

Downlink Multiple Access and Multiplexing for Evolved UTRA

R1-050438

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Samsung Electronics Co. Ltd.

Downlink Multiple Access and Multiplexing

1. Working Assumptions and Design Criteria
2. Possible Options for Downlink MA and Multiplexing
3. An option of Frequency Domain Spreading with Code Multiplexing
4. Preliminary Simulation Data for the Options
5. Recommendations on Downlink MA and Multiplexing

- OFDMA based system
- Support of scalable BW up to 20 MHz
- FDD (Frequency Division Duplexing) system
- TTI length: 0.67ms
- Support of fast packet scheduling as often as TTI
- Support of HARQ
- Support of AMC
- Frequency Reuse Factor: 1
 - For cell edge users, effective reuse could be larger than one
- Support of mobile speed up to 350 km/h

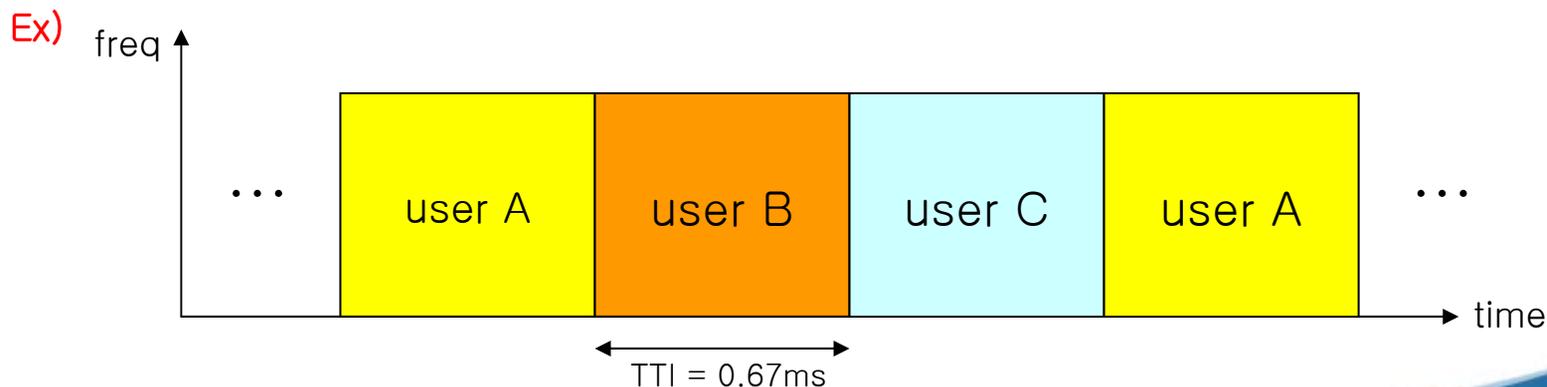
- Design goal is to meet the requirements on high spectral efficiency and low latency
- A System has to efficiently support various kinds of traffic types and mobile environments with minimum overheads in both DL and UL:
 - Real-time, near real-time, delay tolerant services
 - Different mobile speeds
 - Various Multi-path environments
- We consider three dimensions, i.e., frequency, time and code domains in terms of “Multiple Access and Multiplexing”

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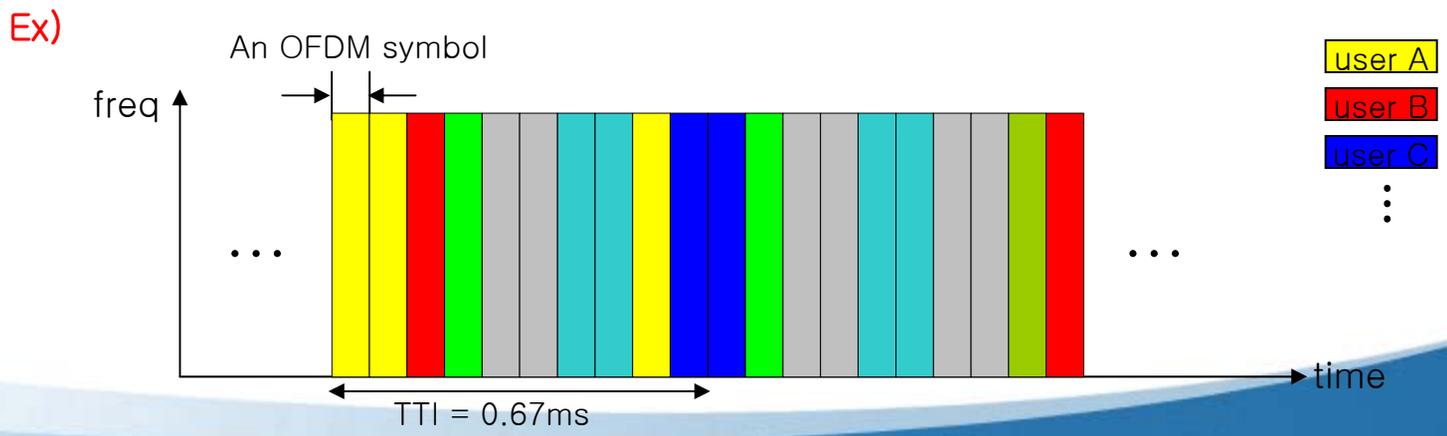
Possible Options for Downlink MA (1/5)

