ISDB-T seminar(10/2008)
in Philippines

Presentation 2

Technical Overview & Transmission System of ISDB-T

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Digital Broadcasting Expert Group (DiBEG)

Japan

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Contents

1. 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 OFDM Transmission with Time Interleave.

2. Requirement/Solution

2.1 Requirement for ISDB-T

No.	Item	Requirement	Note
1	High quality	HDTV should be possible in 6MHz bandwidth	
2.	Robustness	Robustness against multi-path, urban noise, fading and any other interference	
2. 2(1) 2(2)	Flexibility Service Flexibility Reception flexibility	 Any kinds of service are possible in 6MHz bandwidth Any kinds of reception system are possible, fixed/mobile/portable in same bandwidth	 HD/SD possible
3	Effective utilization of frequency resource	SFN(Single Frequency Network) is possible to reduce frequency.	
4.	Interactivity	Harmonization with network	
5	Data casting		
6.	Commonality	Maximum commonality is need to reduce receiver cost. Especially, to digital radio, common standard is desirable.	

See DiBEG homepage for details

2.2 Technical solutions for these requirement

High quality/ service flexibility

Following technologies are adopted in ISDB-T;
(1)Flexible multiplex technology (MPEG-2 systems),
(1)Flexible and high efficiency video/ audio coding system (MPEG-2 and MPEG AAC).
As a result, many kinds of broadcasting service, such as (a)HDTV, (b)HDTV+SDTV, (c)Multi-channel SDTV, are possible in one standard. ISDB-T receiver receives any type of service described above.

- For the technical details, See “section 4.1 of this session”
- For the service application, See seminar “Service application”

ISDB-T transmission system

ISDB-T adopts very unique and high performance transmission technology, named “Segmented OFDM Transmission with Time Interleave”. This transmission technology enables many advantages described after compared to other DTTB system

- For advantages, see next 2 pages.
- For the technical details, See “section 5. of this session”

Service Image of ISDB-T in Japan

One transmitter supports any kind of service

Broadcaster

10110 . . .

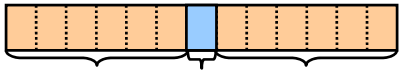
Digital Broadcasting

Sports

News

Disaster

Multiplexing to One



HDTV Portable HDTV

12 Segment

Compressed by MPEG2

1 Segment

Compressed by H.264

Original Image

For large Screen Television

High Definition Picture

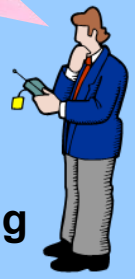
High Quality Sound

At home

In the Bus

Anytime Anywhere

In the train



While walking

For Portable Terminal

Advantages of ISDB-T Transmission system

(1) Robustness/ reception flexibility

To give the robustness against such degradation factor, ISDB-T adopts OFDM transmission system with “Time Interleave” technology.

As a result, ISDB-T gives following features compare to other DTTB systems;

(a) lower transmitter power,

(b) possibility of indoor antenna reception,

(c)mobile/portable reception service, etc.

(2) Effective utilization of frequency resource

By adopting OFDM transmission system, it is possible to construct Single Frequency Network(SFN). As a result, possible to reduce frequency resource for relay transmitter(repeater).

Further more, using same frequency for plural transmitters of same network, mobile/ portable receiver is not required to change receiving channel.

(3) Mobility/ Portability

To enable fixed/ mobile/portable reception service in same channel, ISDB-T developed new transmission technology, named “Segmented OFDM transmission system”.

As a result, fixed/mobile & portable service in same channel is possible.

“One-seg” service, its unique portable service of ISDB-T, uses 1 segment of 6MHz.

One seg receiver is easily mounted into mobile-phone, portable PDA, USB tuner ,etc, so it enable the broadcast service of “Any time, Any place”

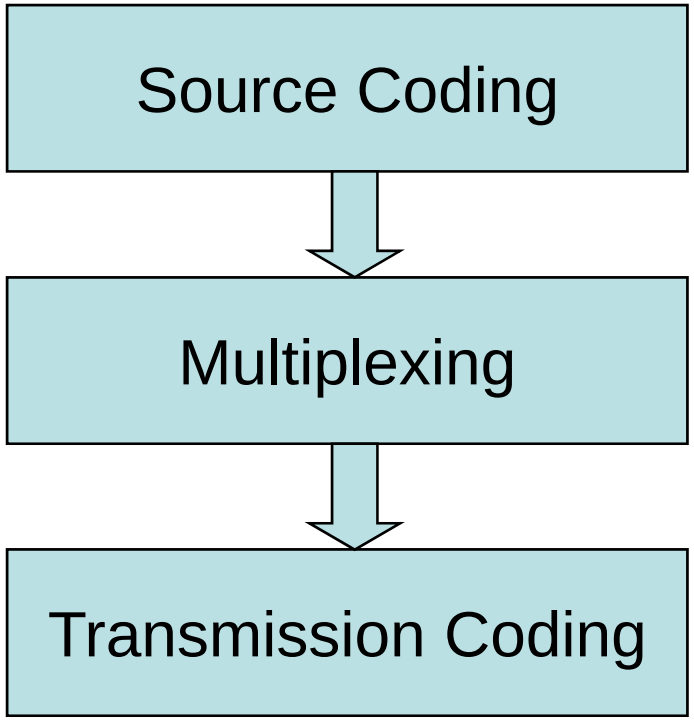
(4) One-seg service

One-seg service, uses 1 segment of 6MHz, dose not need another channel, so not need more transmitter.. it leads save of frequency resource and broadcaster’s infrastructure cost. And more, One-seg receiver operates as narrow band reception, this operation saves consumption power. As a result, long time reception is possible by battery.

3. Structure of ISDB-T Standard

- **Structure of Japan's Digital Broadcasting system**

General View of Structure

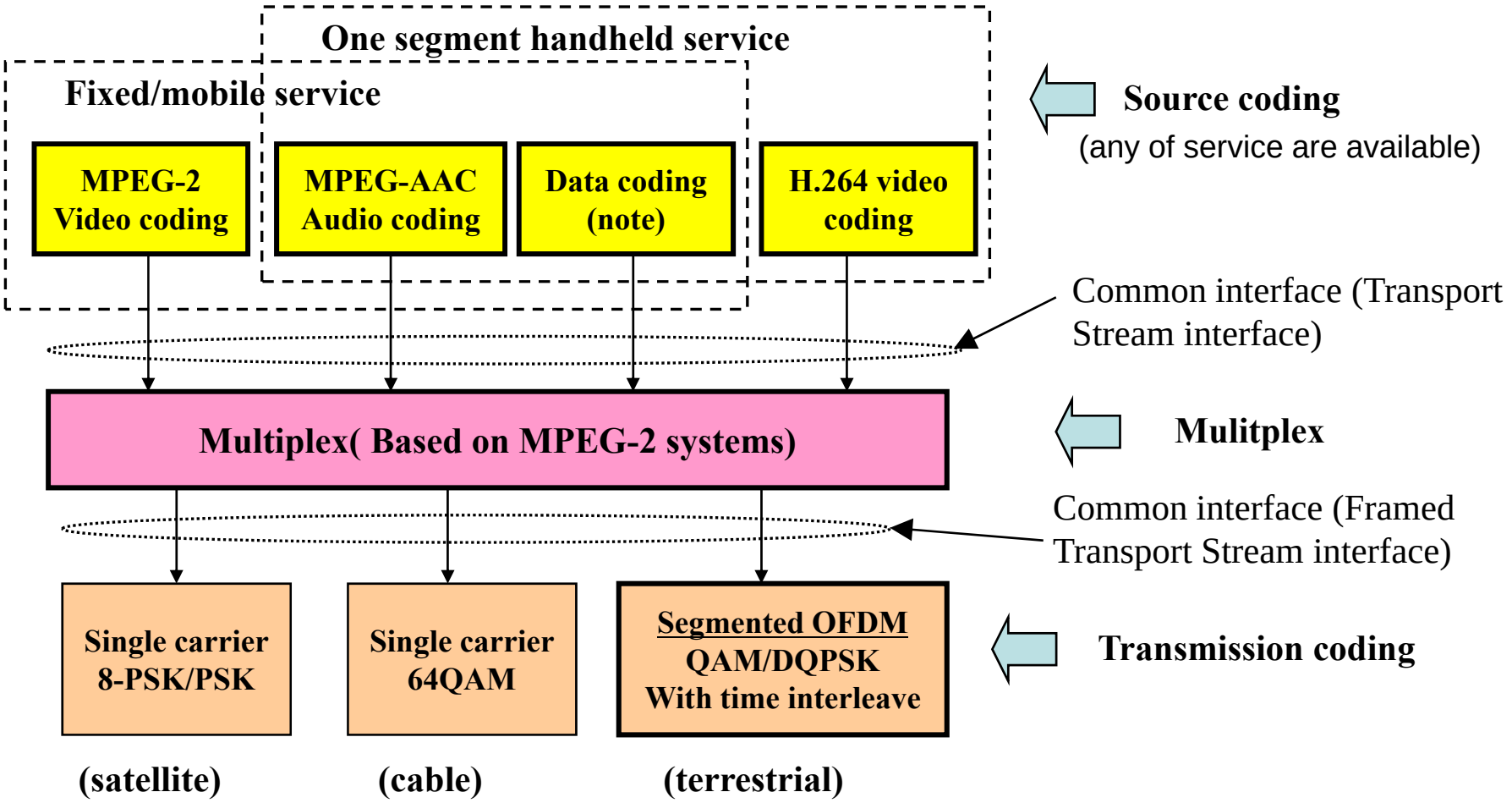


- Common for all Broadcast media to keep commonality
- Any services are available

- Multiplex all data from Source coding
- Interface to transmission media by TS format

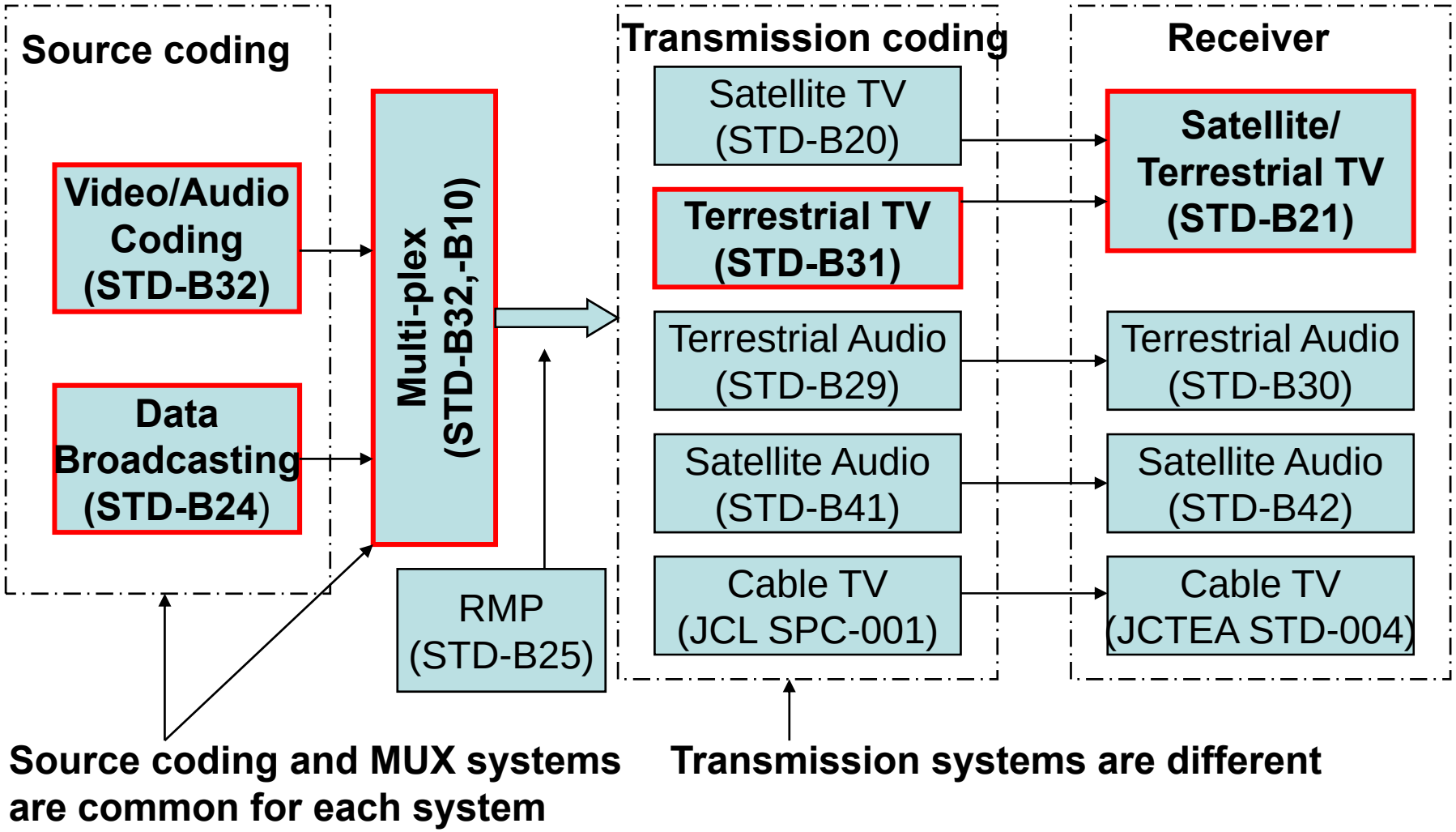
- Modulation system is optimized for each media

•Continued (details of structure)



(note) both BML and MHP are available,
But in Japan now BML is only service in.

