Basic study of Next-Generation Digital Terrestrial Broadcasting transmission system for handheld and mobile reception

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- Introduction
  - Current DTTB system in Japan
- Targets of NGBT
  - Fixed and handheld/mobile reception
  - MIMO for fixed reception
- Core technologies for handheld/mobile reception
  - MISO for handheld/mobile reception
  - STBC(Space Time Block Code)
  - SFBC(Space Frequency Block Code)
  - Channel estimation
- Laboratory experiments
- Conclusion

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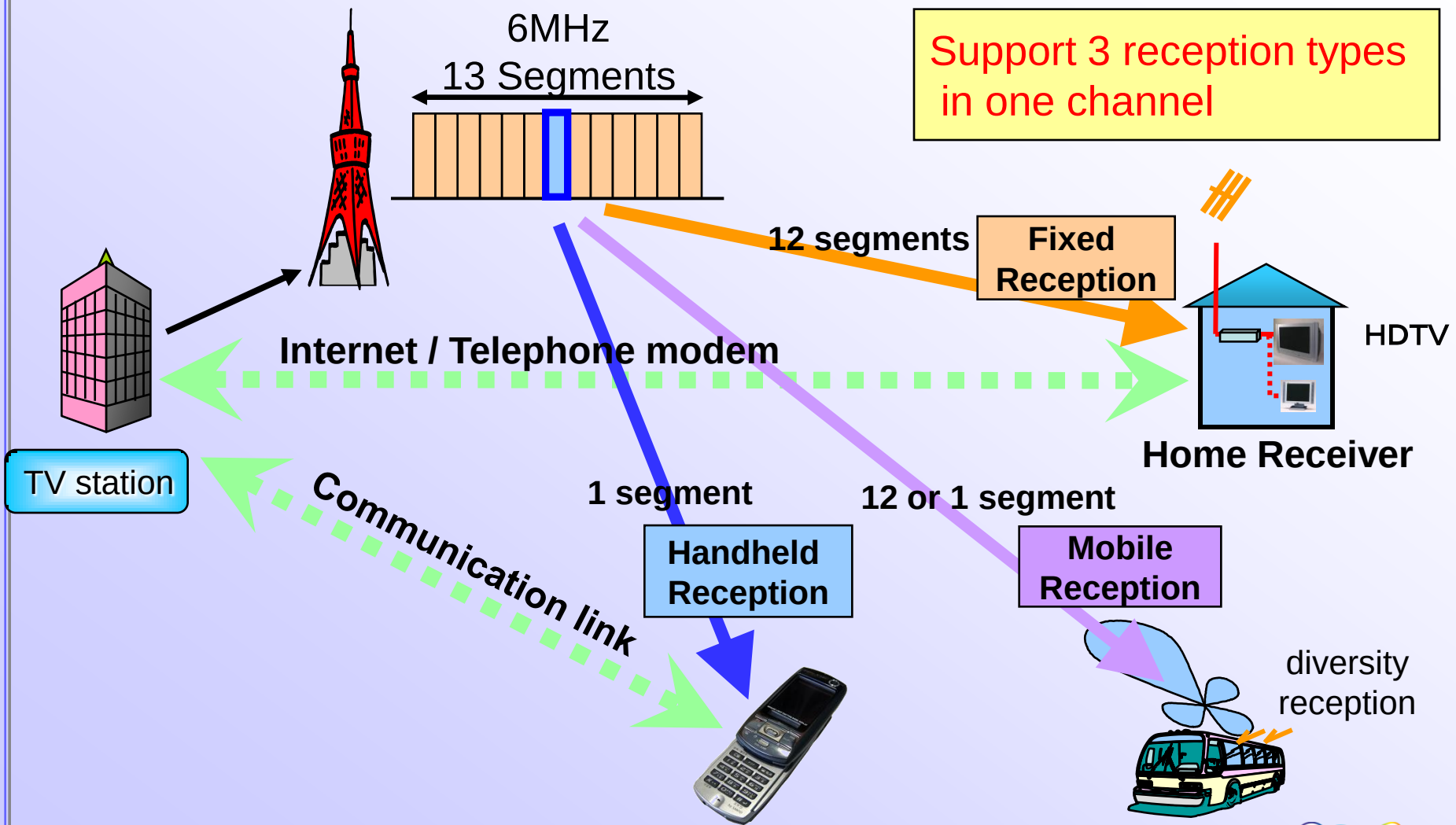
Current DTTB system in Japan

