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School of Electrical Engineering & Computer Science

Performance Evaluation of OFDMA and Multicarrier CDMA Systems on Airport Surface Area Channels

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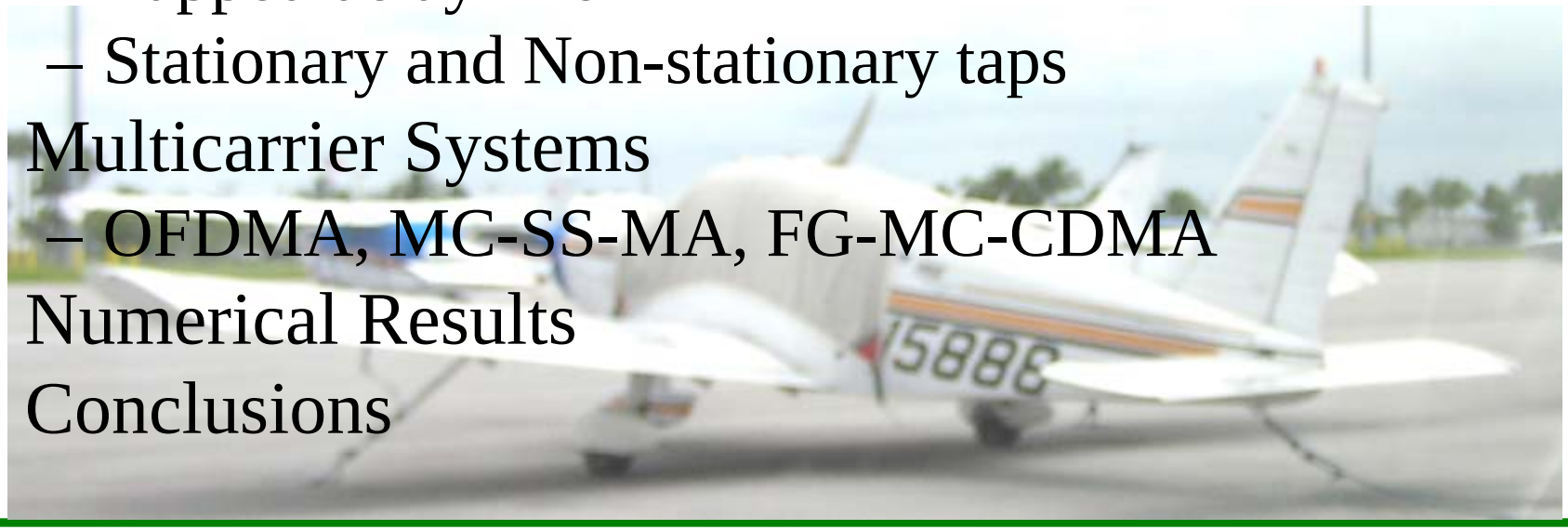
Outline

- Introduction/background
  - Importance of performance evaluation on airport surface area channels
  - Multiple choices of systems, i.e. 802.16e system
- Channel model
  - Tapped delay line
  - Stationary and Non-stationary taps
- Multicarrier Systems
  - OFDMA, MC-SS-MA, FG-MC-CDMA
- Numerical Results
- Conclusions

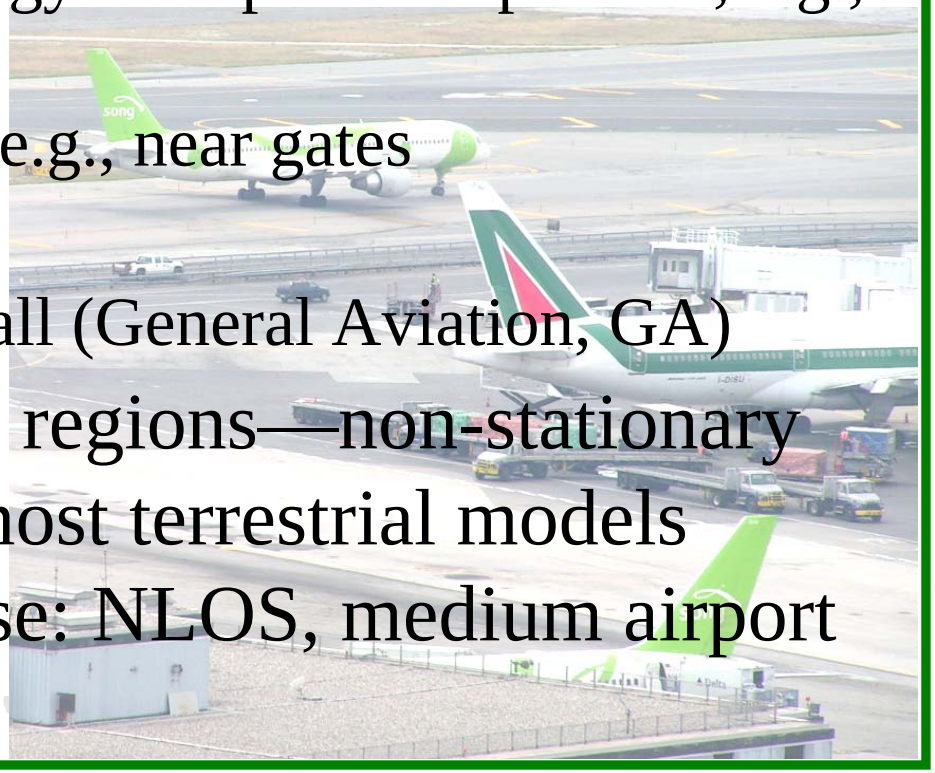


Introduction

- Increasing communication demands on ASA
  - MLS extension band, 5.091-5.15 GHz, primary candidate for deploying new communication system
- ACAST channel characterization project
  - Stochastic channel models for E-MLS band
  - Enables system performance evaluations in realistic channel conditions
- OFDM/OFDMA/MC-SS commercially popular
  - 802.16e (“WiMAX), MC-CDMA, MC-SS-MA
  - New systems, i.e. FG-MC-CDMA

