Presentation 5-2

Technology of ISDB-T_{SB}
- Digital Radio System -

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KBP ISDB-T seminar

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DiBEG JAPAN

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DiBEG

Digital broadcasting experts group

ISDB-T_{SB} system

- ISDB-T_{SB}

Integrated Services Digital Broadcasting for Terrestrial Sound Broadcasting

- System for terrestrial digital sound broadcasting (in VHF / UHF).
- Intended for vehicular, portable and fixed reception.
- Recommended as System F of Recommendation ITU-R BS.1114-6.
- Commonality with ISDB-T of the DTTB system (also recommended as System C of Recommendation ITU-R BT.1306-3 System C).

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Requirements for ISDB-T_{SB}

- Mobile and handheld reception
  - Car audio
  - Cell phone, PDA, PC
- High quality audio
  - Equivalent to CD
  - Multi-channel audio (5.1 surround, multilingual, etc.)
- Multimedia services
  - Data services
  - Information related to current program
  - Independent information (latest news, weather forecast, traffic information, etc.)
  - Electronic program guide
- Saving frequency resources
  - Limited channels for digital radio
  - Reduction of guard bands between adjacent ISDB-T_{SB} channel
  - Simple assignment of channels for ISDB-T_{SB}

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Technologies to realize requirements for ISDB-T_{SB}

- Mobile and portable reception
  - OFDM modulation scheme
- High quality audio
  - MPEG-2 AAC (advanced audio coding)
    - ◆MPEG-2 AAC+SBR (spectral band replication)
- Multimedia services
  - MPEG-2 Systems (MPEG-2 TS)
- Video services
  - MPEG-4 H.264 AVC
- Saving frequency resources
  - BST (band-segmented transmission) -OFDM
  - Connected transmission and SFN (single frequency network)

Features of ISDB-T_{SB} I

- Ruggedness
  - OFDM adding guard interval
  - Two-dimensional frequency-time interleaving
  - Concatenated error correction codes (convolutional code + RS)
- Wide variety of transmission
  - BST-OFDM
  - Two kinds of transmission bandwidth
    - One OFDM-segment for single-segment transmission (bandwidth: 430 kHz)
    - Three OFDM-segments for triple-segment transmission (bandwidth: 1.29 MHz)
- Flexibility
  - Multimedia services: Audio, text, still picture, simplified video and data services
    - Multiplexing of payload data is based on MPEG-2 systems
  - Wide selectable transmission parameters for broadcasters' services
    - Transmission parameters such as modulation, error correction are dynamically reconfigurable by TMCC (transmission and multiplexing configuration control).
    - Information bit rate ranges from 280 kbps to 5.3 Mbps.
- Commonality and interoperability
  - MPEG-2 systems
    - Commonality and interoperability with many other systems in TS (transport stream) layer

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Features of ISDB-T_{SB} II

- Efficient transmission and source coding
  - 'Connected transmission' without guard bands
  - MPEG-2 AAC
    - AAC+SBR (Spectral Band Replication) have been adopted (Option).
- Independency of broadcasters
  - Independent RF channel (OFDM-segment) for each broadcaster
    - Broadcasters can select transmission parameters for their own services.
    - BST-OFDM
- Low power consumption
  - The slower the system clock, the lower the power consumption.
    - Narrow band (430kHz), low bit rate system
- Hierarchical transmission and handheld reception
  - Up to two layers in the triple-segment transmission
    - Selectable parameters in each layer: Modulation, Coding rates, Length of Time interleaving
    - Parameters are sent in the TMCC signal.
  - Handheld reception
    - The middle of triple-segment can be received by the 'One-Seg' receiver.
      - Common transmission scheme for both television and sound broadcasting

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Transmission parameters of OFDM-segment

ISDB-T Mode	Mode 1	Mode 2	Mode 3
Bandwidth	430kHz (6/14 MHz)		
Carrier spacing	3.968kHz	1.984kHz	0.992kHz
Useful symbol duration	252 μs	504 μs	1.008 ms
Total number of carriers	108	216	432
Guard Interval duration	1/4, 1/8, 1/16, 1/32 of useful symbol duration		
Number of symbols per frame	204		
Subcarrier modulation	DQPSK, QPSK, 16QAM, 64QAM		
Inner code	Convolutional Code (1/2, 2/3, 3/4, 5/6, 7/8)		
Outer code	RS (204,188)		
Interleaving	frequency and time interleaving (2 dimensional)		
Length of time interleaving	0 – 1 s (depends on length of interleaving and symbol duration)		
Information rate	280k - 1.8Mbps		