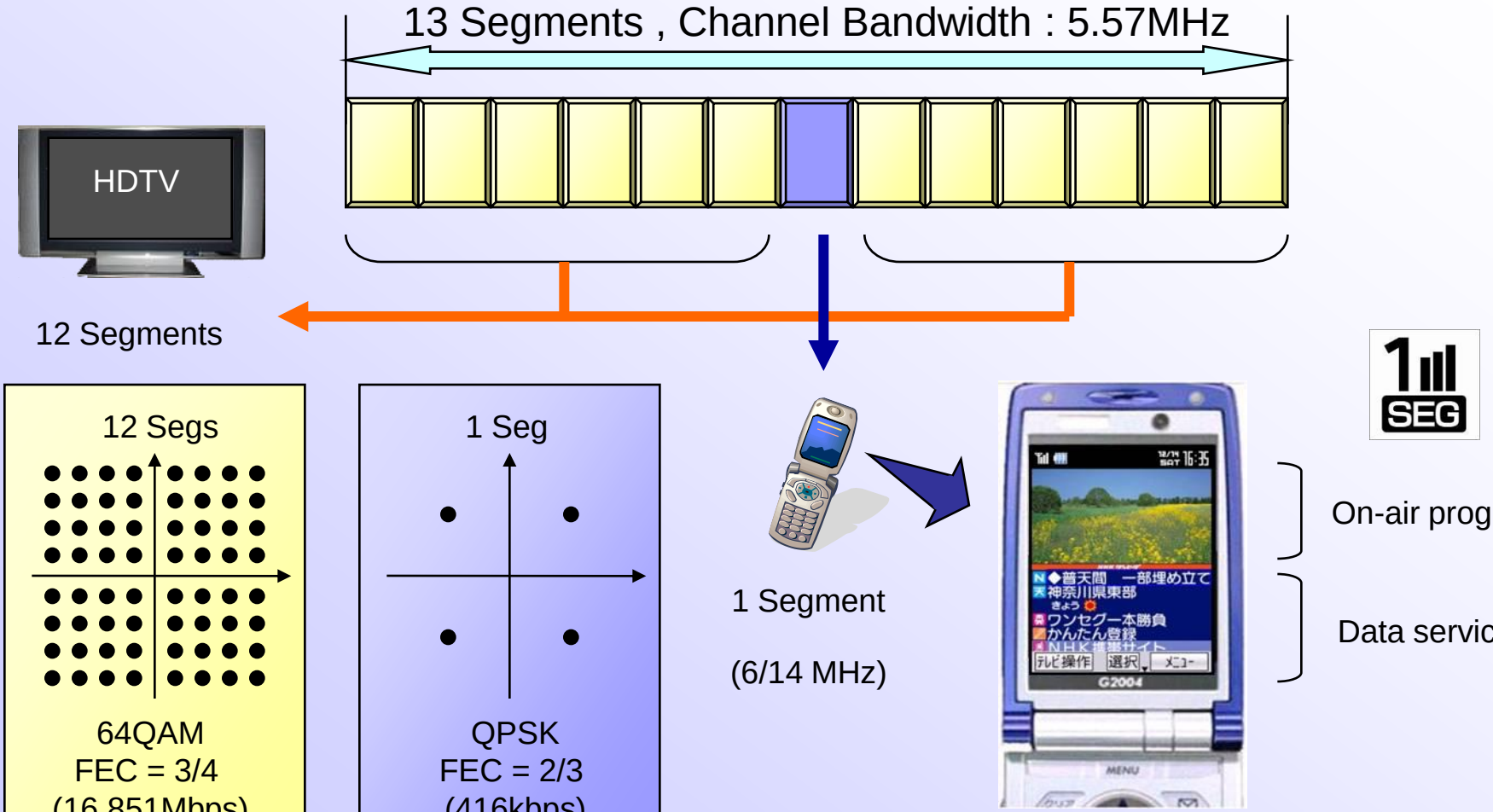
ISDB-T is

- the DTTB system in Japan.
- the robust system.
  - OFDM
  - Frequency and Time-interleaving, etc
- the flexible system.
  - Hierarchical transmission by segmented OFDM
    - HDTV / multi-SDTV service for fixed and mobile
    - One-Seg service for handheld

Features of ISDB-T system



Example of hierarchical transmission

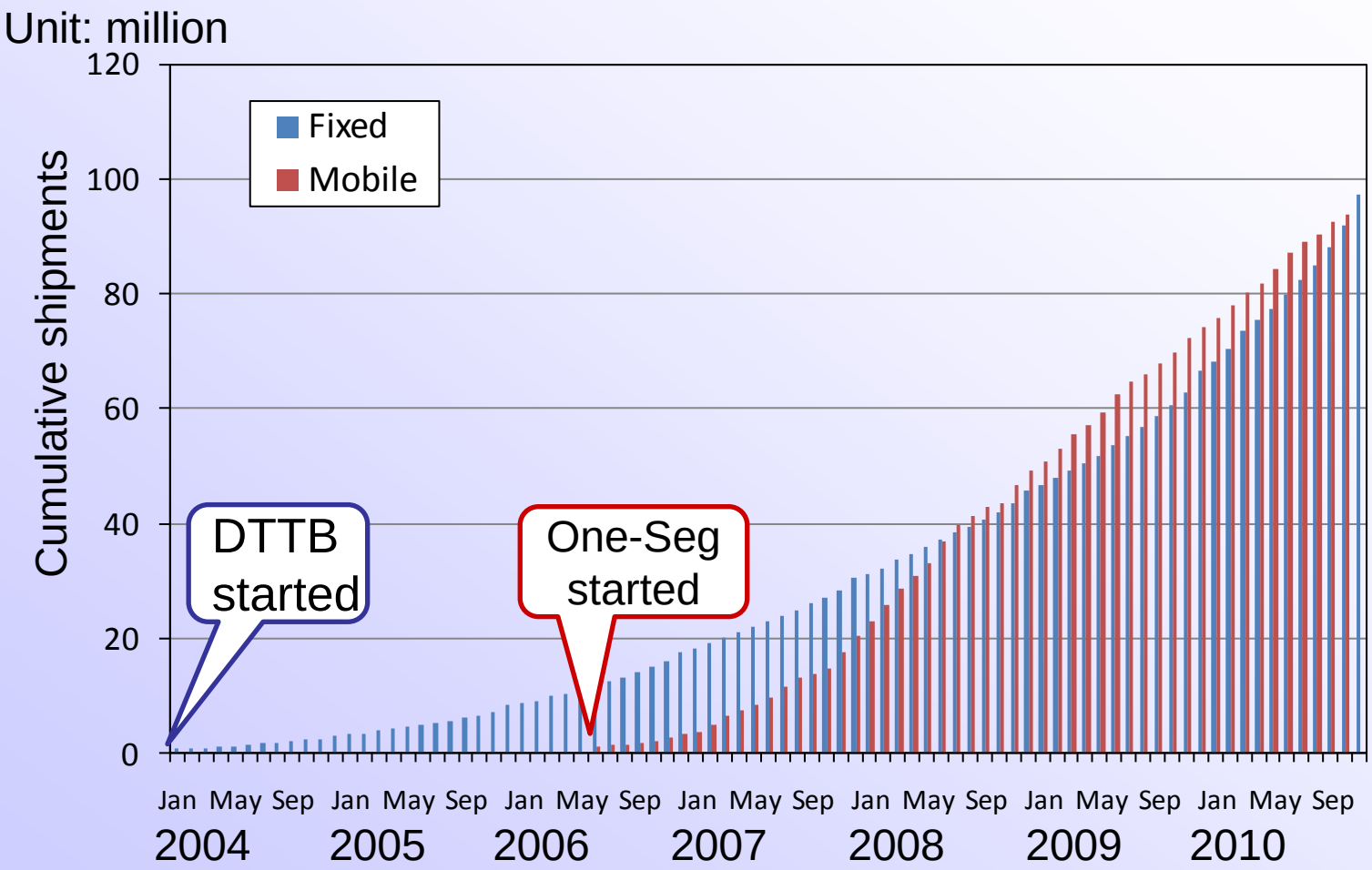


Layer B
High capacity

Layer A
Robust

(ex. of 2-layer transmission)

Shipments of ISDB-T receivers



93.7 millons One-Seg receivers were shipped.

97.2 millions fixed receivers were shipped.