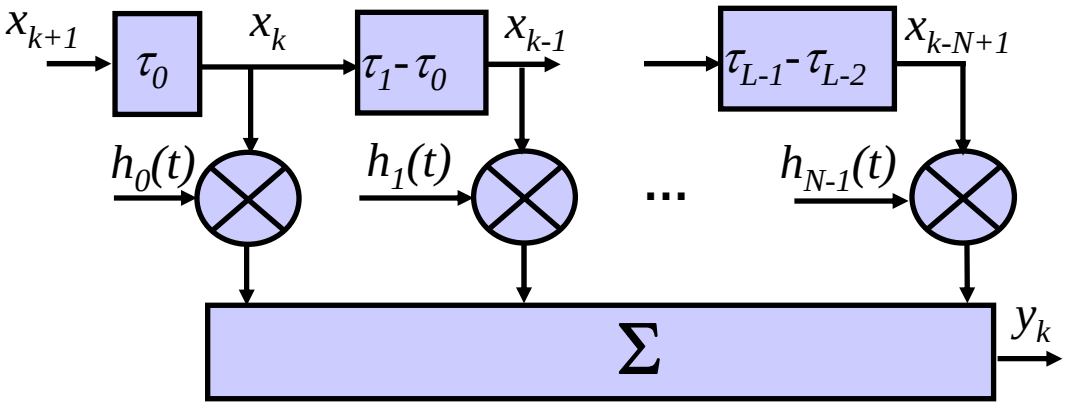
Airport Environment Description

- Airport surface area classification
  - LOS-O: Open areas, e.g., runways, some taxiways
  - NLOS-S: mostly NLOS w/dominant specular component plus low energy multipath components, e.g., near terminals
  - NLOS: obstructed LOS, e.g., near gates
- Airport sizes
  - Large, Medium, and Small (General Aviation, GA)
- Aircraft inhabit all three regions—non-stationary channel, in contrast to most terrestrial models
- We focus on ~ worst case: NLOS, medium airport



Tapped Delay Line Channel Model

- Tapped delay line structure



$$h_k(t) = z_k(t)\alpha_k(t)e^{j\phi_k(t)}$$

– Weibull *pdf* for $\alpha_k(t)$: $p_w(r) = \frac{\beta}{a^\beta} r^{\beta-1} exp\left[-\left(\frac{r}{a}\right)^\beta\right]$

β: shape factor; determines fading severity

a: scale factor $= \sqrt{E\left(r^2\right)/\,\Gamma\left([\,2/\beta\,]+1\right)}$

– $z_k(t)$ is a 2-state, first-order Markov model

Criteria for Channel Models

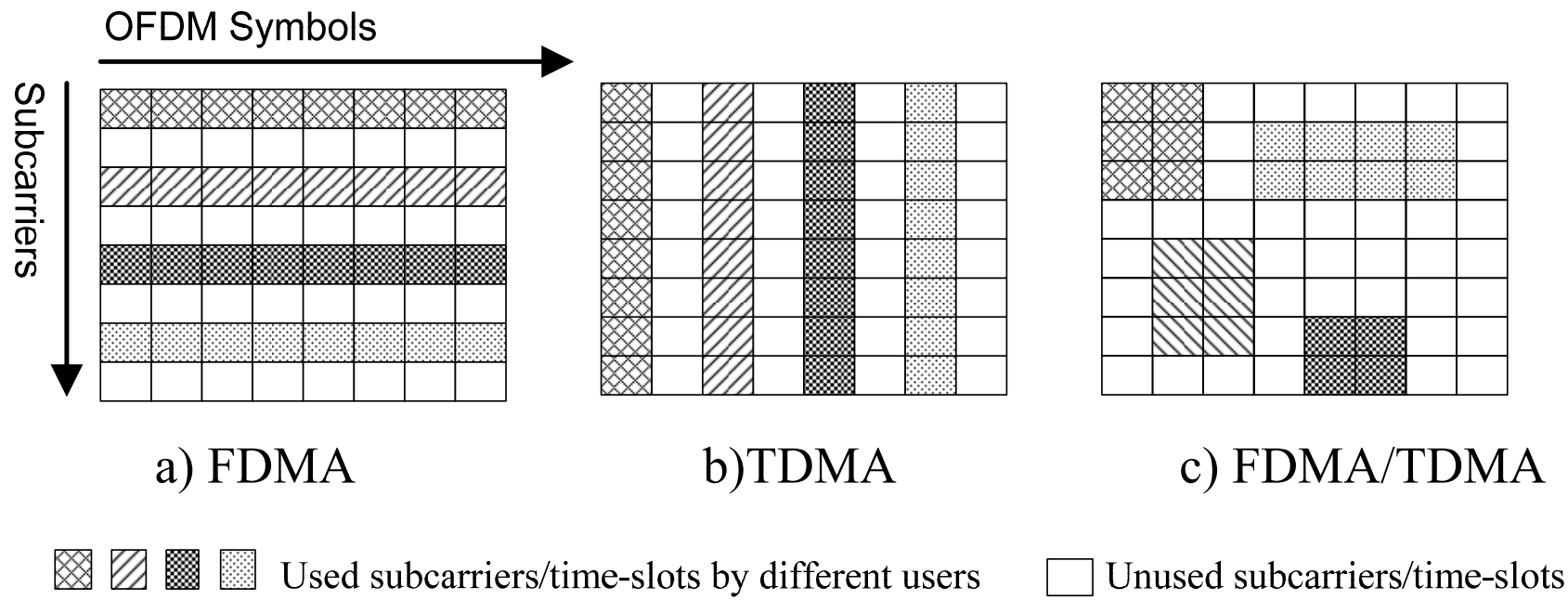
- Number of taps (*N)*
  - Criterion 1: *Mean RMS delay spread*
  - Criterion 2: *Maximum duration of the CIR*
- Aggregate energy
  - Criterion 1: For NLOS, 95% aggregate energy
  - Criterion 2: All taps, i.e., 100% aggregate energy
- Non-Stationary/Stationary
  - Criterion 1: Persistence process and correlation among taps
  - Criterion 2: No Persistence process, uncorrelated taps