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Transmission capacities I

Carrier Modulation	Convolutional Code	Information Bits (kbps)			
		Guard Interval Ratio 1/4	Guard Interval Ratio 1/8	Guard Interval Ratio 1/16	Guard Interval Ratio 1/32
DQPSK QPSK	1/2	280.85	312.06	330.42	340.43
	2/3	374.47	416.08	440.56	453.91
	3/4	421.28	468.09	495.63	510.65
	5/6	468.09	520.10	550.70	567.39
	7/8	491.50	546.11	578.23	595.76
16QAM	1/2	561.71	624.13	660.84	680.87
	2/3	748.55	832.17	881.12	907.82
	3/4	842.37	936.19	991.26	1021.30
	5/6	936.19	1040.21	1101.40	1134.78
	7/8	983.00	1092.22	1156.47	1191.52
64QAM	1/2	842.57	936.19	991.26	1021.30
	2/3	1123.43	1248.26	1321.68	1361.74
	3/4	1263.36	1404.29	1486.90	1531.95
	5/6	1404.29	1560.32	1652.11	1702.17
	7/8	1474.50	1638.34	1734.71	1787.28

Information bit rates for the single-segment transmission
(segment BW = 6/14MHz)

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Transmission capacities II

Carrier Modulation	Convolutional Code	Information Rate (Mbps)			
		Guard Interval Ratio 1/4	Guard Interval Ratio 1/8	Guard Interval Ratio 1/16	Guard Interval Ratio 1/32
DQPSK QPSK	1/2	0.842	0.936	0.991	1.021
	2/3	1.123	1.248	1.321	1.361
	3/4	1.263	1.404	1.486	1.531
	5/6	1.404	1.560	1.652	1.702
	7/8	1.474	1.638	1.734	1.787
16QAM	1/2	1.685	1.872	1.982	2.042
	2/3	2.246	2.496	2.643	2.723
	3/4	2.527	2.808	2.973	3.063
	5/6	2.808	3.120	3.304	3.404
	7/8	2.949	3.276	3.469	3.574
64QAM	1/2	2.527	2.808	2.973	3.063
	2/3	3.370	3.744	3.965	4.085
	3/4	3.791	4.212	4.460	4.595
	5/6	4.212	4.680	4.956	5.106
	7/8	4.423	4.915	5.204	5.361

Information bit rates for the triple-segment transmission

Note: In case of the triple-segment transmission, information rate can be calculated by the combination of segment information rates

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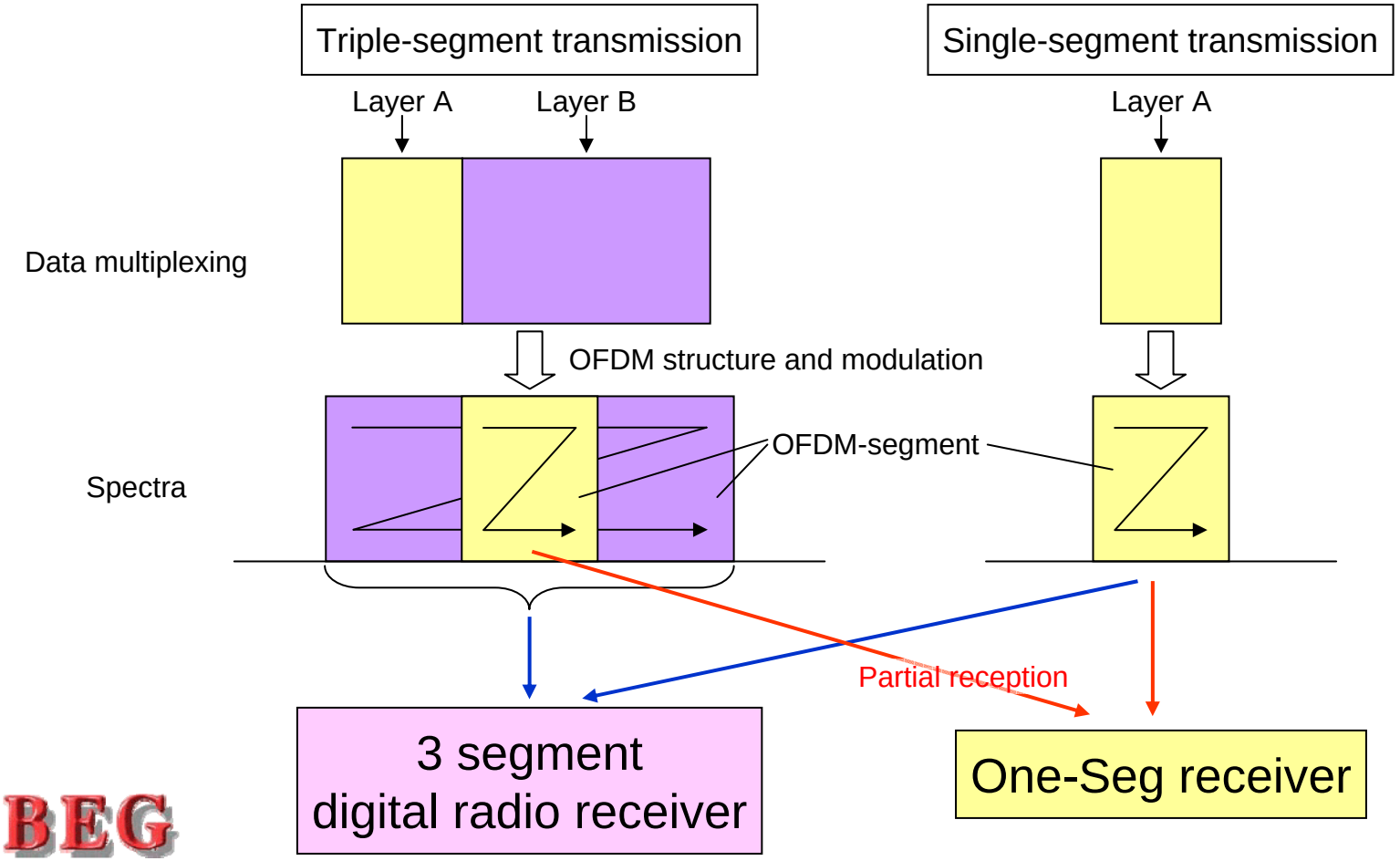
ISDB-T Services (fixed and mobile)