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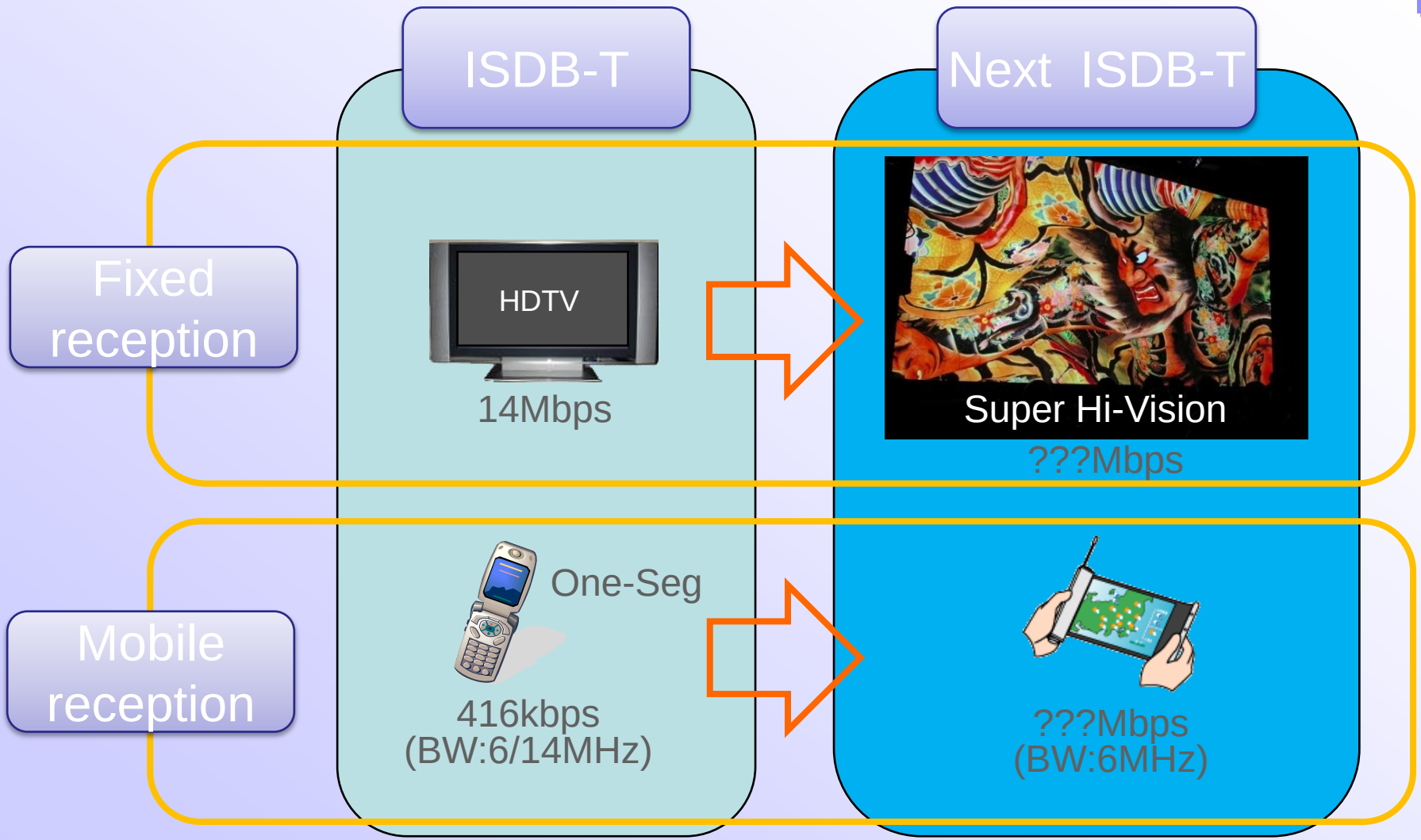
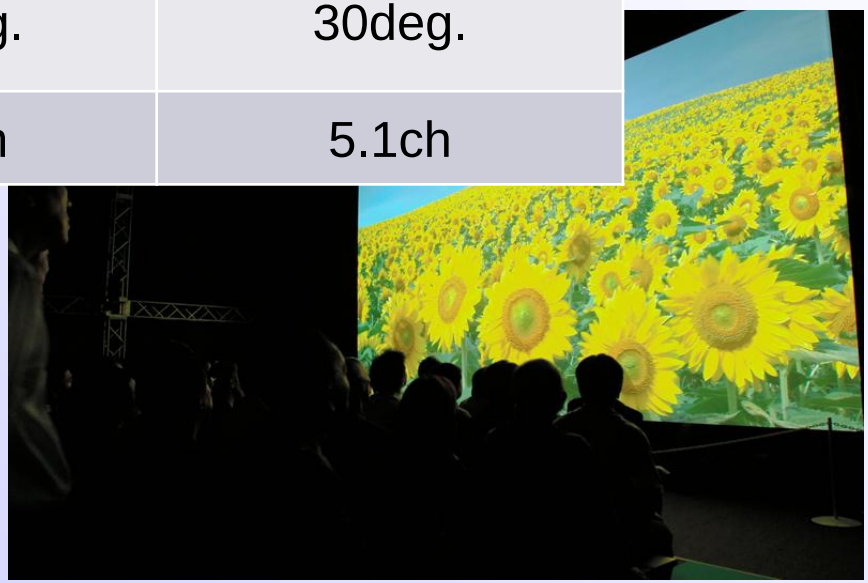
Targets of NGBT



Super Hi-Vision

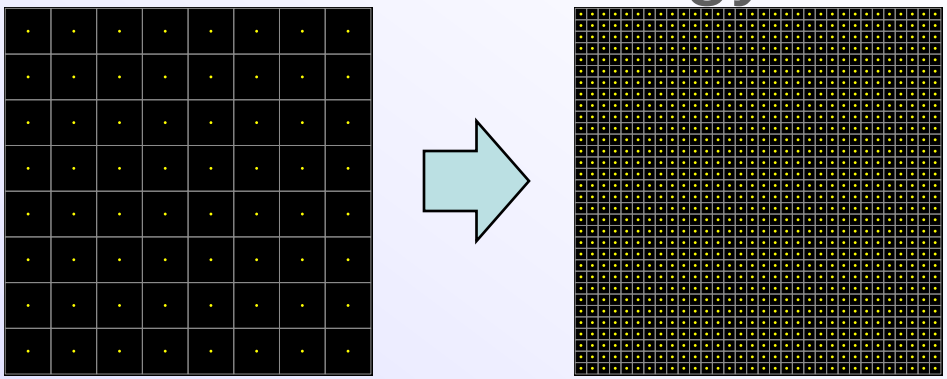
	Super Hi-Vision	Hi-Vision
Number of pixels	4320 × 7680	1080 × 1920
Aspect ratio	16:9	16:9
Standard viewing distance (H:Height of the screen)	0.75H	3H
Standard angle of view (horizontal plane)	100deg.	30deg.
Sound system	22.2ch	5.1ch

× 16



MIMO for Fixed reception

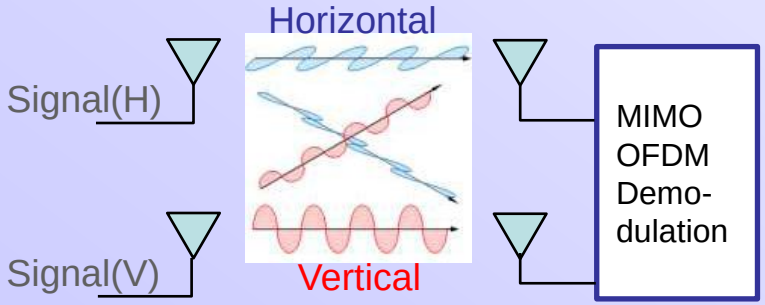
- Ultra-multilevel OFDM Technology
  - 1024QAM



64QAM(6bit)
ISDB-T in current use

1024QAM(10bit)

- Dual Polarized MIMO Technology
  - Dual Polarized Antenna
  - MIMO Channel Estimation



