Mobile Communications

TCS 455

Dr. Prapun Suksompong

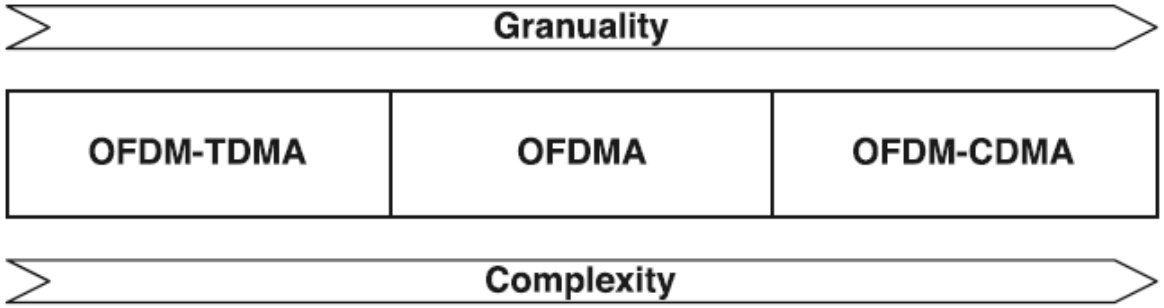
prapun@siit.tu.ac.th

Lecture 26

Office Hours:
BKD 3601-7
Tuesday 14:00-16:00
Thursday 9:30-11:30

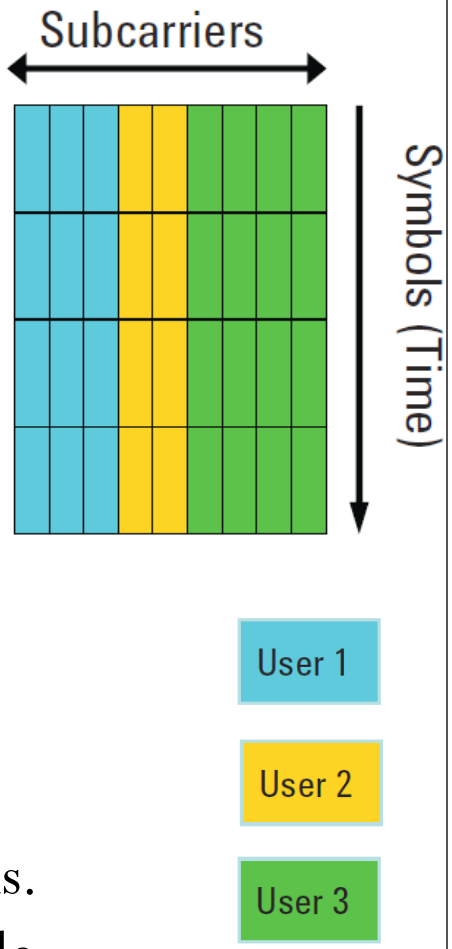
OFDM-based Multiple Access

- Three multiple access techniques
  1. OFDMA,
  2. OFDM-TDMA, and
  3. OFDM-CDMA



