Evaluations of an Adaptive Single-carrier TDMA System

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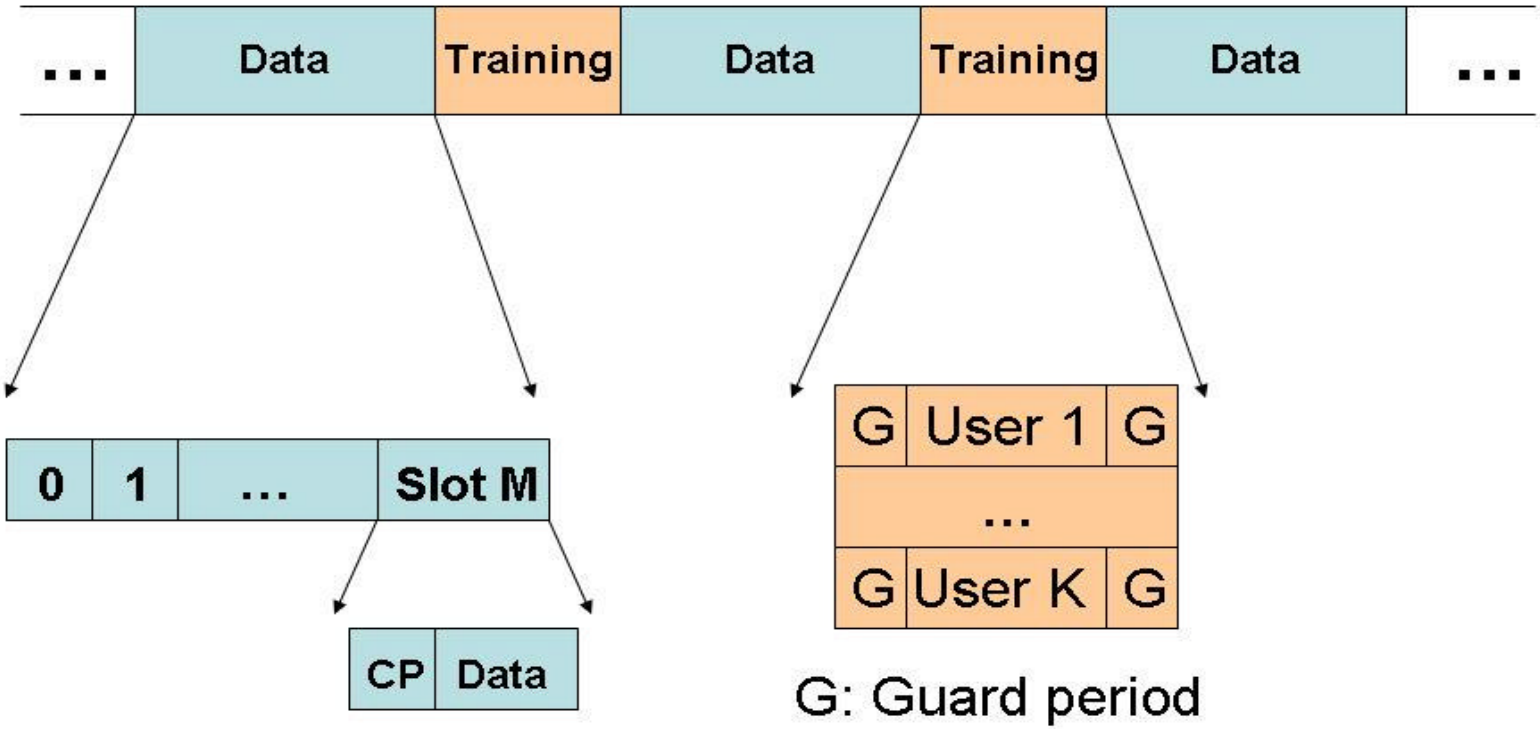
Background

- OFDM
  - A promising technique for the future downlink
  - High PAPR, which requires highly linear power amplifier
  - Time and frequency synchronization
- Single carrier TDMA
  - In a single user case, a single-carrier TDMA system with a properly designed frequency-domain equalizer can give a comparable performance to an OFDM system
- Our proposal
  - An adaptive single carrier TDMA system with scheduling

Structure of the uplink



The air interface

- Two prerequisites
  - Multiuser channel estimation – Least Square method
  - Channel prediction – Linear MMSE predictor
- The channel is frequency-selective. An equalizer is needed in the receiver to mitigate the dispersive channel.
  - Frequency-domain linear equalizer
  - Frequency domain decision feedback equalizer
- The adaptive modulation scheme is optimized to maximize the throughput including also the ARQ part of the transmission.
- A scheduler allocates the channel to the user who has the best equalized SNR.

Channel descriptions

- The carrier frequency is 1900 MHz.
- The planed bandwidth is 5 MHz. One block (3335 symbols) is 667 μs long.