- TDMA TTI by TTI
 - One user is scheduled for each TTI
 - Pros
 - Minimum DL/UL control overhead
 - Cons
 - Inefficient to convey small packets
 - Cannot utilize Multi-User Diversity in frequency domain
 - Could be applied to:
 - The bulk of the traffic



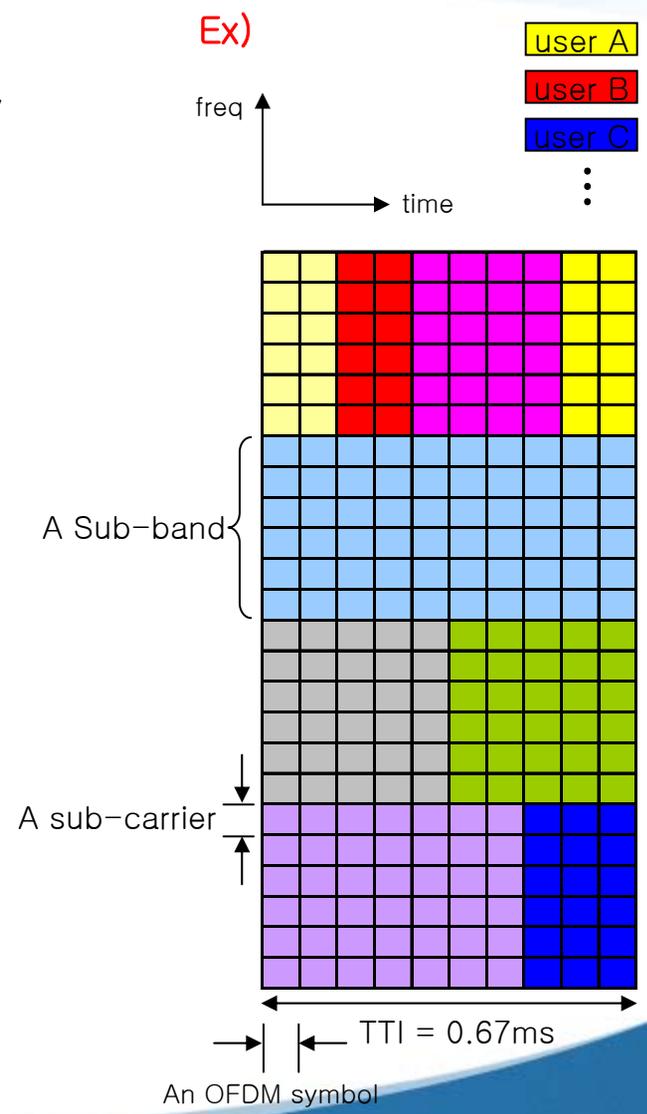
Possible Options for Downlink MA (2/5)

- TDMA within a TTI
 - One or multiple OFDM symbols can be assigned to different users
 - Pros
 - Frequency Diversity within a TTI
 - Maybe less receiver complexity in terms of FFT operation
 - More efficient than “TDMA TTI by TTI” in conveying small packets
 - Cons
 - Cannot utilize Time diversity within a TTI, especially for high speed users (How much ? See the simulation data)



Possible Options for Downlink MA (3/5)

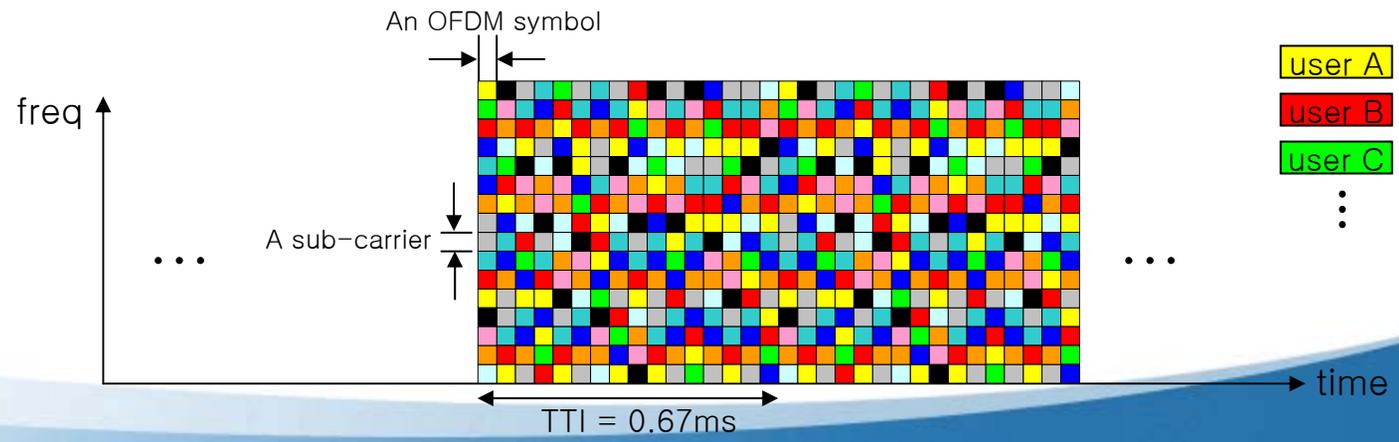
- FDMA within a TTI
 - Called as “**FS(Frequency Scheduling) mode**” for convenience sake
 - Total system BW is divided into N sub-bands where each sub-band has a group of contiguous sub-carriers
 - One or multiple sub-bands can be allocated to an user
 - A sub-band could be allocated to one or multiple users in TDM manner for small packets
 - Pros
 - To exploit Multi-user Diversity gain in the frequency domain
 - Cons
 - More UL feedback overhead compared to TDMA approach
 - Could be applied to :
 - Low speed users