Different Channel Models

- Model-1 (M1)
  - Number of taps: *Mean RMS-DS*
  - Aggregate Energy: 95%
  - Non-Stationary taps
- Model-2 (M2)
  - Number of taps: *Maximum duration of CIR*
  - Aggregate Energy: 100%
  - Non-Stationary taps
- Model-3 (M3)
  - Number of taps: *Maximum duration of CIR*
  - Aggregate Energy: 100%
  - Stationary taps

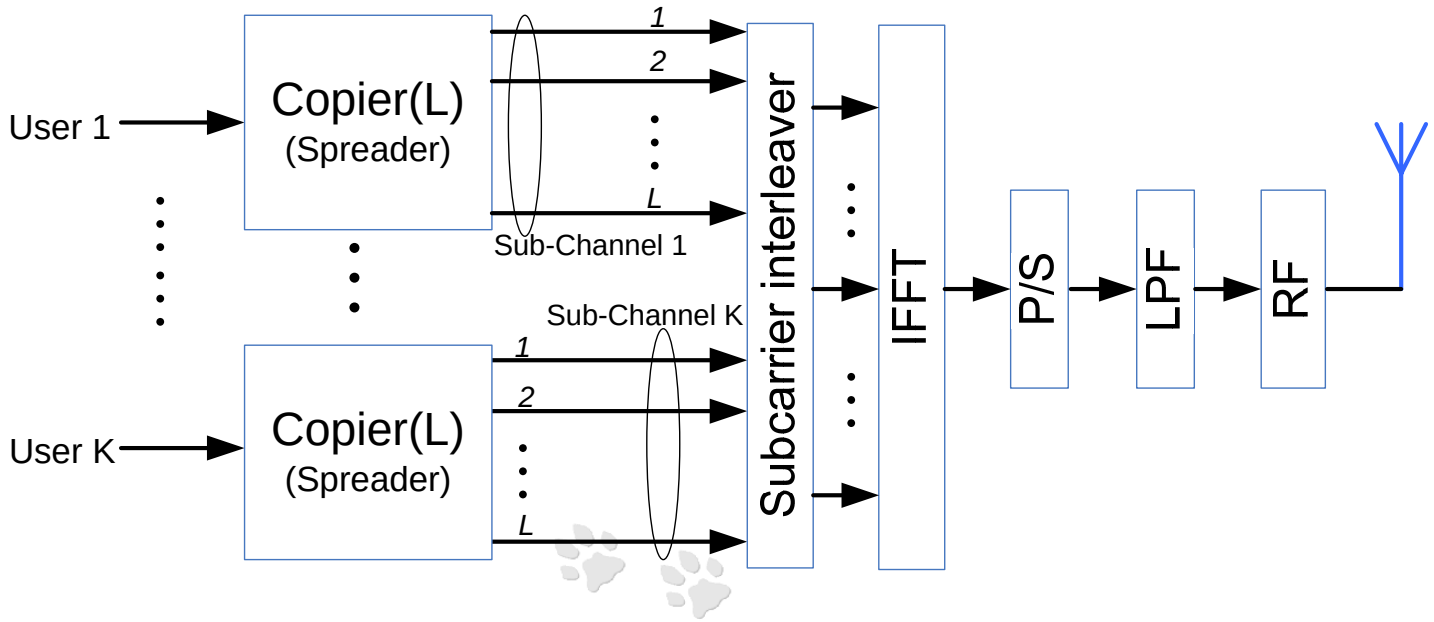
OFDMA System

- Complex radio resource allocation in 802.16e
- General multiple access for OFDM/OFDMA