- Digital Terrestrial Television Broadcasting
  - 13 OFDM-segments system
  - SD Multi-broadcasting (broadcasting some SD programs simultaneously)
  - Services for handheld and mobile reception terminals (One-Seg service)
  - HDTV broadcasting
  - Data broadcasting
  - Engineering services to increase receiver functions and resolve problems by using broadcast waves

- Terrestrial Digital Sound Broadcasting (ISDB-T_{SB})
  - 1 or 3 OFDM-segments system
  - Providing high-quality sound broadcasting and data broadcasting based on text, still pictures, simplified videos, etc.
  - Compatible with One-Seg service for mobile

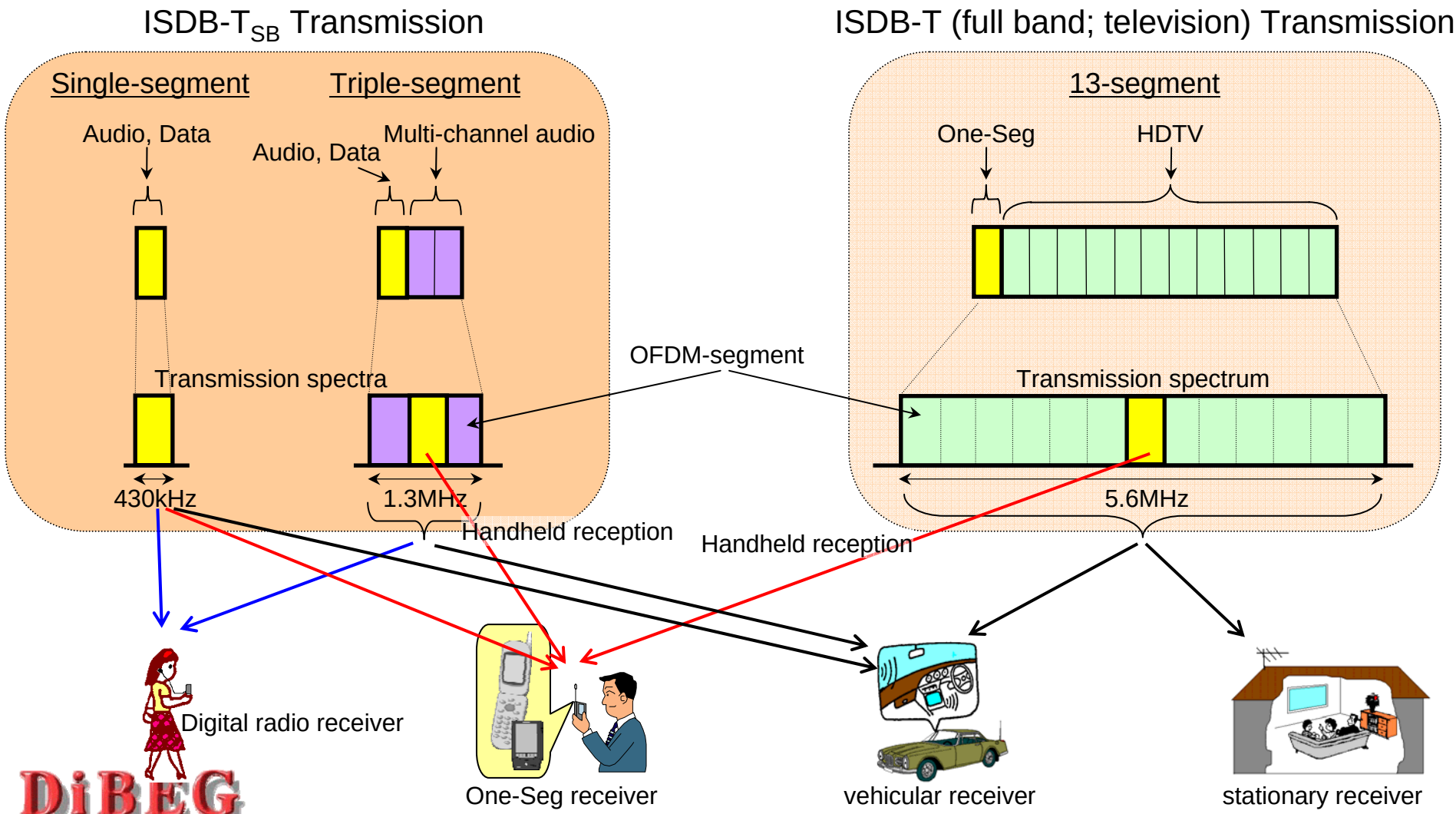
Hierarchical transmission (Triple-segment transmission)