Possible Options for Downlink MA (4/5)

- Frequency Hopping
 - Called as “**TFD(Time-Frequency Diversity) mode**” for convenience sake
 - Pros
 - Fully achieve time and frequency diversity within a TTI
 - Best performance for high speed users due to diversity gain
 - Cons
 - Cannot utilize frequency scheduling gain
 - Could be applied to:
 - High speed users
 - Applications to which full time-freq diversity is required, such as Common Control Channels

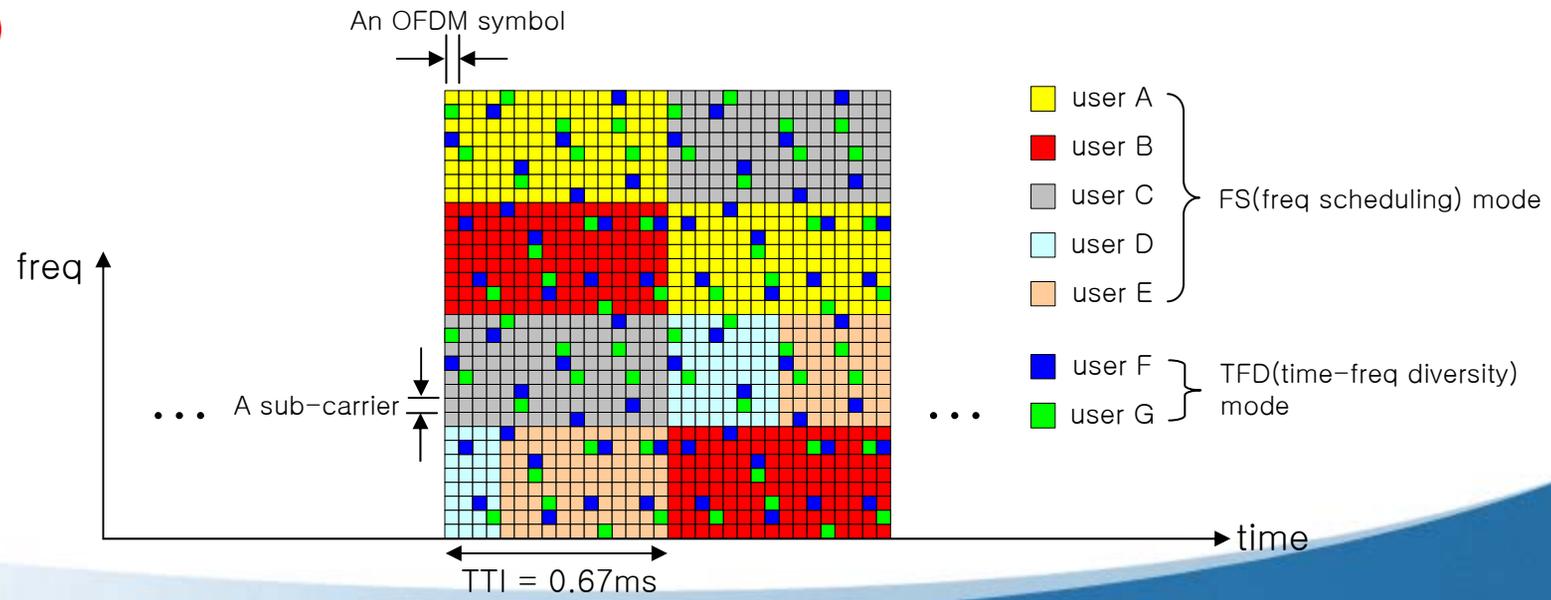
Ex)



Possible Options for Downlink MA (5/5)

- Hybrid FD/FS mode
 - Pros
 - Muxing of high and low speed users
 - Best performance for high and low speed users
 - Fully achieve time and frequency diversity within a TTI for high speed users
 - Frequency scheduling gain for low speed users
 - Could be applied to:
 - Muxing of high and low speed users

Ex)

