



# 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

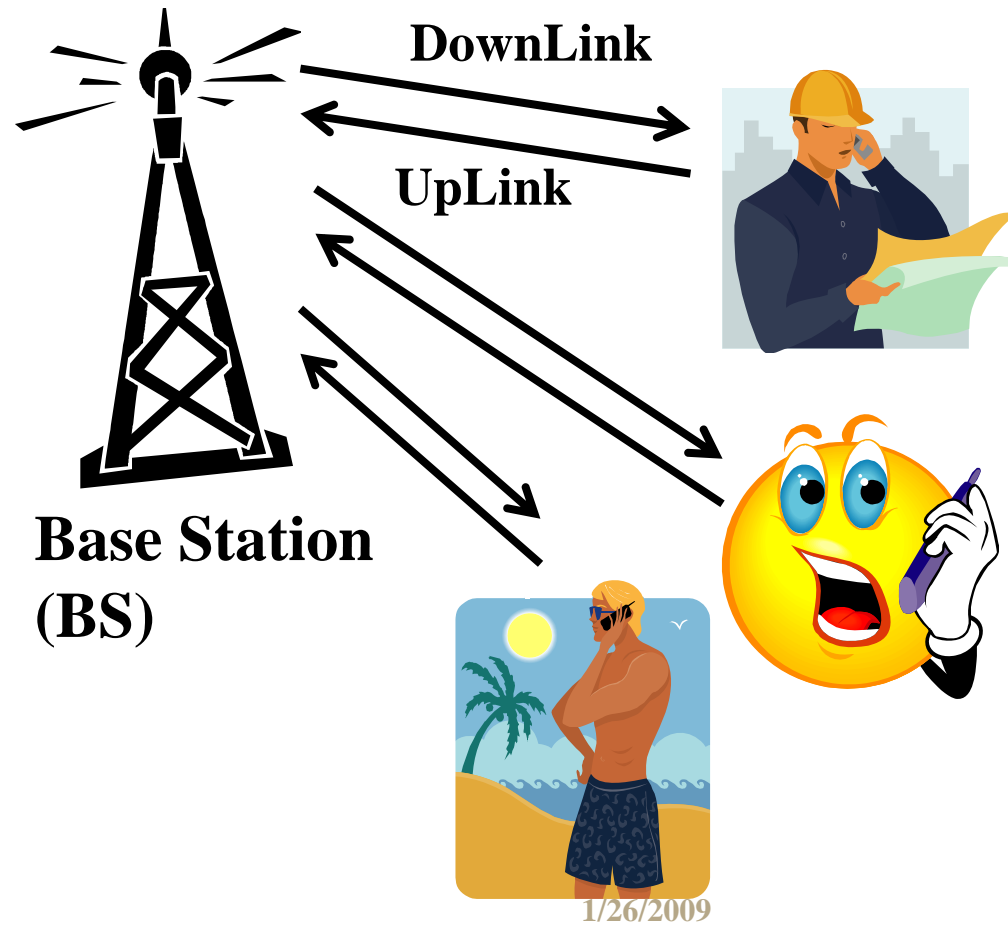




## Willcom **WILLCOM CORE** : Next Generation PHS(XGPHS)

- 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

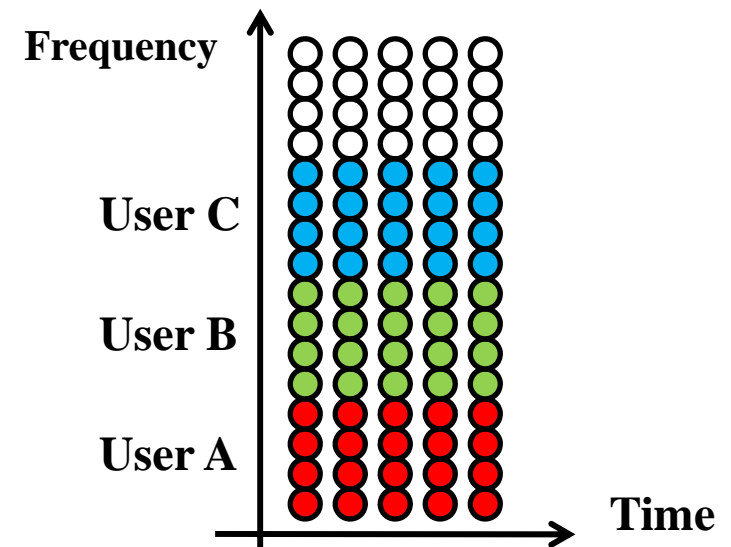
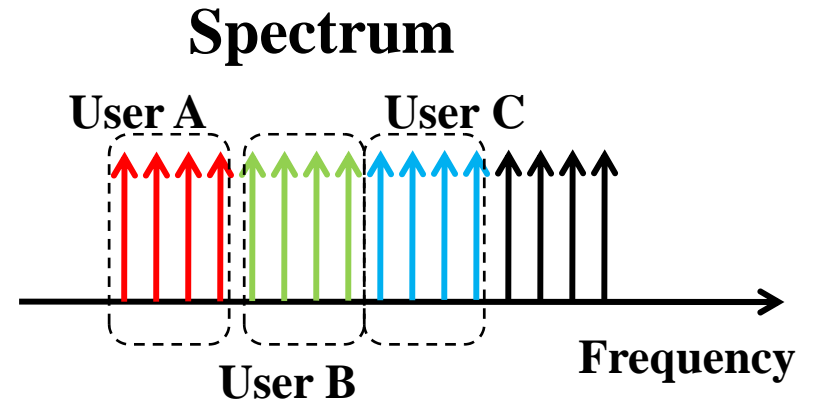
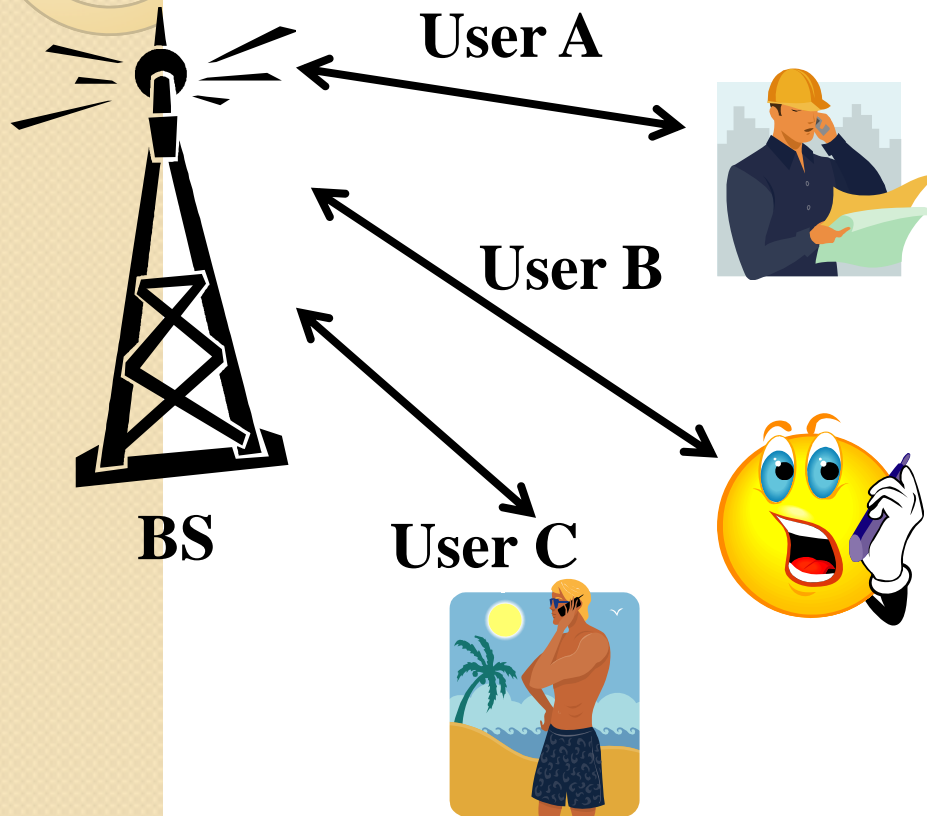
# Multiple Access