ARIB standard structure



Note: Cable transmission system standards are defined at another consortium

4. Features of ISDB-T (footnote)

4.1 High quality/Service Flexibility

(1) High quality

Japan started the research and development for HDTV about 30 years ago, and has a leadership for HDTV hardware/ software in the world.

Because of these background, High quality is the most important requirement for digital broadcasting system.

In satellite broadcasting in Japan, started from 1997, HDTV service is real broadcast service, so ,even in digital terrestrial broadcasting service, HDTV is also adopted.

Japan adopts MPEG-2 for HDTV/SDTV compression system. So both HDTV/SDTV are supported in Digital broadcasting.

(footnote) Please refer DiBEG homepage, details are written in “ISDB-T report”

(2) Service flexibility

In ISDB-T system, service flexibility is realized by 2 techniques written below.

(a) MPEG-2 video coding technology/ MPEG-AAC audio coding technology

MPEG-2 video coding technology, which is adopted in Japanese digital broadcasting, supports many kinds of video quality/format. For video quality/format, Japanese digital broadcasting adopt many kinds of video quality/format described in Table 2-1

For audio system, MPEG-AAC, highest compression and quality audio coding system, is adopted for digital broadcasting in Japan. MPEG-AAC also supports many kinds of audio quality/format In Table 2-2, audio quality/format specified in Japanese digital broadcasting are shown.

Digital broadcasting receiver in Japan should be specified to decode any kinds of video/audio quality/format described in Table4-1 and Table4-2.

In addition above, digital receiver specification specifies that the video output format to display should be selectable according to display specification.
So ,following format conversion is possible, (1)HDTV→SDTV, (2)SDTV→HDTV.
As described above, ISDB-T receiver has a flexibility for video/ audio quality/ format.

And it is possible to enjoy HDTV program on SDTV display by converting video format. Therefore, ISDB-T receiver can support the variation of broadcasting service, such as, HDTV,HDTV+SDTV, multi-SDTV, etc, by one receiver.

For audio system, many quality/format, such as monaural/ stereo/bi-lingual/ multi-channel stereo are supported, and more, down-mix from multi-channel to monaural and stereo is specified, so, legacy audio system can be used.

Table 4-1 Video Format

Number of lines		525	525	750	1125
Number of active lines		483	483	720	1080
Scanning system		Interlaced	Progressive	Progressive	Interlaced
Frame frequency		30/1.001 Hz	60/1.001 Hz	60/1.001 Hz	30/1.001 Hz
Field frequency		60/1.001 Hz			60/1.001 Hz
Aspect ratio		16 : 9 or 4 : 3	16 : 9	16:9	16 : 9
Line frequency f_H		15.750/ 1.001kHz	31.500/ 1.001 kHz	45.000/ 1.001 kHz	33.750/ 1.001 kHz
Sampling frequency	Luminance signal	13.5 MHz	27 MHz	74.25/1.001MHz	74.25/1.001MHz
	Color-difference signals	6.75 MHz	13.5 MHz	37.125/ 1.001MHz	37.125/ 1.001MHz
Numbers of samples per line	Luminance signal	858	858	1650	2200
	Color-difference signals	429	429	825	1100
Number of samples per active line	Luminance signal	720	720	1280	1920
	Color-difference signals	360	360	640	960
Filter characteristics		See Fig. 1	See Fig. 2	See Fig. 3	
Line synchronizing signal		See Fig. 4		See Fig. 5	See Fig. 6
Field synchronizing signal		See Fig. 7	See Fig. 8	See Fig. 9	See Fig. 10

(ARIB STD-B32 Part 1, chapter 2.4)

Table 4-2 Audio Format

Parameter	Restriction
Audio mode Possible audio modes	Monaural, stereo, multichannel stereo (3/0, 2/1, 3/1, 2/2, 3/2, 3/2+LFE) (Note 1), 2-audio signals (dual monaural), multi-audio (3 or more audio signals) and combinations of the above
Recommended audio mode	Monaural, stereo, multichannel stereo (3/1, 3/2, 3/2+LFE) (Note 2), 2-audio signals (dual monaural)
Emphasis	None

(Note 1) Number of channels to front/rear speakers:	Example:3/1 = 3 front + 1 rear 3/2 = 3 front and 2 rear
(Note 2) LFE = Low frequency enhancement channel	

ARIB STD-B32 part 2 Chapter 5.1

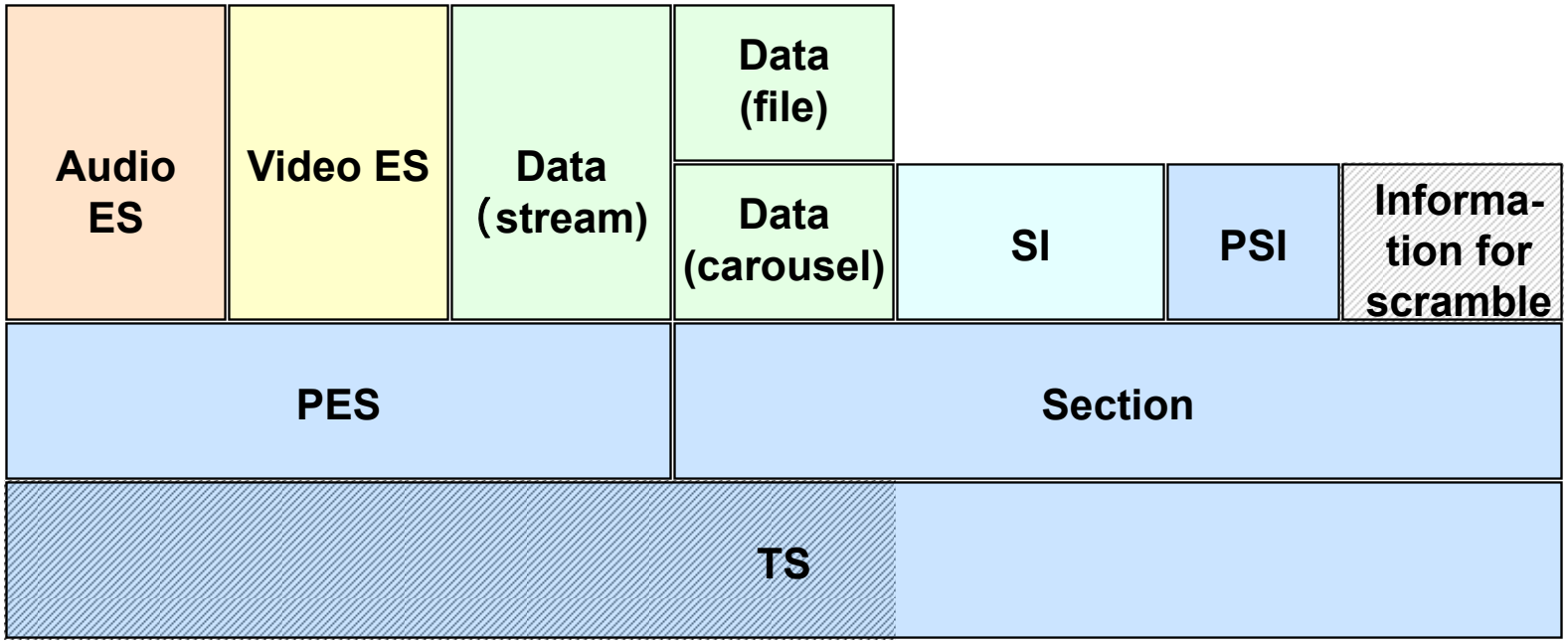
(b) MPEG-2 systems for multiplex

ISDB-T adopts MPEG-2 systems as multiplex technology.
In MPEG-2 systems, all broadcast contents, video/audio/data are multiplexed by Transport Stream Packet format .
Therefore, any type of contents/service can be multiplexed.
The concept of Multiplex is shown in Figure 4-1

As shown in Figure 4-1, stream type contents, such as video, audio and stream type data, are converted to PES(Packet Elementary Stream) format and finally converted to TS format and Multiplexed.

On the other hand, non stream type data contents are converted to Section format and finally converted to TS format and multiplexed.

Figure 4-1 Multiplexed format in ISDB-T system



(note) signal format of PES, TS and Section area is defined in ARIB STD-B32, based on MPEG-2 systems

(note) PSI is defined in both STD-B32 and STD B10. In STD-B32, only outline related to MPEG -2 systems is defined

4.2 Features of ISDB-T 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

The details of Transmission system are described in next section 5.

5. ISDB-T Transmission System

It is not enough time to explain details of Transmission system, so focus to following important points