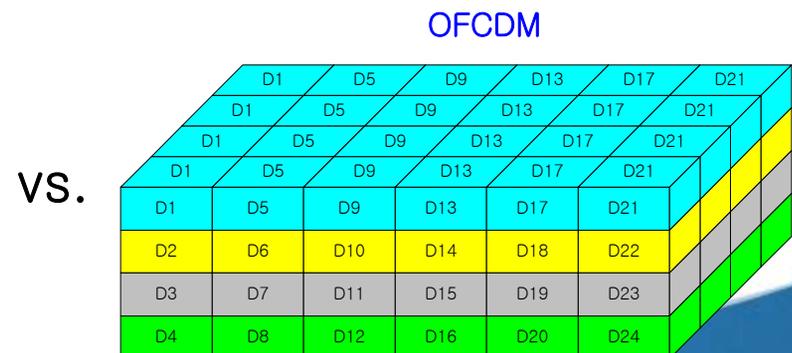
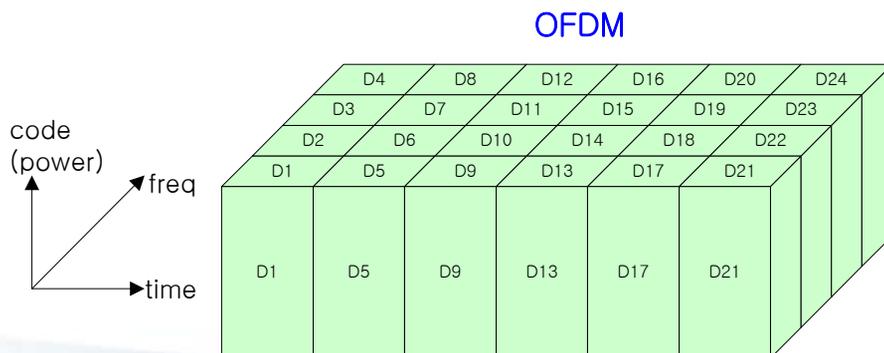


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Frequency Domain Spreading with CDM

- Do we need to consider Frequency Domain Spreading with code multiplexing e.g., OFCDM?
- Features of OFCDM
 - Provide Diversity Gain in frequency domain
 - Performance degradation due to Orthogonality Loss
- We need to carefully evaluate performance of OFCDM compared to OFDM
 - What are the advantages of including the additional complexity with OFCDM?
 - Is it desirable to employ a single scheme for all the cases and all the Physical Channels?