# Multiplexing

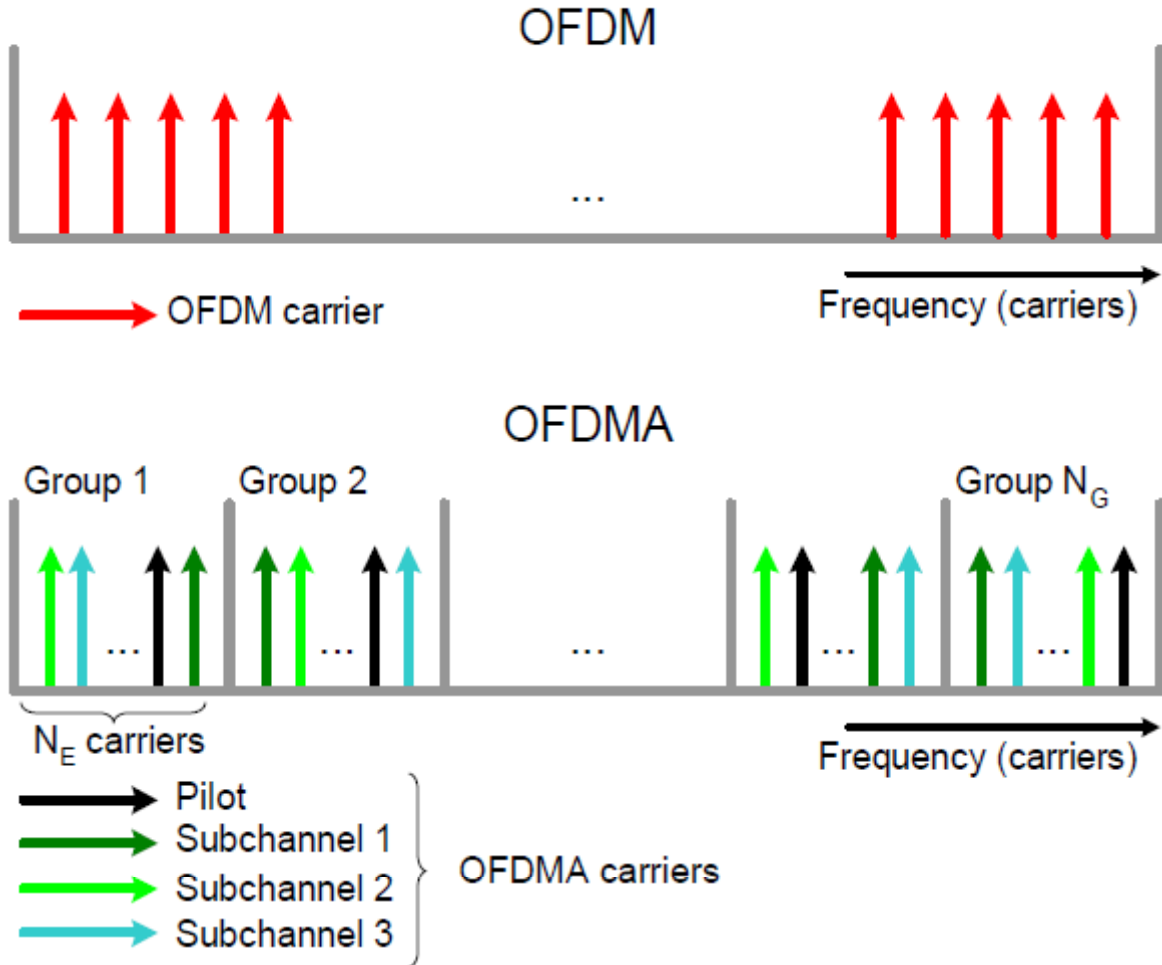
- Separate Downlink and Uplink
  - FDD : Frequency Division Duplex
  - TDD: Time Division Duplex
- Separate Each User
  - FDD : Frequency Division Duplex
  - TDD: Time Division Duplex
  - OFDM: Orthogonal Frequency Division Multiple Access
- BWA systems  
Mobile WiMAX, XG-PHS use TDD-OFDMA!

