OFDMA SYSTEM

Mobile WiMAX 802.16e and Next Generation PHS

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New Broadband Wireless Access Service in Japan

- Japan government assigned 2.5GHz BWA bands to Two Companies on 2007/December.
  1. UQ communications (KDDI)
     - 2,595MHz - 2,625MHz 30MHz bands
     - Mobile WiMAX (802.16e, OFDMA)
  2. Willcom
     - 2,545MHz - 2,575MHz
     - (2,545 - 2,555MHz after 2014)
     - XG-PHS (OFDMA, SC-FDMA)
- They starts service on 2009.

Wireless Communication Services

- In-door
  - WLAN
    - 802.11b (CDMA) → 802.11g/a (OFDM) → 802.11n (MIMO-OFDM)
- Out-door
  - Cell Phones
    - PDC, CDMA, CDMA2000, WCDMA → 3.9G LTE (OFDMA, SC-FDMA)
    - PHS → XG-PHS (OFDMA, SC-FDMA)
  - New
    - WiMAX (802.16d, OFDMA) → Mobile WiMAX (802.16e, OFDMA)

ALL systems are shifting to OFDM/OFDMA.

UQ communications

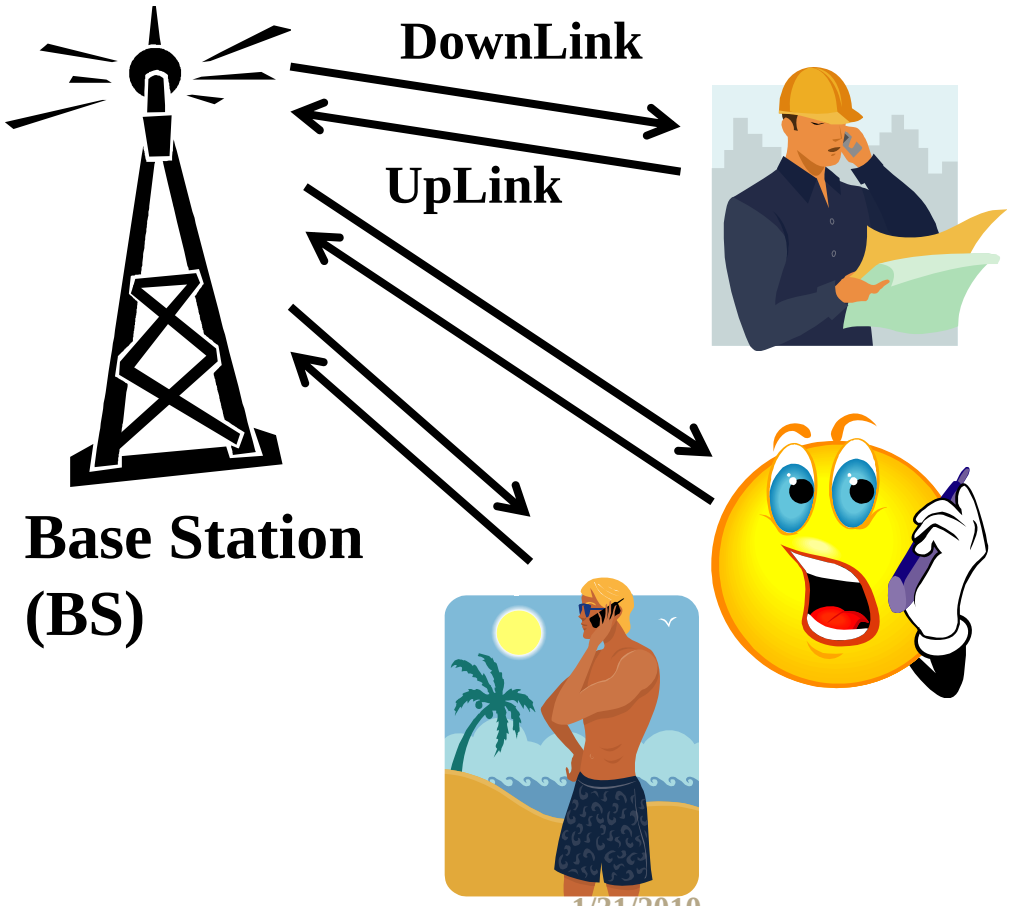
- Mobile WiMAX

- Schedule
  - 2008/8 : 1st Base Station
  - 2009/2: Experimental Service in Tokyo/Yokohama
  - 2009/summer: Public service starts in limited area

Willcom **WILLCOM CORE :** Next Generation PHS(XGPHS)

- 2009/4：limited Area Service in Tokyo
- 2009/10：Public Service Starts in Tokyo, Nagoya, Osaka
- - 2012/3: All prefecture’s capital city
- - 2013/3： Other city Area in Japan