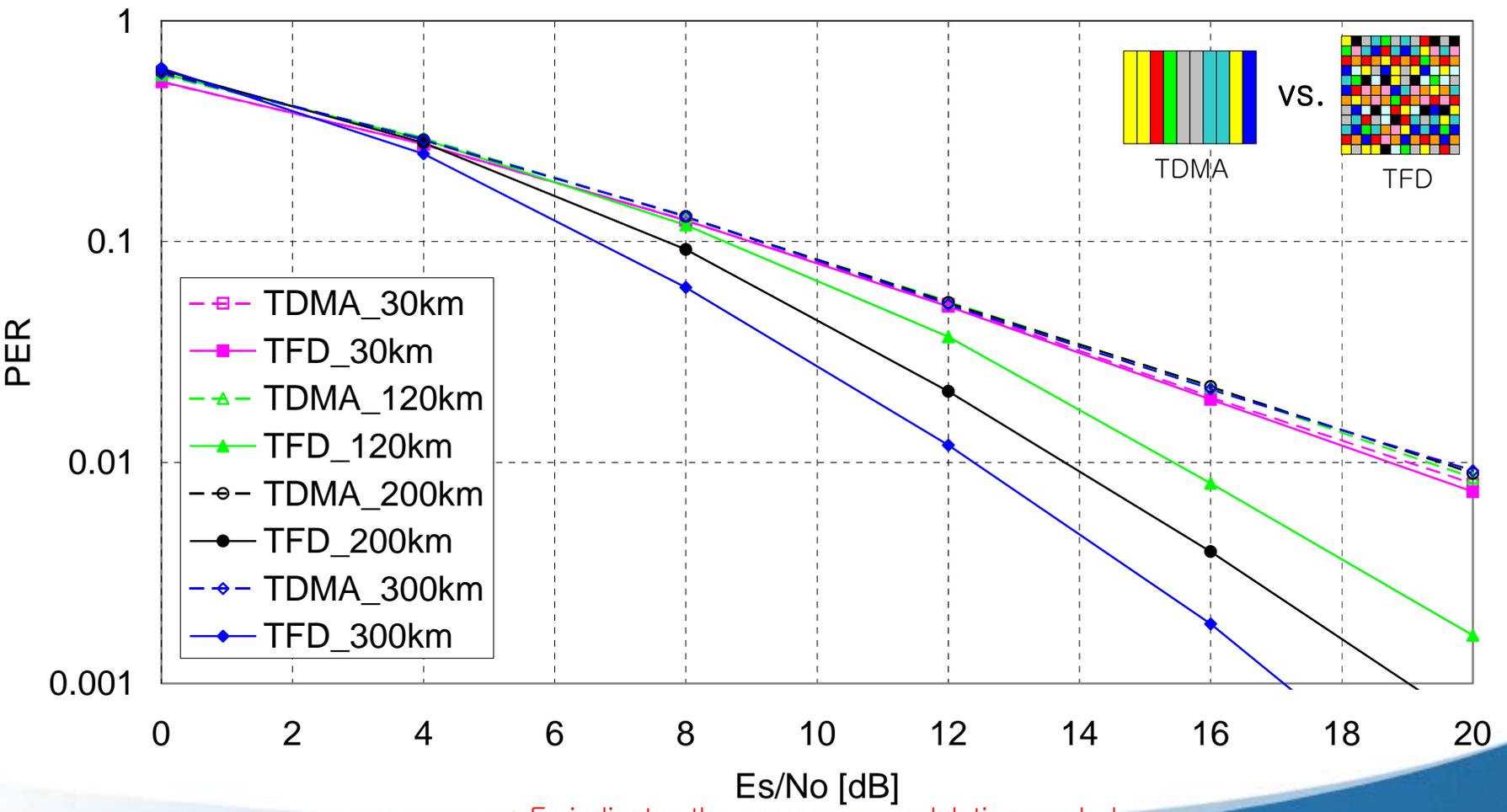


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Time Diversity within a TTI ? (1/2)

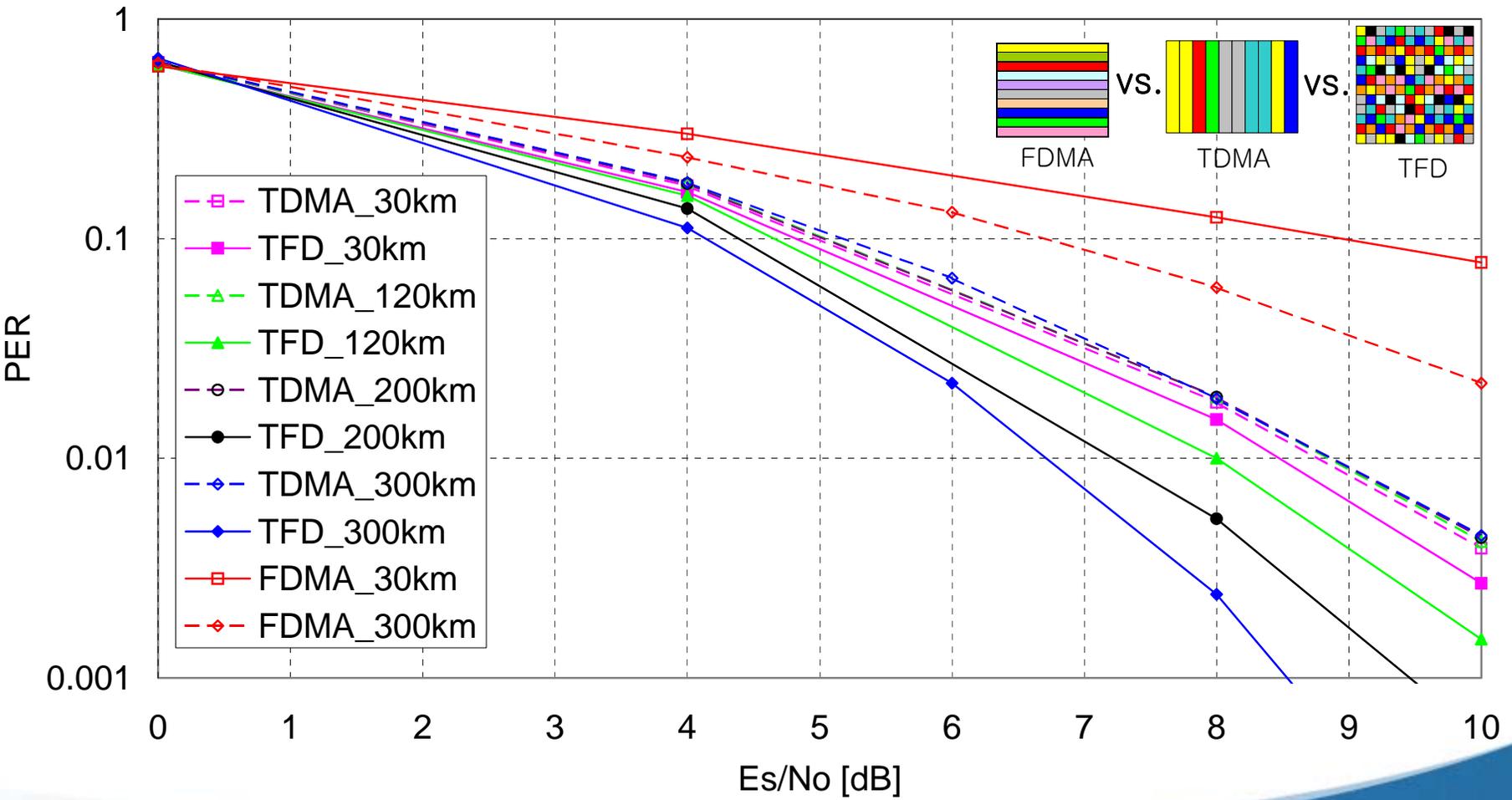
Performance Comparison of TDMA vs. TFD:
Single Path Model, 768bits/0.67ms, Turbo code (R = 0.375)