OFDM-TDMA

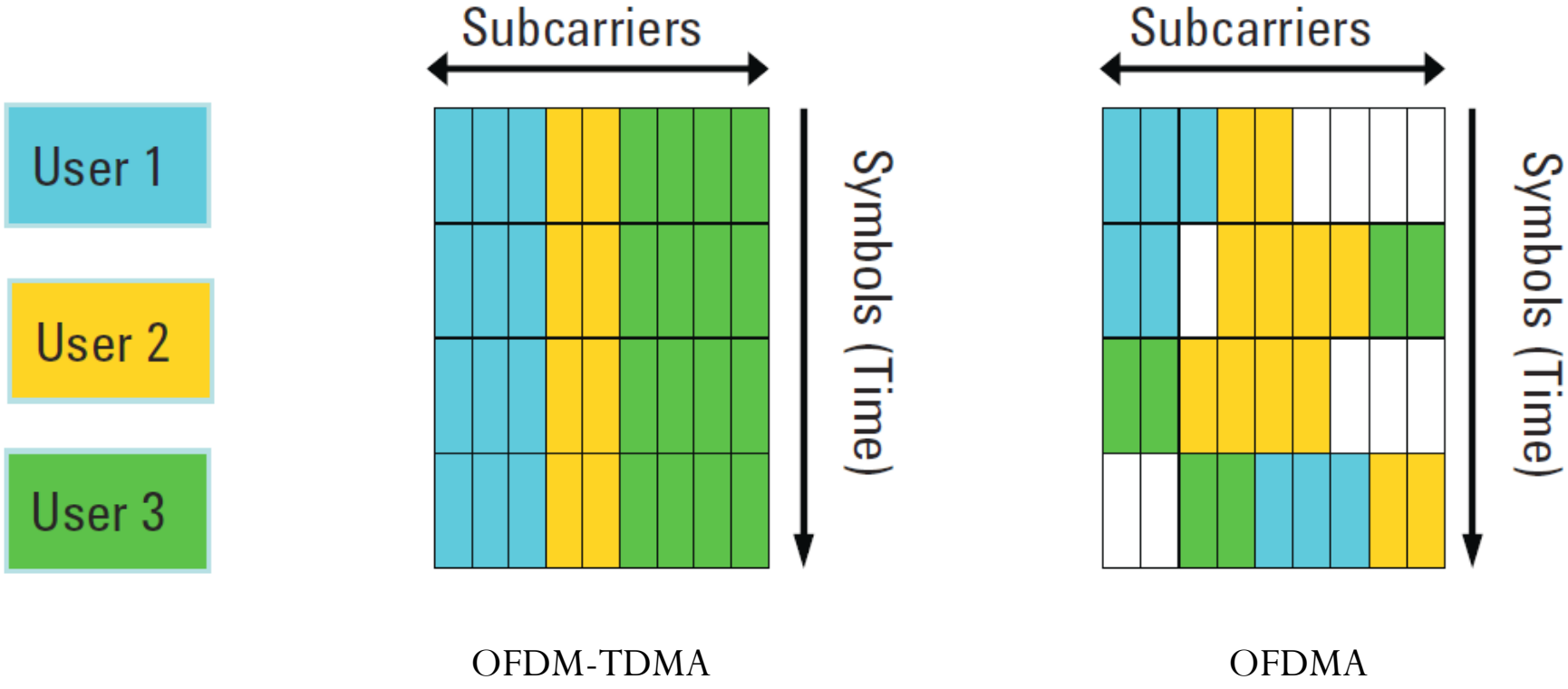
- A particular user is given all the subcarriers of the system for any specific OFDM symbol duration.
- Thus, the users are separated via time slots.
- All symbols allocated to all users are combined to form a OFDM-TDMA frame.
- Allows MS to reduce its power consumption, as the MS shall process only OFDM symbols which are dedicated to it.
- Different OFDM symbols can be allocated to different users based on certain allocation conditions.
- Since the OFDM-TDMA concept allocates the whole bandwidth to a single user, a reaction to different subcarrier attenuations could consist of leaving out highly distorted subcarriers



OFDMA

- Available subcarriers are distributed among all the users for transmission at any time instant.
- The subcarrier assignment is made at least for a time frame.
- Based on the subchannel condition, different baseband modulation schemes can be used for the individual subchannels
- The fact that each user experiences a different radio channel can be exploited by allocating only “good” subcarriers with high SNR to each user.
- The number of subchannels for a specific user can be varied, according to the required data rate.