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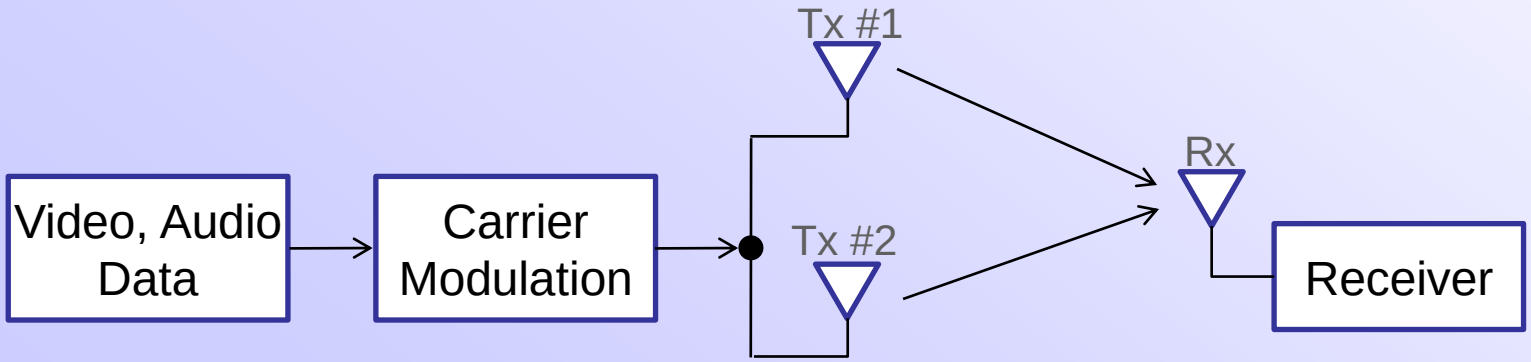
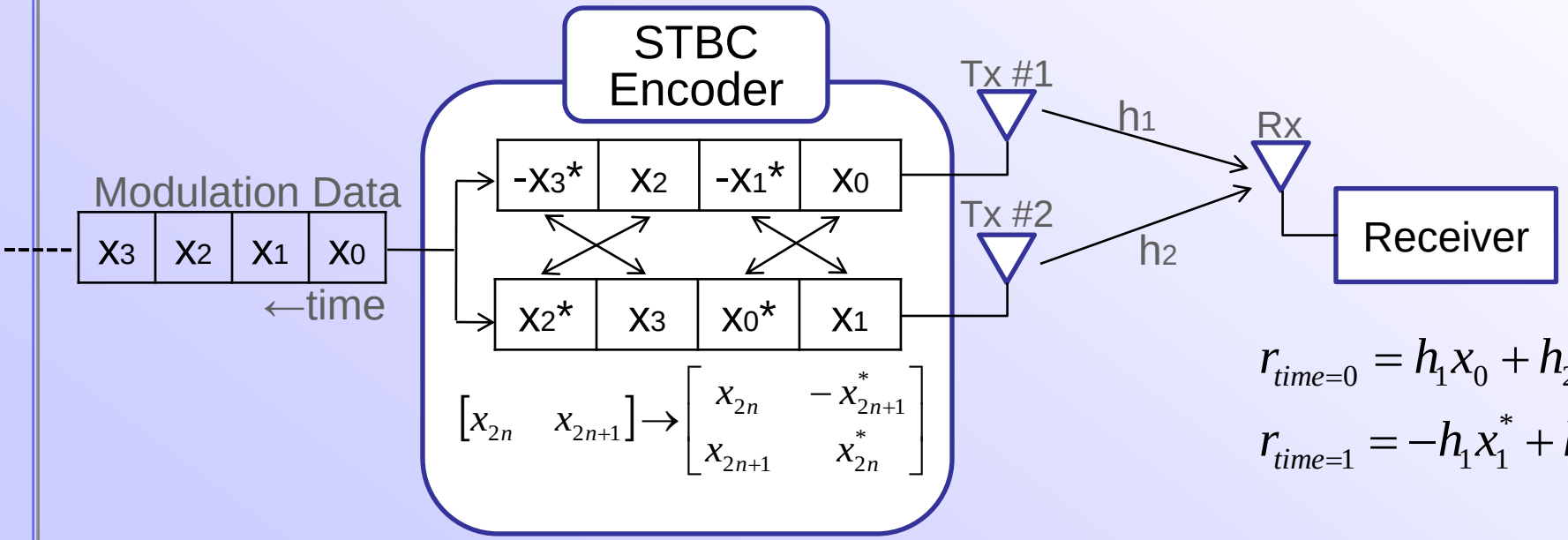
MISO for handheld/mobile reception

- Handheld/mobile reception
  - Reception environments and conditions are always changing during movement.
- MISO(Multiple-Input Single-Output)
  - 2 transmission antennas
  - 1 receiving antenna
- The same data is sent from 2 Tx antennas.



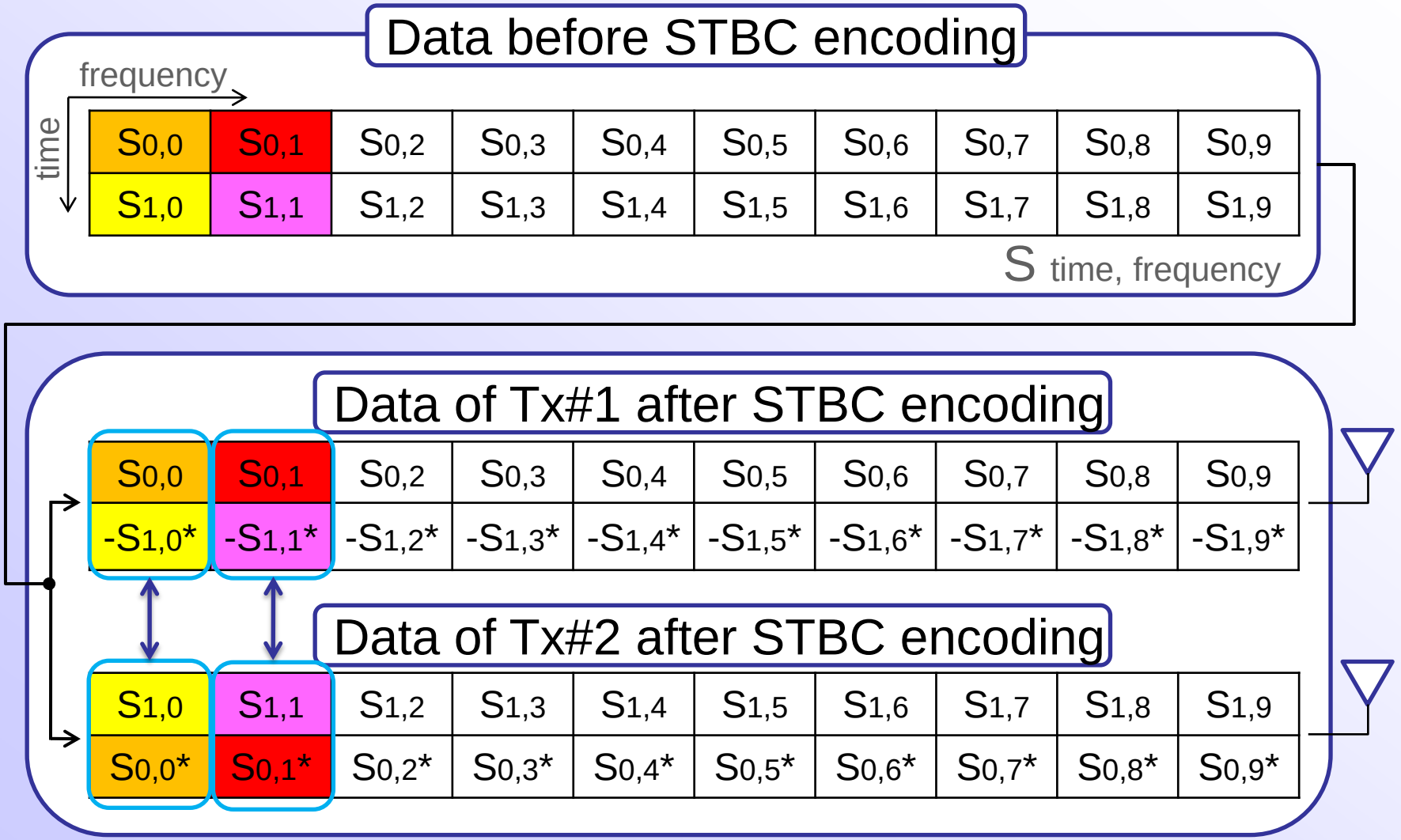
STBC(Space Time Block Code)

- STBC is
  - a kind of transmission data encoding method.
  - replacing and encoding two modulation data (Alamouti) in the time division.