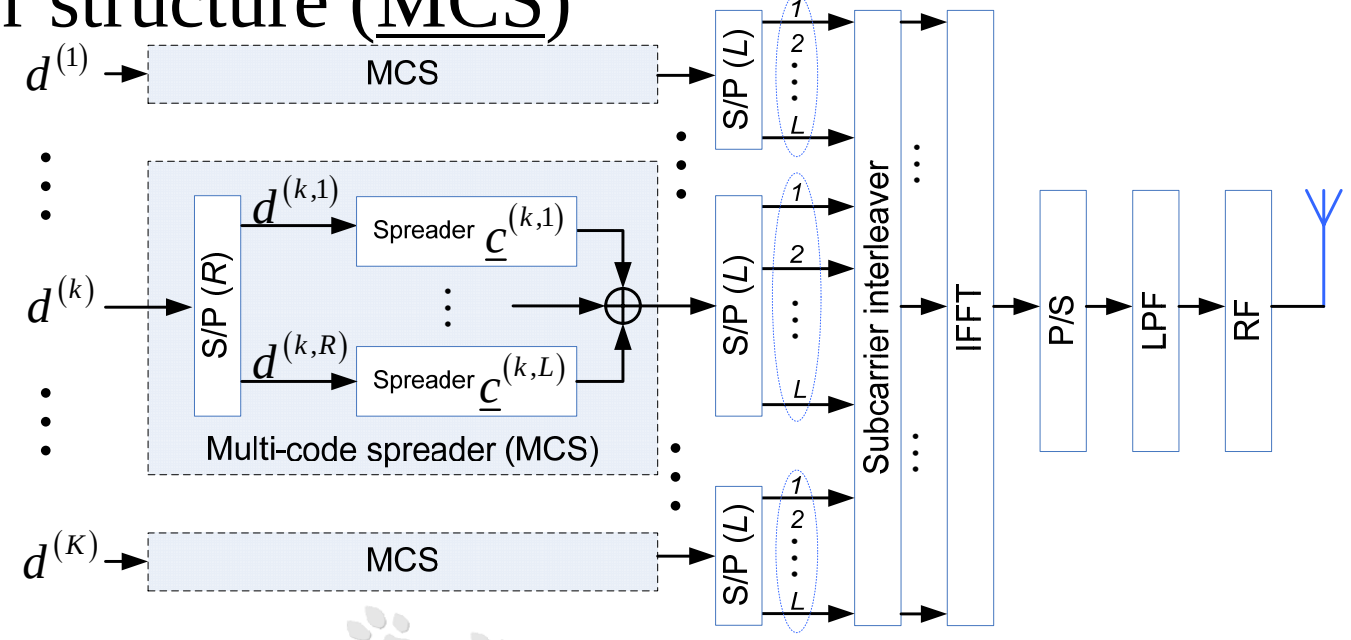
OFDMA with Repetition Code

- Resource allocation
  - FDMA: group of subcarriers dedicated exclusively to one user
  - TDMA: frame based transmission
- Transmitter structure



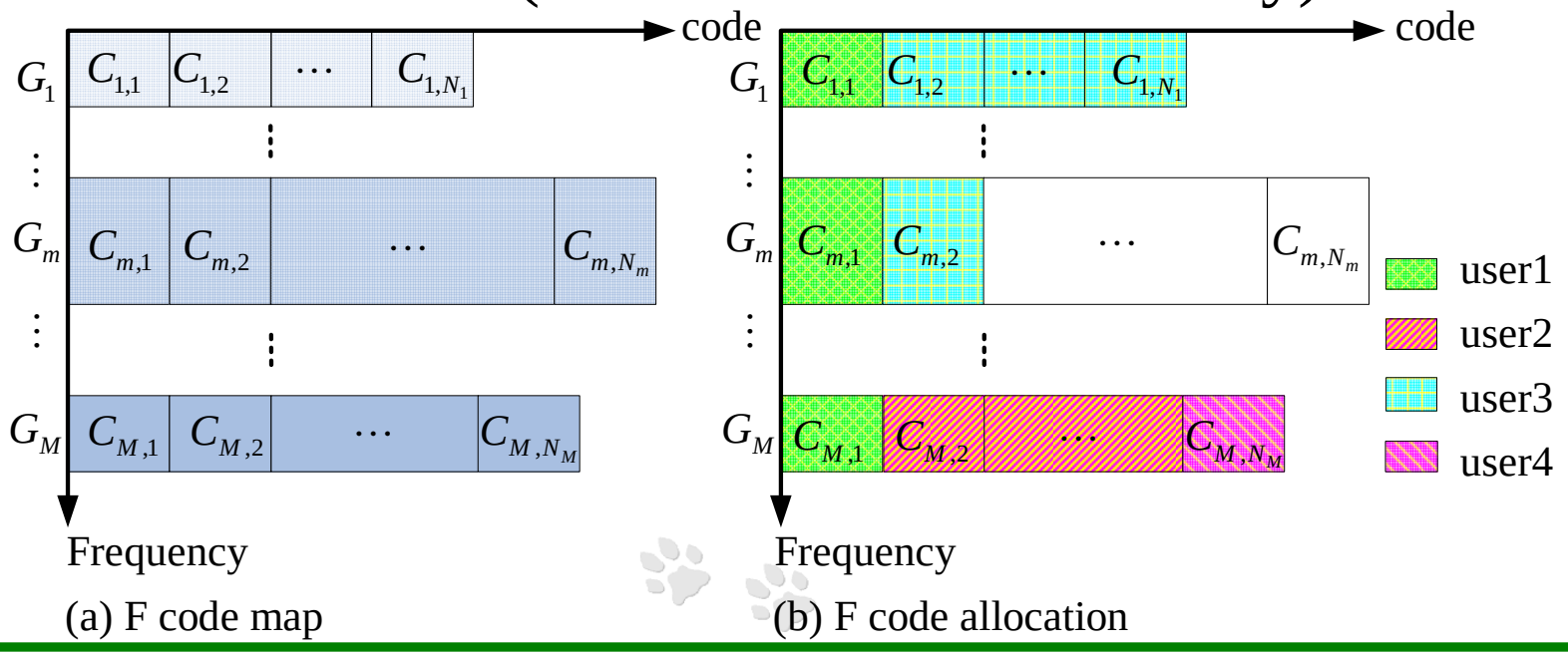
SS-MC-MA

- Resource allocation
  - FDMA/CDM: group of subcarriers dedicated exclusively to one user, CDM for data rate increase
  - TDMA: frame based transmission
- Transmitter structure (MCS)