Multiple Access

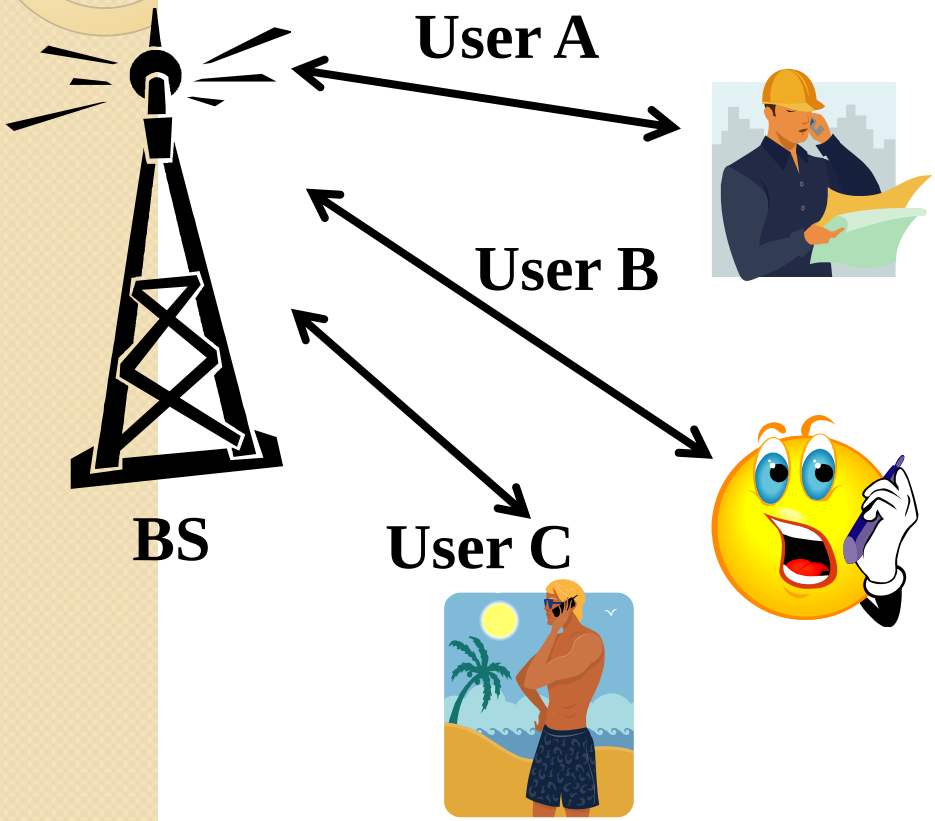


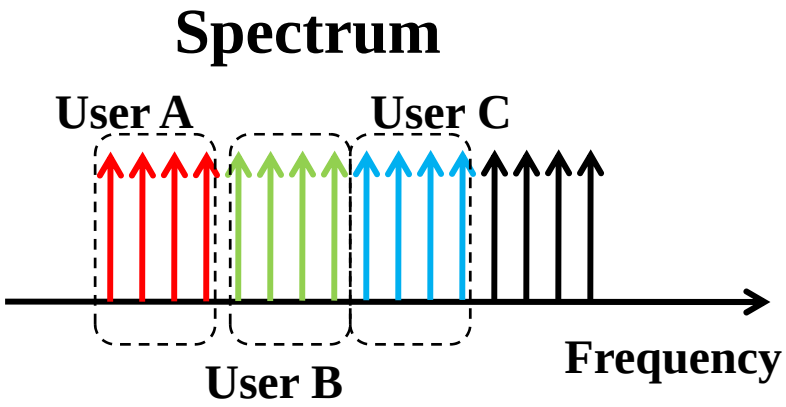
1/31/2010

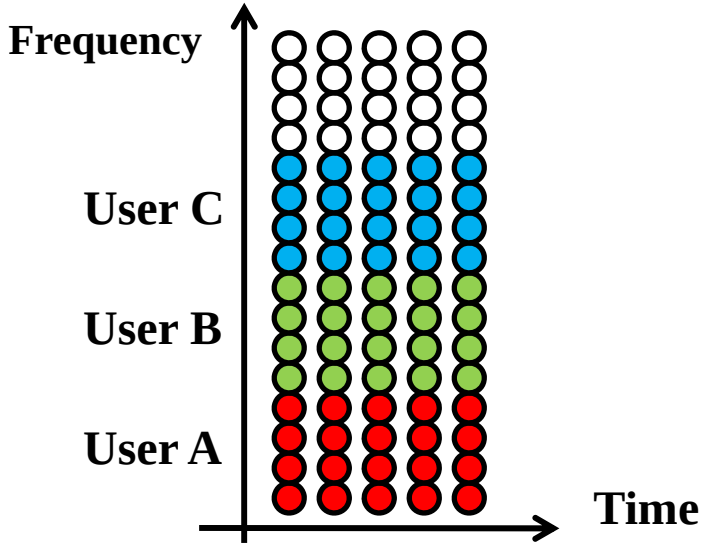
Multiplexing

- Separate Downlink and Uplink
  - FDD : Frequency Division Duplex
  - TDD: Time Division Duplex
- Separate Each User
  - FDD : Frequency Division Duplex
  - TDD: Time Division Duplex
  - OFDM: Orthogonal Frequency Division Multiple Access
- BWA systems
  Mobile WiMAX, XG-PHS use TDD-OFDMA!