Case 1
- training length = 409 symbols
- Data size (fft size) = 128
- CP size = 26
- 19 slots/block

less variable in a slot

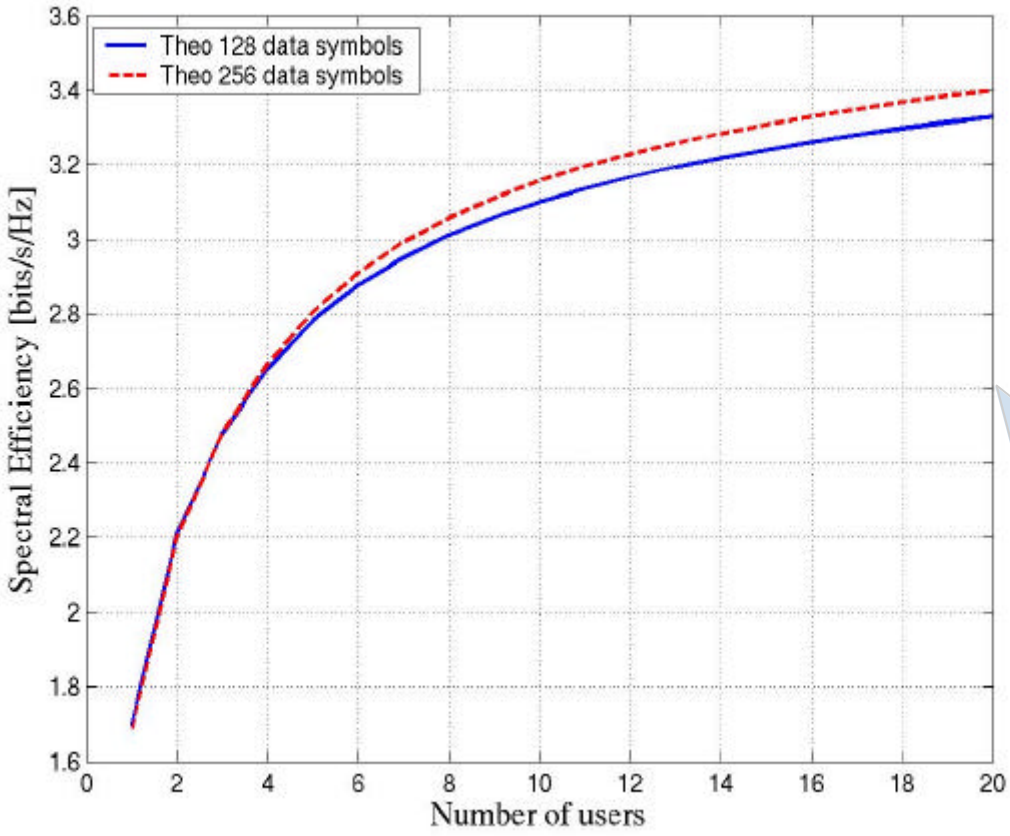
Case 2
- training length = 515 symbols
- Data size (fft size) = 256
- CP size = 26
- 10 slots/block

lower overhead ratio

The power delay profile (modified ITU-IV Channel A)

Tap	Relative delay [ns]	Average power [dB]
1	0	0
2	400	-1.0
3	800	-9.0
4	1000	-10.0
5	1800	-15.0
6	2600	-20.0

Analysis on the spectral efficiency



- We assume the equalized channels are time-invariant within the time-slots and independent flat Rayleigh fading between the time-slots.
- All the users are allocated with equal average received power.
- Received SNR = 16 dB.
- The channels to different users fade independently.
- The effect of overhead ratio and channel variability.