- Transmission segment groups having different transmission parameters
- Maximum of two layers can be transmitted simultaneously in a channel
- 'One segment reception' is possible



ISDB-T transmission concept and its reception

Transmission example

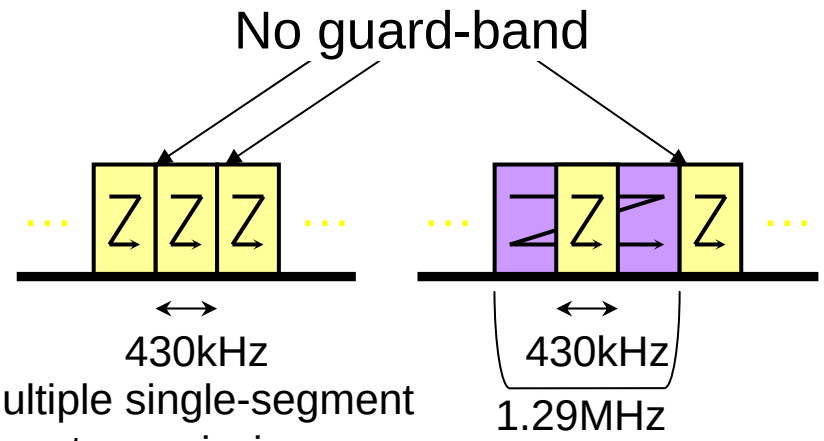


Connected transmission

- Transmission of multiple OFDM-segments of multiple broadcasters from the same transmitter without guard bands.
  - All OFDM-segments in the connected transmission are synchronized (i.e. orthogonal).
  - No Guard-bands are necessary to separate adjacent channels.
- Maximum of 13 OFDM-segments can be connected in a transmitter.

Connected transmission

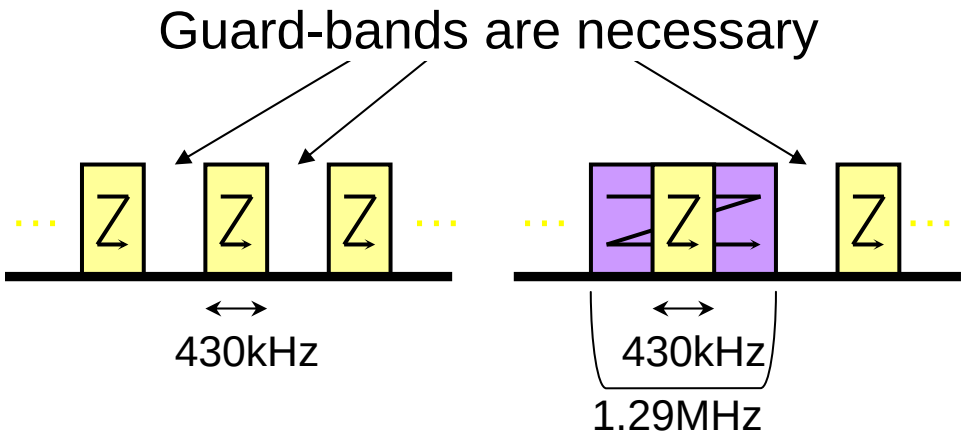
(Synchronized transmission)



Multiple single-segment transmission

Non-connected transmission

(Non-synchronized transmission)



Digital Radio in Japan

- **Since 10th of October, 2003, test broadcasting has been taking place at two Development Test Stations located in Tokyo and Osaka.**
  - Serves as an independent new medium
    - Analog AM and FM are to continue.
  - Frequency: 188-192MHz (VHF ch.7)
  - Information bit rate:
    - 330kbps (single-segment transmission)