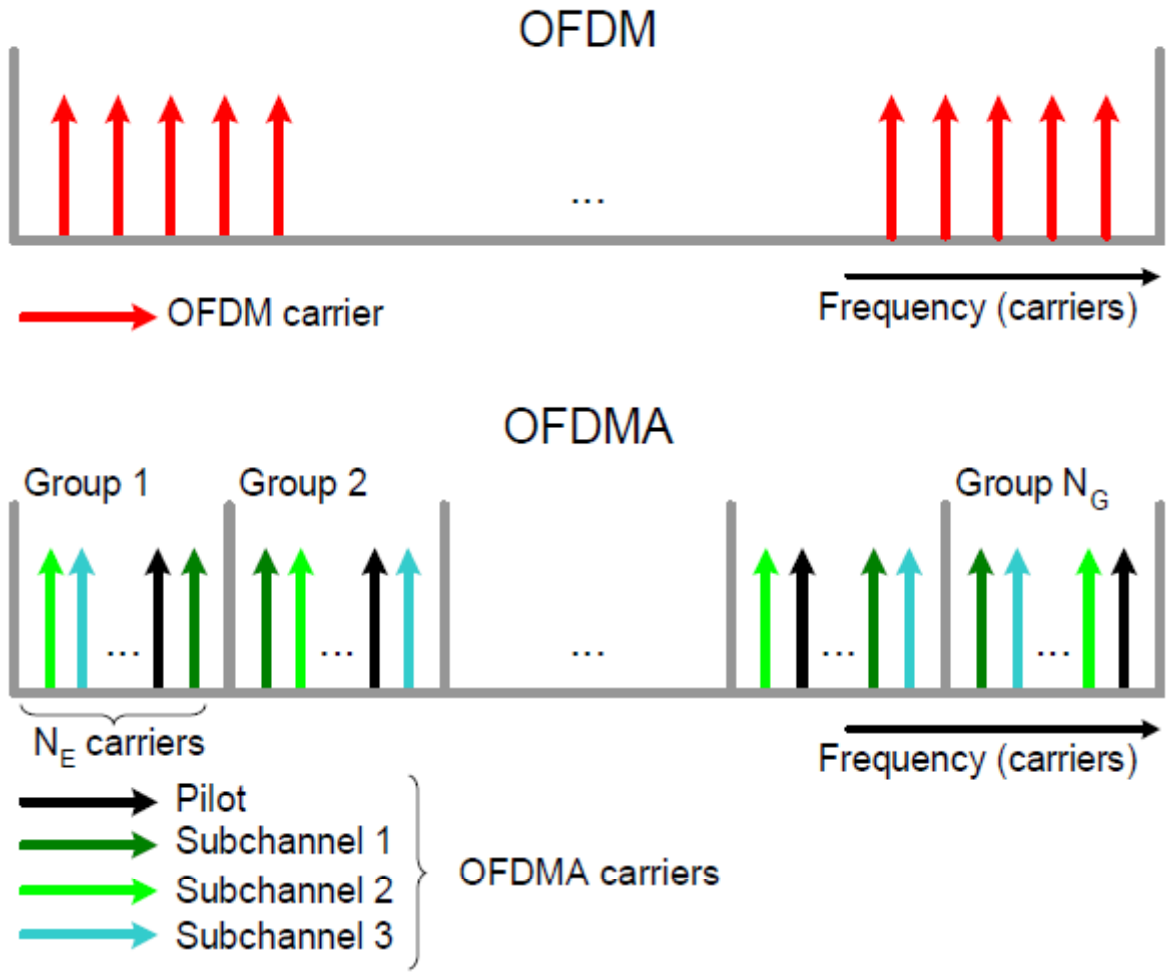
OFDMA


User A
User B
User C
BS

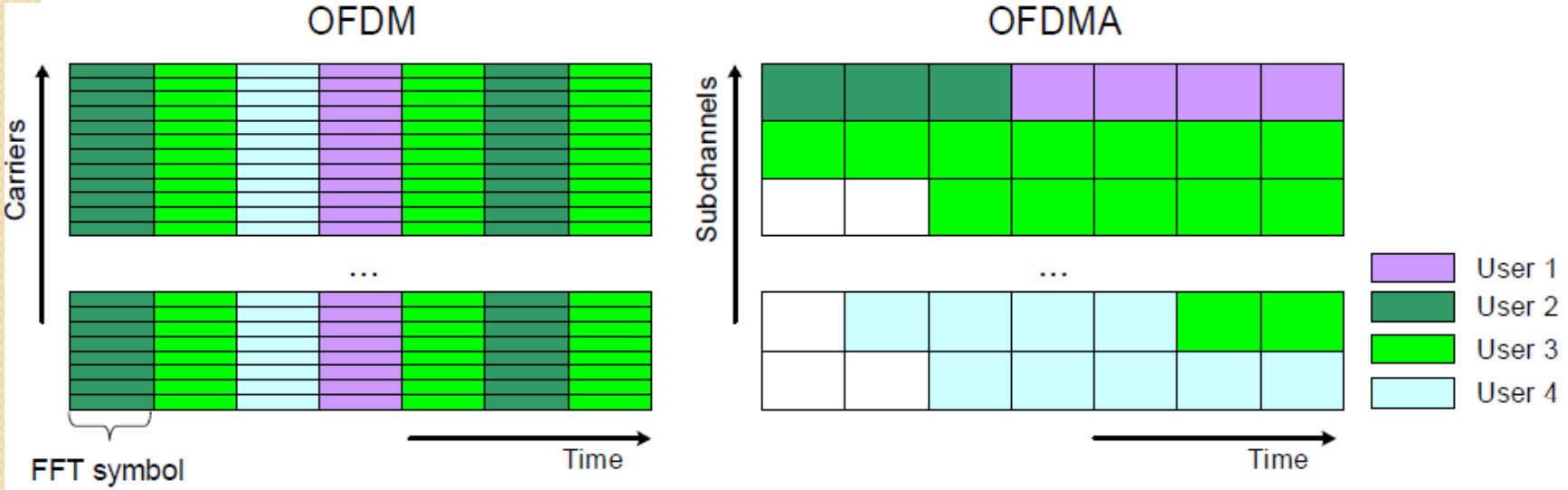

Spectrum
User A
User C
User B
Frequency


Frequency
User C
User B
User A
Time

OFDM vs OFDMA (1)



OFDM vs OFDMA (2)



(1)

MOBILE WIMAX

IEEE 802.16e

2005-06-27 IEEE P802.16e/D9, June 2005

Draft IEEE Standard for
Local and metropolitan area networks

Part 16: Air Interface for Fixed and Mobile Broadband Wireless Access Systems

Amendment for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands

Sponsor
LAN MAN Standards Committee
of the
IEEE Computer Society

and the
IEEE Microwave Theory and Techniques Society

802.16e Mobile WiMAX Highlights

- 16e targeting 1-3 mile radius mobile broadband connection for pedestrians and automobiles.

Max subscriber throughput	1Mbps/uplink, 3Mbps/downlink
Max sector throughput (10Mhz band)	18Mbps/downlink; 6Mbps/uplink
Frequency reuse	1
Mobility	up to 120 Km/hour
Handoff	under 150ms
Service coverage	Macro (1Km), Micro (400m), Pico (100m)
Roaming	seamless roaming with cellular and WLAN
QoS offering	unsolicited grant service; real-time; non real-time; best-effort
Uplink/Downlink ratio	software adjustable

Applications for 16e

- *According to QoS (Quality of Service) levels, most of applications are covered.*

QoS Class	Data Type	Application	
unsolicited grant service	periodic interval, fixed-sized packet; real time	T1/E1; VoIP with silience suppression	**Mobile Phone**
unsolicited grant service	periodic interval; variable-sized packet; real time data stream	video telephony; interactive video game; VoD/AoD	**Video Phone**
real time polling service	variable-sized packet; delay-tolerant data stream; minimum data rate	high speed file transfer; MMS; Web browsing	**Internet**
best effort service	no minimum service level	FTP, WWW, E-mail	

Scalable OFDMA service

- According to available BW, several FFT sizes are supported.
- Table shows an example.

parameter	Values			
multiple-access	OFDMA			
bandwidth [MHz]	1.25	5	10	20
FFT size	128	512	1024	2048
tone spacing [KHz]	11.16			
cyclic prefix overhead	1/8			
OFDMA symbol duration [us]	100.8			
number of symbols in a frame	same, depending on the frame length			

Data Rate example

- Frame = 10ms
  - Downlink = 7.5ms
  - Uplink = 2.5ms
- 10MHz Bandwidth

Data Rate (Mbps)	Raw	DL raw	UL raw	DL net	UL net
QPSK 1/2	8.89	6.67	2.22	5.68	1.84
QPSK 2/3	11.85	8.89	2.69	7.58	2.46
QPSK 3/4	13.33	10.00	3.33	8.52	2.76
16QAM 1/2	17.78	13.33	4.44	11.37	3.69
16QAM 2/3	23.70	17.78	5.93	15.16	4.92
16QAM 3/4	26.67	20.00	6.67	17.05	5.52
64QAM 1/2	26.67	20.00	6.67	17.05	5.52
64QAM 2/3	35.56	26.67	8.89	22.73	7.37
64QAM 3/4	40.00	30.00	10.00	25.57	8.29
64QAM 5/6	44.44	33.33	11.11	**28.29**	9.22

Mobile WIMAX 8.75MHz SPEC

- BW 8.75MHz
- n 8/7
- Sampling Freq 10.000MHz
- FFT size 1024
  - DL Null=184, Pilot=120, Data=720
  - UL Null=184, Pilot=280, Data=560
- # of sub-channels
  - DL (2cluster) 30 channel
  - UL (6 tile) 35 channel
- Sub-carrier space 9.765625KHz
- Useful Symbol Tb 102.4us
- Guard Interval Tg 12.8us
- OFDM symbol Ts 115.2us
- Symbols in Frame 48(5ms frame)

- Modulation
  - QPSK,16/64QAM
- CC
  - DL R=1/2, 2/3, 3/4, 5/6
  - UL R=1/2, 2/3, 5/6
- Repetition x2, x4, x6
- Data Channel
  - DL PUSC only
  - UL PUSC only