5.1 What is Segmented OFDM transmission and its merits?

5.2 Hierarchical Transmission System

5.3 Time Interleave

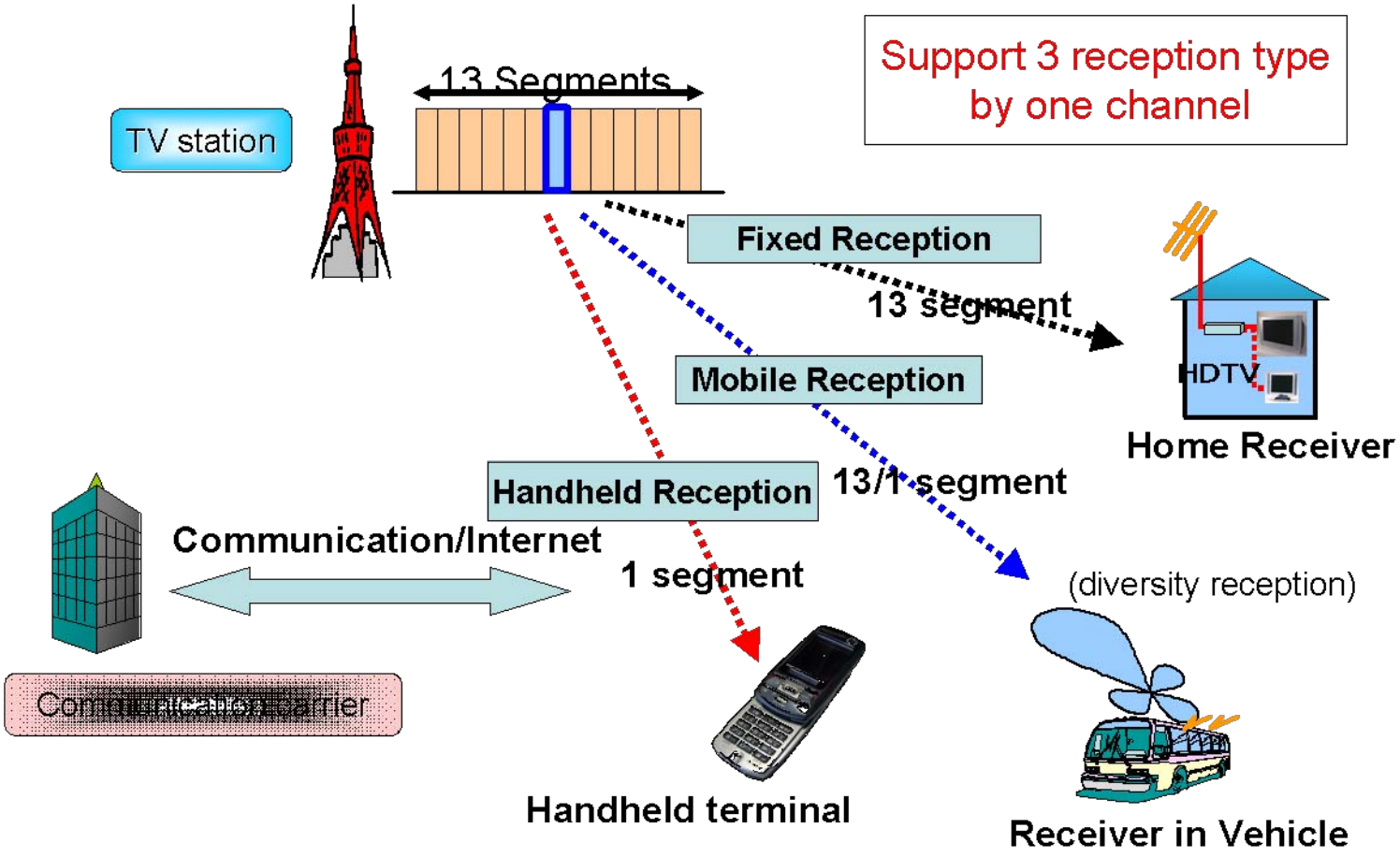
5.4 OFDM Modulation

5.5 One-Seg Service

5.1 What is Segmented OFDM?(1/4)

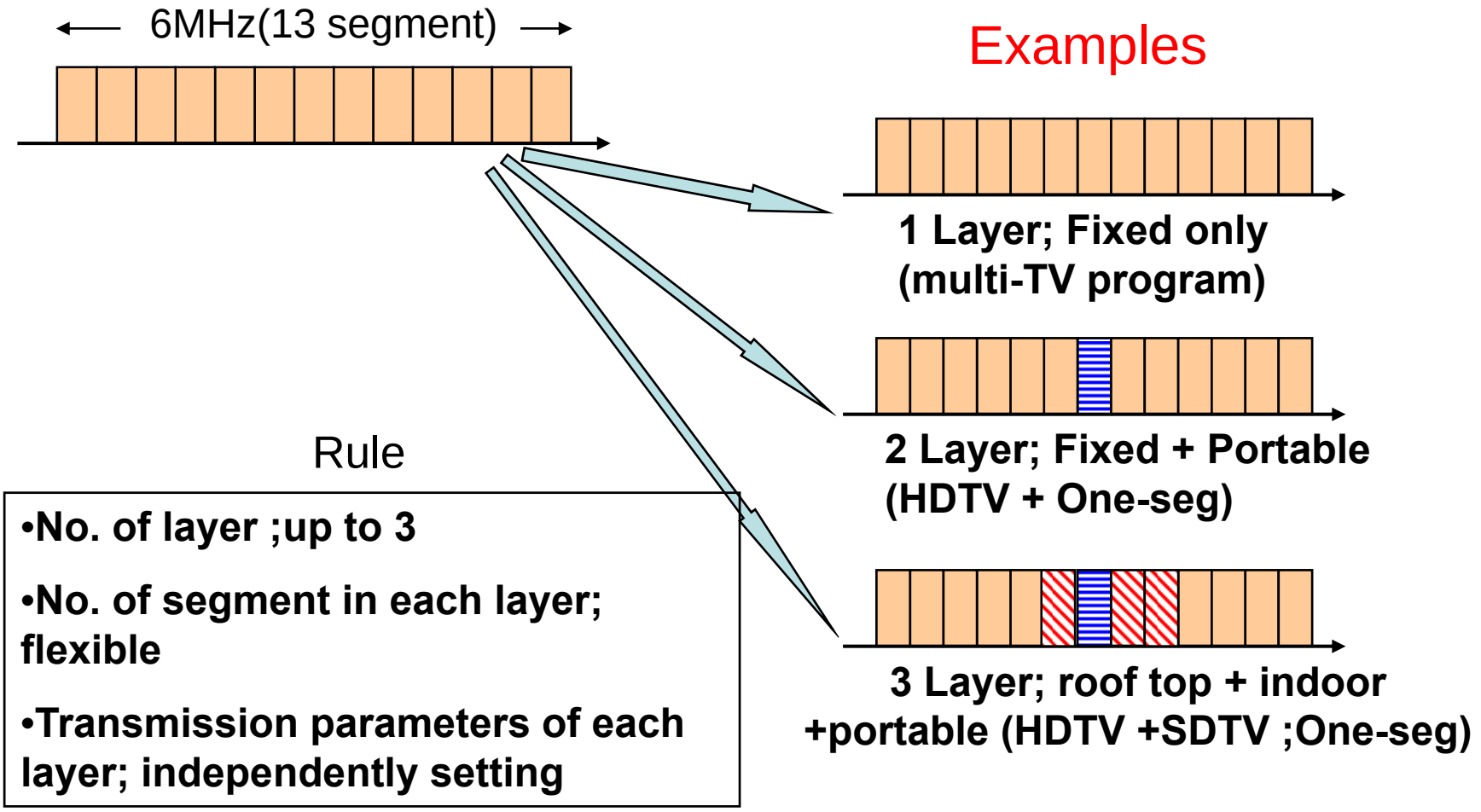
- Purpose

To enable multi reception service within same band.



5.1 What is Segmented OFDM?(2/4)

- Hierarchical transmission

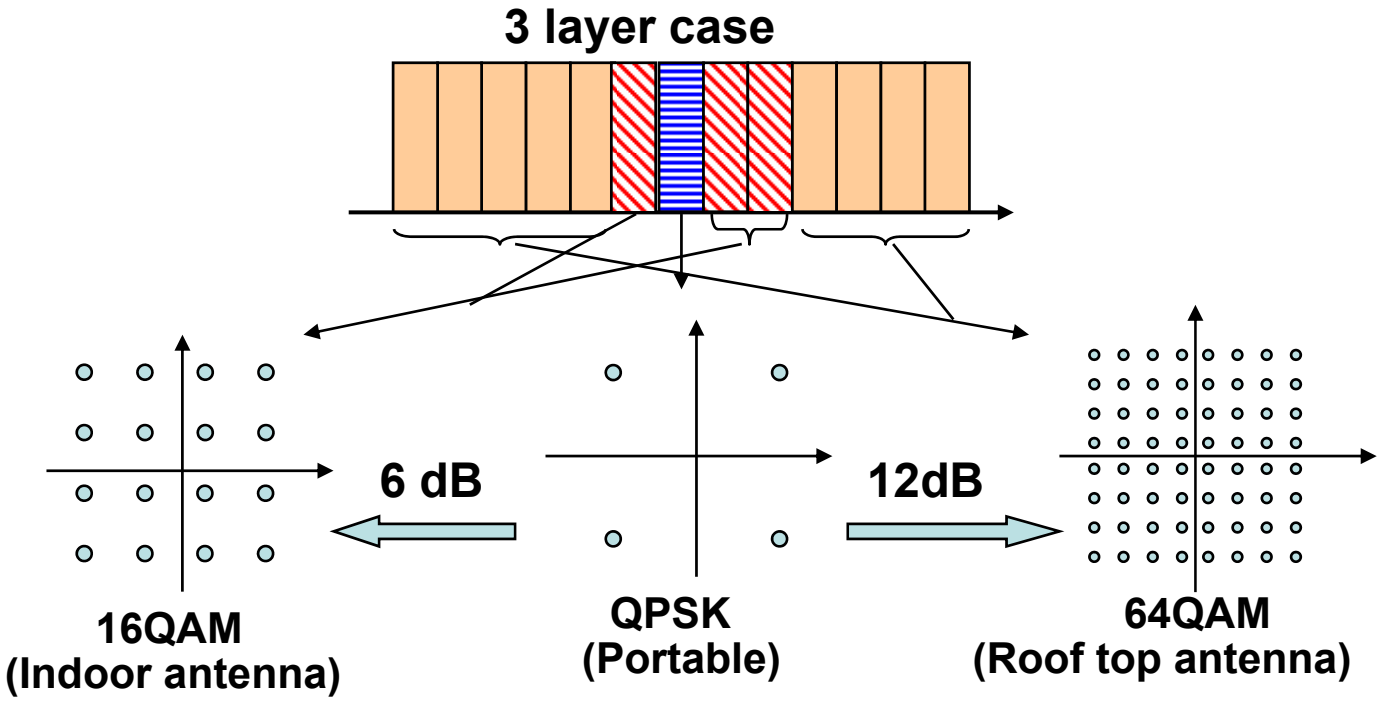


Rule

- **No. of layer ;up to 3**
- **No. of segment in each layer; flexible**
- **Transmission parameters of each layer; independently setting**

5.1 What is Segmented OFDM?(3/4)

- Hierarchical transmission

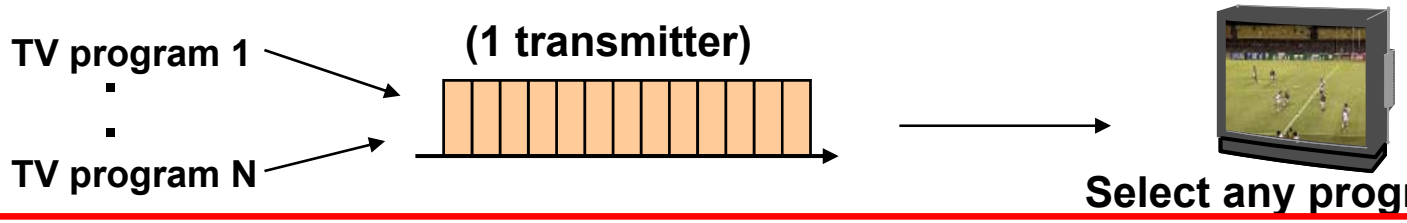


As shown above, ISDB-T transmission system supports maximally 3 reception style.
Therefore, any of transmission system can be arranged according to the service concept in one frequency channel and one transmitter

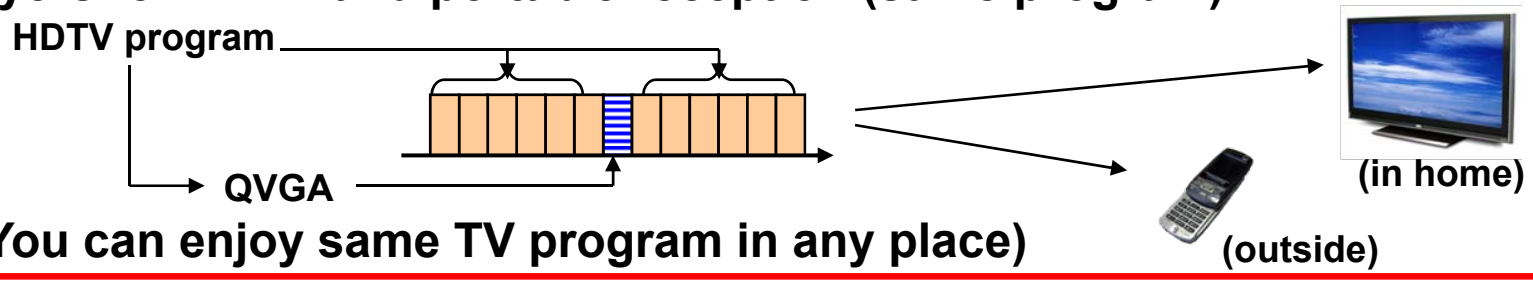
5.1 What is Segmented OFDM?(4/4)

Examples of Broadcasting service by using Hierarchical transmission

(1) Single layer multi-program for stationary reception

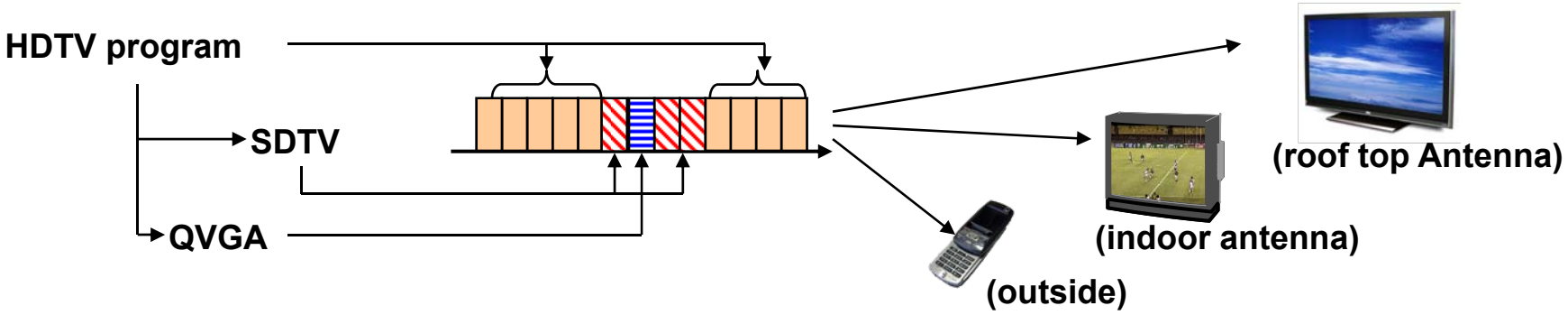


(2) 2 layers for HDTV and portable reception (same program)