      Mode: 3, Guard interval ratio: 1/16, Modulation: QPSK, Coding rate: 1/2
    - 440kbps (With video , single-segment transmission)

      Mode: 3, Guard interval ratio: 1/16, Modulation: QPSK, Coding rate: 2/3
  - High quality audio
    - Audio coding: MPEG-2 AAC (AAC+SBR; optional)
    - Audio bit rate: 144 kbps for stereo (= near CD quality)
  - A digital radio broadcaster can send still pictures and simplified videos.
    - Video coding: MPEG-4 H.264 AVC same as One-Seg service of ISDB-T
  - Data broadcast description: BML (broadcast markup language)

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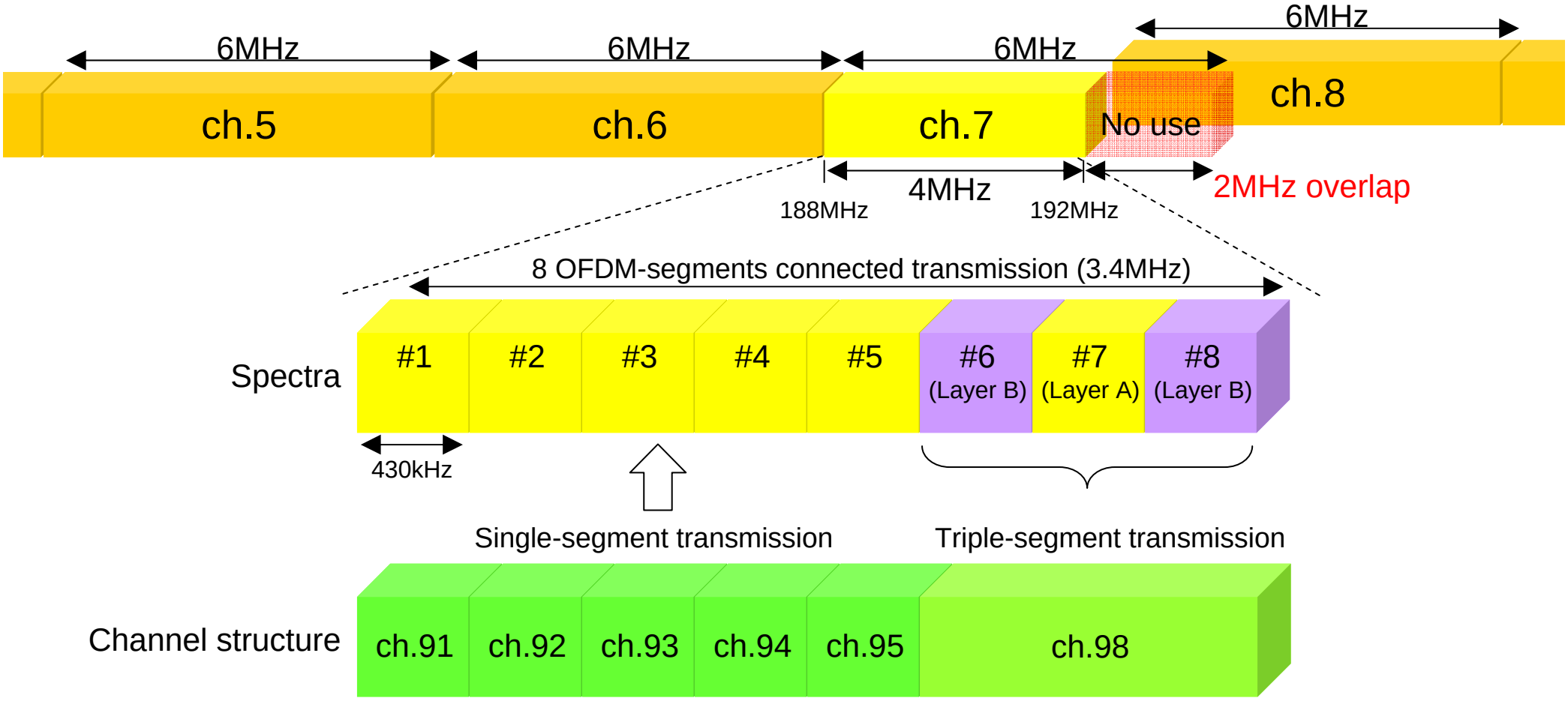
License for Digital Radio in Japan

Licensed party	Digital Radio Promotion Association (DRP)	
Transmitting station	Tokyo station	Osaka station
Start	10th October , 2003	
Center frequency	190.214286 MHz (on television channel 7)	
Transmission power (power/ERP)	2,400 W (3,000 W)	240 W (770W)
Transmitting site	Tokyo tower	Mt. Ikoma
Coverage	Tokyo metropolitan area	Osaka metropolitan area

- The members of DRP include NHK, radio broadcasters, TV broadcasters, data broadcasting companies, trading companies, automakers and other companies interested in digital radio. Approximately 70 organizations and companies from every part of Japan have joined the association.