Frame Structure

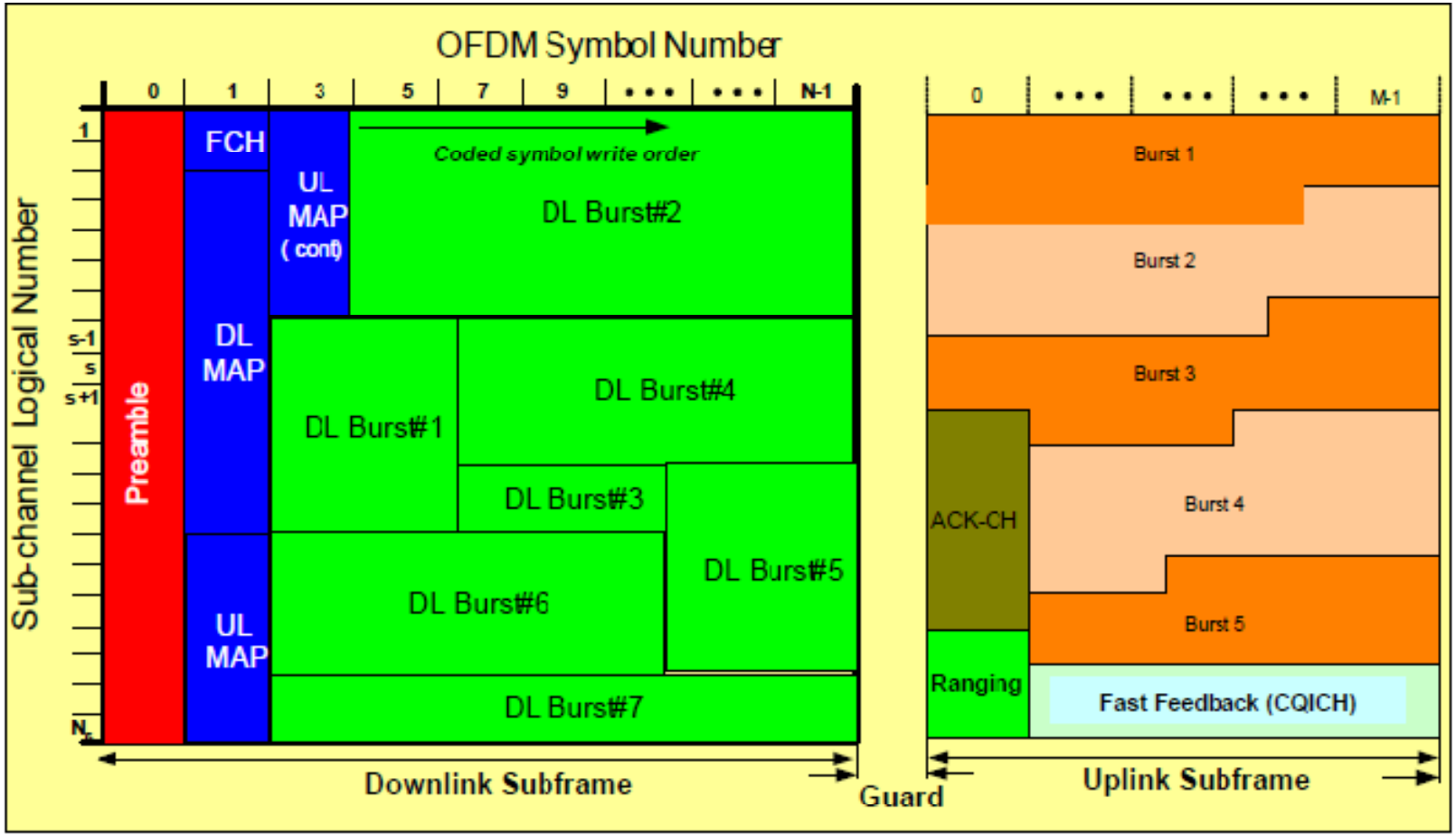
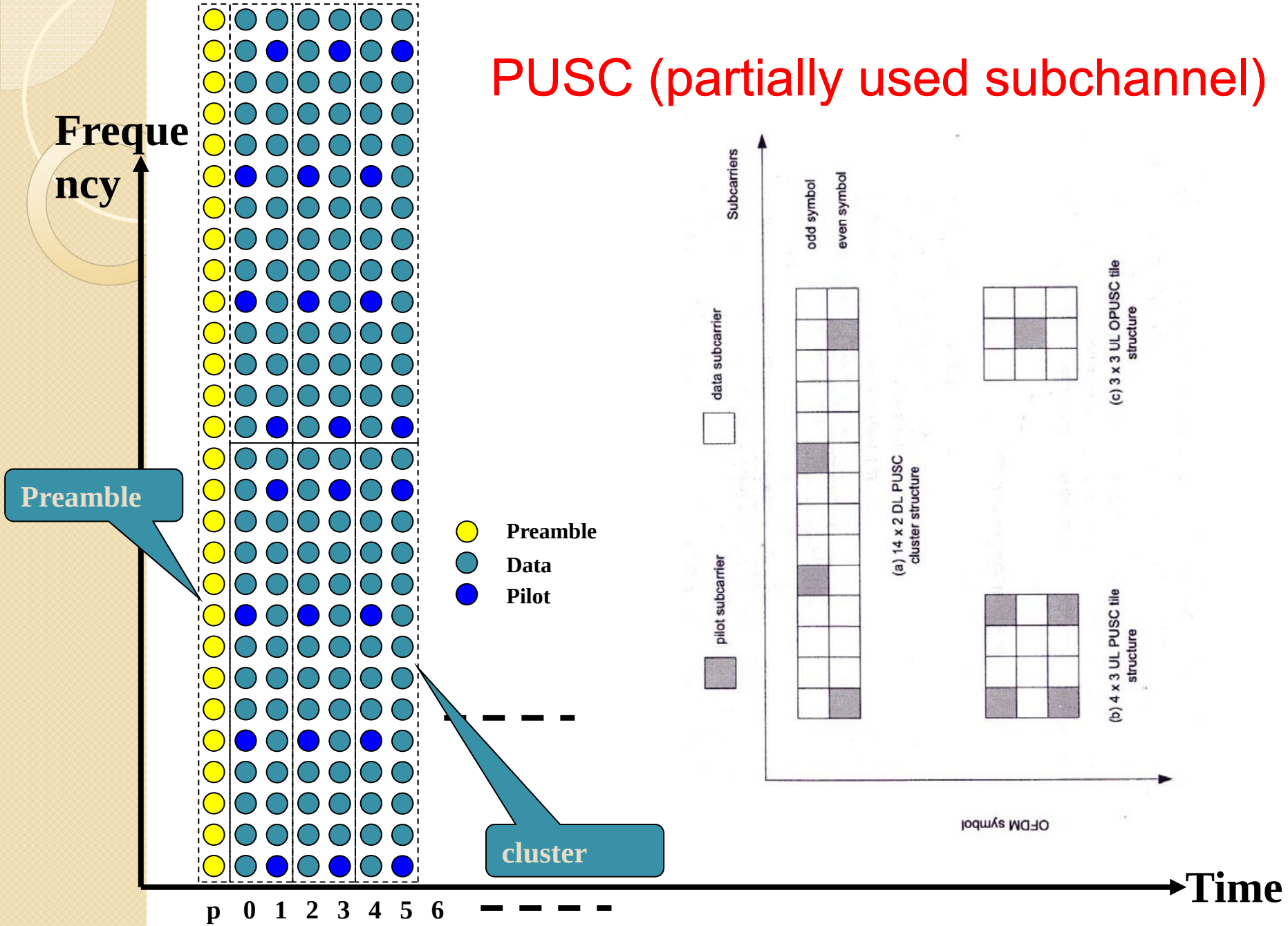