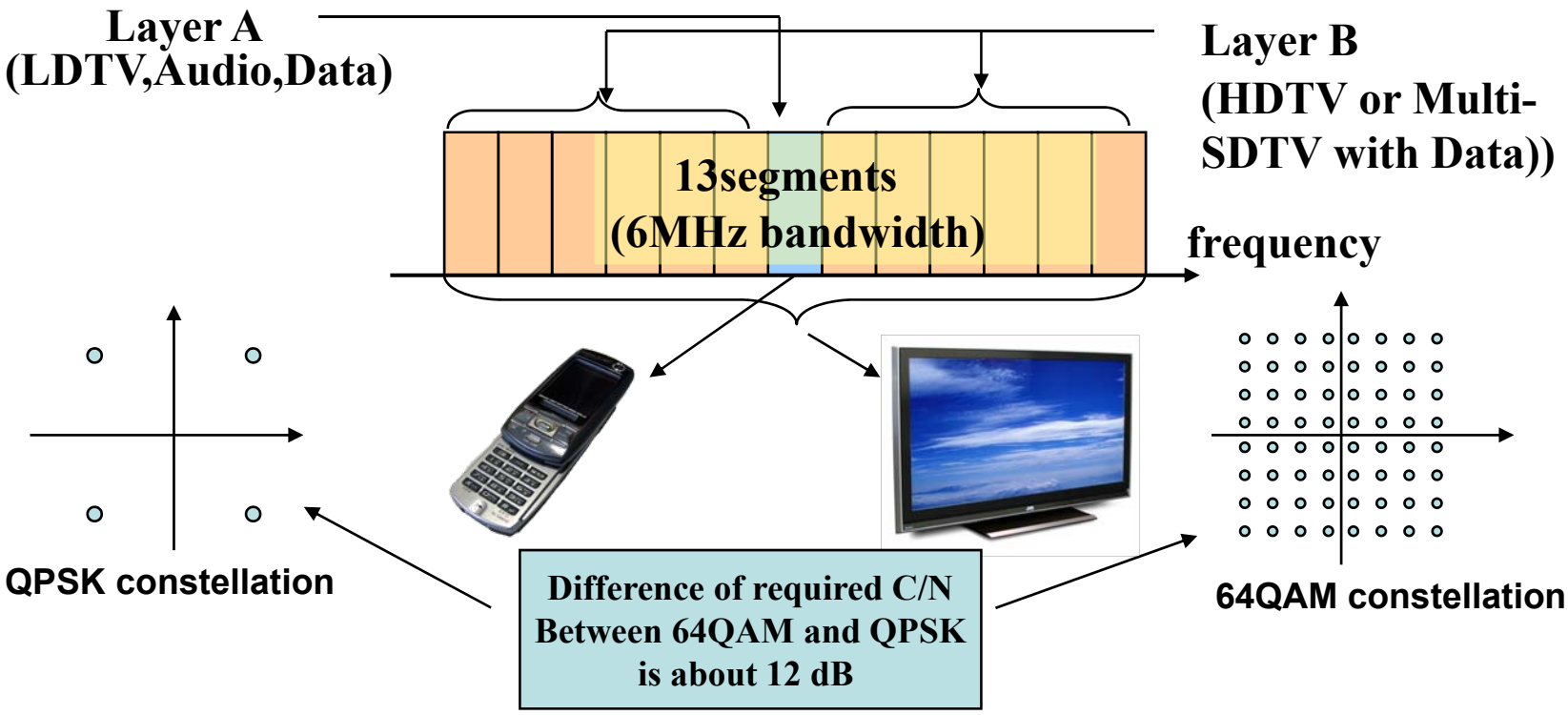
(You can enjoy same TV program in any place)

(3) 3 layers for HDTV , SDTV and portable reception (same program)



ISDB-T Hierarchical service in Japan (HDTV + One-seg service)

(Example; 1seg + 12 seg)



*13 segments are divided into layers, maximum number of layers is 3.

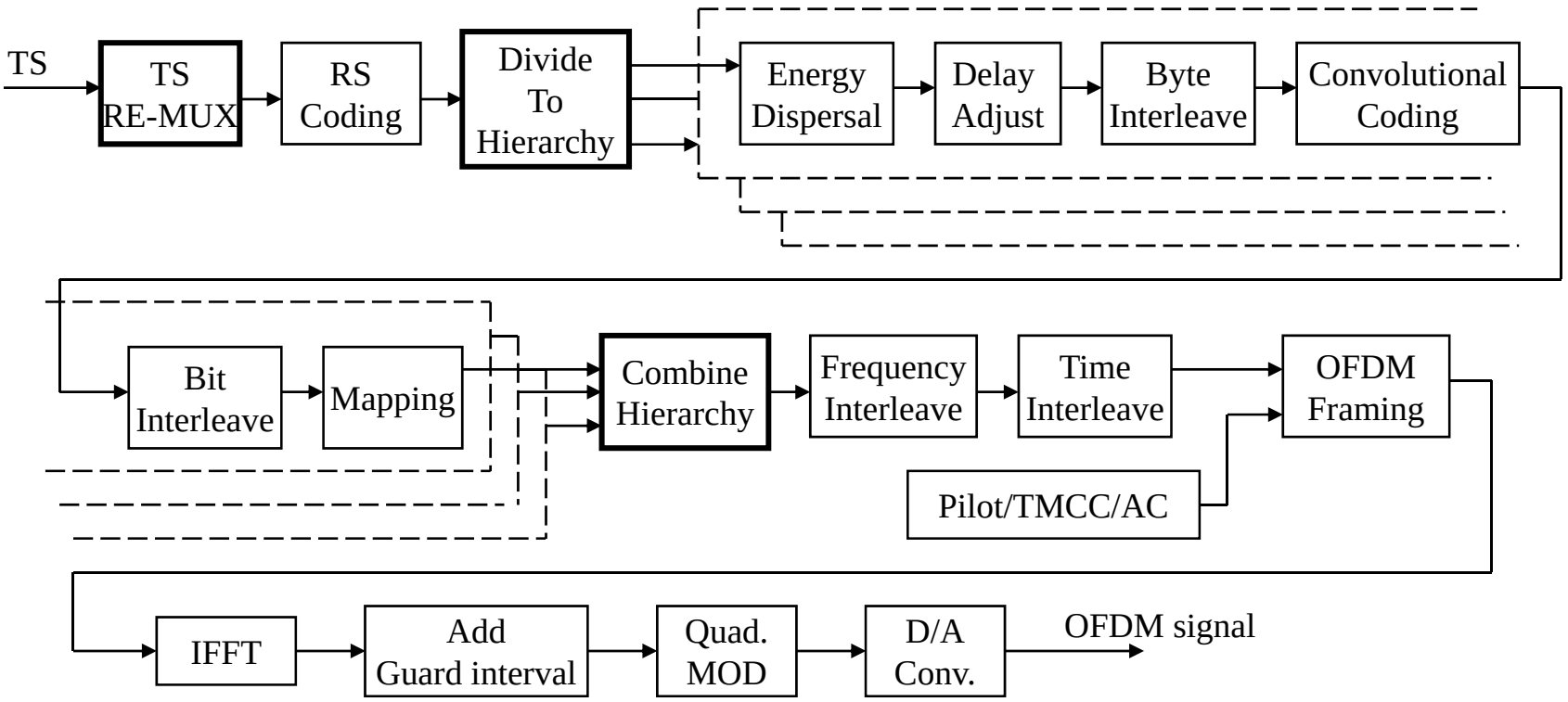
*Any number of segment for each layers can be selected (totally 13 segment)

*Transmission parameter sets of each layer can be set independently
(In above example, modulation index of each layer are different)

Parameters of ISDB-T (6MHz Bandwidth)

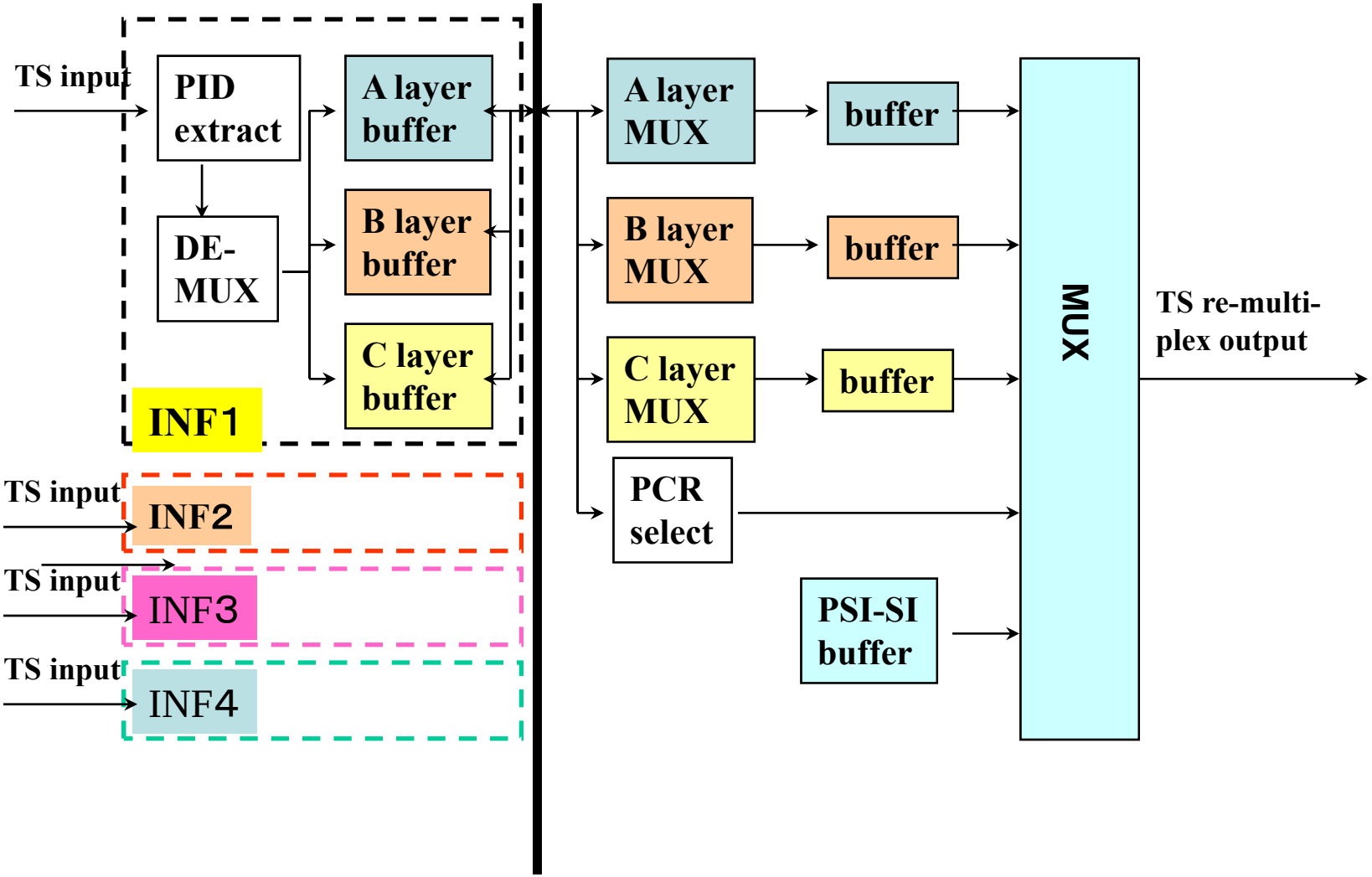
ISDB-T mode	Mode 1 (2k)	Mode 2 (4k)	Mode 3 (8k)
Number of OFDM segment	13		
Useful bandwidth	5.575MHz	5.573MHz	5.572MHz
Carrier spacing	3.968kHz	1.984kHz	0.992kHz
Total carriers	1405	2809	4992
Modulation	QPSK , 16QAM , 64QAM , DQPSK		
Number of symbols / frame	204		
Active symbol duration	252μ s	504μ s	1.008ms
Guard interval duration	1/4 , 1/8 , 1/16 , 1/32 of active symbol duration		
Inner code	Convolutional code (1/2 , 2/3 , 3/4 , 5/6 , 7/8)		
Outer code	RS (204,188)		
Time interleave	0 ～ 0.5s		
Useful bit rate	3.651Mbps ～ 23.234Mbps		

5.2 Hierarchical transmission



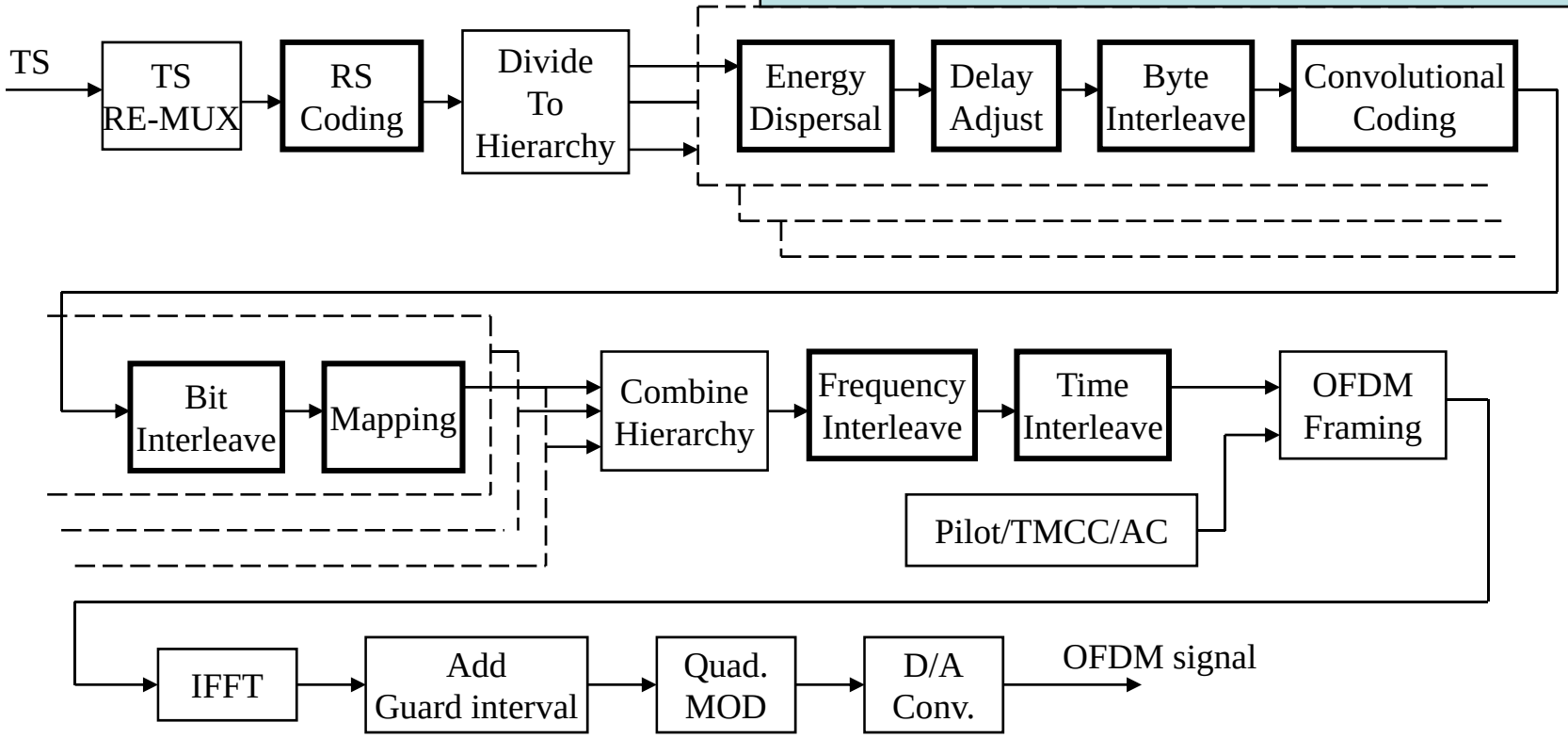
- **Maximally 3 Layer transmission in one Transport Stream**
- **Any combination of transmission parameter is available for each layer**