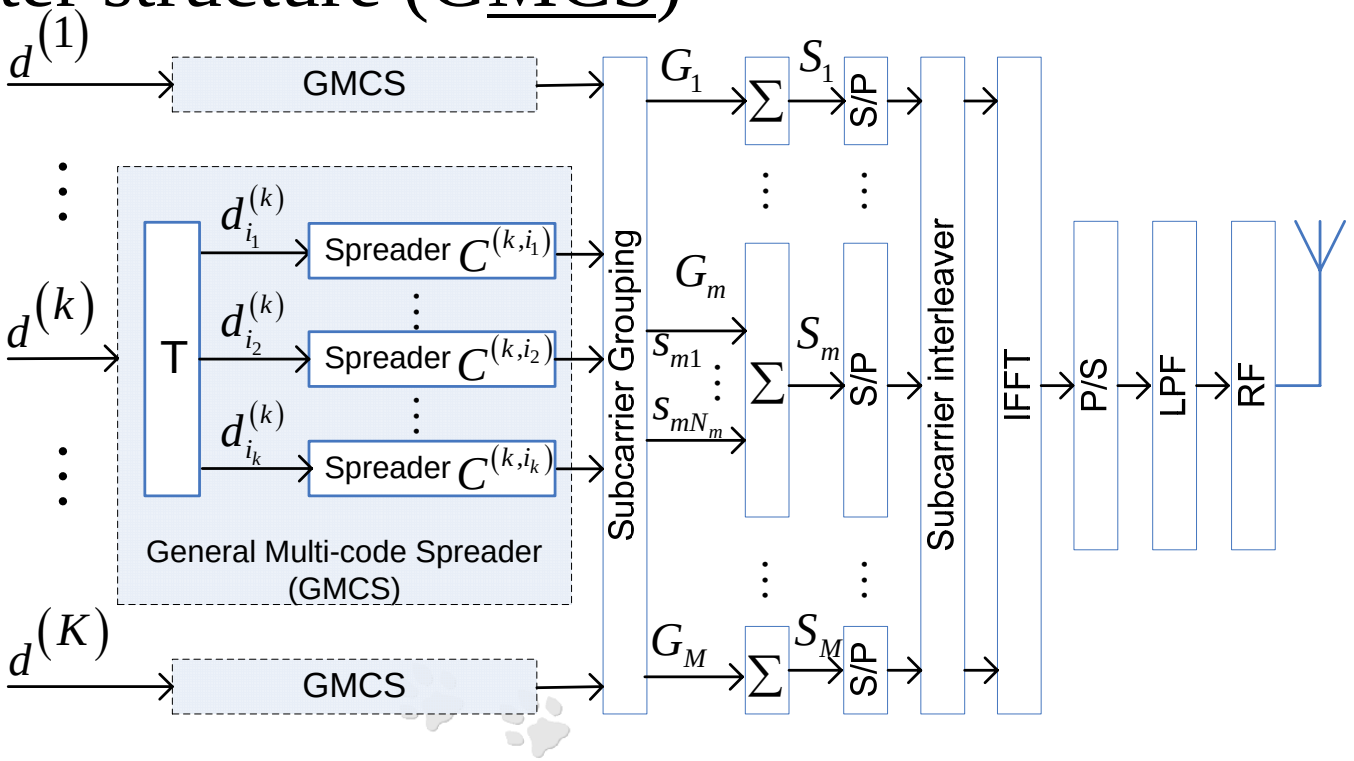
FG-MC-MA (1/2)

- Resource allocation
  - Subcarrier grouping and code-selection
    - Group m has N_m codes of length L_m
  - F code allocation
  - Data allocation (users' choice—flexibility)