Figure 7: WiMAX OFDMA Frame Structure

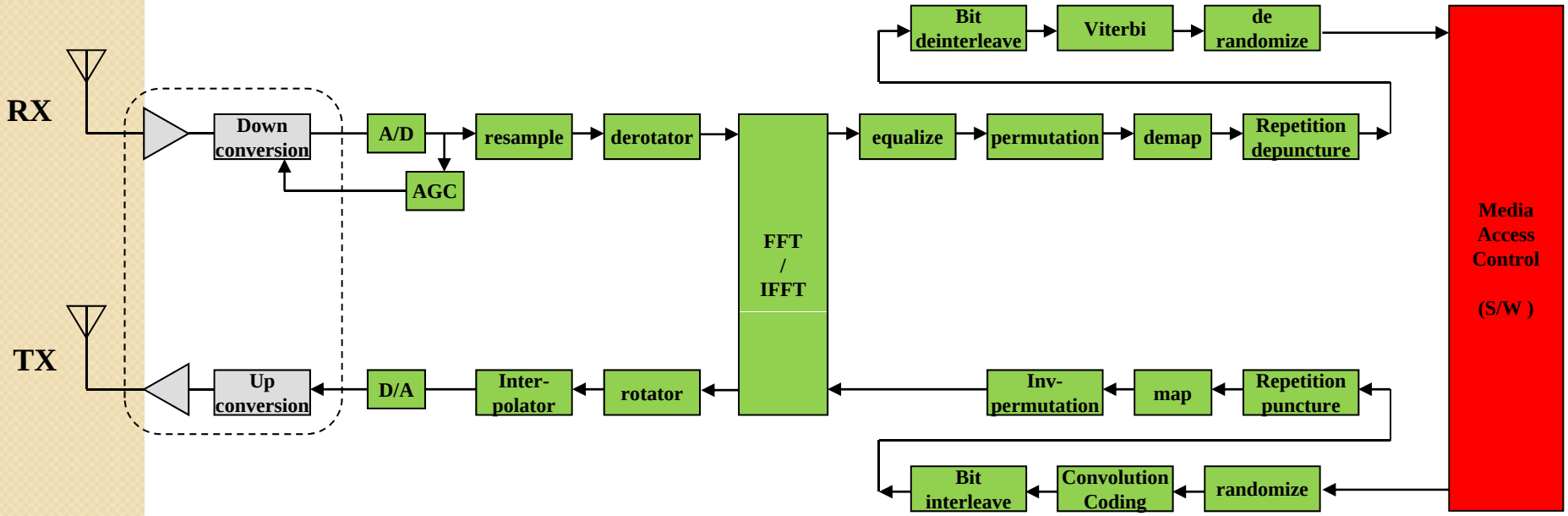
Frame

- Preamble: PN code of Base Station ID
- FCH: frame control header
- DL-MAP: detail Downlink information
- UL-MAP: detail Uplink infromation
- Burst: user data
- Sub-Channel: group of sub-carriers
  - FUSC（downlink fully used subchannelization）
  - PUSC（Partially used subchannelization）
  - Advance Modulation and Coding subchannels （AMC）

PUSC (partially used subchannel)



802.16e Transceiver Architecture



(2)

XG-PHS

NEXT GENERATION

PERSONAL HANDYPHONE SYSTEM

PHS MoU

PHS MoU Document
A-GN4.00-01-TS

Title: Next Generation PHS Specifications (Revision3)
Version: 01
Date: October 26, 2007
PHS MoU Classification: Unrestricted

PHS MoU Group

c/o Association of Radio Industries and Businesses (ARIB)
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TEL +81-3-5510-8599 FAX +81-3-3592-1103

PHS and XG-PHS

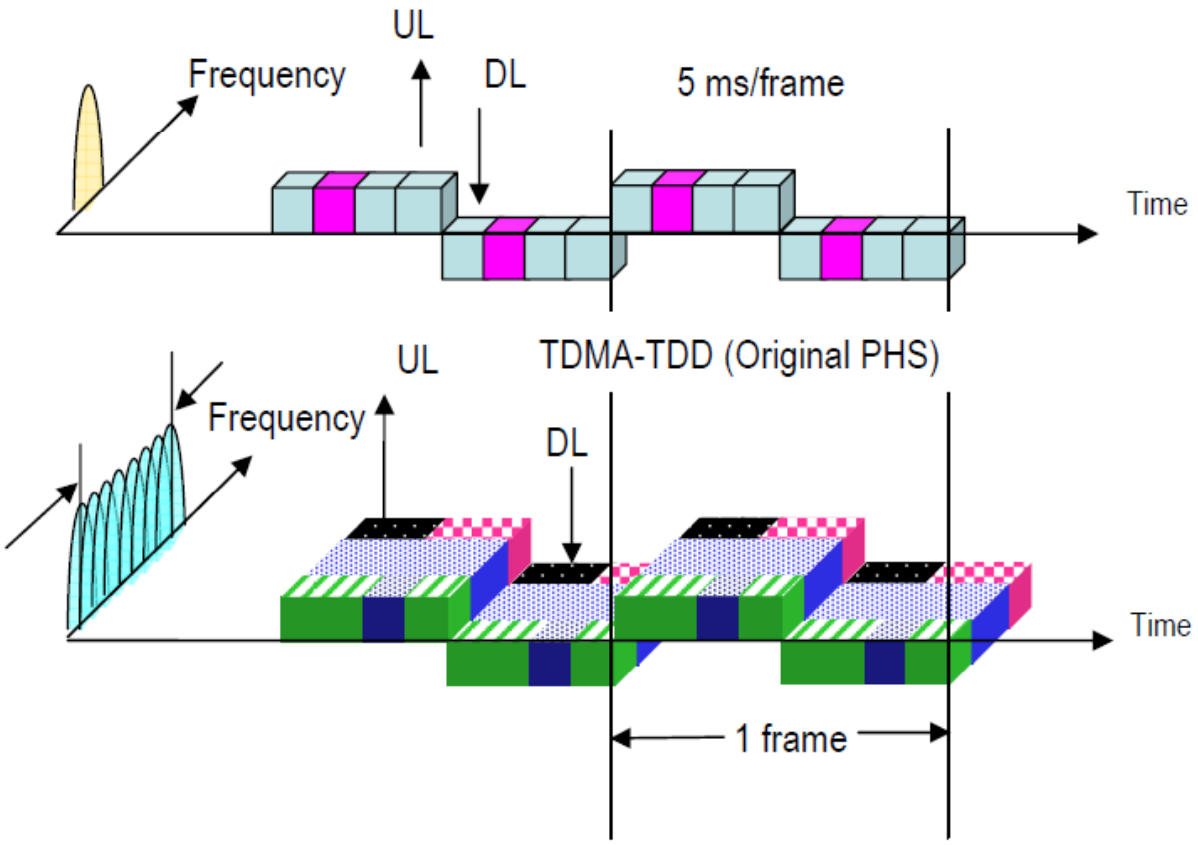


Figure 2.3 OFDMA/TDMA-TDD (XG-PHS)