Blockdiagram of TS re-multiplexer



2. Time Interleave

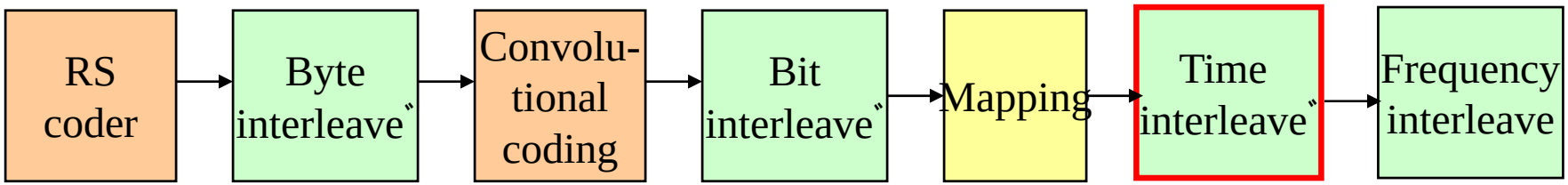
Block diagram of ISDB-T



- **Concatenated Error Correction System; Convolutional+Reed-Solomon**
- **4 kinds of Interleave; Byte/Bit/Time/Frequency**
- **4 kinds of Modulation Parameters;QPSK/DQPSK/16QAM/64QAM**

Any kinds of coding rate and modulation parameters can be set for each layer independently

Kind of interleave and these effect



Byte interleave

Byte interleave is located between outer coder and inner coder. Randomize the burst error of Viterbi decoder output

Bit interleave

Bit interleave is located between convolutional coding and mapping. Randomize the symbol error before Viterbi decoding

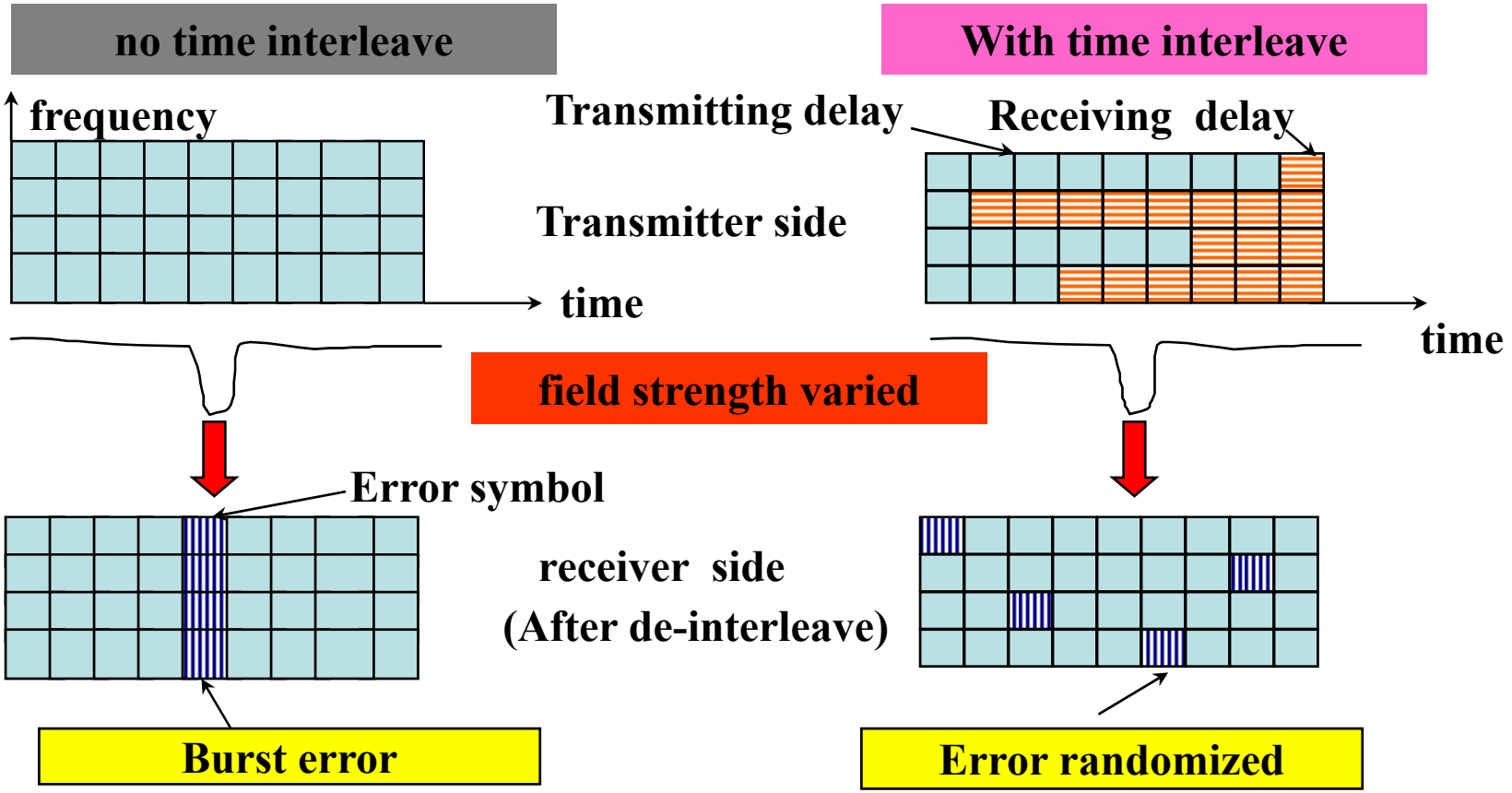
Time interleave

Time interleave is located at the output of maping(modulation). And randomize the burst error of time domain which is mainly caused by impulse noise, fading of mobile reception, etc.

Frequency interleave

Frequency interleave is located at the output of time interleave. Randomize the burst error of frequency domain which is mainly caused by multi-path , carrier interference, etc.

Effect of time interleave

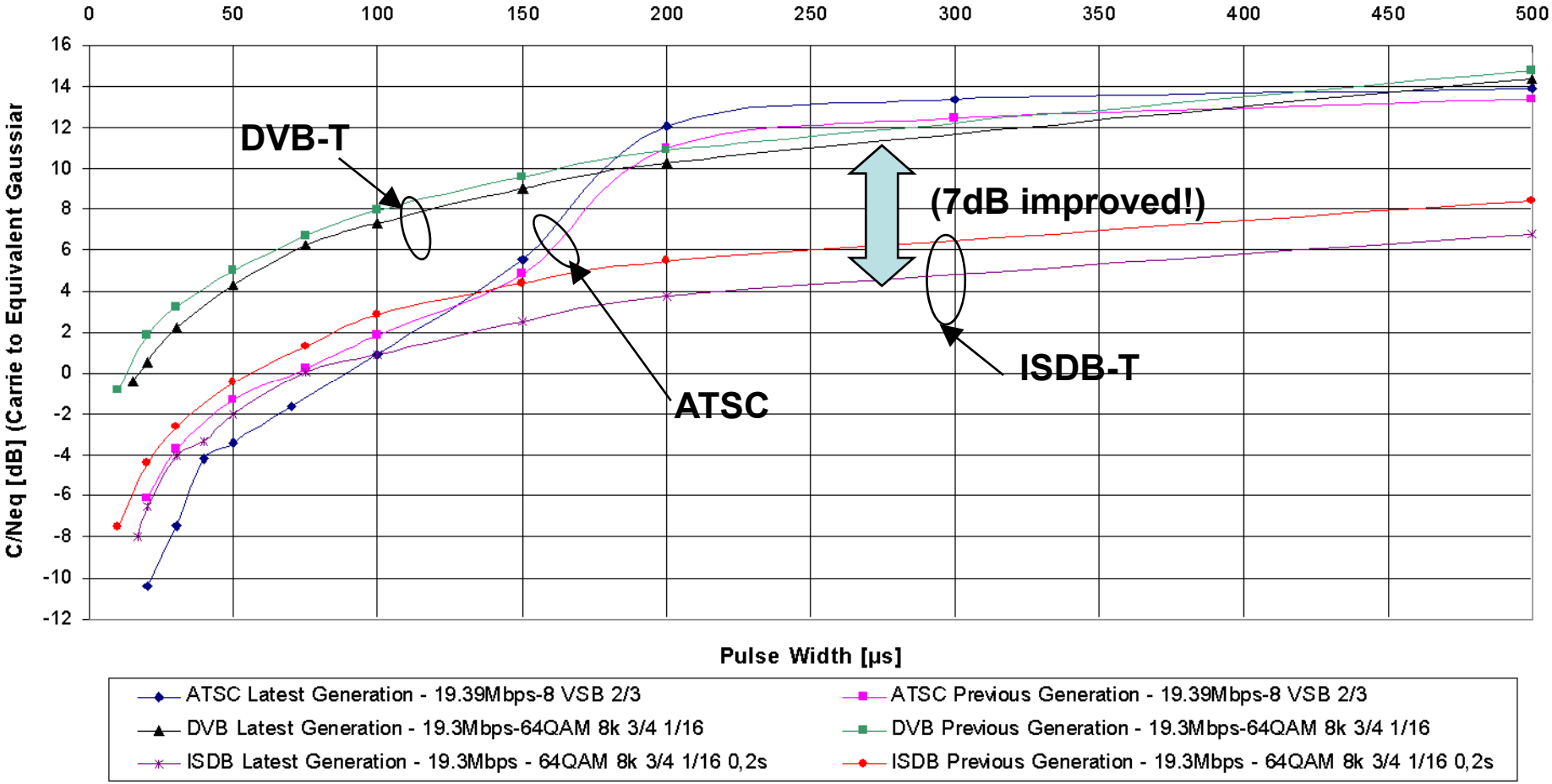


Time Interleave is effective not only for signal level fluctuation but also for impulse interference

What is the merit of Time- Interleave? (2/2)