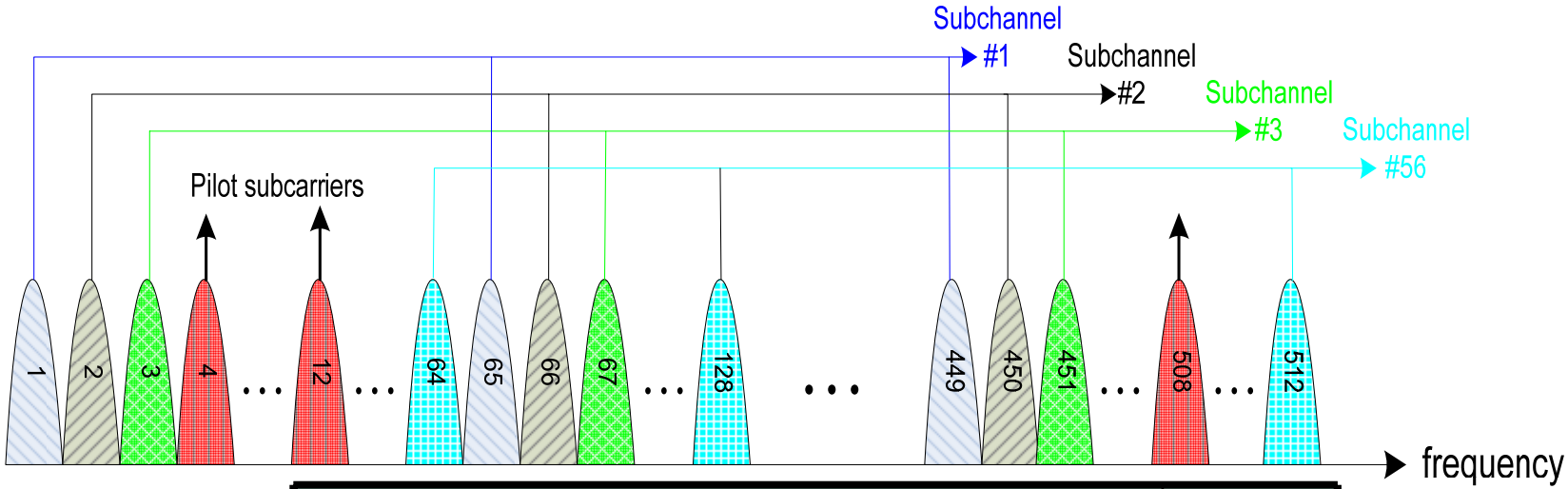


FG-MC-MA (2/2)

- Resource allocation
  - Combination of FDMA with MC-CDMA
  - TDMA: frame based transmission
- Transmitter structure (GMCS)



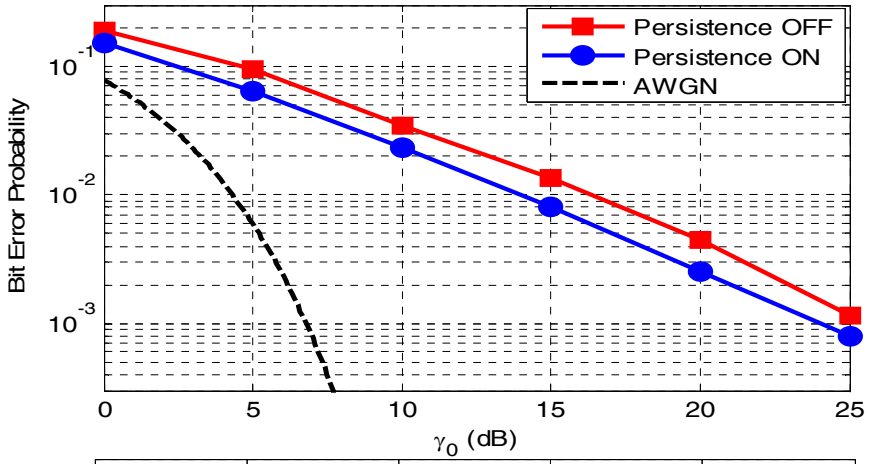
Simulation Parameters

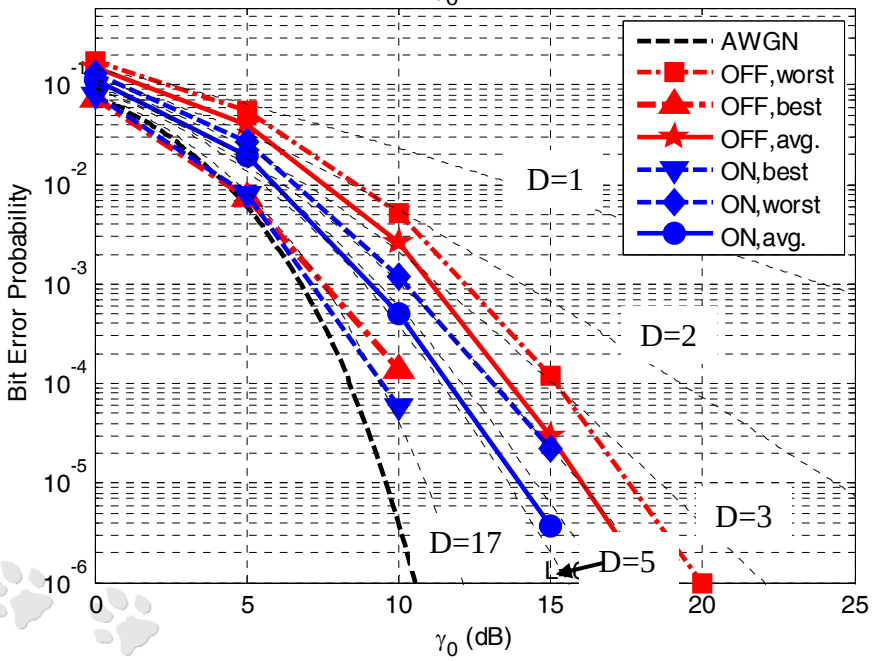


Parameter	Value
Bandwidth BW (*MHz*)	10
Number of subcarriers N	512
Number of data subcarriers N_d	448
Number of subchannels N_{ch}	56
Number of subcarriers per subchannel J	8
Basic OFDM symbol duration T_b (μs)	51.2
Cyclic prefix duration T_g (μs)	1.6
Number of OFDM symbols per frame N_s	50

Numerical Results (1)