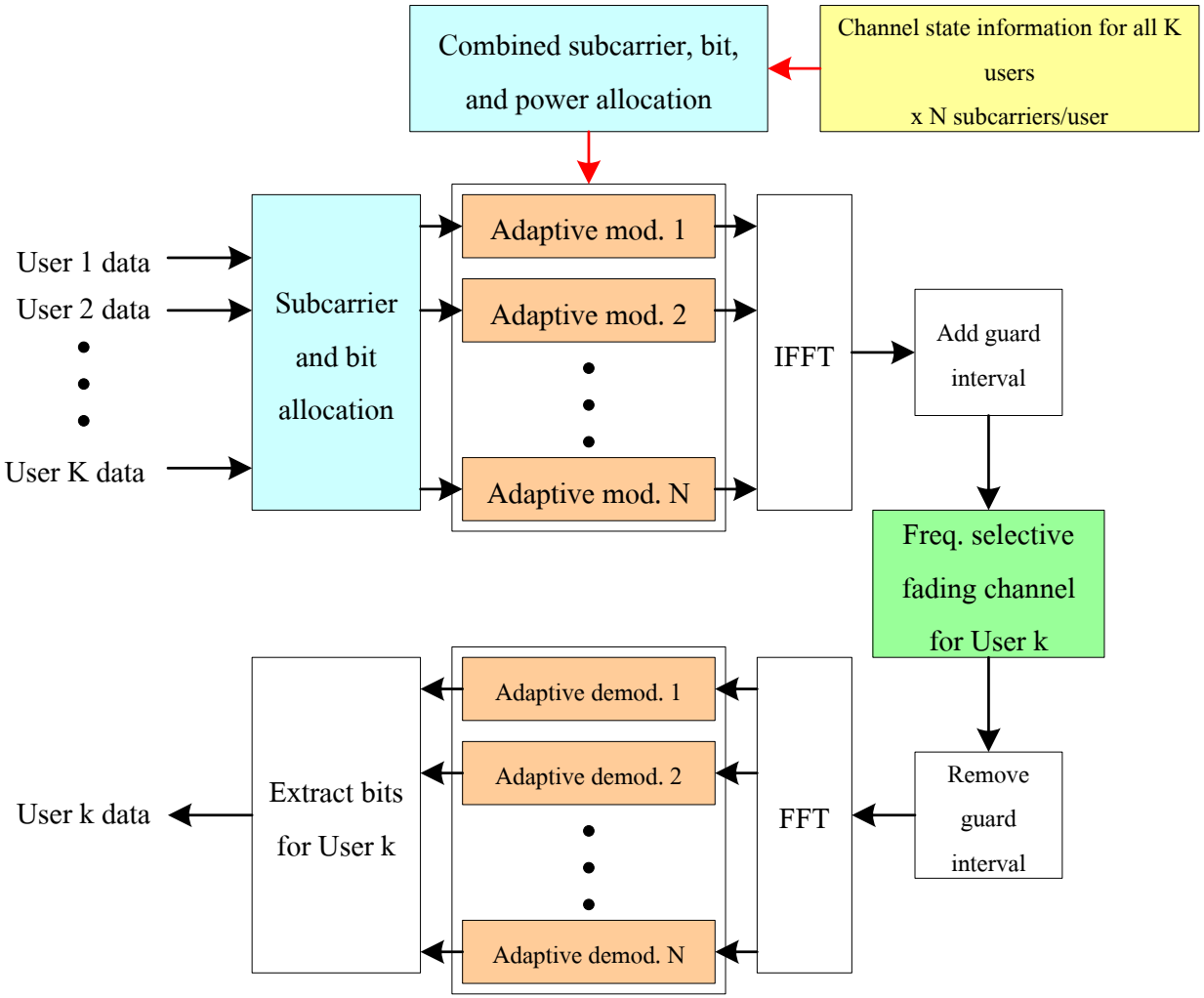
OFDM-TDMA vs. OFDMA



OFDM-TDMA

OFDMA

OFDMA Block Diagram



OFDM-CDMA

- User data are spread over several subcarriers and/or OFDM symbols using spreading codes, and combined with signal from other users.
- Several users transmit over the same subcarrier. In essence this implies **frequency-domain spreading**, rather than time-domain spreading, as it is conceived in a DS-CDMA system.