# OFDMA

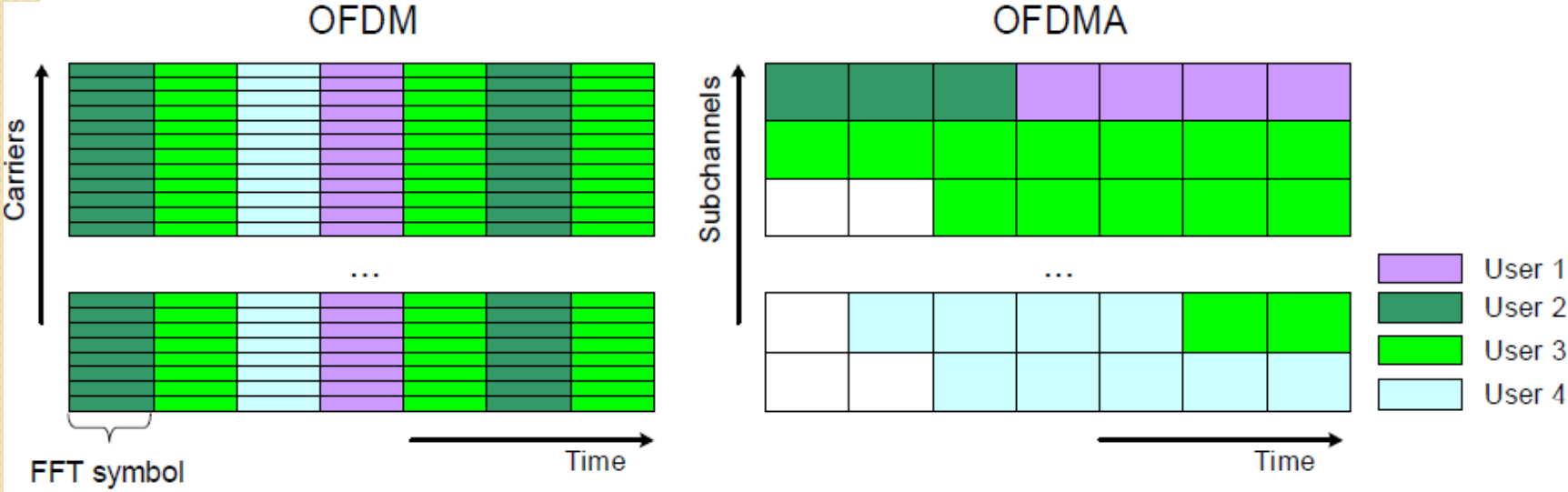




# OFDM vs OFDMA (1)



# 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.

<b>Max subscriber throughput</b>	1Mbps/uplink, 3Mbps/downlink
<b>Max sector throughput (10Mhz band)</b>	18Mbps/downlink; 6Mbps/uplink
<b>Frequency reuse</b>	1
<b>Mobility</b>	up to 120 Km/hour
<b>Handoff</b>	under 150ms
<b>Service coverage</b>	Macro (1Km), Micro (400m), Pico (100m)
<b>Roaming</b>	seamless roaming with cellular and WLAN
<b>QoS offering</b>	unsolicited grant service; real- time; non real-time; best-effort
<b>Uplink/Downlink ratio</b>	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
unsolicited grant service	periodic interval; variable-sized packet; real time data stream	video telephony; interactive video game; VoD/AoD
real time polling service	variable-sized packet; delay-tolerant data stream; minimum data rate	high speed file transfer; MMS; Web browsing
best effort service	no minimum service level	FTP, WWW, E-mail

**Mobile Phone**

**Video Phone**

**Internet**

# 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	<b>28.29</b>	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