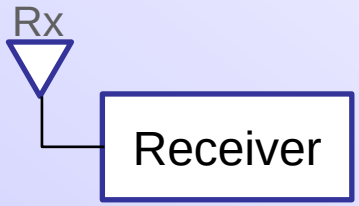
x*: complex conjugate of x

Apply STBC to OFDM



STBC decoding

- STBC of OFDM encodes two data of the symbol data and the following symbol data of the same frequency.
- STBC decoding uses as the channel characteristics of h1 of the symbol and h1 of the following symbol, which are the same.



$$r_{time=0} = h_1 x_0 + h_2 x_1$$

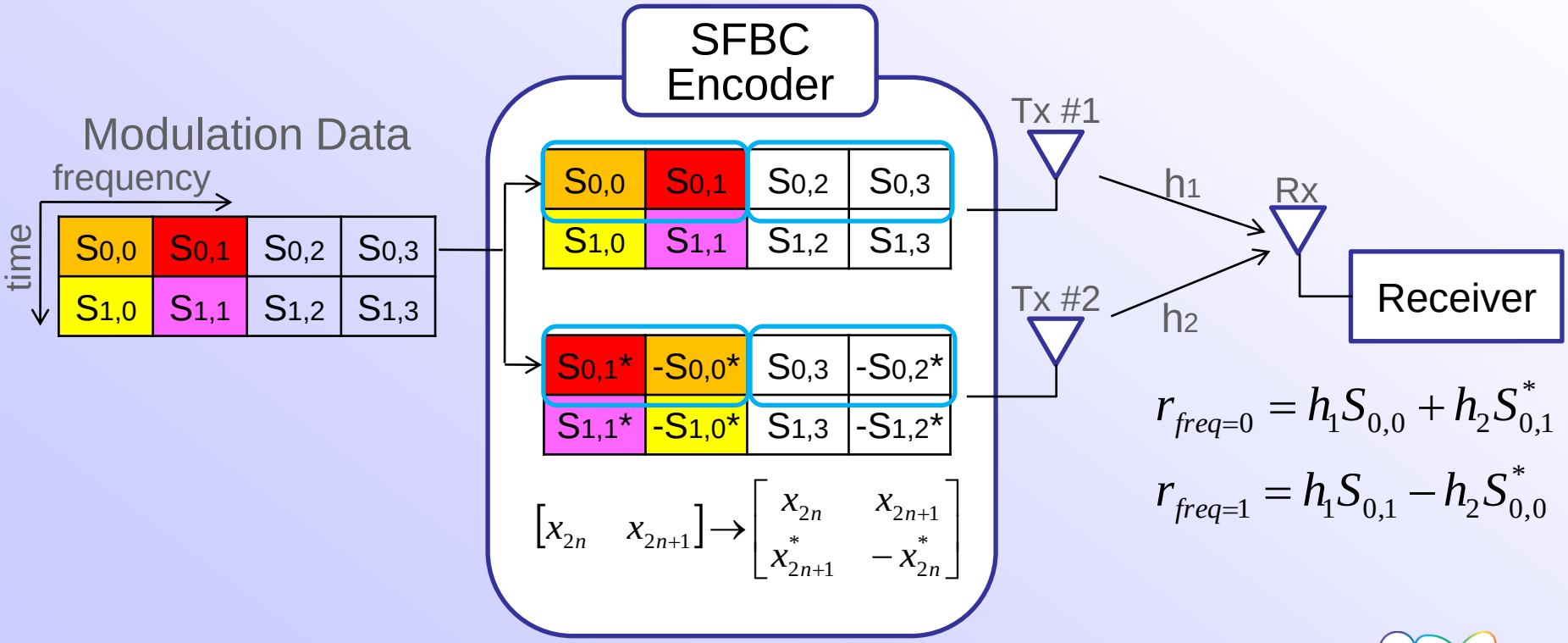
$$r_{time=1} = -h_1 x_1^* + h_2 x_0^*$$

- In the ISDB-T, the length of the OFDM symbol is 1008 μsec.
- The channel characteristic of change in handheld/mobile reception during 1008 μsec.
- The h1 of time=0 and the h1of time=1 are not the same.
- So, STBC decoding is very difficult.

We have been examining the SFBC in the frequency division.

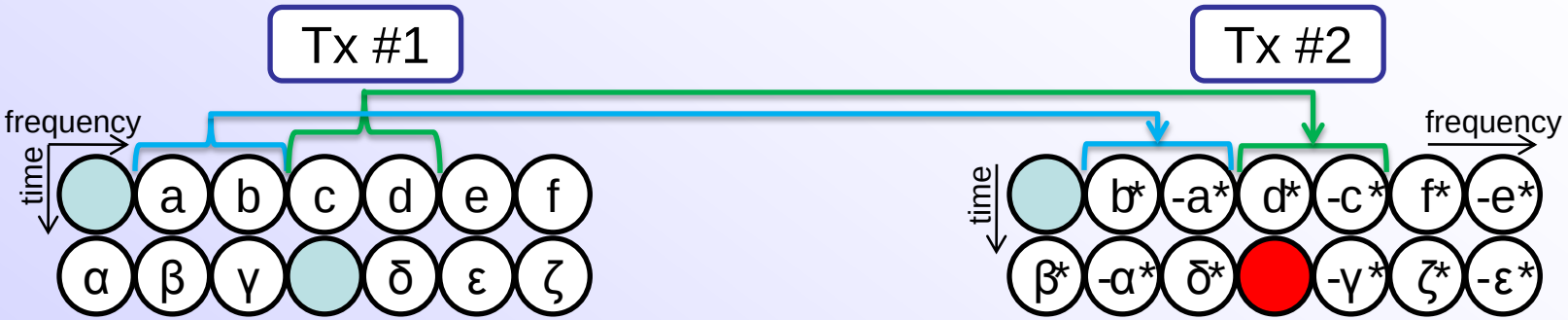
SFBC(Space Frequency Block Code)

- Replace and encode two modulation data in the frequency division.
- Tx#1 antenna sends the modulation data as it is.
- Tx#2 antenna sends the encoded data.