* E_s indicates the energy per modulation symbol

Time Diversity within a TTI ? (2/2)

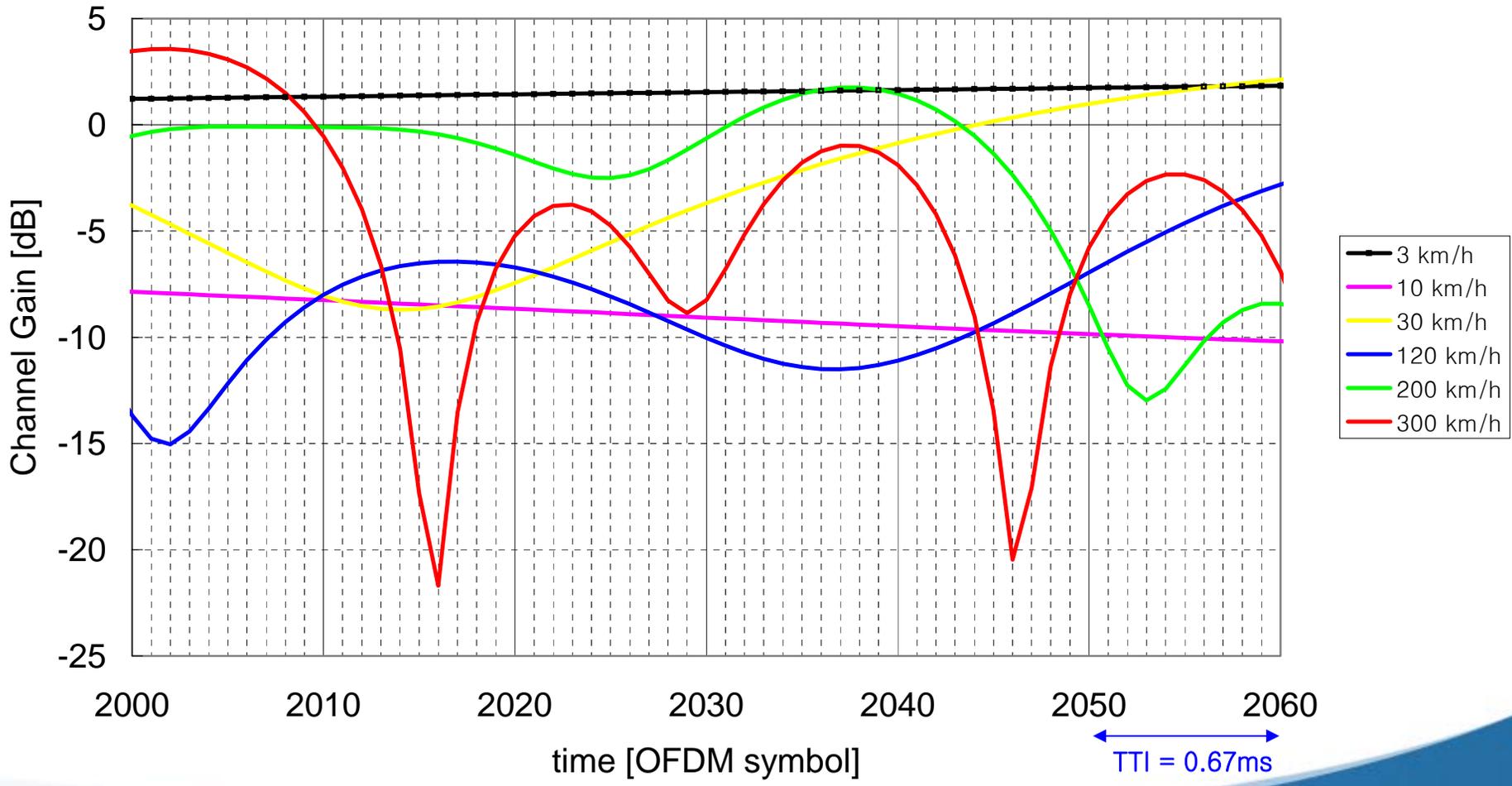
Performance Comparison of FDMA vs. TDMA vs. TFD:
 ITU Veh A model, 768bits/0.67ms, Turbo code (R = 0.375)