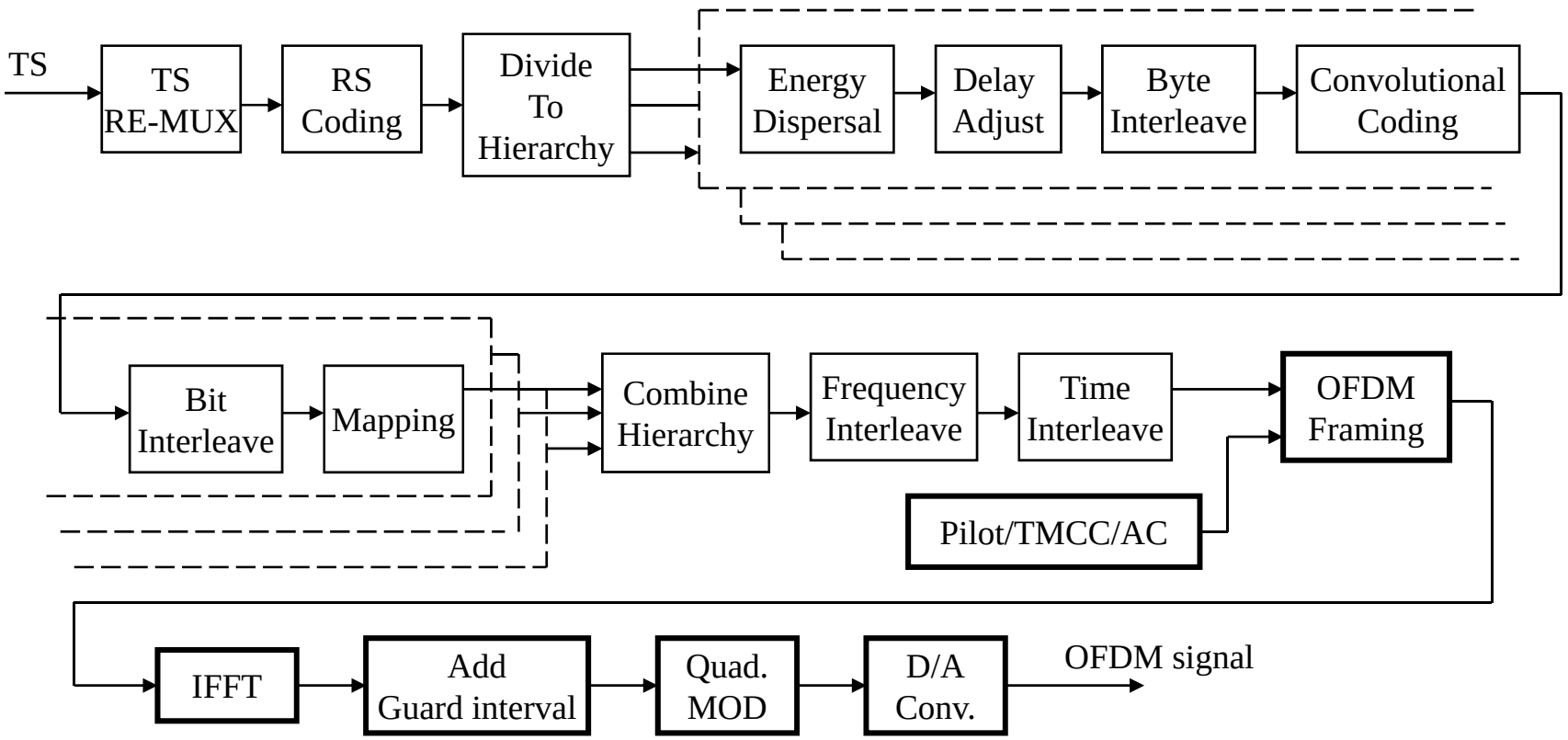
- **How much improved by using Time- Interleave**

Following graph shows degradation by impulse noise, which is dedicated by Mackenzie Presbyterian University measured in Autumn , 2005

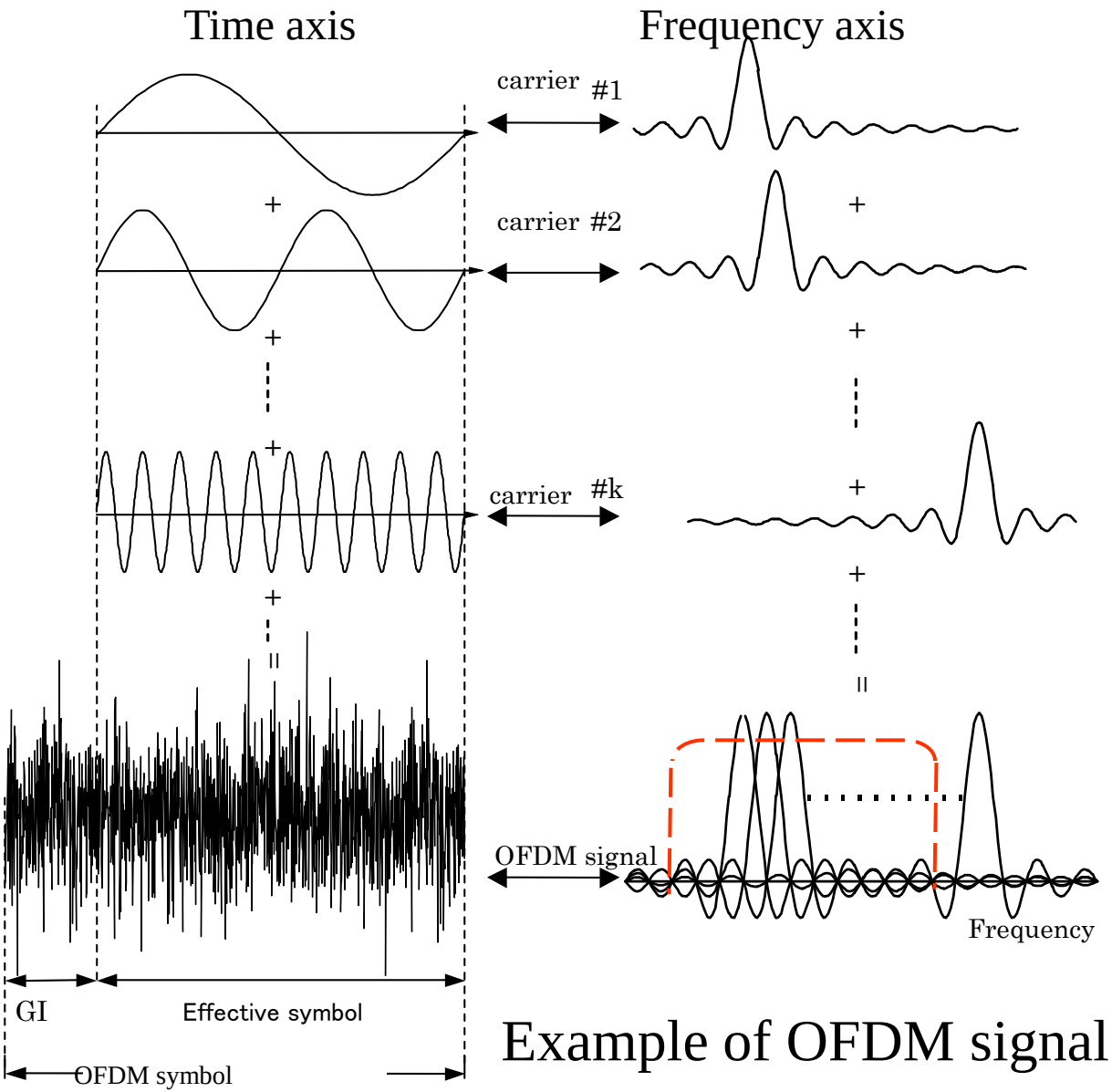


7dB improved ➡ Transmitter power reduced to 1/5 !!

5.3 OFDM Modulation

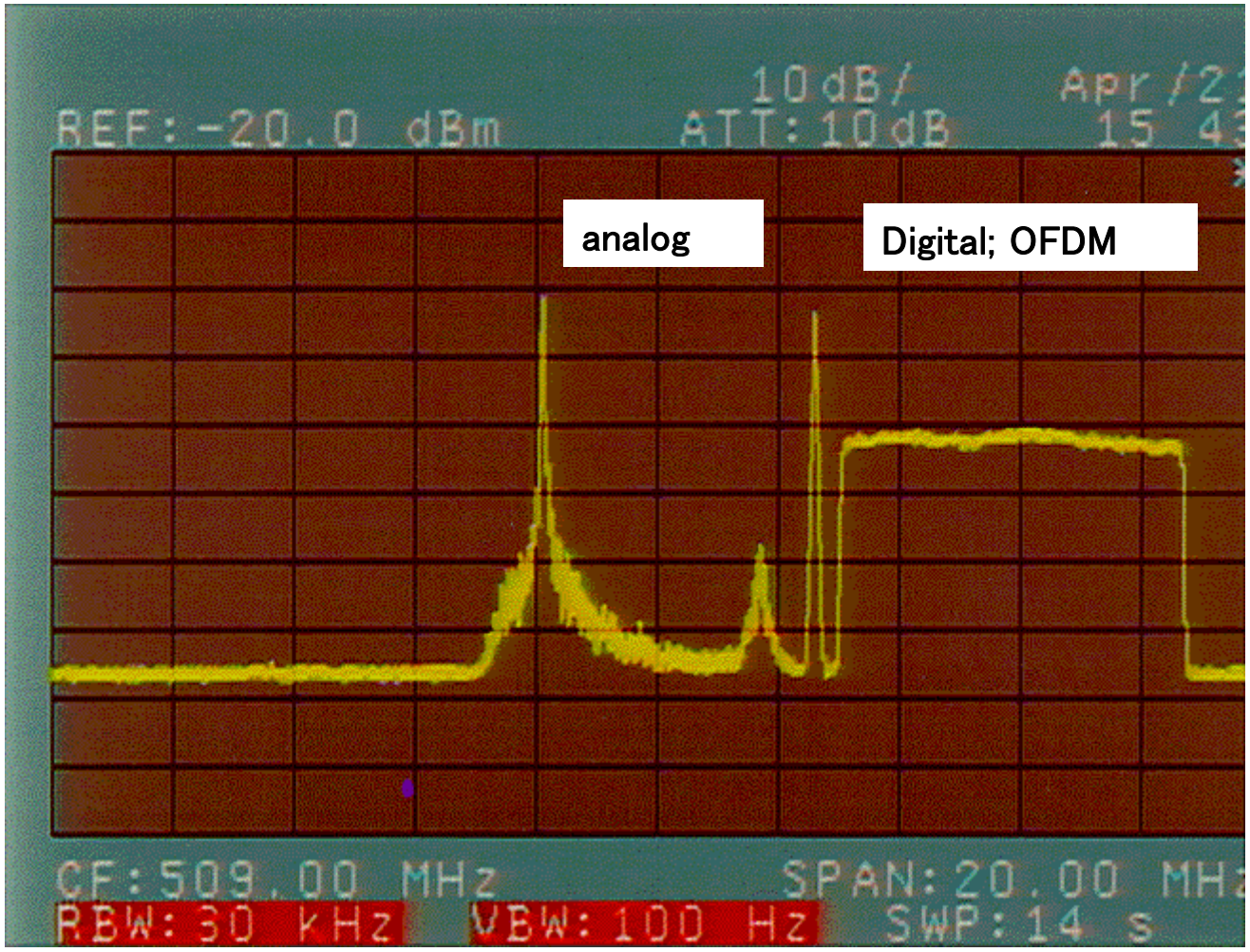


- **3 kinds of OFDM Modulation; 2k, 4k, 8k**
- **4 Kinds of Guard Interval Length; 1/32, 1/16, 1/8, 1/4**



Example of OFDM signal waveform

TV signal spectrum



Performances under multi-path condition (1/2)

- **Why is this performances important?**

(1)Survivality against multi-path caused by mountain, building, etc

⇒ **Very important in Philippines (See figure 1)**

(2) Enable the SFN operation ⇒ **Important to save frequency resource**

(3) Single frequency operation for mobile/portable reception service in any place(in SFN network)