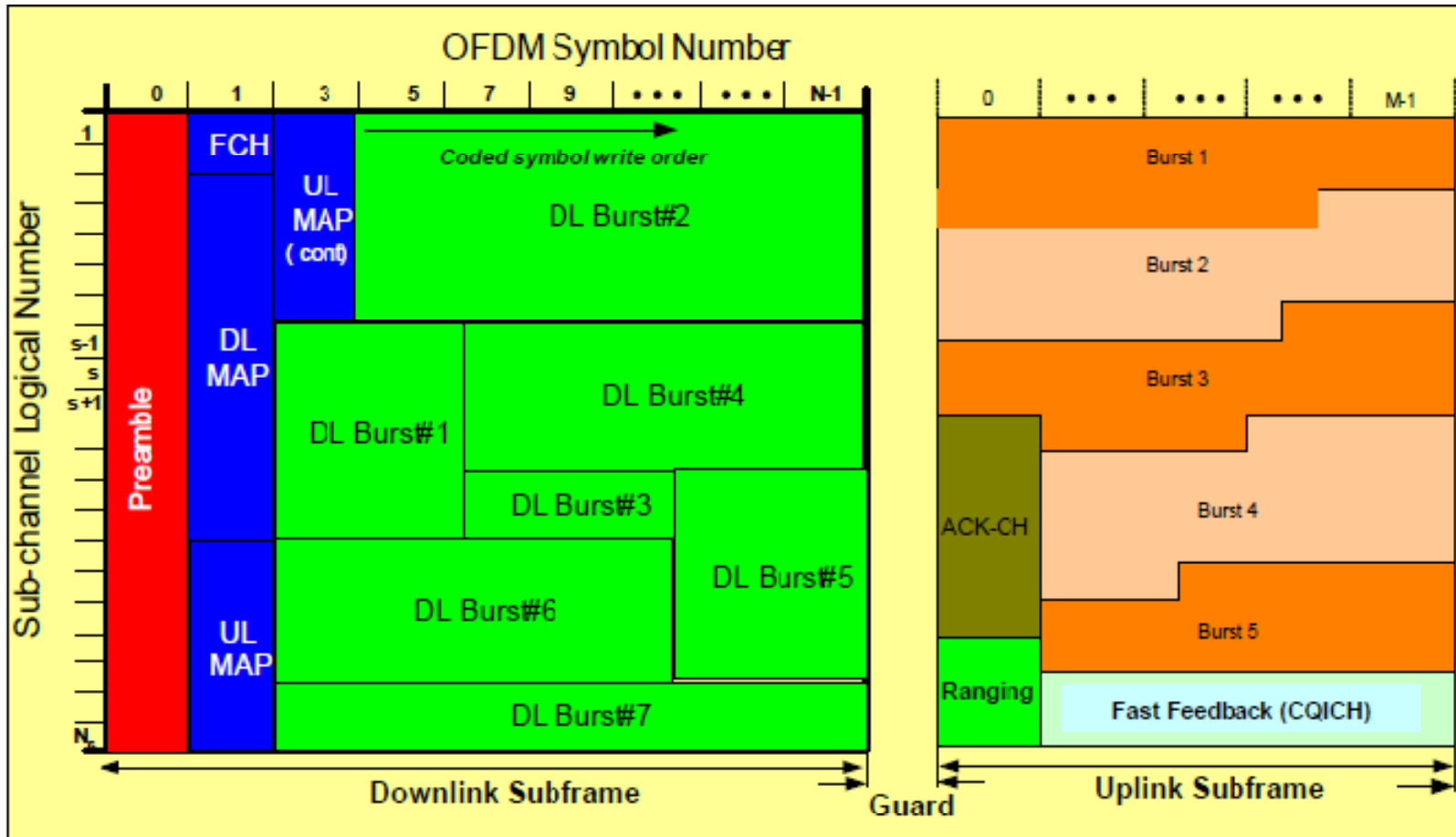
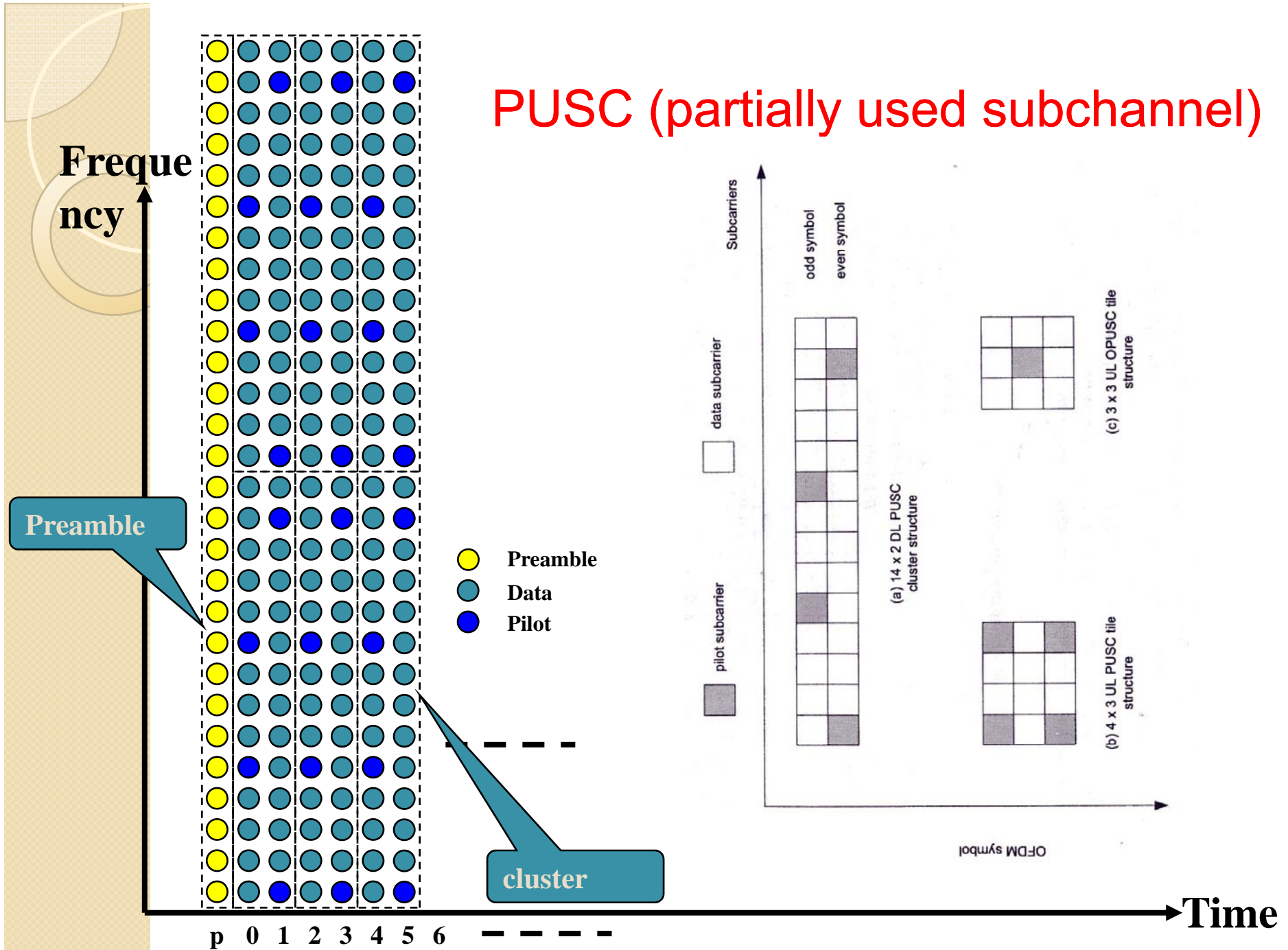