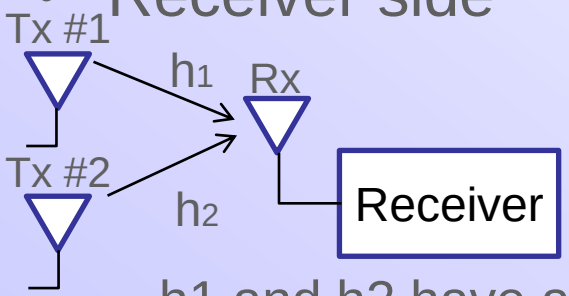


SFBC decoding

- Transmitter side



- Receiver side



$$y_1 = h_1 a + h_2 b^* \quad \cdots ①(\text{freq}=0)$$
$$y_2 = h_1 b - h_2 a^* \quad \cdots ②(\text{freq}=1)$$

h1 and h2 have already been estimated

$$① \times h_1^* \cdots h_1^* y_1 = |h_1|^2 a + h_1^* h_2 b^* \quad \cdots ③$$
$$② ^* \times h_2 \cdots h_2 y_2^* = h_1^* h_2 b^* - |h_2|^2 a \quad \cdots ④$$

③−④

$$a = \frac{h_1^* y_1 - h_2 y_2^*}{|h_1|^2 + |h_2|^2}$$

$$h_1^* y_2 = |h_1|^2 b - h_1^* h_2 a^* \quad \cdots ⑤$$
$$h_2 y_1^* = h_1^* h_2 a^* + |h_2|^2 b \quad \cdots ⑥$$

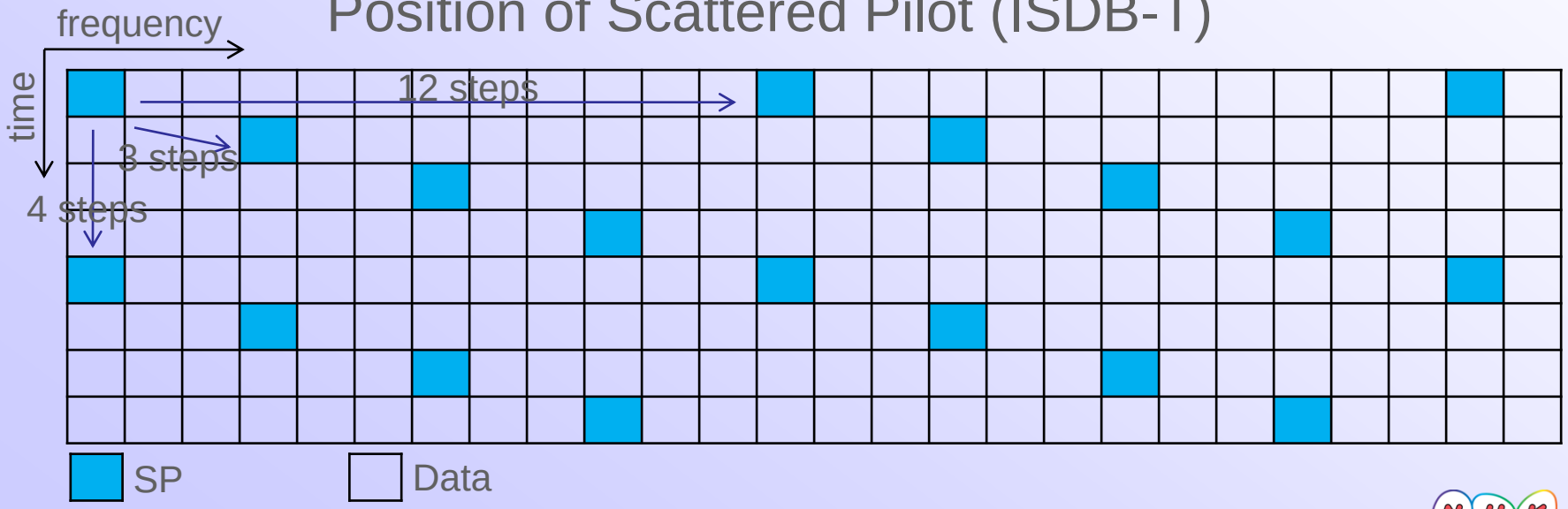
⑤+⑥

$$b = \frac{h_2 y_1^* + h_1^* y_2}{|h_1|^2 + |h_2|^2}$$

Channel estimation

- Need to estimate the channel response before SFBC decoding.
- The h_1 and the h_2 are not the same. So, two channel responses must be calcutated.
- Estimate the channel response from the scattered pilot (SP: reference signal) .

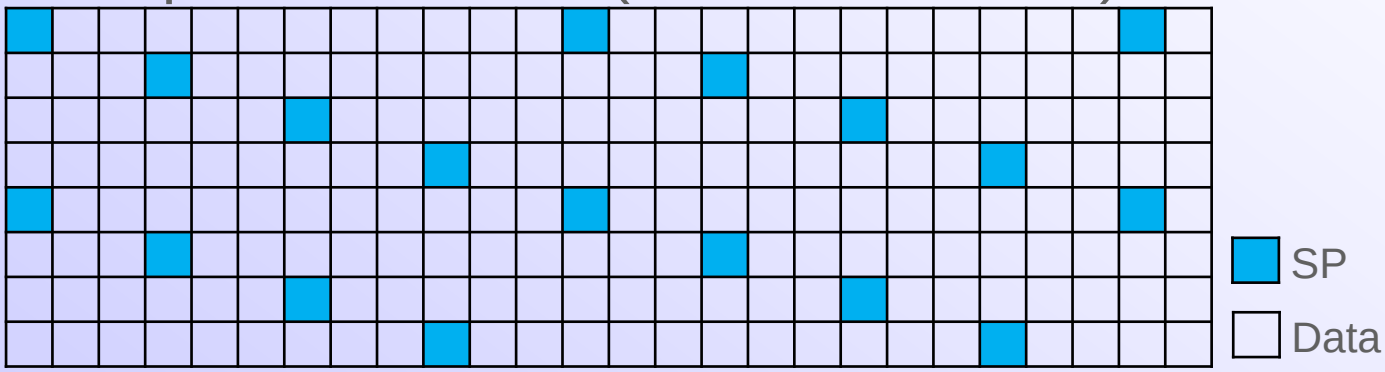
Position of Scattered Pilot (ISDB-T)



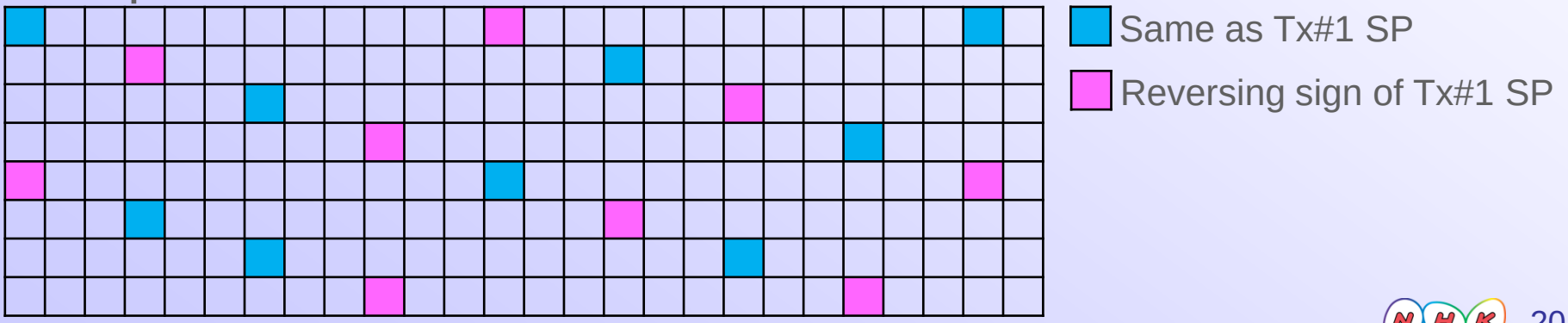
SP pattern of MISO

- Tx #1 and Tx #2 of the SP position are the same.
- Tx #2 SP of sign is the reverse of Tx #1 SP.