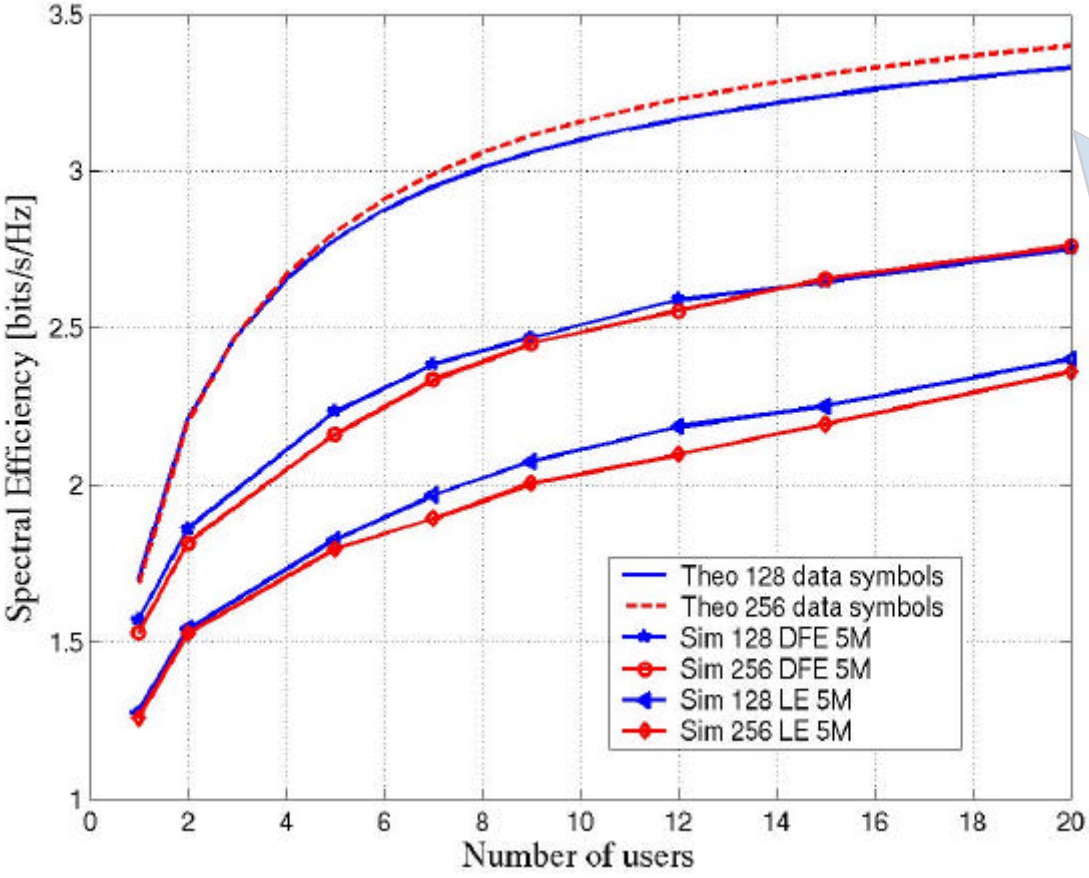
Simulations

- The channels are frequency-selective Rayleigh fading.
- We assume perfect estimation and prediction of the impulse response of each slot of each user.
- The Equalizer:
  - Assumes the channel is invariant during one time-slot. Therefore each time-slot has a unique equalized SNR.
  - The FD-DFE is designed to cancel all the echoes.
  - The equalized SNR is defined as

$$SNR = \frac{\hat{s}_h^2}{MMSE}$$

where $\hat{s}_h^2$ is the filtered signal variance and MMSE is the minimum mean square error of the equalizer.

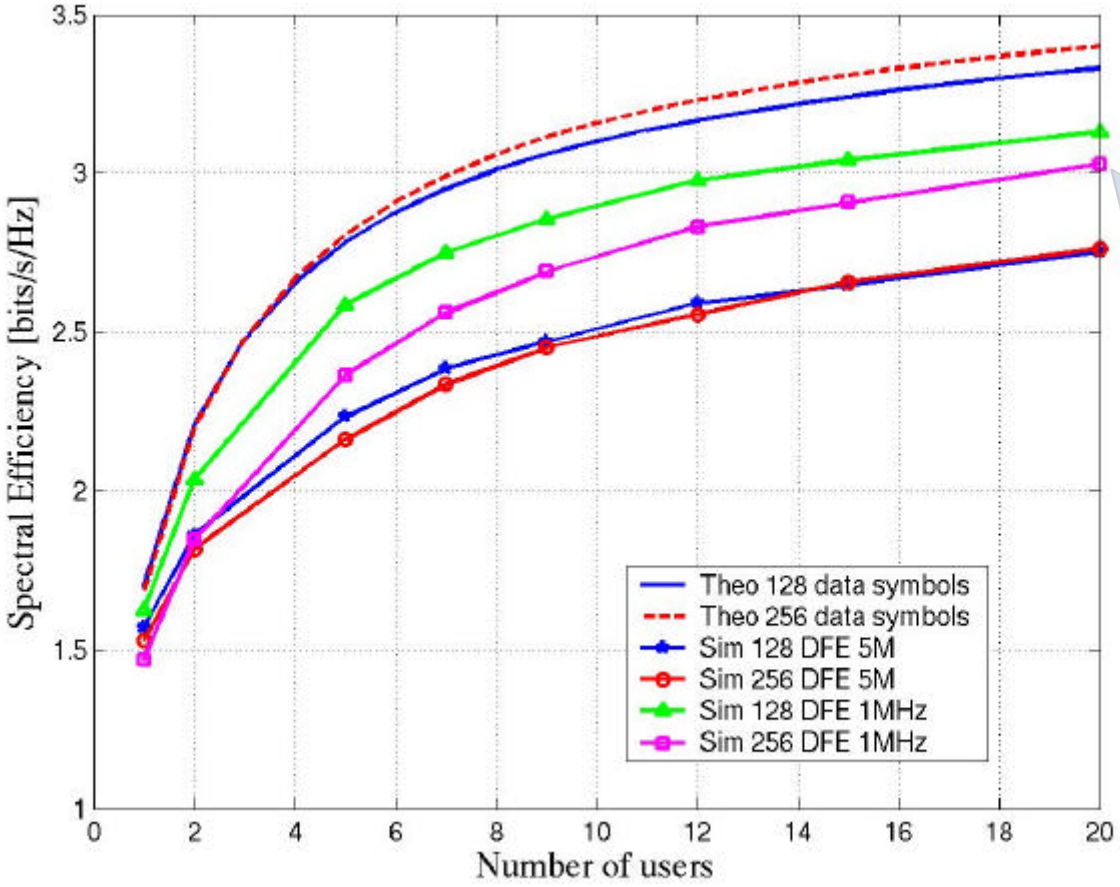
Results — spectral efficiency of 5MHz Channels