Chapter 6

Applications: WiMAX

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WiMAX

- WiMAX = Worldwide Interoperability for Microwave Access
- Provide wireless data over long distances.
- TG proceedings can be found at http://ieee802.org/16/tge/index.html.
- Certification is done by the WiMAX Forum (www.wimaxforum.org)
- Oct 2007: ITU officially approved WiMAX as part of the 3G standard. It is the first non-cellular tech to get approval as 3G.
- IEEE 802.16
  - Completed in 2001
  - Intended primarily for telecom backhaul applications in point-to-point line-of-sight configurations using spectrum above 10 GHz.
  - Use a radio interface based on a single-carrier waveform.

“Fixed” WiMAX

- 802.16-2004 based systems
- Fixed broadband wireless MAN
- Added multiple radio interfaces, including one based on OFDM-256 and one based on **OFDMA**.
- Support point-to-multipoint communications, sub-10 GHz operation, and non-line-of-sight communications.
- Potential applications include wireless Internet Service Provider (ISP) service, local telephony bypass, as an alternative to cable modem or DSL service, and for cellular backhaul for connections from cellular base stations to operator infrastructure networks.

“Mobile” WiMAX

- Used to describe 802.16e-2005 based systems.
- 802.16e-2005 = 802.16-2004 standard + 802.16e amendment
- Specify **scalable** OFDM for the physical layer and makes further modifications to the MAC layer to accommodate high-speed mobility
- Adds **mobility** capabilitie including support for radio operation while mobile, handovers across base stations, and handovers across operators.
- Not backward-compatible with IEEE 802.16-2004 networks
- Employ many of the same mechanisms as HSPA to maximize throughput and spectral efficiency, including high-order modulation, efficient coding, adaptive modulation and coding, and Hybrid Automatic Repeat Request (HARQ).
- The principal difference from HSDPA is the use of **OFDMA**.
  - OFDM systems exhibit greater orthogonality on the uplink, so IEEE 802.16e-2005 may have slightly greater uplink spectral efficiency than even HSUPA.

Trend

- WiMAX has emerged as a potential alternative to cellular technology for wide-area wireless networks.
- WiMAX is trying to challenge existing wireless technologies—promising greater capabilities and greater efficiencies than alternative approaches such as HSPA.
- But as WiMAX, particularly mobile WiMAX, has come closer to reality, vendors have continued to enhance HSPA, and actual WiMAX advantages are no longer apparent.
- Any potential advantages certainly do not justify replacing 3G systems with WiMAX.
- Instead, WiMAX has gained the greatest traction in developing countries as an alternative to wireline deployment.