SP pattern of Tx #1(same as ISDB-T)



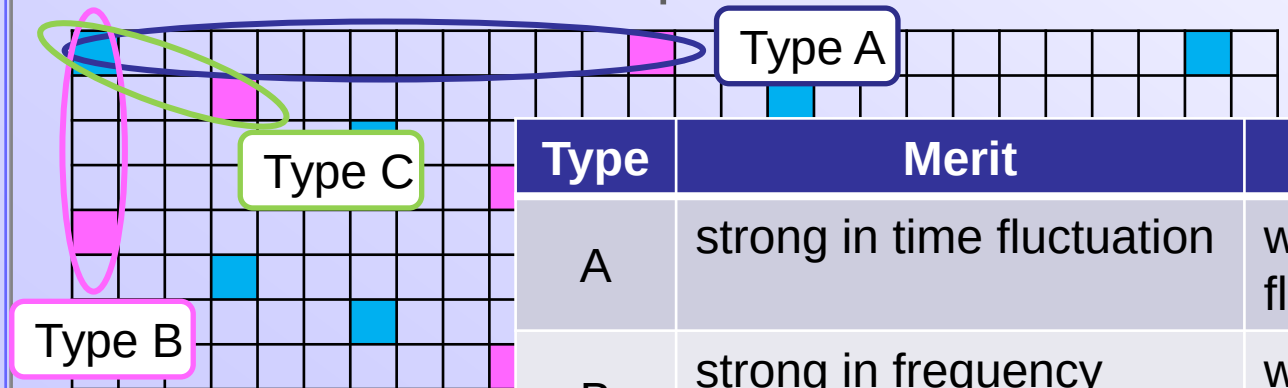
SP pattern of Tx #2



Three types of Channel estimation

- h_1 and h_2 are estimated using both Tx #1 SP and Tx #2 SP.
- There are 3 types of channel estimation.
  - Type A : paired with SP in the frequency domain
  - Type B : paired with SP in the time domain
  - Type C : paired with SP in the frequency and time domain

SP pattern of Tx



Type	Merit	Demerit
A	strong in time fluctuation	weak in frequency fluctuation
B	strong in frequency fluctuation	weak in time fluctuation
C	between of A and B	between of A and B

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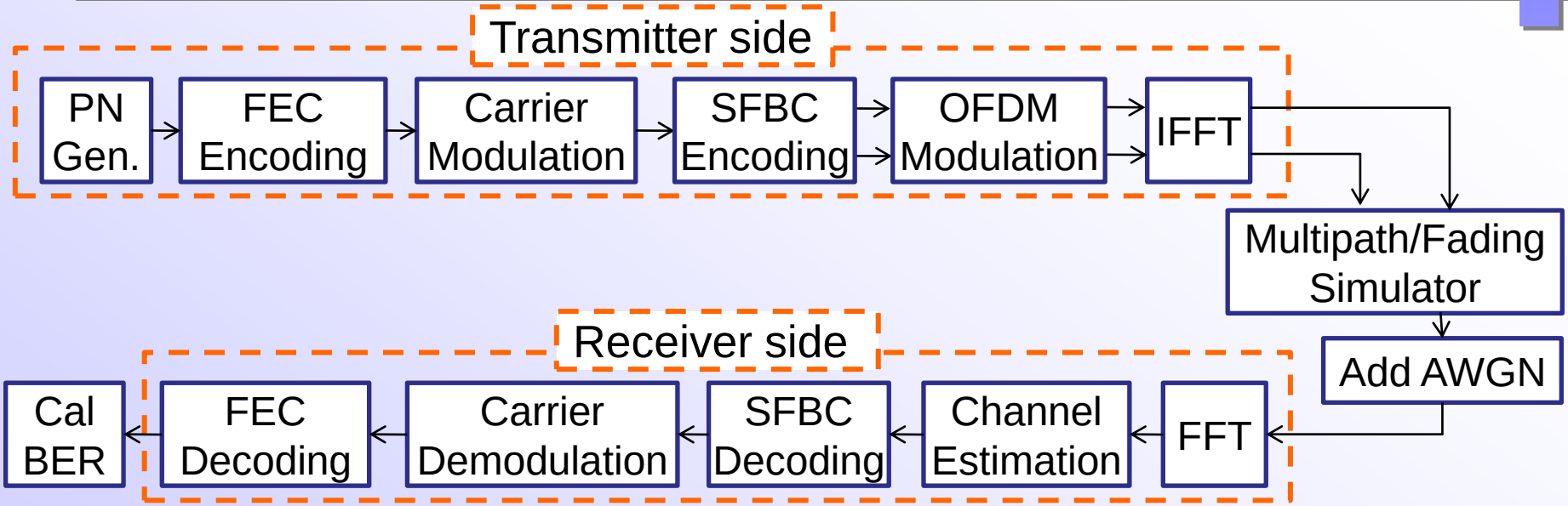
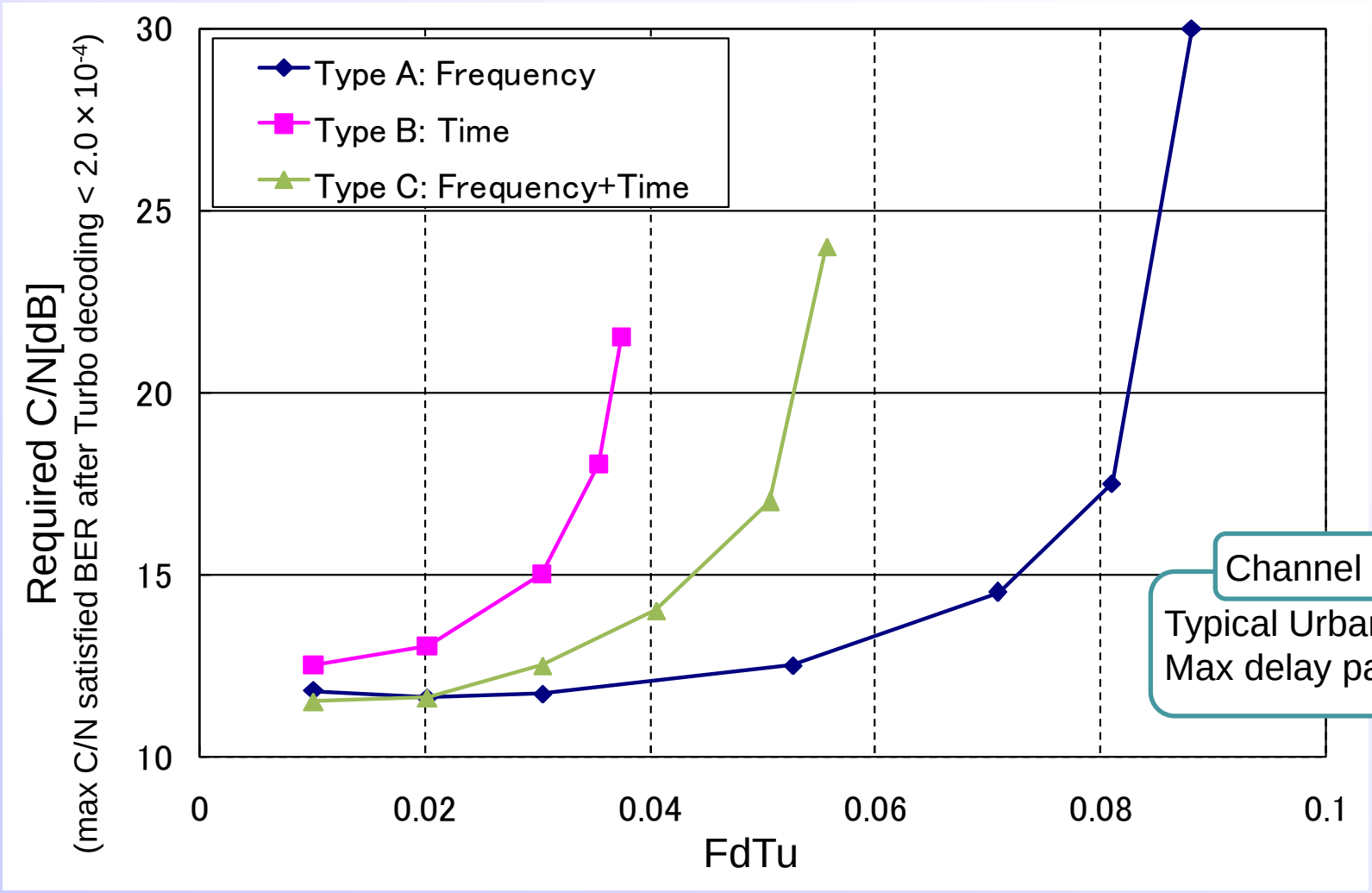
Conditions of laboratory experiments