Figure 7: WiMAX OFDMA Frame Structure

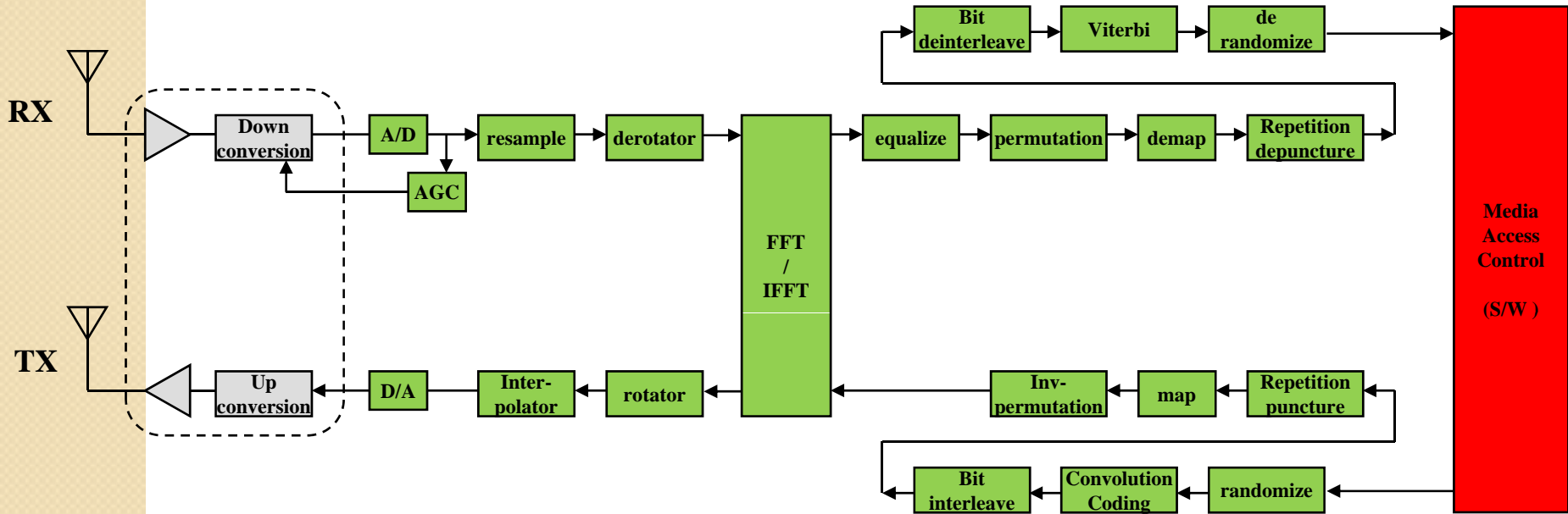
# Frame

- Preamble: PN code of Base Station ID
- FCH: frame control header
- DL-MAP: detail Downlink information
- UL-MAP: detail Uplink information
- 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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# PHS and XG-PHS

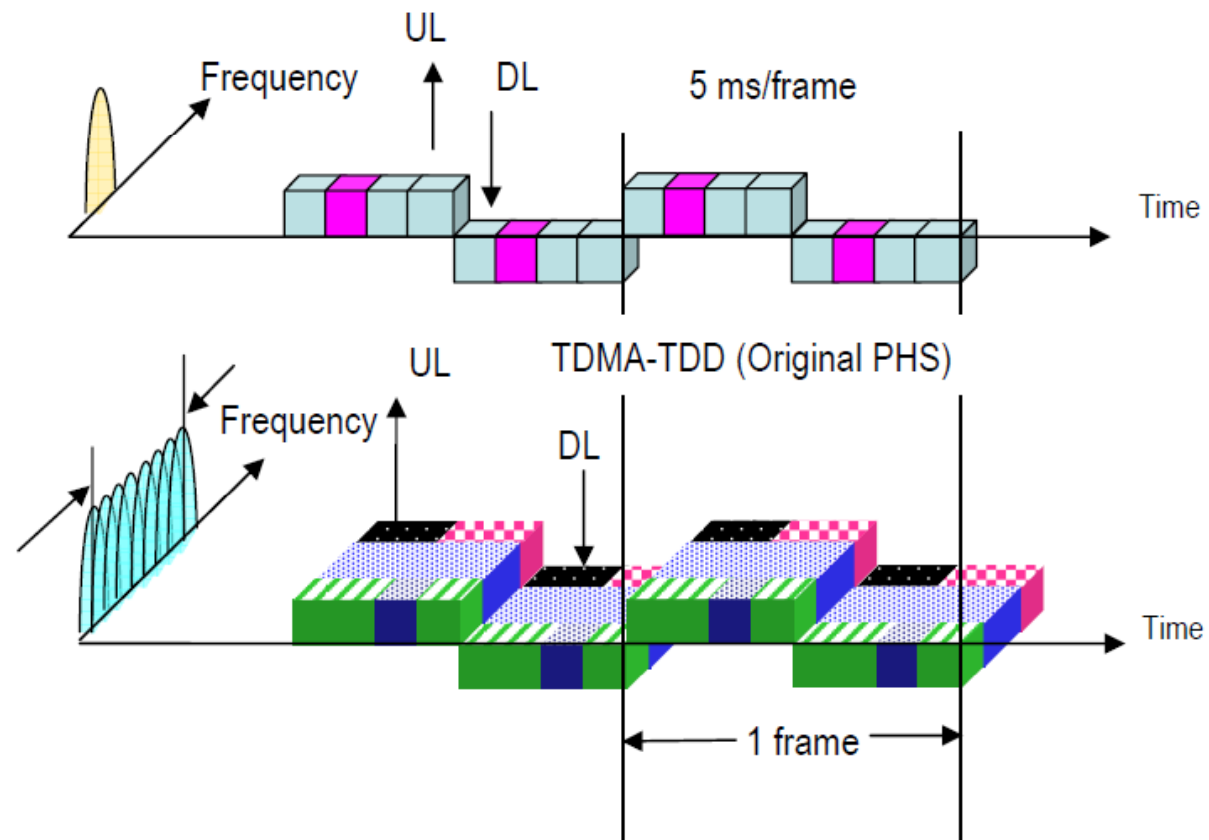


Figure 2.3 OFDMA/TDMA-TDD (XG-PHS)



# 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, 36lch) for each down/up link
    - 4 CCH PRU + 36 ICH PRU
    - CCH:  $324 \text{ sc} * 4 = 1296 \text{ sc} / 2.5 \text{ ms}$  (BPSK,  $R=1/2$ )
    - ICH:  $372 \text{ sc} * 36 = 13392 \text{ sc} / 2.5 \text{ ms}$
- ICH Performance (DL+UL)