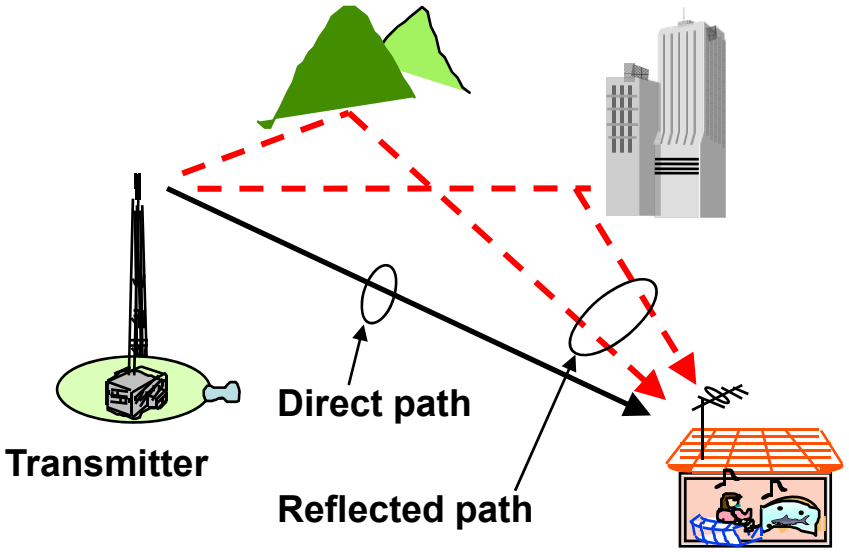


Fig.1 Image of multi-path condition

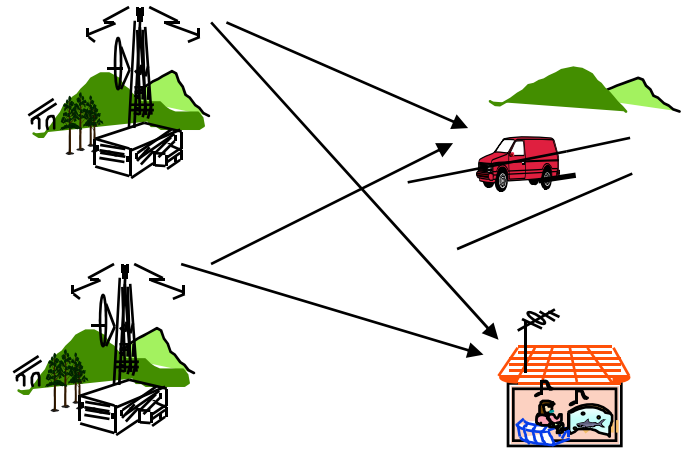
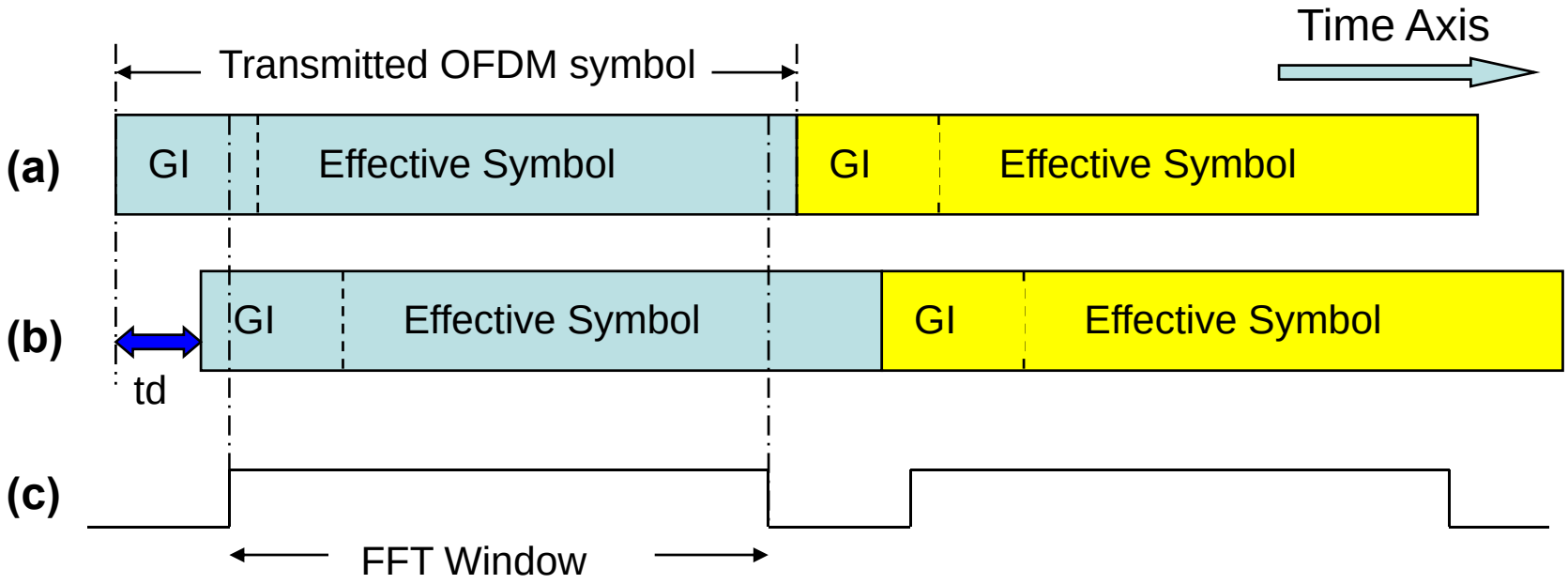


Fig.2 Image of SFN operation

Effect of guard interval



(a) : Direct wave from transmitter, (b) : reflected wave (multi-path wave)

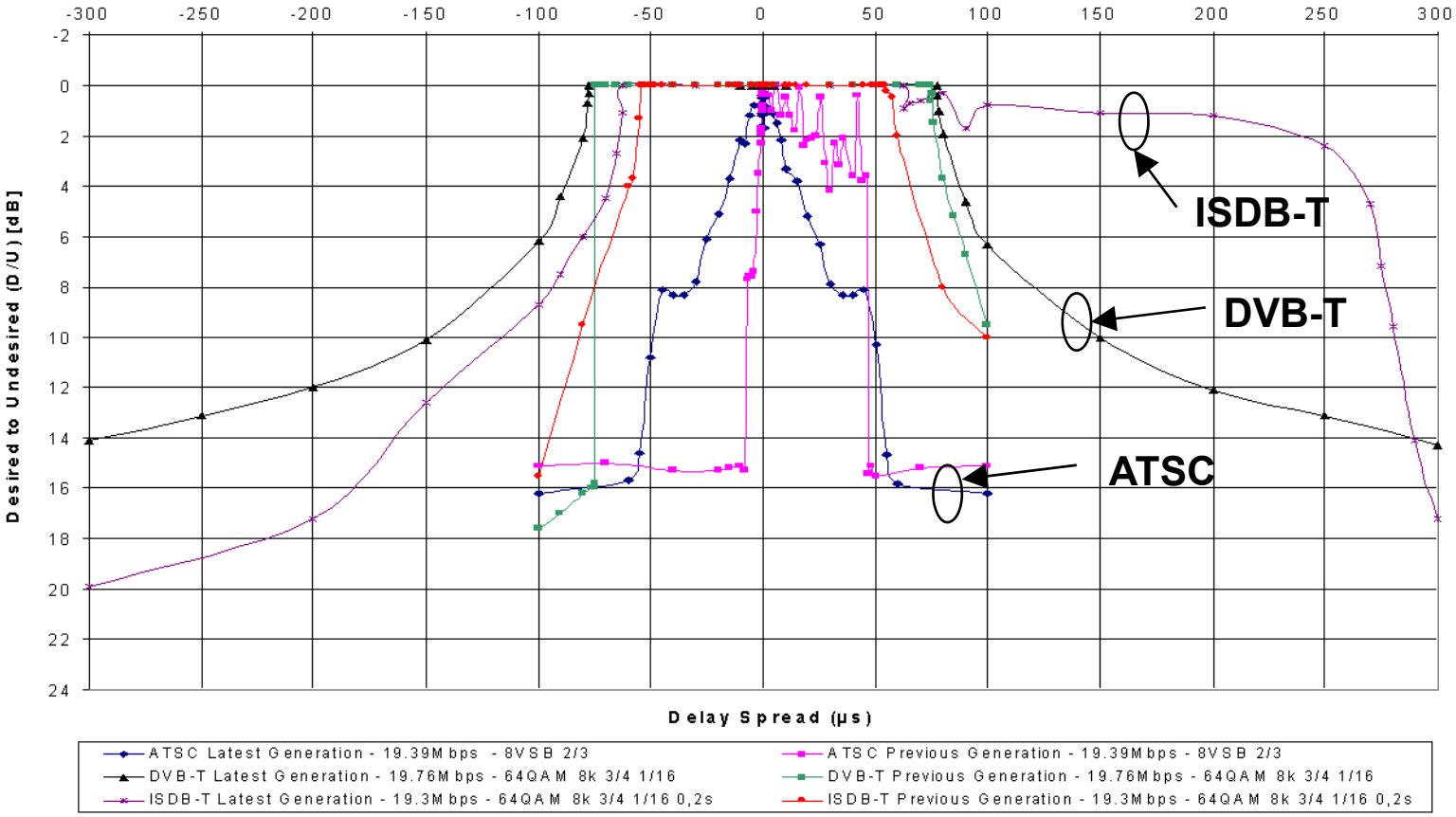
GI: Guard Interval , td: delay time of multi-path, (c) FFT window of receiver

FFT window of receiver cuts a signal with Ts (effective symbol) length, this signal is fed to FFT to demodulate OFDM signal. If FFT window can be set within the interval of “transmitted OFDM symbol”, Inter Symbol Interference (ICI) is not occurred.
As a result, if multi-path delay time is no longer than GI, multi-path interference is almost compensated.

Performances under multi-path condition

- **Performances of each DTTB systems**

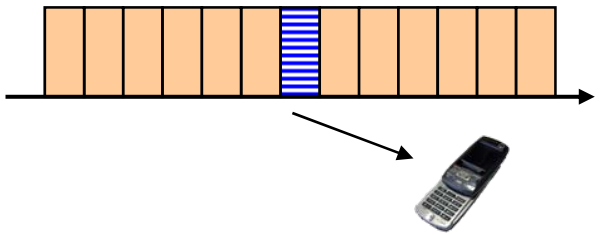
Following graph shows degradation by single multi-path, which is dedicated by Mackenzie Presbyterian University measured in Autumn , 2005



ATSC is weak against multi-path

5.5 One-Seg; Unique service in ISDB-T (1/2)

- **What is One-seg?**



In ISDB-T, center segment can be received by portable terminal. This service is named One-seg. This TV service is unique for ISDB-T, another system have not such service.

- **What is most important factor for portable reception?**

⇒ Power consumption should be low.

- **How ISDB-T reduces power consumption?**

By making use of narrow band reception and demodulation, the signal processing speed is reduced to 1/8 of full band reception. Another system cannot realize above service.

5.5 One-Seg; Unique service in ISDB-T (2/2)

- **What kinds of One-ser receiver in Japan?**

Many kinds of receivers are now in market, by end of February, over 5 million, and estimated over 10 million by this summer

(One seg receiver in Cellular Phone)

※画像はVGN-TX92S

(oOne-seg receiver in PC)

(digital Audio Player)

Digital receiver will be introduced/explained in “Digital Receiver” session.

6. ISDB-Tsb; Digital Audio Broadcasting (Family of ISDB-T)

6.1 Features of ISDB-Tsb

(1) What is ISDB-T_{SB}

ISDB-Tsb transmission system is unique in ISDB-T family. This transmission system has been standardized for narrow band ISDB-T transmission system, which is focused to audio and data service, therefore, called ISDB-Tsb.

(2) Commonality with ISDB-T

(a) Same segment transmission construction. But ,considering narrow band reception, only 1 segment and 3 segment transmission systems are standardized

(b) Adopt same transmission parameters as ISDB-T.

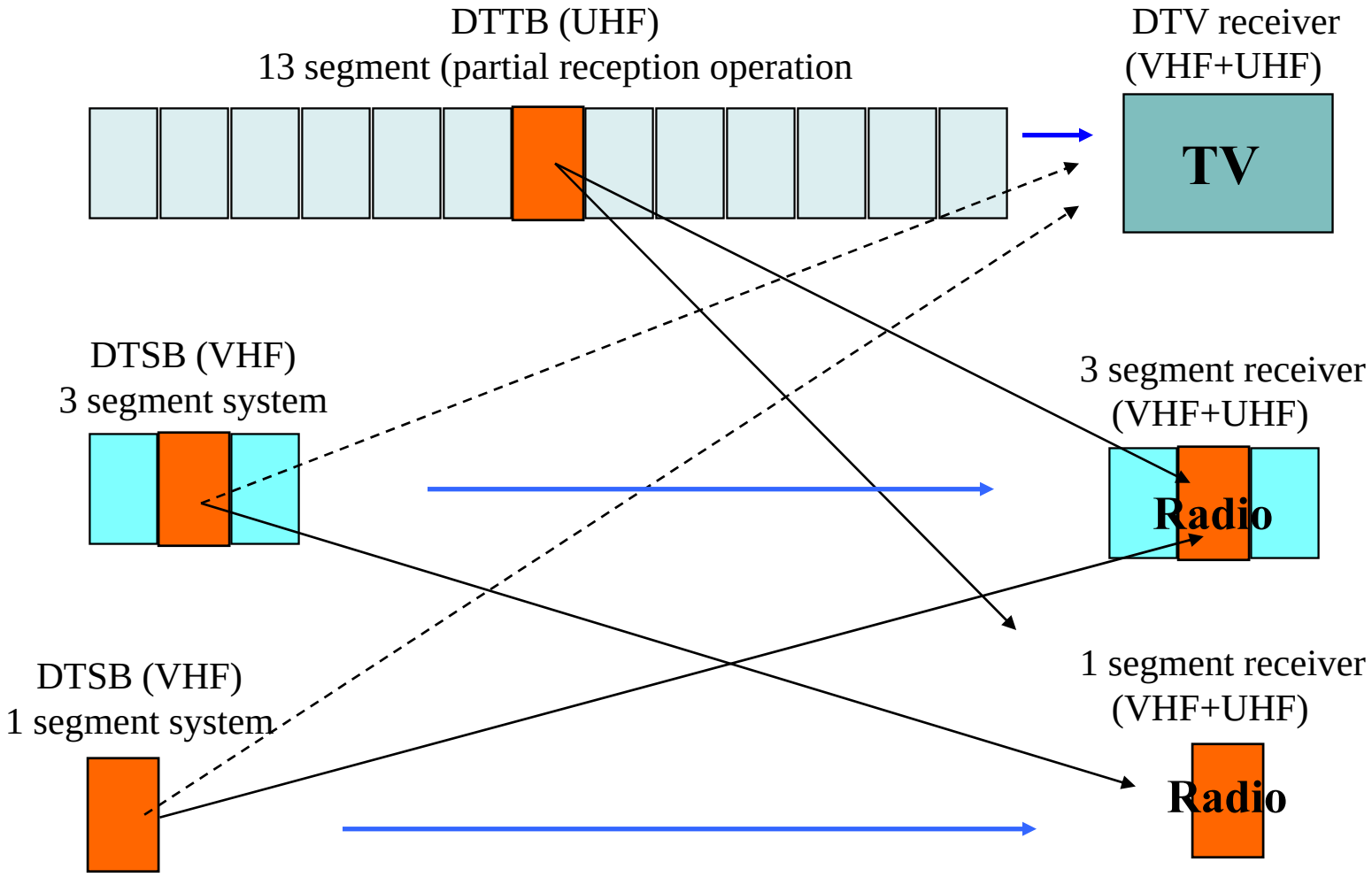
(c) Commonality of 1 segment receiver with ISDB-T partial reception