Frequency assignment for DRP test broadcasting

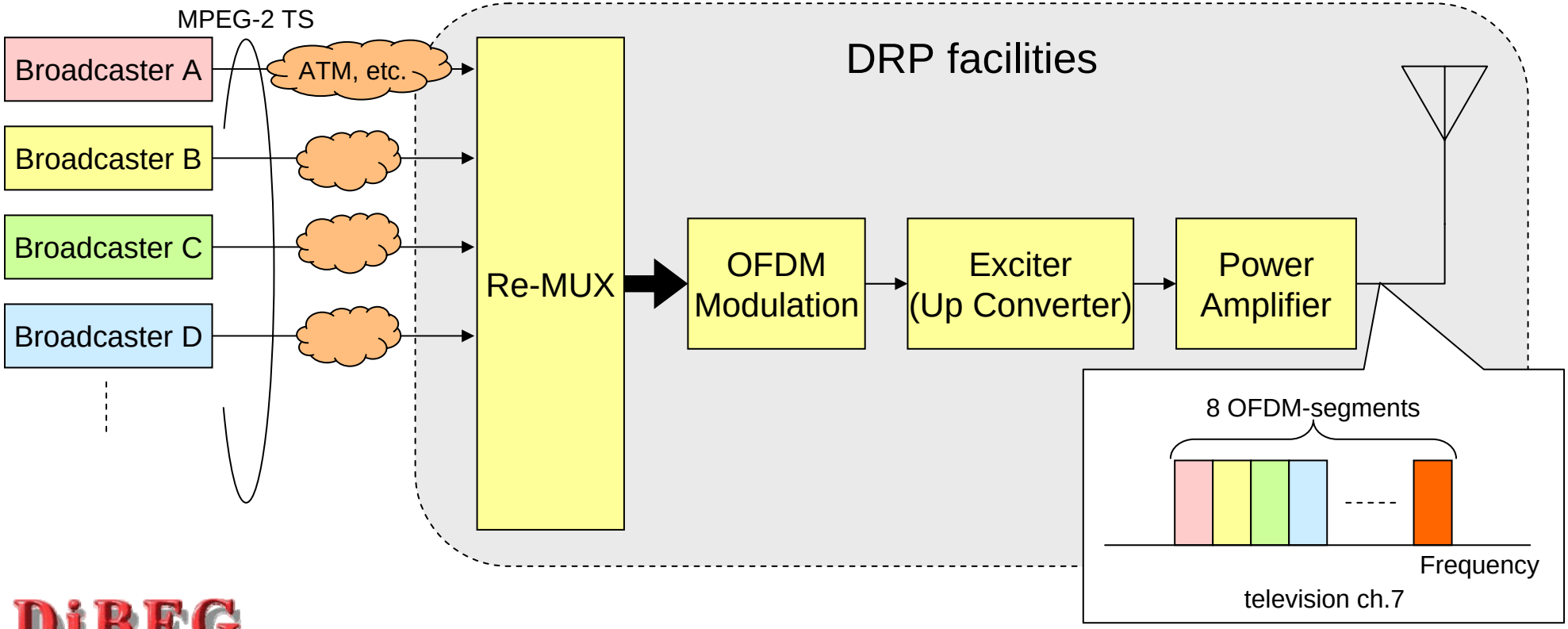
- VHF band (for analog television broadcasting)



- DRP Osaka is all single-segment transmission.

Connected transmission in DRP

- Each broadcaster sends MPEG-2 TS packets to DRP.
- The TS packets are re-multiplexed and structured into OFDM-segments.
- 8 OFDM-segments are connected to an OFDM signal, and transmitted.
- Receivers can tune to a preferred channel to enjoy the programs.