	ICH Performance (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

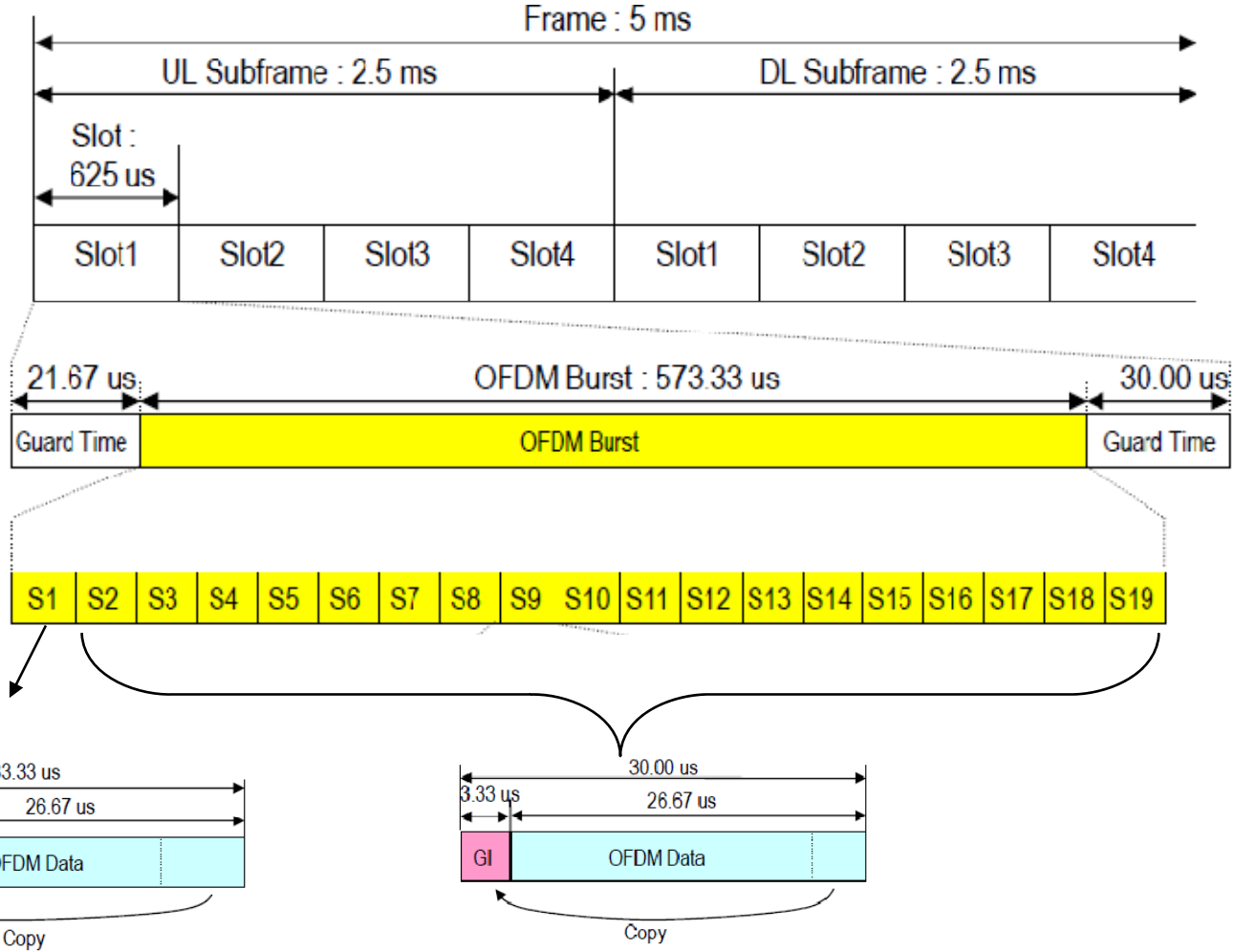
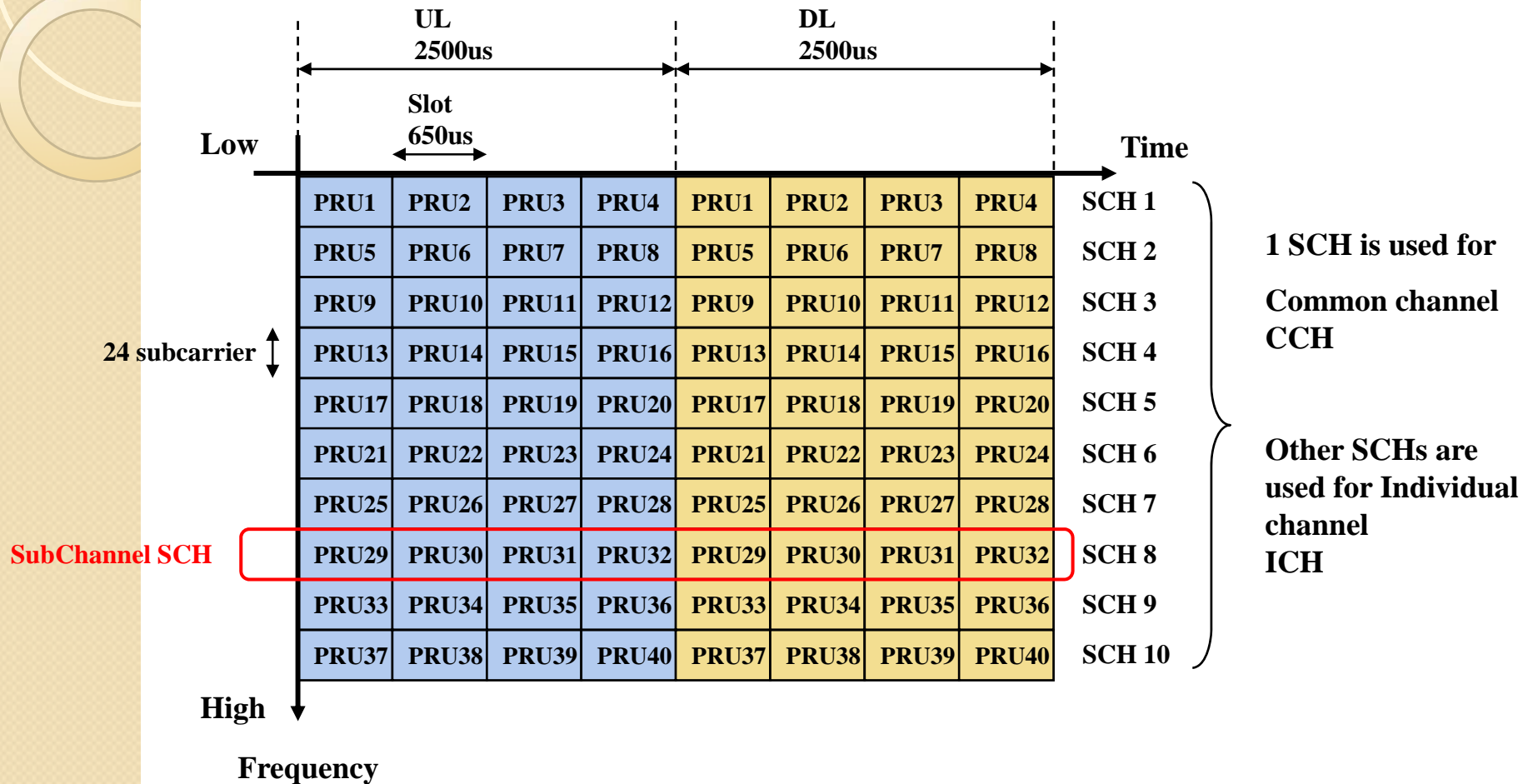


