kbps
Modulation: QPSK (1/2)
- Low Bit Rate Video: AVC/H.264
- Data Broadcasting
Handheld terminals for ISDB-T (prototypes)

Service will start in next spring
Handheld terminals

- Get information related to a program with low-bit-rate video from data broadcasting or Internet

  **Low-bit-rate video from broadcasting channel**
  - Video: AVC/H.264 (about 128 kbps)
  - Audio: AAC-SBR (about 48 kbps)
  - Data Broadcasting
  - Closed caption
  - Wake up function in case of emergency

  **Information from broadcasting and communication channel**
## Service model of 1-segment service for handheld communication terminals

- Various types of services can be realized using functionalities combining 1-segment service reception and mobile communication

### Linkage from broadcasting to communication

<table>
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<tr>
<th>Broadcasting program view</th>
<th>Data broadcasting view</th>
<th>Handheld data online</th>
<th>Link to web sites</th>
</tr>
</thead>
</table>
| To receive and view broadcasting program with mobile terminal | To receive data broadcasting on the air (due to low bit rate, content is limited.) | - TV program is on the air  
- Data is received via the Internet (without limit of bandwidth) | Full screen display of internet content (TV program does not appear on the screen) |

- NHK
- BML
Network-Linked Service for handheld reception(1)

- Get the information related to a program with low-bit-rate video from data broadcasting

Low-bit-rate video from broadcasting channel

Choose summary from the display

Data broadcasting provides summary of the program.
Network-Linked Service for handheld reception(2)

- Rich information will be available through Internet

Choose “On-Line” from the display

Connect to Internet

Select “Cast”

Display the profile of the cast
Waking up a handheld receiver with an emergency warning

Receive only Emergency Warning Signal (EWS)

Tsunami warning issued

Wake up handheld receiver

Emergency warning broadcast

Power Consumption: under 3nW (desired)

The system does not employ FFT, but instead stays on stand-by for the EMS frequency component.

Low power consumption

Stand-by mode

Explanation

Active mode to receive emergency warning broadcast
Improved AVC/H.264 video encoder

Conventional image using AVC/H.264 scheme

Image processed with picture quality enhancement technology
Transmission test for handheld reception

- 7 directions (spokewise)
- 1, 3, 5, 10, 15, 20, 25, 30 km

Receiving antenna height: 1.5m
Receiving antenna: Cross dipole antenna
Distribution of measured field strength

Average attenuation from Eo (free space electric field strength) = 29dB
Broadcasting based on Home Servers
Broadcasting based on home servers

- Home Server: large-capacity storage unit for TV programs
- Enables anytime viewing by using metadata

Service will start around 2007

Program + Metadata

High-function EPG
Favorite program
Related information

Home server

Stored programs and information collected over several months

Highlight viewing

Internet
Service example for broadcasting based on home servers and Internet

- Broadcasting
- Digest viewing/Interactive viewing
- Digest viewing of “desired” scenes
- NHK text based on home servers used in school classroom
- Network-linked broadcasting services
  - Broadband linkage
  - Cellular phone linkage
- Diverse services that meet individual needs
- Home server
- Internet
- Municipality, School
- Spoken command “I want to select program that I missed”
- Continuing education

Explanations

Digest teaching material

Continuing education

Diverse services that meet individual needs
4. NHK STRL Vision "NEXT"
NHK STRL Vision “NEXT”

To View
To view a faraway scene as if it were nearby in real time

To Know
To enable sender and viewers to share information and emotions

To Use
To utilize information media for a broad range of daily activities and in times of emergency

“Human-oriented” system
R&D Framework

Broadcasting technology that learns from human possibilities

To View
Ultimate broadcasting system conveying a strong sensation of reality

To Know
Advanced content production and agile news-reporting systems

To Use
Ubiquitous and universal services

System technology

- Audio-video technology conveying a heightened sensation of reality
- Content production technology that incorporates the knowledge of production experts
- Network technology; Security technology
- Highly functional wireless transmission technology
- Flexible system construction technology

<Approaches>

Image/speech recognition, language processing
Analysis and application for knowledge and sensibility
Psychology; Physiology

Ultrahigh-resolution video devices, Ultra large-capacity recording devices
Devices with new functions
Nanophotonics materials

Human science

Fundamental device technology
5. Typical research and development in NHK STRL
Typical research and development

- View
  - Super Hi-Vision
  - Integral 3-D television
  - Electro-holography

- Know
  - Metadata production system
  - Advanced program production system using wired and wireless IP networks
  - Advanced imaging devices
  - Ultrahigh-speed high-sensitivity camera
  - Ultrahigh-sensitivity HDTV new-super-HARP handheld camera

- Use
  - Flexible displays
  - TV agent system
Research on Ultimate System with Heightened Sensation of Reality
Super Hi-Vision
(Ultra-high-definition, Wide-screen System with 4000 Scanning Lines)

- Future TV System with Greater Sensation of Reality
  - Effects
    - Strong sensation of reality (as if you are there)
    - More exciting live TV programs
  - Our objectives
    - Examine physical and psychological effects
    - Enhance the reality sensation for future TV systems

Explanation
Integral 3-D television

- Natural and realistic autostereoscopic images can be viewed from any viewpoint.
  - Requires no special viewing glasses
  - Different aspects of the object can be seen depending on the viewing position
  - 3-D effects viewable at any viewing angle

- STRL’s prototype can shoot and display 3-D images in real-time.