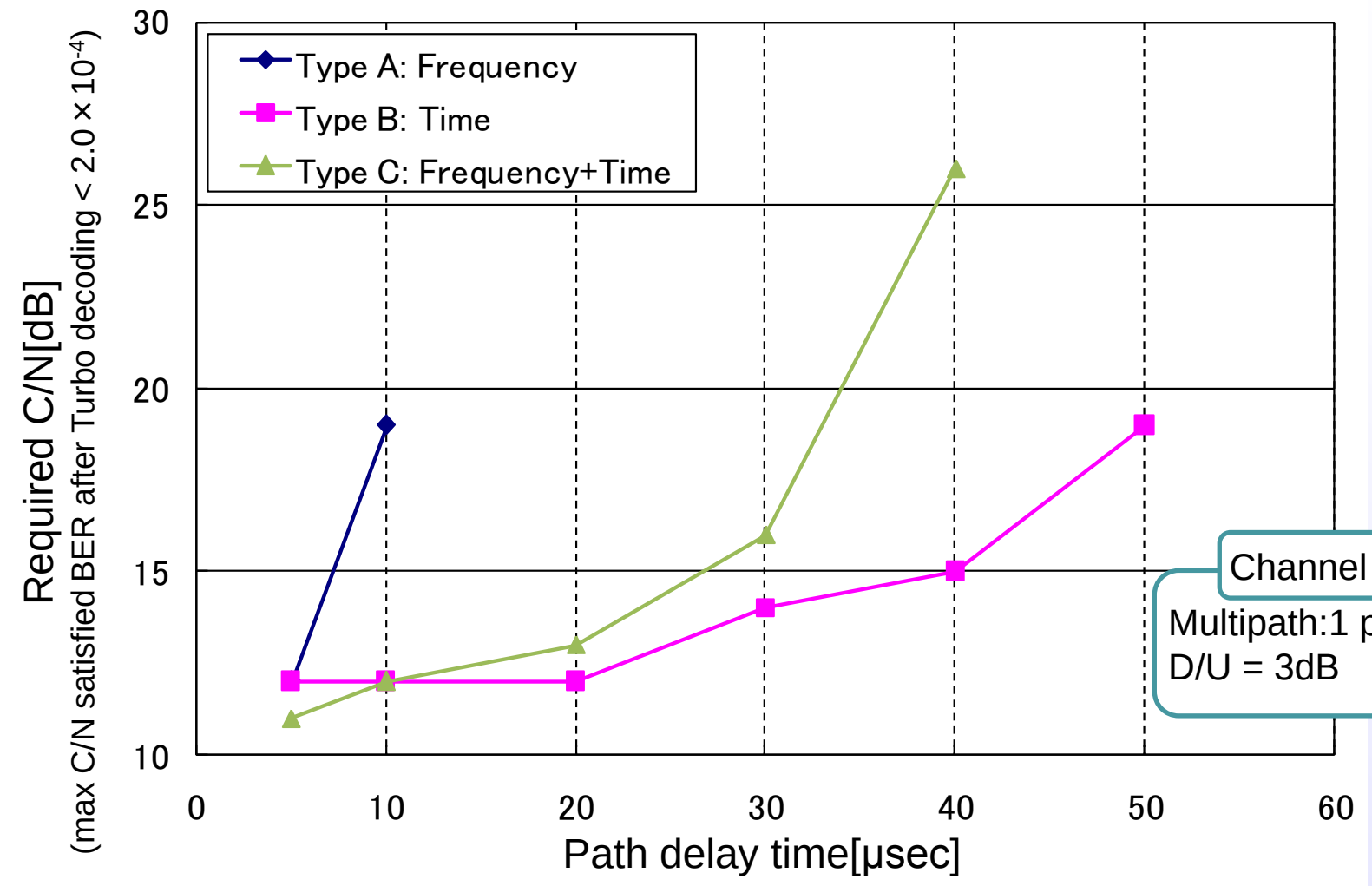


Transmission parameters	
Length of OFDM signal	504μsec
Number of carriers	2809
Guard interval ratio	1/8
Modulation method	16QAM
FEC, rate	Turbo code, 1/2
Time interleaving	430msec
Transmission encode	SFBC

Result #1 of laboratory experiments



Result #2 of laboratory experiments



Channel model

Multipath:1 path

D/U = 3dB

Conclusion

- Introduced the two technologies of MISO for handheld/mobile reception.
  - SFBC
  - Channel estimation

- Fixed and mobile reception were examined separately.
- The most desirable system is one that can transmit data for both fixed and mobile reception in one channel as well as ISDB-T.
- In the future, we will study hierarchical transmission.

Thank you for your attention!