XG-PHS OFDM TYPE4 10MHz Spec

- System BW 10.0MHz
- Effective BW 9.0MHz
- Sampling Freq 19.2MHz
- FFT size 512
  - 24subcarrier/PRU * 10 PRU
  - 240subcarrier
- Number of PRU in Frequency axis
  - 10 PRU
- Sub-carrier space 37.5KHz
- Useful Symbol Tb 26.67us
- Guard Interval Tg 1/4(S1)=6.66us
  1/8(他)=3.33us
- OFDM symbol Ts 1/4(S1)=33.33us
  1/8(他)=30.00us

- Frame length 5.000ms
  - 96000 point in 19.2Msps
- UL/DL 2.5ms
  - SLOT 625us
    - Head Guard 21.67us
    - Burst Time 573.33us
    - Tail Guard 30.00us

Data Rate example

- Frame = 5ms
  - Downlink =Uplink = 2.5ms
- 10MHz Bandwidth
  - 40PRU (4Cch, 36Ich) for each down/up link
    - 4 CCH PRU + 36 ICH PRU
    - CCH: 324 sc * 4=1296sc/2.5ms (BPSK, R=1/2)
    - ICH: 372sc*36=13392sc/2.5ms
- ICH Performance (DL+UL)

	ICH Peromance (Mbps)			
Code Rate	QPSK(2b/sc)	16QAM(4b/sc)	64QAM(6b/sc)	256QAM(8b/sc)
R=1/2	5.36	10.71	16.07	21.43
R=2/3	7.14	14.28	21.43	28.57
R=3/4	8.04	16.07	24.11	32.14
R=5/6	8.93	17.86	26.78	35.71
R=7/8	9.37	18.75	28.12	37.50

Time Domain

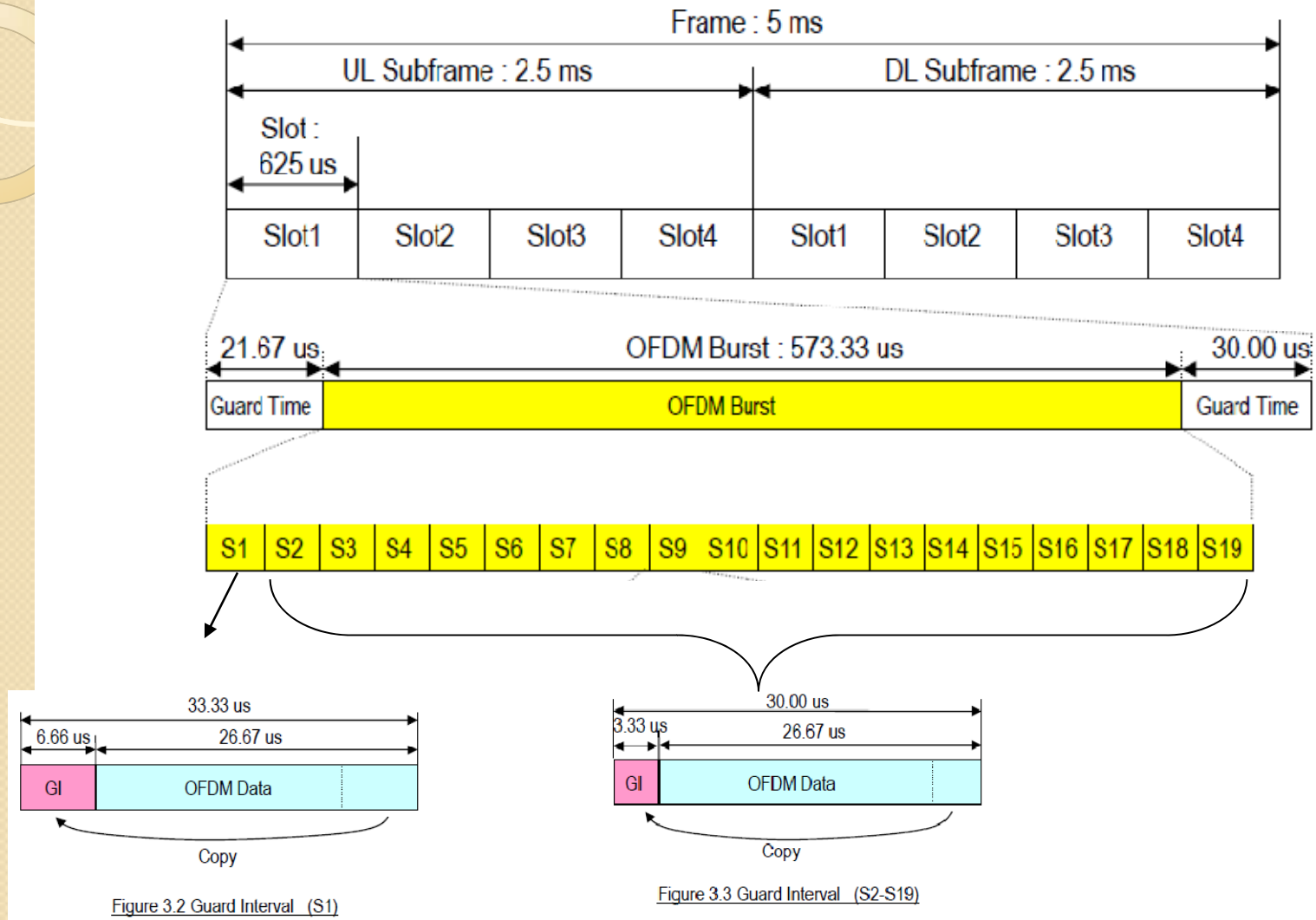
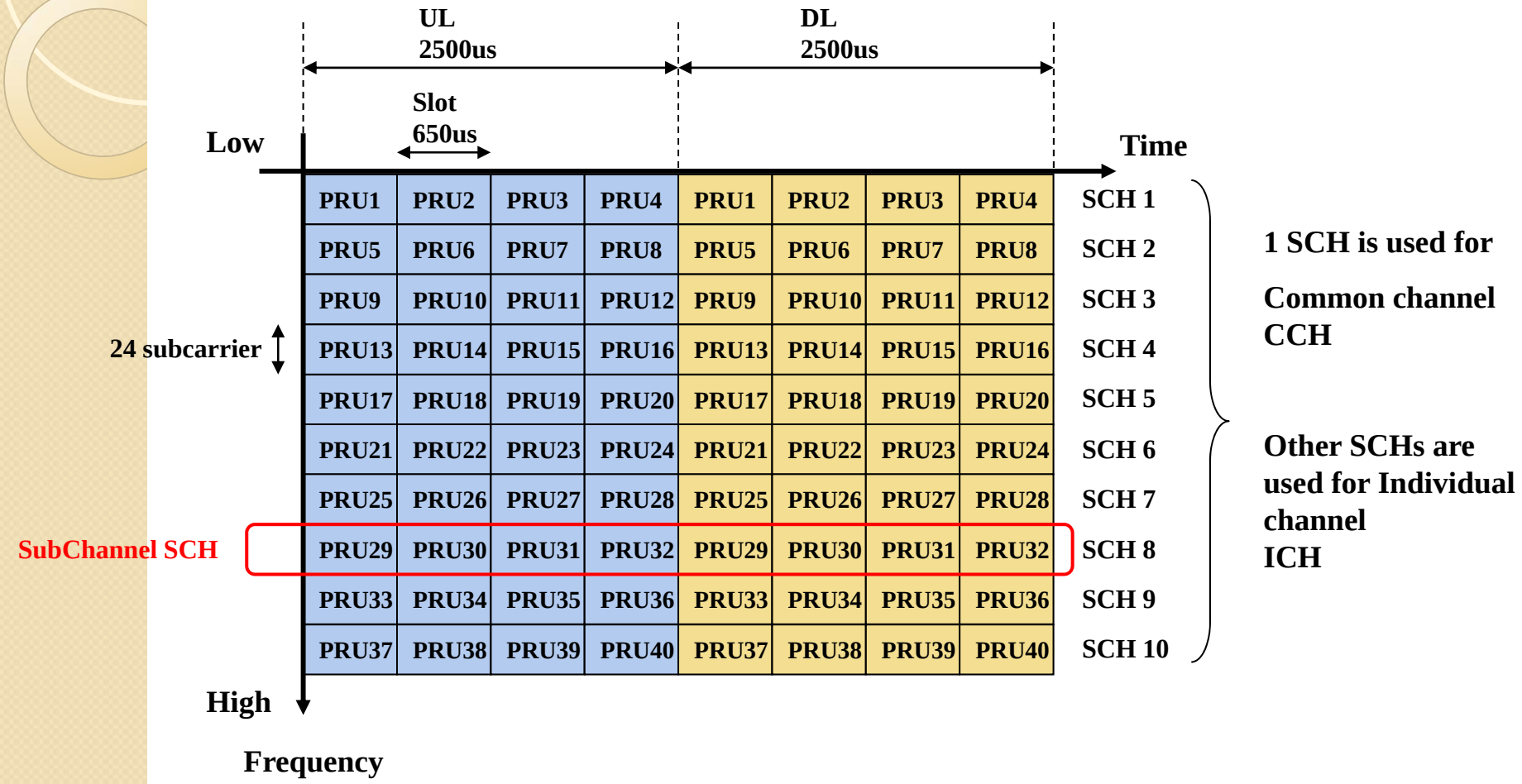