Transmission Facilities in DRP Tokyo

Rack room of master control

- Synchronization
- Re-MUX
- OFDM modulation

Digital radio transmitter

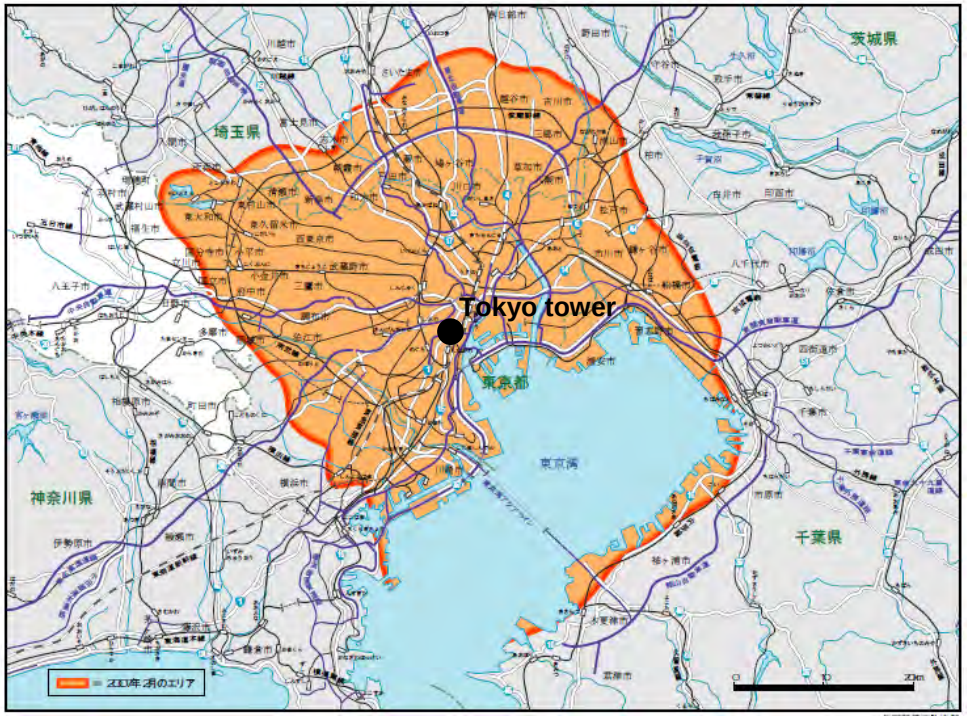
- Duplex system
- Adaptive digital pre-distortion type

Tokyo tower

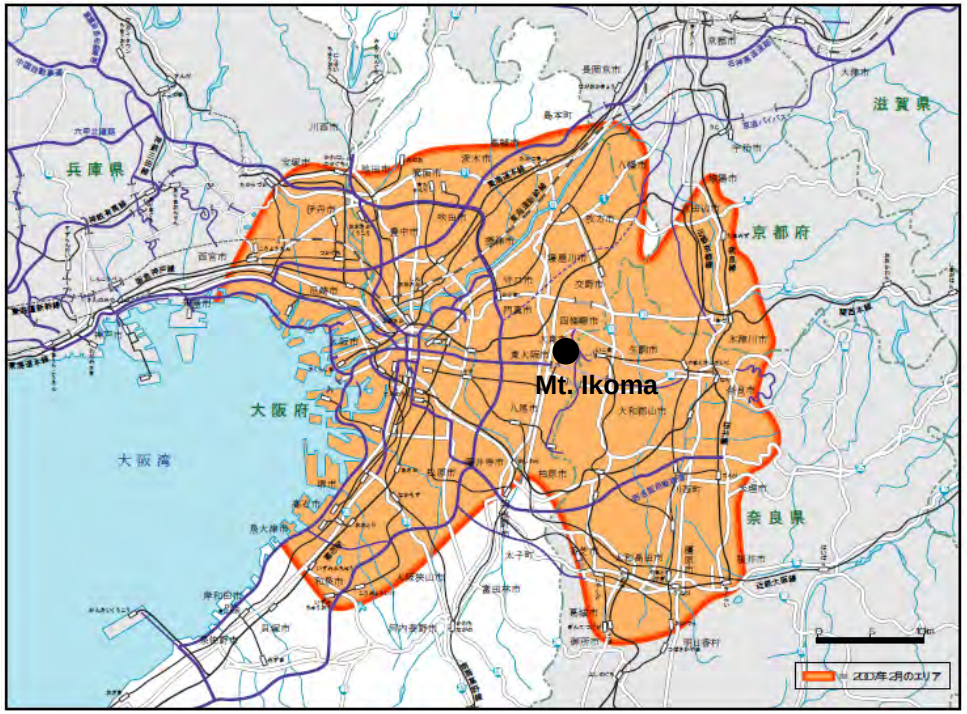
Transmitting antenna

- Omni-directional multi-panel antenna
- Double-stack 2L- twin loop, 9 panels
- Vertical polarization

Test broadcasting Area



Tokyo test broadcasting area



Osaka test broadcasting area

Mobile phone type receivers in the commercial market

					
Sony Ericsson	Toshiba	Toshiba	Sharp	Hitachi	Toshiba
					
Sony Ericsson	Toshiba	Sanyo	Sanyo	Sony Ericsson	Sanyo

http://www.d-radio.or.jp/howto/mobile.html

USB type receivers for PC in the commercial market

			
SKNET	BUFFALO	PIXELA	Corega

http://www.d-radio.or.jp/howto/pc.html

http://buffalo.jp/products/catalog/multimedia/dh-kone4g_u2ds/

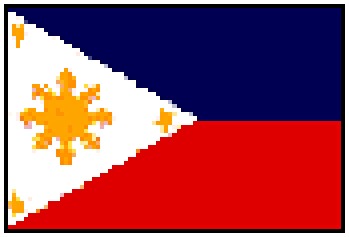
Possible to record broadcast directly in built-in memory