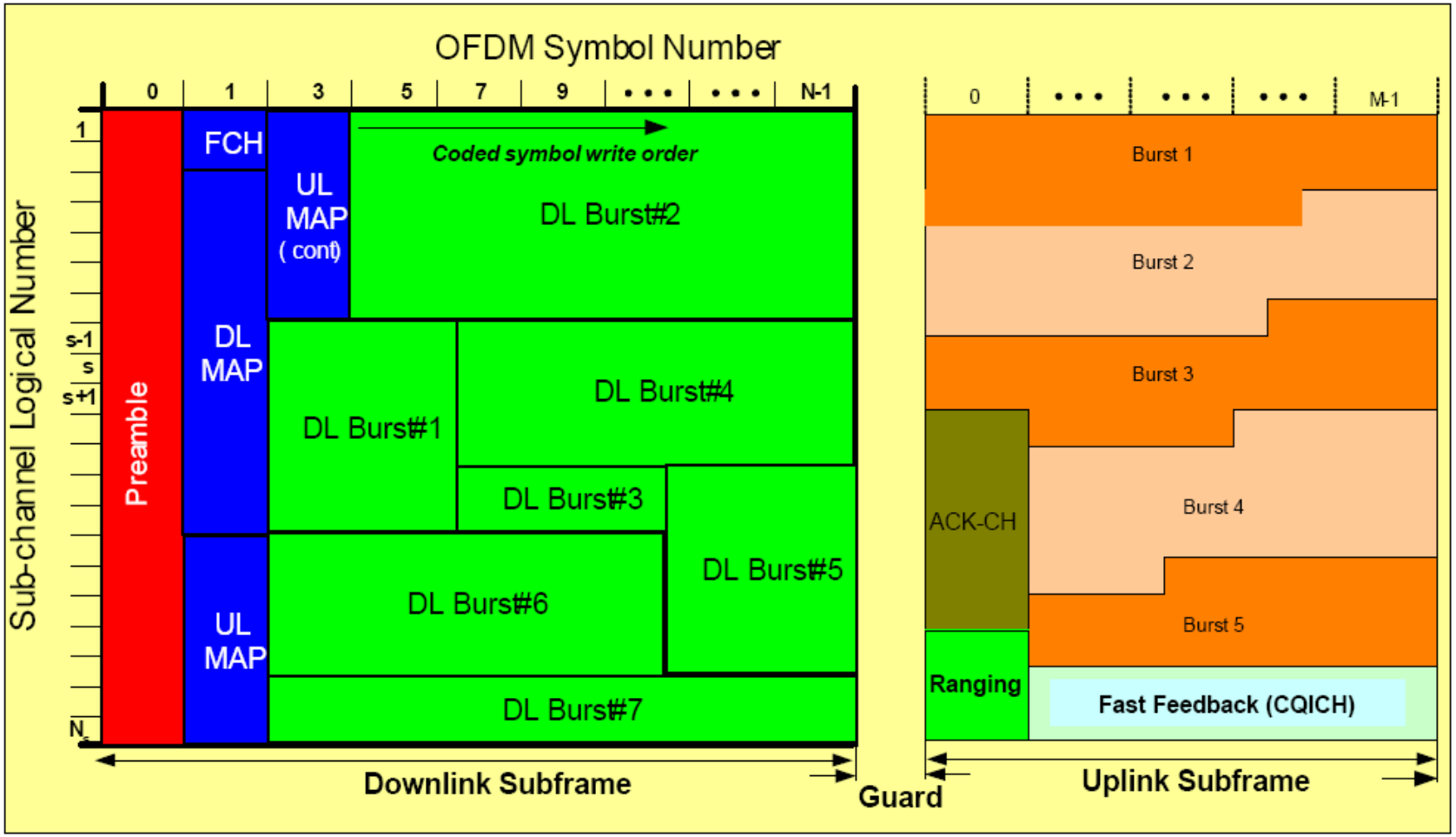
OFDMA

- Orthogonal Frequency Division Multiple Access.
- The multi-user version of OFDM
  - Dynamically assign subset of subcarriers to individual users for intervals of time.
- WiMAX is the first cellular standard that employs OFDMA.
- Large number of sub-carriers (up to $2^{11} = 2048$).

Resource Allocation

- Active (data and pilots) sub-carriers are grouped into subsets of subcarriers called **subchannels**.
- Subchannels are further grouped into **bursts** which can be allocated to wireless users.
- Each burst allocation can be changed from frame to frame.
- This allows the BS to dynamically adjust the bandwidth usage according to the current system requirements.
- Based on feedback about the channel conditions, the system can implement adaptive user-to-subcarrier assignment.
  - As long as these subcarrier assignments are executed quickly, fast fading and narrow-band co-channel interference performance is improved compared to OFDM.
  - This, in turn, improves system spectral efficiency.

OFDM frame structure (TDD)



Scalable OFDMA (S-OFDMA)

- A multiple-access/multiplexing scheme
- Provide
  - multiplexing operation of data streams from multiple users onto the downlink sub-channels and
  - uplink multiple access by means of uplink sub-channels.
- Support scalable channel BWs from 1.25 to 20 MHz (to comply with varied worldwide requirements).
- The FFT size is scalable from 128 to 2,048.
  - When the available bandwidth increases, the FFT size is also increased such that the **subcarrier spacing is always 10.94kHz**.
  - This keeps the OFDM symbol duration, which is the basic resource unit, fixed and therefore makes scaling have minimal impact on higher layers.
- Allow for the data rate to scale easily with available channel bandwidth.