Figure 3.2 Guard Interval (S1)

Figure 3.3 Guard Interval (S2-S19)

# Frequency Domain



# Control Common Channel CCH PRU structure

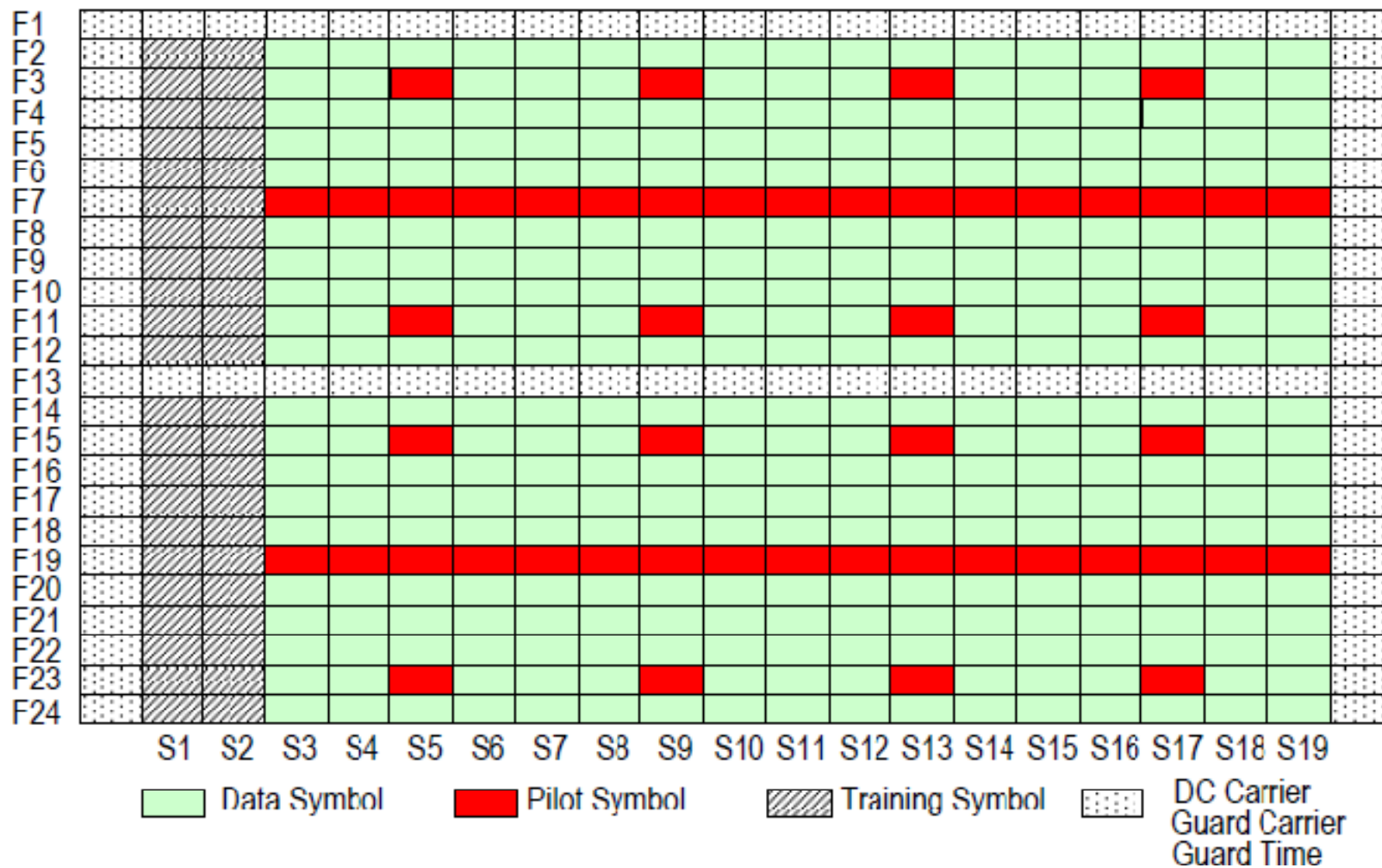


Figure 3 43 OFDM PRU Structure for CCCH

# Individual Channel ICH PRU structure

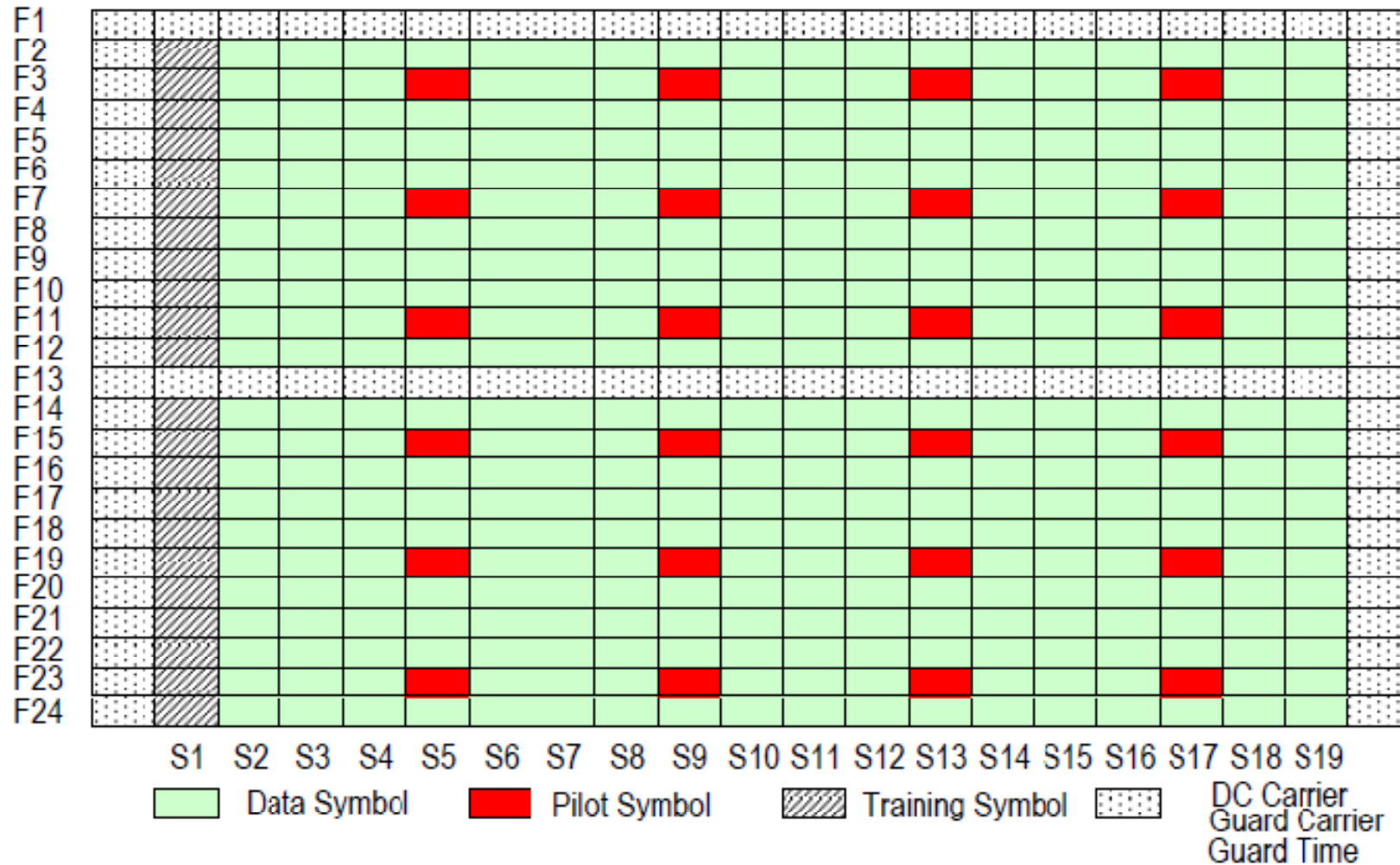
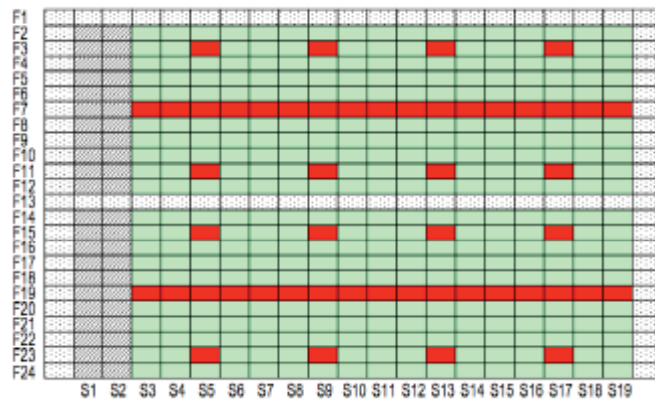


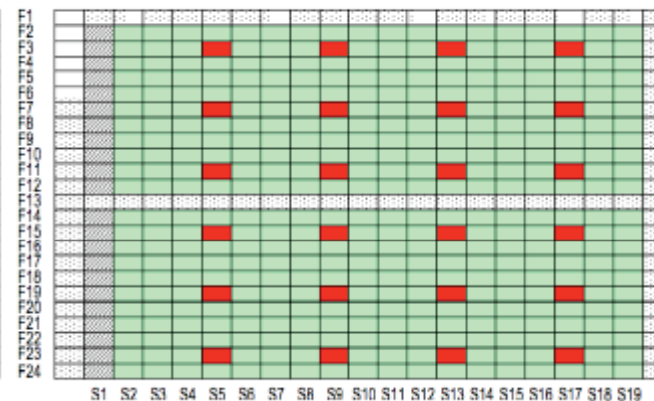
Figure 3.44 OFDM PRU Structure for ANCH

# CCH and ICH

**CCH(制御用チャンネル)**



**ICH(個人用チャンネル)**



Data Symbol
  Pilot Symbol
  Training Symbol
  DC Carrier  
Guard Carrier  
Guard Time

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



# Final Report Task

- Choose one digital system using FPGA, DSP, Processor.
- Investigate the Hardware architecture and describe it in the report.
- Dead line : Feb 13<sup>th</sup> Friday.
- Language: English or Japanese
- Send PDF file to [wada@ie.u-ryukyu.ac.jp](mailto:wada@ie.u-ryukyu.ac.jp)