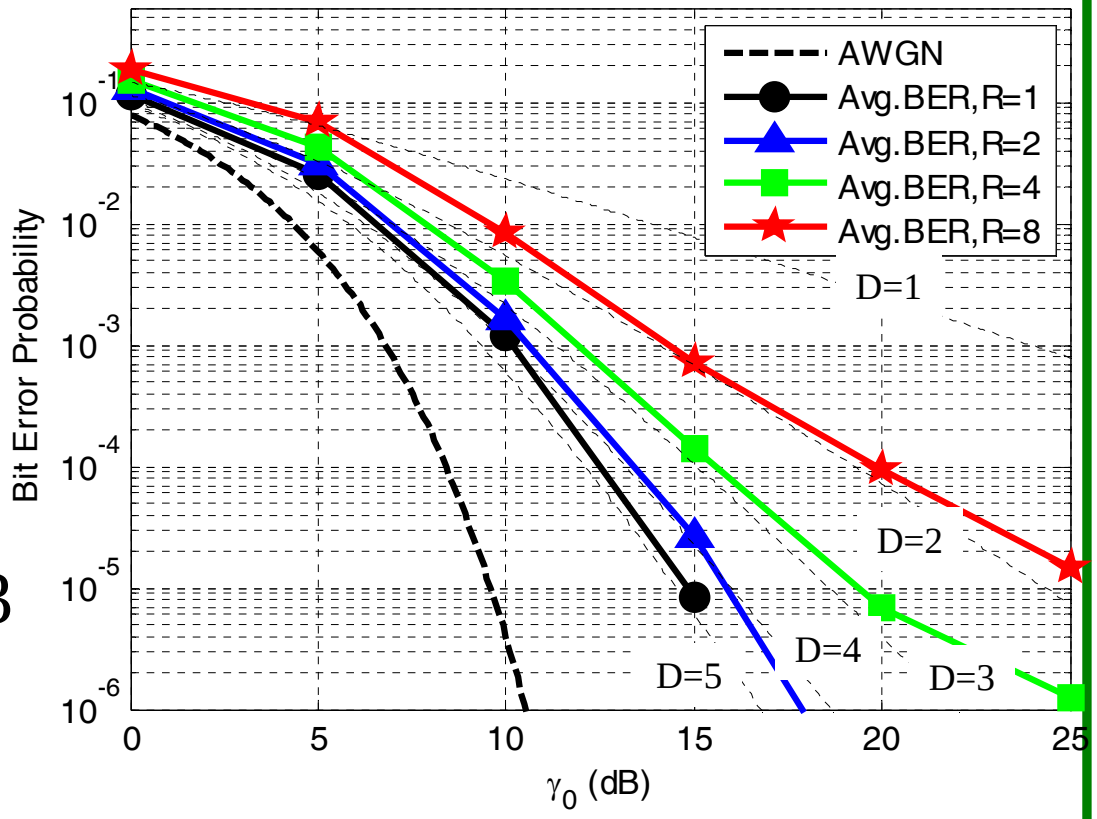
- Basic OFDM
- OFDMA with repetition code
  - 56 users (R=1)
  - Persistence ON M2
  - Persistence OFF M3 (WSSUS)





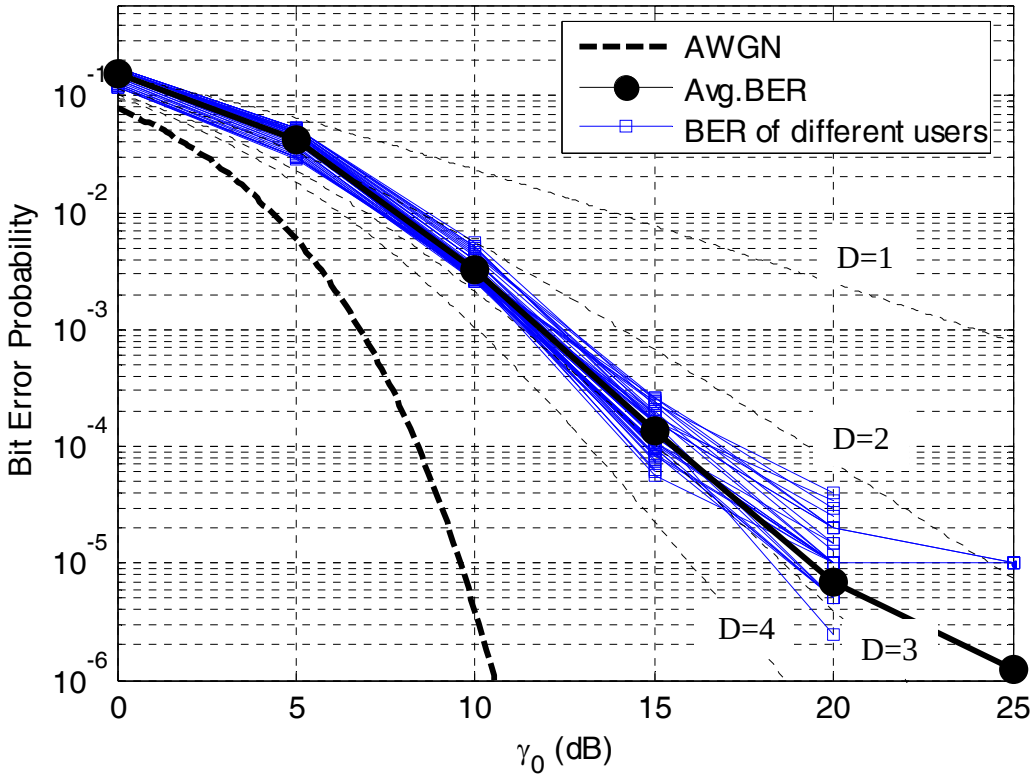
Numerical Results (2)