* E_s indicates the energy per modulation symbol

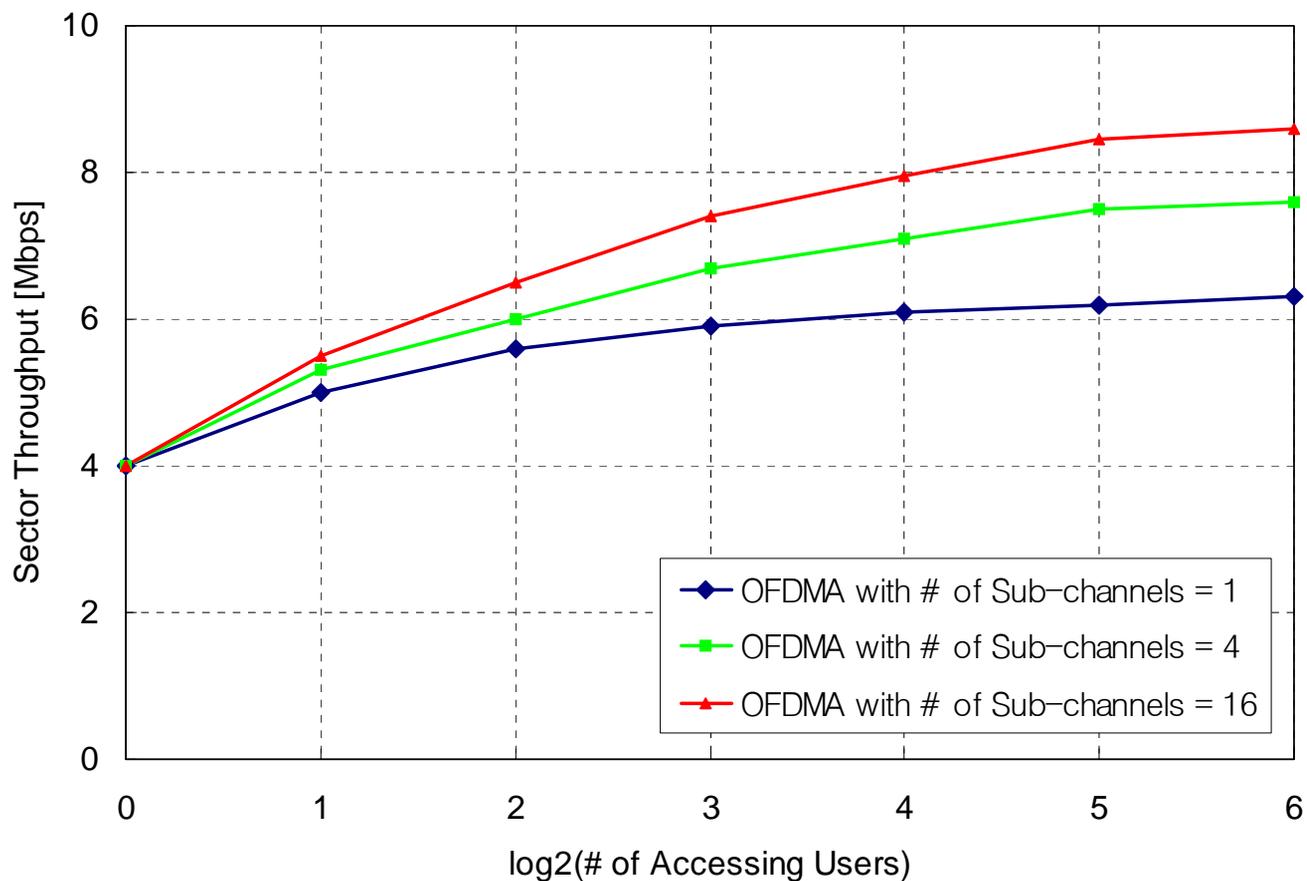
Why Time Diversity within a TTI ?

Example of Rayleigh Fading Channel



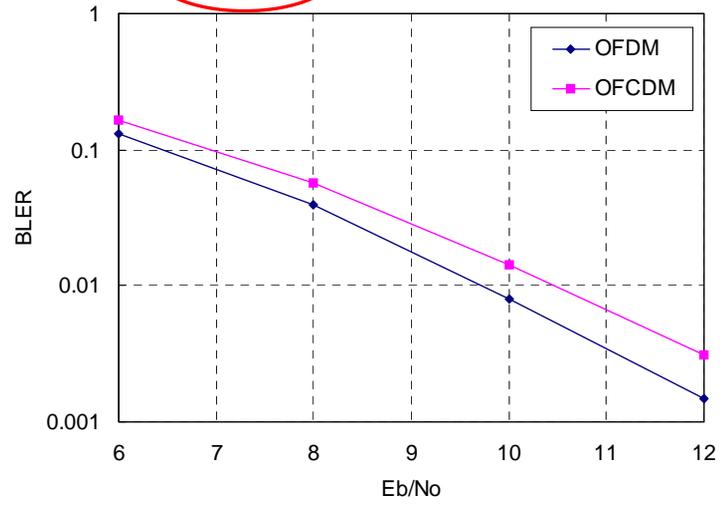
Frequency Scheduling Gain ?