Figure 3.2 Guard Interval (S1)

Figure 3.3 Guard Interval (S2-S19)

Frequency Domain



Control Common Channel CCH PRU structure

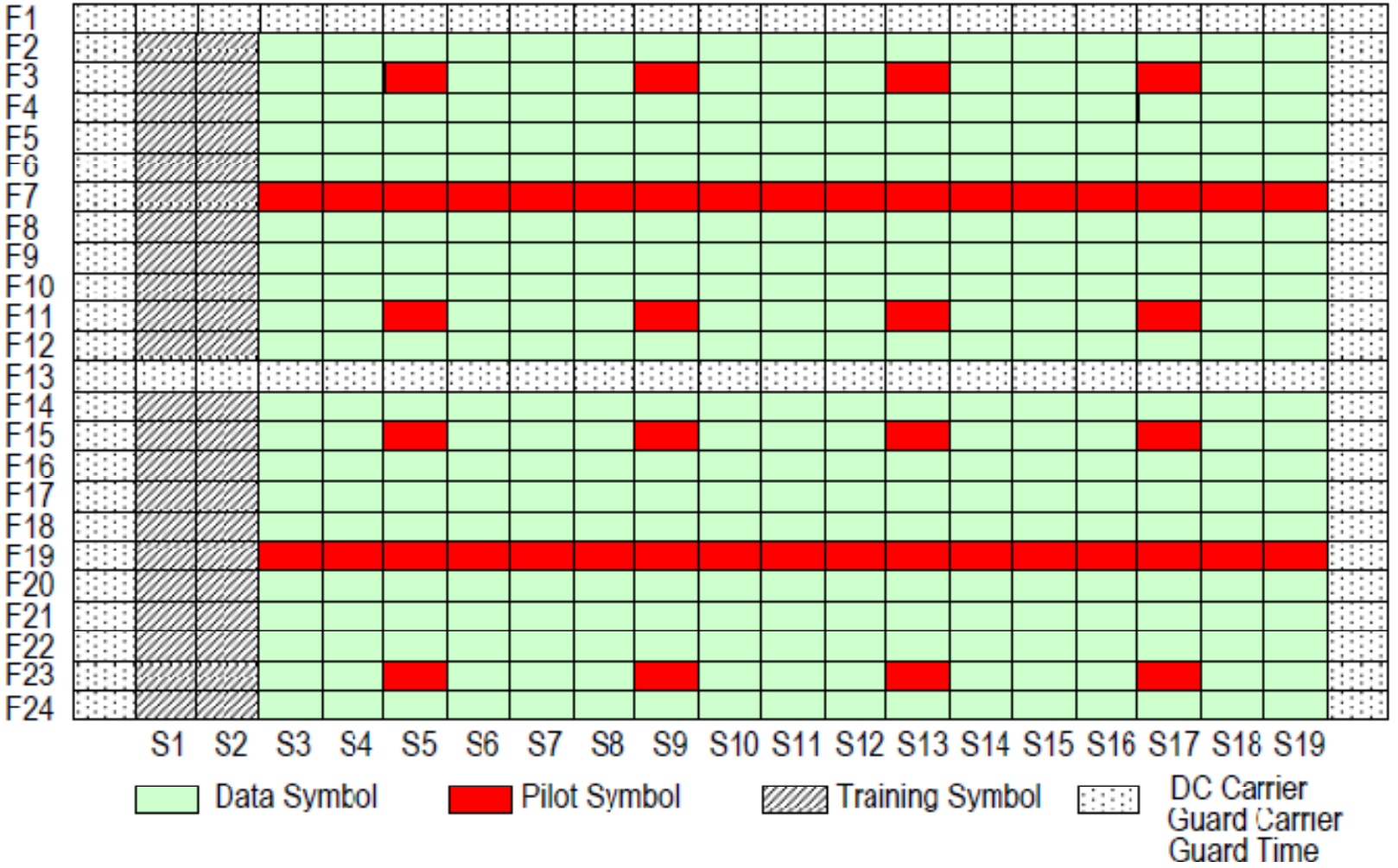


Figure 3.43 OFDM PRU Structure for CCCH

Individual Channel ICH PRU structure

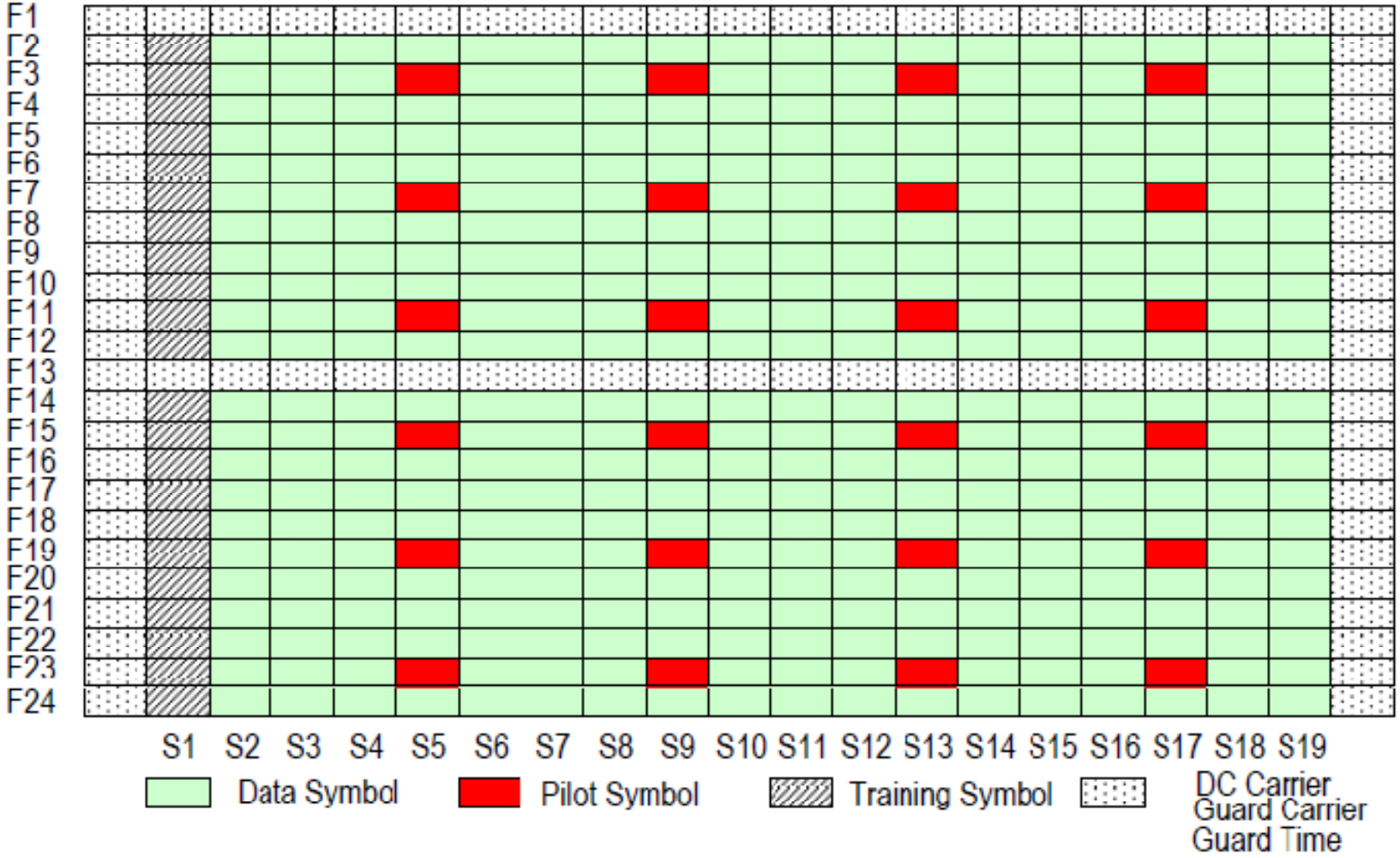
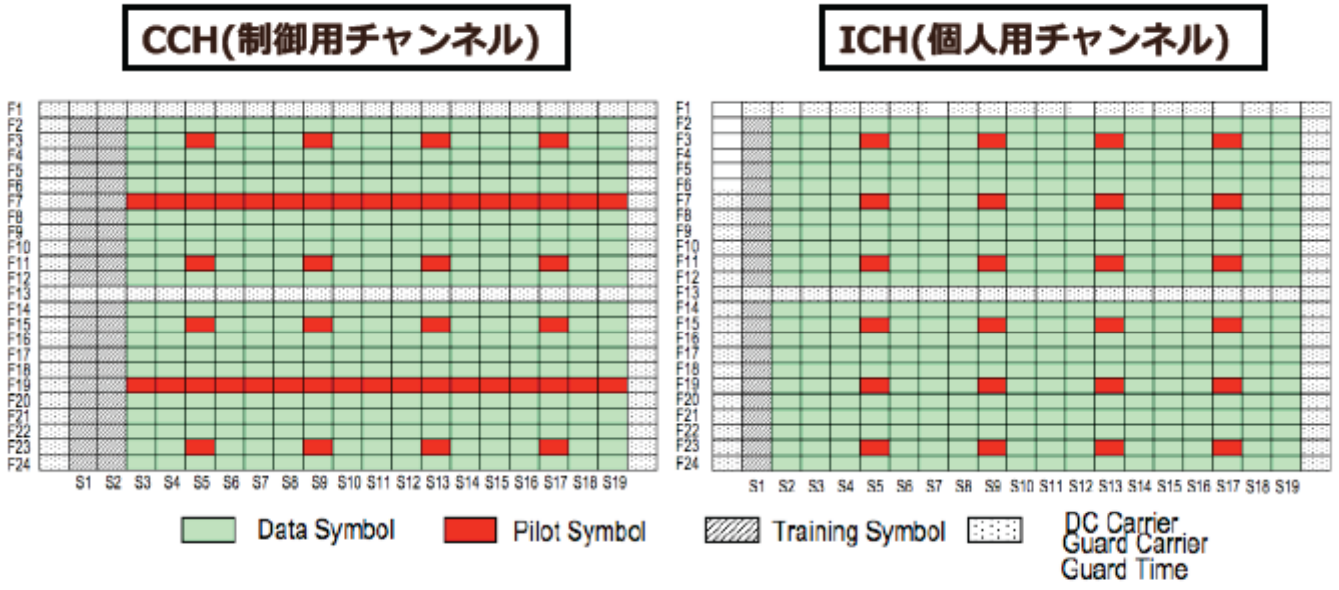


Figure 3.44 OFDM PRU Structure for ANCH

CCH and ICH



Name	CCH	ICH
Data Symbol	324	372
Pilot Symbol	50	24
Training Symbol	44	22
Null Symbol (DC Carrier,Guard Carrier)	38	38

Summary

- Next Generation Broadband Wireless Access services are introduced.
- OFDMA is key Technology.
- New two services coming soon in Japan
  1. Mobile WiMAX (IEEE 802.16e)
  2. XG-PHS
     - TDD-OFDMA
     - Several ten's Mbps similar to WLAN for large area