- SS-MC-MA
  - 56 users (R=1, 2, ..,8)
  - Equal to OFDMA w/rep code when R=1
  - M2 results here
  - M2 better than M3



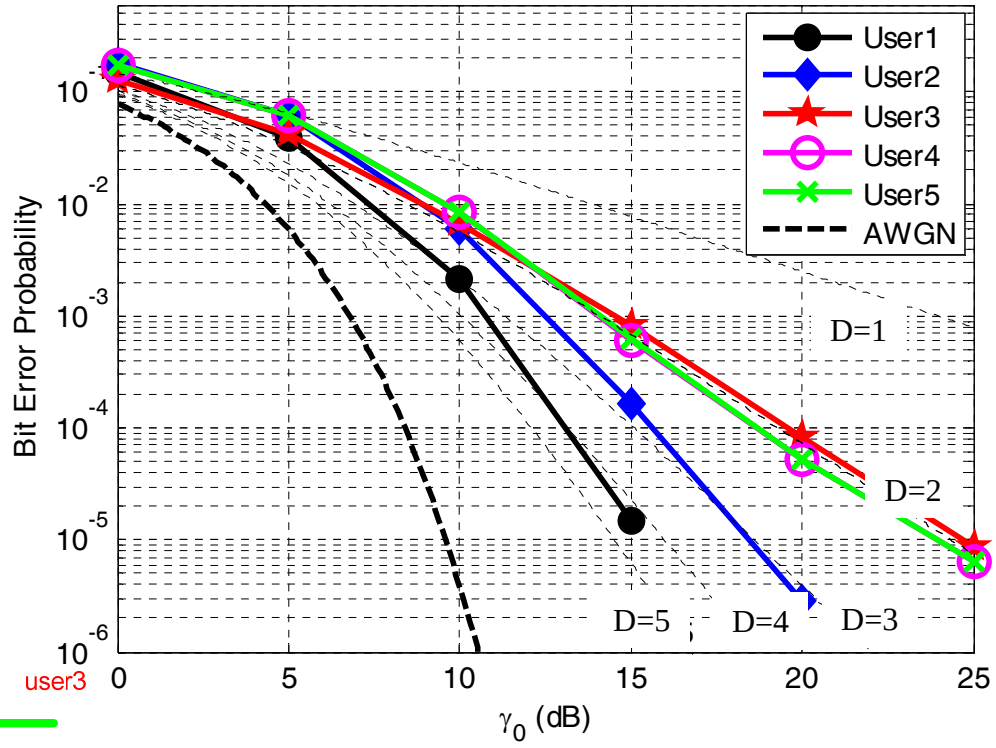
Numerical Results (3)

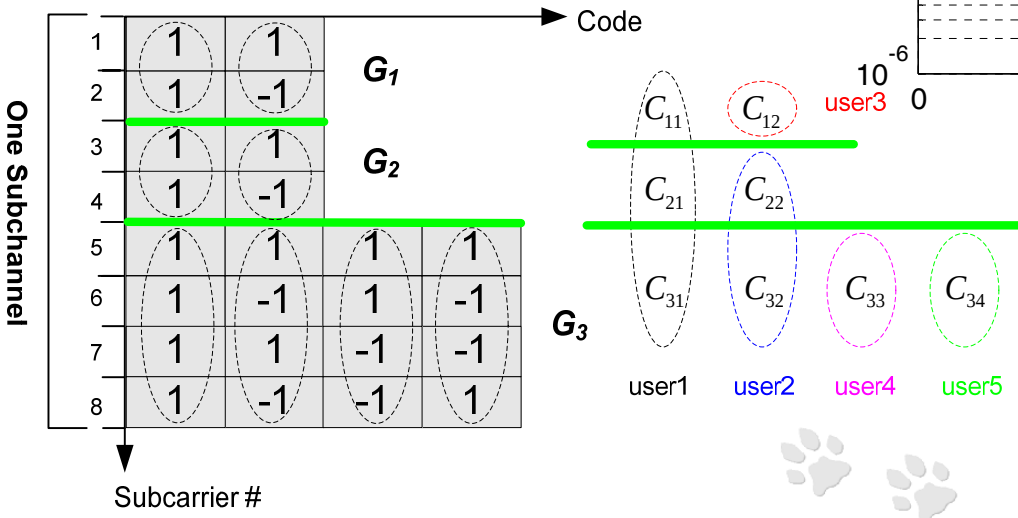
- SS-MC-MA (R=4)
  - Different users from different sub-channels have different performance



Numerical Results (4)

- FG-MC-CDMA
  - 5 users (R=56), or equivalently 5×56 users (R=1)
  - Code allocation in one subchannel





Conclusions

- Objective-oriented design of different MC-SS
  - Best performance/lowest data rate = OFDMA with coding
  - Increased data rate/performance, complexity = MC-SS-MA
  - Most flexibility in terms of both date rate and performance/complexity=FG-MC-CDMA
- Transceiver designs can use a common platform for upgrades/flexibility
- Lack of standardization advantage versus 802.16e OFDMA
- Further evaluation required to assess other considerations, e.g. channel estimation