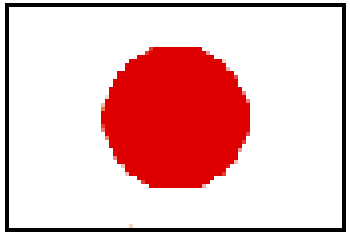
Summary of ISDB-T_{SB} system I

- Recommended as System F of Recommendation ITU-R BS.1114-6.
- MPEG-2 systems
  - MPEG-2 TS: Commonality and interoperability
- MPEG-2 AAC
  - AAC+SBR adopted (optional)
- Ruggedness
  - OFDM, frequency-time interleaving, concatenated error correction codes
- BST-OFDM
  - 1 or 3 OFDM-segments system, wide selectable transmission parameters
- Effective frequency utilization
  - Connected transmission, SFN
- Independency of broadcasters in transmission
  - BST-OFDM, flexibility of transmission parameters
- EWS (emergency warning system)
  - Provides safety and ease.
- Low power consumption
- Hierarchical transmission and partial reception
- Compatibility with 'One-Seg' receiver

Summary of ISDB-TSB system II

- Test broadcasting digital radio in Japan commenced in October 2003.
  - Frequency: 188-192MHz
    - Connected transmission of 8 OFDM-segments
      - DRP Tokyo: 5 single-segment transmissions and 1 triple-segment transmission
      - DRP Osaka: 8 single-segment transmissions
  - Transmission power
    - DRP Tokyo: 2,400W / ERP 3000W
    - DRP Osaka: 240W / ERP 770W
  - Information bit rate:
    - 330kbps (single-segment transmission)
    - 440kbps (With video , single-segment transmission)
  - Audio coding: MPEG-2 AAC (AAC+SBR; optional)
  - A digital radio broadcaster can send still pictures and simplified videos.
    - Multi-channel audio
      - 5.1 surround sound
      - Multilingual news and weather
    - Simplified video service
      - H.264 coding will be adopted (the same as 'One-Seg').





Salamat po!

Thank you for your attention !

DRP

http://www.d-radio.or.jp/en/index.html

NHK STRL

http://www.nhk.or.jp/strl/english/index.html

Reference

Example of Program Table

	Audio services (with data services related to the program)				Independent data services	
	main	sub 1	sub 2	sub 3	NHK	VICS
17:00	Selectable cooking Tonight's dinner (1)	Selectable cooking Tonight's dinner (2)	Selectable cooking Tonight's dinner (3)	Selectable cooking Tonight's dinner (4)	Selective news	Road traffic information service
17:10	Fun music					
17:25	Sound passage					
17:55	Kids English (A)	Kids English (B)	Kids English (C)	Kids English (D)		
18:00	Multilingual folktale (Japanese)	Multilingual folktale (English)	Multilingual folktale (Chinese)	Multilingual folktale (French)		
18:10	Radio theater					
19:00	News	Slower speech news				
19:15	Multilingual weather forecast (Japanese)	Multilingual weather forecast (English)	Multilingual weather forecast (Korean)	Multilingual weather forecast (Chinese)		
19:50	The Soul Music					

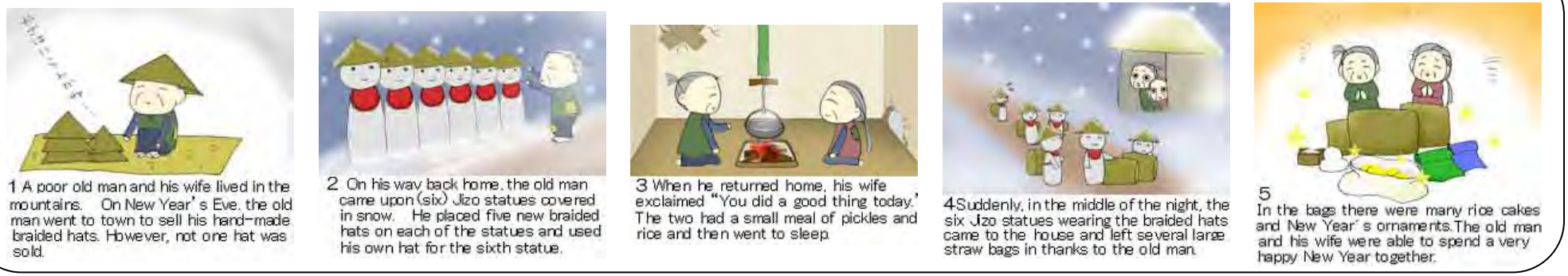
VICS: Vehicle Information and Communication System

For example Digital Radio Program

Multilingual folktale

- Data service of still pictures corresponding to each language

English (sub1)



Japanese (main)

Chinese (sub2)

French (sub3)