Imaging system

- Lens array for imaging with 160(H) x 118(V) small lenses

Super-high-definition camera (2000 scanning line equivalent)

Viewing a little higher

Vertical parallax

Viewing a little lower

Explanation
Electro-holography

- Technology to record and reproduce optical information with the use of optical interference ---> reproduce ideal autostereoscopic images
- Applied to a three-dimensional television system
- Many issues to be overcome ---> low quality and narrow viewing zone
Research on Advanced Content Production and Mobile News-reporting Systems
Metadata production system

- Program script and shooting plan can be used for metadata production for drama and documentary programs.
- Metadata can be efficiently produced for sports programs by combining image recognition, speech recognition, natural language processing, etc.

Live program production

Video data

Audio data

Metadata recognition

Speech recognition

Natural language processing

Metadata:
- 10 minutes
- 30 seconds
- A shot on goal by Nakata

Services for mobile receivers

Data broadcasting

Service based on home servers

Internet

Explanation
Advanced program production system using wired and wireless IP networks

- Program production system using broadcasting equipment and contents not only within a broadcasting station but also other stations or archive facilities via broadband networks.
Advanced imaging devices

- Compact ultrahigh-sensitivity camera capable of vivid nighttime shots
- Imaging device using organic films for a palm-size camera system
Ultrahigh-speed high-sensitivity camera

- Captures clear images of phenomena too quick for the naked eye under ordinary lighting conditions
- Shoots at 1 million frames per second (high sensitivity)

Picture example
Baseball  Golf  Soap Bubble  Balloon
Ultrahigh-sensitivity HDTV new-super-HARP handheld camera

- For emergency night time reporting
- Clear HDTV picture under moonlit conditions
- 200x the sensitivity of a CCD camera, 50,000x for still pictures

Picture captured by conventional CCD camera (Gain: +42 dB)

Picture captured by HARP camera

Explanation
Research on Ubiquitous and Universal Services
Flexible displays

- Flexible organic electroluminescence (EL) display
- Flexible liquid crystal display

Flexible Organic Electroluminescence Display
Flexible Liquid Crystal Display (A4 size)
Organic TFT-driven Liquid Crystal Display (5x5 elements)
TV agent system

- Let’s anyone easily operate digital broadcasting receivers
- New Q&A function with a spoken dialogue TV operation capability.
6. Other technologies from the Open House 2005
Other technologies

- Program productions
  - 1080/60p HDTV system
  - Bone conduction intercom headsets for broadcaster

- Transmission technologies
  - Millimeter-wave mobile camera
  - Luneberg lens antenna system for HDTV transmission

- Presentations
  - Field emission display
  - Tactile presentation system for visually impaired persons

- Fundamentals
  - Digital holographic memory
  - Spintronics
Program productions
1080/60p HDTV system

- For improving the quality of HDTV image
  - Progressive-scanning HDTV camera system
Bone conduction intercom headsets for broadcaster

- To overcome difficulty for hearing sounds under some situation, a bone conductive intercom was developed.
- Bone conduction uses a mechanism whereby the human body's bones transmit sound by their vibration.
Transmission technologies
Millimeter-wave mobile camera

- Wireless HDTV camera system using MIMO-OFDM transmission
- Wireless camera system free up camerawork

By forming many radio-wave paths, the camera can send high-quality video signals containing twice the information that would be possible otherwise.
Luneberg lens antenna system for HDTV transmission

- Luneberg lens antenna instead of parabolic antenna for satellite communications
  - Small, lightweight antenna
  - Prompt satellite transmission

A radio signal entering from the focal point refracts at the boundary surfaces of thirteen dielectric layers, which have different relative permittivities between 1 and 2, and it radiates from the opposite side as a plane wave.

A spherical shape is difficult to fix in place, but a hemispherical shape obtains the same effect as a sphere if a reflector is installed at the bottom.

Lens antenna mechanism
Presentations
Tactile presentation system for visually impaired persons

- High-resolution tactile display for graphical information
- Tactile navigator enables a user to navigate a GUI’s screen or table through touch
Field emission display

- For Super Hi-Vision programs to be viewed in the homes of the future
- Thin field emission displays with high luminous efficiency
- Compact flat display with high picture quality and low power consumption
Digital holographic memory

- Holographic recording using optical interference as an advanced recording technology
Spintronics

- Key technology for a future recording device.
- The spin-injection magnetization reversal technology is capable of performing pinpoint recording onto a small magnetic dot, without magnetic field spread.
- This technology enables high-density recording at lower current, which means less power consumption.
7. Summary
Summary

- R&D based on NHK STRL vision “NEXT”
  - “NEXT”: NHK EX Technology (Express, Excel and Expand)
  - Broadcasting technology that learns from human possibilities
- for ultimate broadcasting systems
- for advanced program production and news-reporting systems
- for ubiquitous and universal services

Broadcasting will play an important role in the creation of culture and in the lives of people.

Collaboration with organizations in the world
Thank you for your attention!