* System Bandwidth = 5 MHz

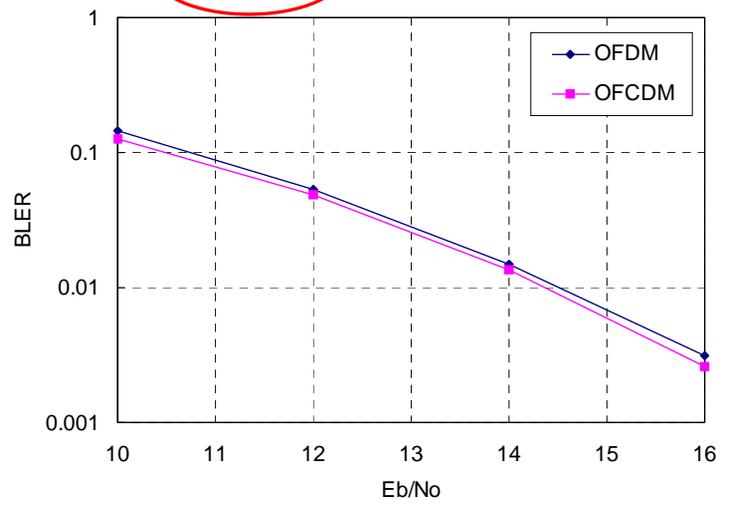


OFDM vs. OFCDM ?

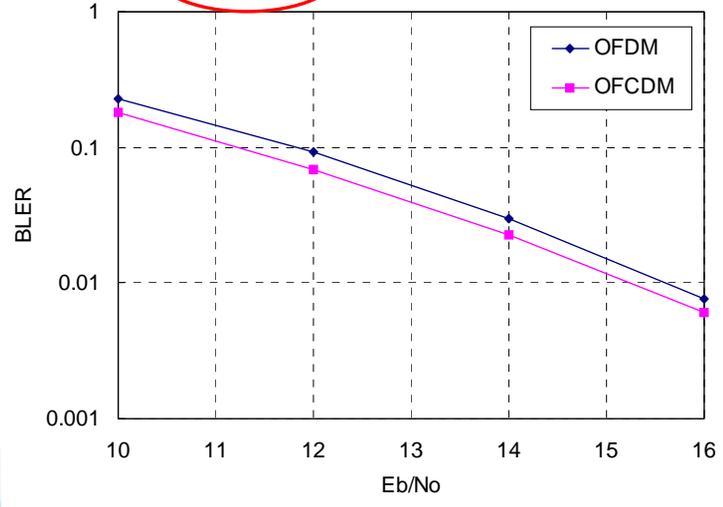
Code Rate:1/3, Veh A 30km, QPSK



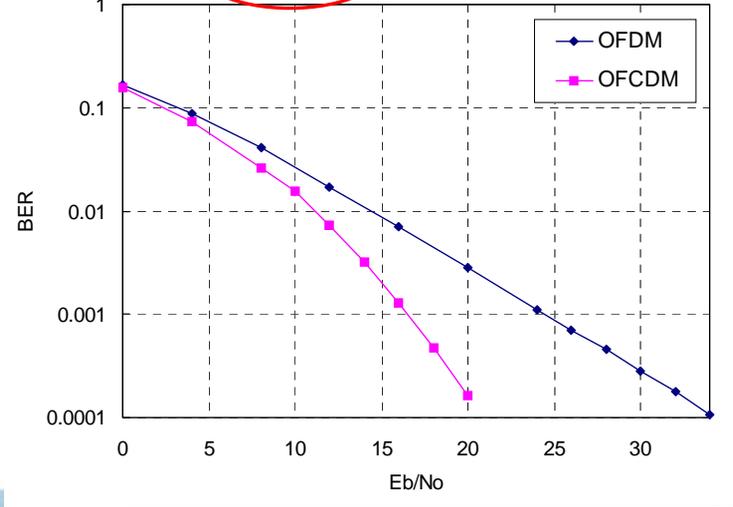
Code Rate:3/4, Veh A 30km, QPSK



Code Rate:4/5, Veh A 30km, QPSK



Uncoded BER, Veh A 30km



Observations on the Simulation Results

- For High-speed users,
 - Time diversity gain exists even within a short TTI duration of 0.67 ms:
 - It was observed that “TFD” performs better than “TDMA”.
 - Frequency diversity significantly improves the performance:
 - It was observed that “FDMA” performs much worse than “TFD” or “TDMA” which exploits frequency diversity over the entire BW.
- For Low-speed users,
 - As the number of sub-channels each of which consists a group of contiguous sub-carriers increases, system throughput increases.
- On the performance of OFCDM,
 - OFCDM exploiting frequency diversity outperforms pure OFDM in frequency selectivity channel in spite of orthogonality loss in case high code rates such as 4/5 is used
 - Uncoded BER performance of OFCDM is much better than that of pure OFDM

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1. Downlink Resource Allocation, MA and Multiplexing in two different ways (modes):
 - **TFD (Time-Frequency Diversity) mode**
 - Appropriate for high speed users since channel dependent scheduling would be impossible for these users
 - Various diversity technologies would be useful for high speed users:
 - HARQ, Spatial diversity, Frequency diversity, etc.
 - **FS (Frequency Scheduling) mode**
 - Appropriate for low speed users or MIMO applications
 - Multi-user diversity from channel dependent scheduling and AMC can increase DL spectral efficiency

2. To multiplex TFD and FS modes within a TTI
 - Efficient to multiplex small packets
3. To support OFCDM
 - OFCDM could be beneficial in case high code rate is used
 - OFCDM could be appropriate to channels carrying one bit information such as HARQ ACK/NACK or power control command
- Examples of recommended DL MA and multiplexing