(3) Efficient use of frequency resource

(a) Consecutive transmission system. This system is unique for ISDB-TSB, this transmission system is to transmit plural channel without guard band

(b) To achieve consecutive transmission, phase compensation technology at transmitter side is adopted

6.2 Commonality with ISDB-T
(Digital radio/digital TV compatible receiver)

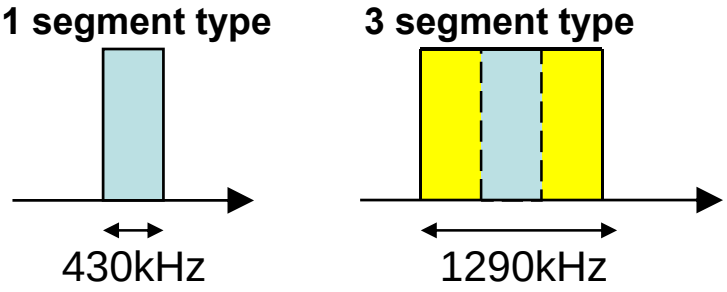


6.3 Efficient use of frequency resource

(Flexibility of channel plan)

For ISDB-Tsb transmission system, any type as follows are available according to usable bandwidth

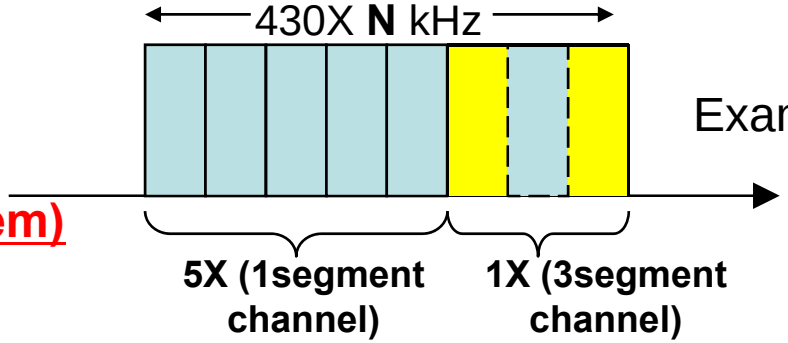
For narrow band channel plan



(One channel in One band)

For wide band channel plan

(Consecutive transmission system)



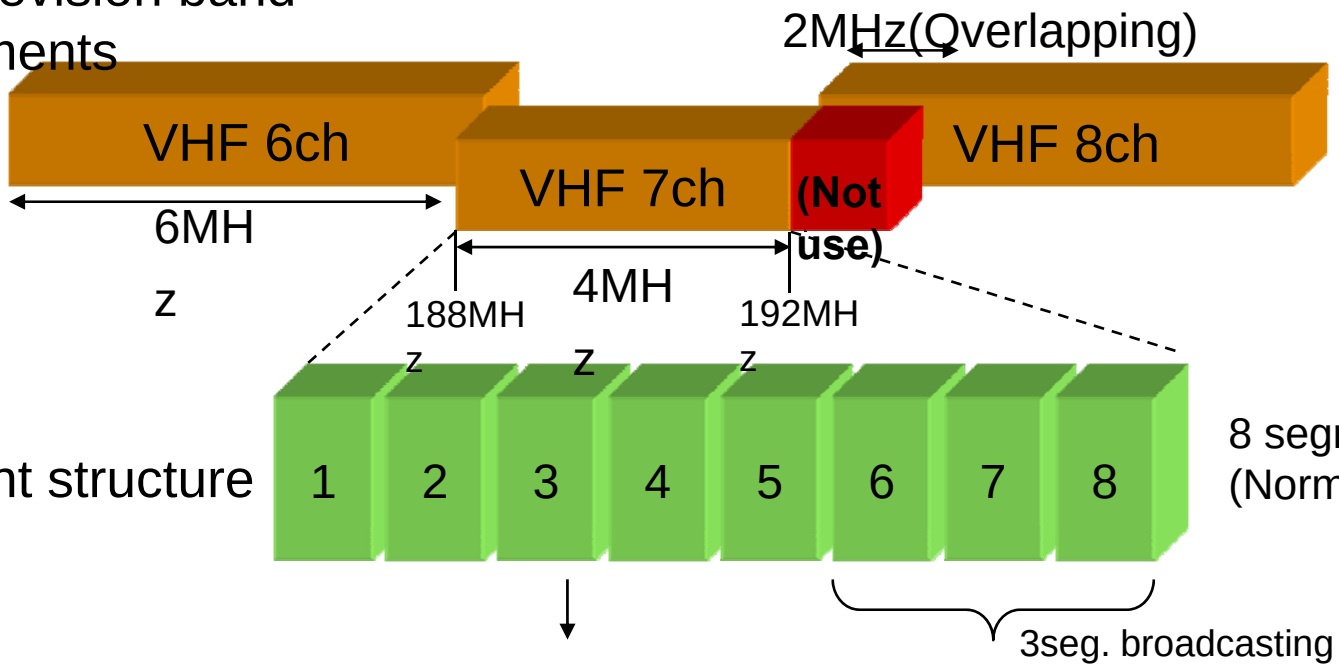
Example; N=8 (note)

(6 channel{1X(1 seg)+1X(3 seg)} in one band)

(note) Any number of segment(up to 13) are available

6.4 Trial Services of DRP

VHF television band assignments



Above example is Tokyo station , Osaka's all programs are 1seg. broadcasting.

7. Comparison of 3 DTTB systems

Forward

For the comparison of 3 DTTB systems(ATSC,DVB-T,ISDB-T), 2 points of view are necessary, one is "Technical aspect", other is "Non technical aspect"

For the technical aspect, it is necessary to investigate including some test result, so ,the details will be presented tomorrow presentation. Today only show "summary of technical comparison table".

On the other hand, Receiver market size is also important issue. Market structure should be carefully investigated, that is, either same market and/ or different market.

Today, I will show you "Market Segmentation for DTTB receiver" as last theme of this presentation

7.1 Technical Aspect

(1) Comparison of Transmission System

3DTTB systems adopt almost common technologies for Multiplexing and video/audio coding system, therefore, **differences between 3 systems depends on the difference of transmission system shown below**

Table 7-1 Transmission system

System		ATSC	DVB-T	ISDB-T
Modulation		8VSB	**COFDM** (QPSK, 16QAM,64QAM)	**SegmentedCOFDM** (DQPSK,QPSK, 16QAM,64QAM)
Inter-leaving	Bit/Symbol	Yes	Yes	Yes
	Frequency	-	Yes	Yes
	time	-	-	**0.1s,0.2s,0.4s,0.8s**
Excess Bandwidth/ Guard Interval		11.5%	1/4,1/8,1/16,1/32	1/2, 1/4, 1/8,1/16,1/32
TMCC		-	-	**Yes**
Information bit rate		19.39 Mbps	3.69 -23.5Mbps	3.65 -23.2 Mbps
Channel bandwidth		6/7/8 MHz	6/7/8 MHz	6/7/8 MHz

(2) Summary of Comparison from Technical Aspect-1/2

Based on the differences of transmission system, show the difference of system performances in Comparison table below

Table 7-2 Comparison of system performances

Any improvement of digital receiver was not considered to make the table below.

Requirements	System conform to requirements
Maximum bit rate under Gaussian noise environment	ATSC
Robustness against multi-path distortion	**(note1)** **ISDB-T** >> DVB-T
Robustness against impulse noise	**ISDB-T**
Wide area single frequency network (SFN) operation	DVB-T, **ISDB-T**
Mobility and Portability	**ISDB-T>** DVB-T

(note1) Indoor reception can be available, its reduce reception cost

(2) Summary of Comparison from Technical Aspect-2/2

Table 7-2 Comparison of system performances

Any improvement of digital receiver was not considered to make the table below.

Requirements	System conform to requirements
Hierarchical transmission (Multiple modulation systems simultaneously in the same channel is possible)	**ISDB-T**>> DVB-T
Both portable/fixed reception service by one channel and one transmitter	**ISDB-T**(note1)
System commonality with digital terrestrial sound broadcasting (One segment receiver is available)	**ISDB-T**(note2)

(note1) Save both frequency resource and Infrastructure cost

(note2) Multi purpose portable receiver is available

Details of 3 systems comparison from technical aspect will be explained in 2nd day.

7.2 Market Segmentation for Digital Receiver

Digital receiver's specifications is not same ,even though based on same technology.

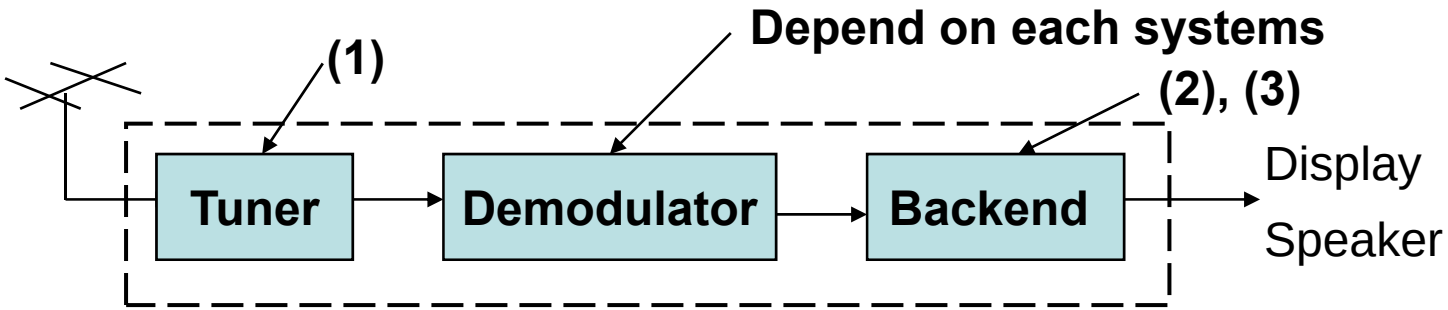
For example, following parameters affect to receiver specifications. So ,we have to carefully check.

Parameters for segmentation

(1) Assigned frequency bandwidth (regulation of each countries)

(2) Field frequency (50/60Hz, compatibility with analog TV system)

(3) Video quality (HDTV/SDTV, coding system, etc)



Simplified block diagram of receiver

As shown above, Tuner and Backend are different because of difference of regulation and difference of quality even though in same system,

•Example: DVB-T Market

DVB-T service system has many variation according to service requests/ regulation of each countries.

Parameters for segmentation

(1) Assigned frequency bandwidth (regulation of each countries)

8MHz BW: United Kingdom, etc
7MHz BW: Australia, etc
6MHz BW: Chinese Taipei,etc

(2) Field frequency (compatibility with analog TV system)

50Hz: many EU countries, Australia, etc
60Hz: Chinese Taipei , etc

(3) Video quality

SDTV only: UK, etc
Start SDTV only ,add HDTV service: France, etc
From original, SDTV +HDTV: Australia, etc

As described above, DVB-T market is segmented to many small market. That is, DVB-T is the set of small market , not single market

An example of DVB-T market segmentation

Bandwidth / Video	6MHz	7MHz	8MHz
SDTV only			UK,etc
Start SDTV only, after add HDTV	Chinese - Taipei		France, etc
From original stage SDTV +HDTV		Australia, etc	

In above table, parameter of field frequency is not indicated. Considering filed frequency, market should be segmented to more cases.

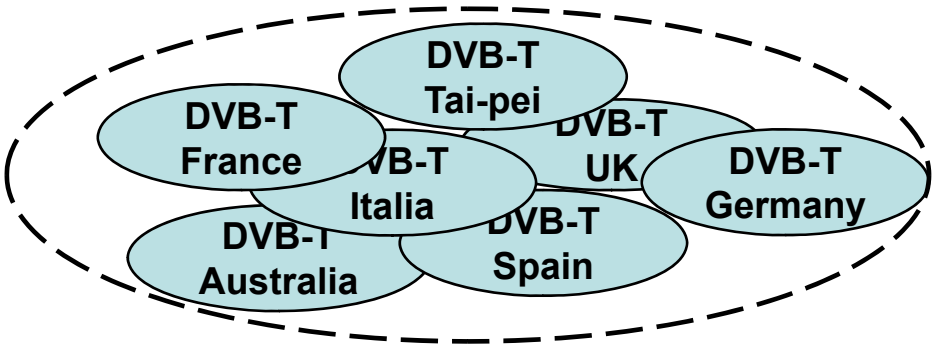


Image of DVB-T Market

As shown in left side figure, DVB-T market seems to be a set of different small market

8. Conclusion

- **ISDB-T was born from high level requirement**
  - **-High quality/service flexibility, Robustness, Resource saving, etc**
- **ISDB-T Transmission system**
  - **-Segmented OFDM Transmission System, It enable hierarchical transmission service, stable mobile/portable reception and indoor reception**
- **One-seg is the unique and attractive service of ISDB-T**
- **ISDB-T has a commonality with ISDB-Tsb (sound broadcasting)**
- **Considering receiver market, account the regulation and service quality/performances.**

Thank you for your attention

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