- The speed of the terminals is 50 km/h.
- ITU-iv channel A
- Received SNR=16dB
- The used modulation formats are:

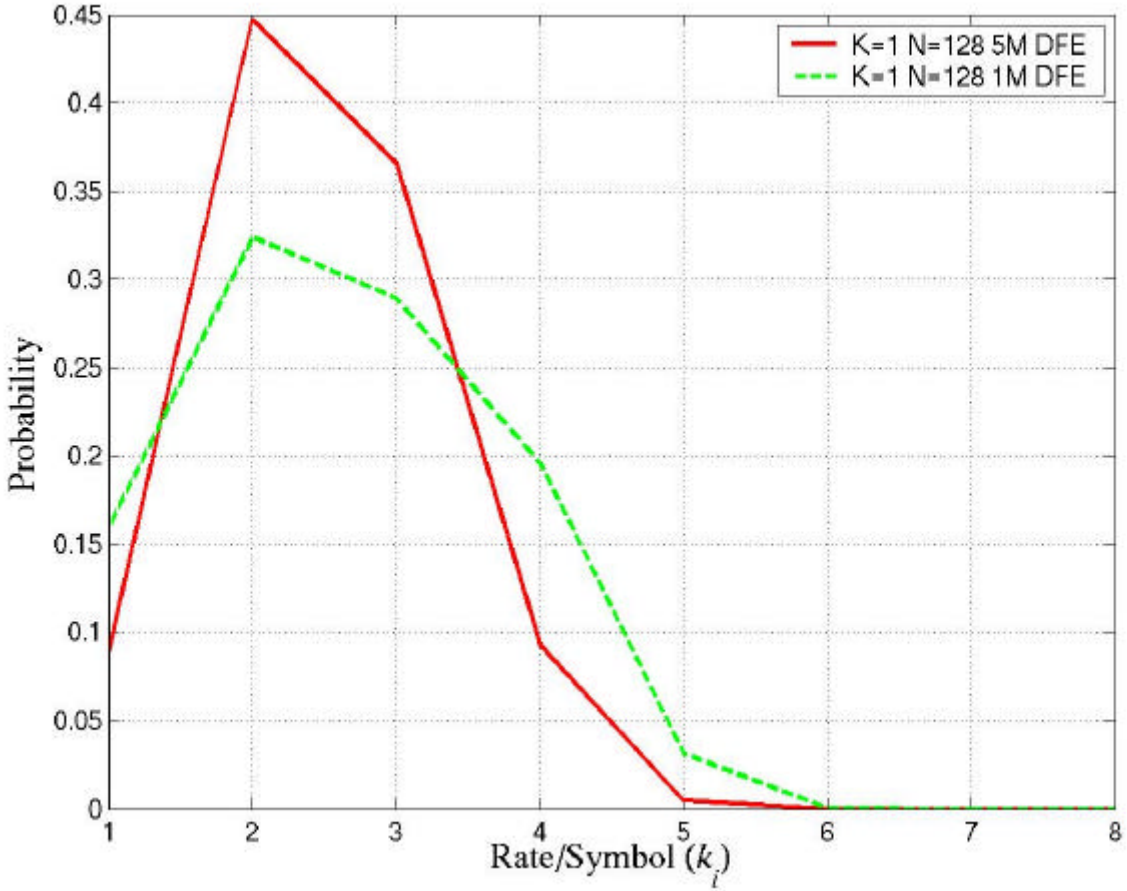
  BPSK, 4-QAM, 8-PSK, 16-QAM, 32 Cross-QAM, 64-QAM, 128 Cross-QAM and 256-QAM

Results — spectral efficiency of 1MHz Channels



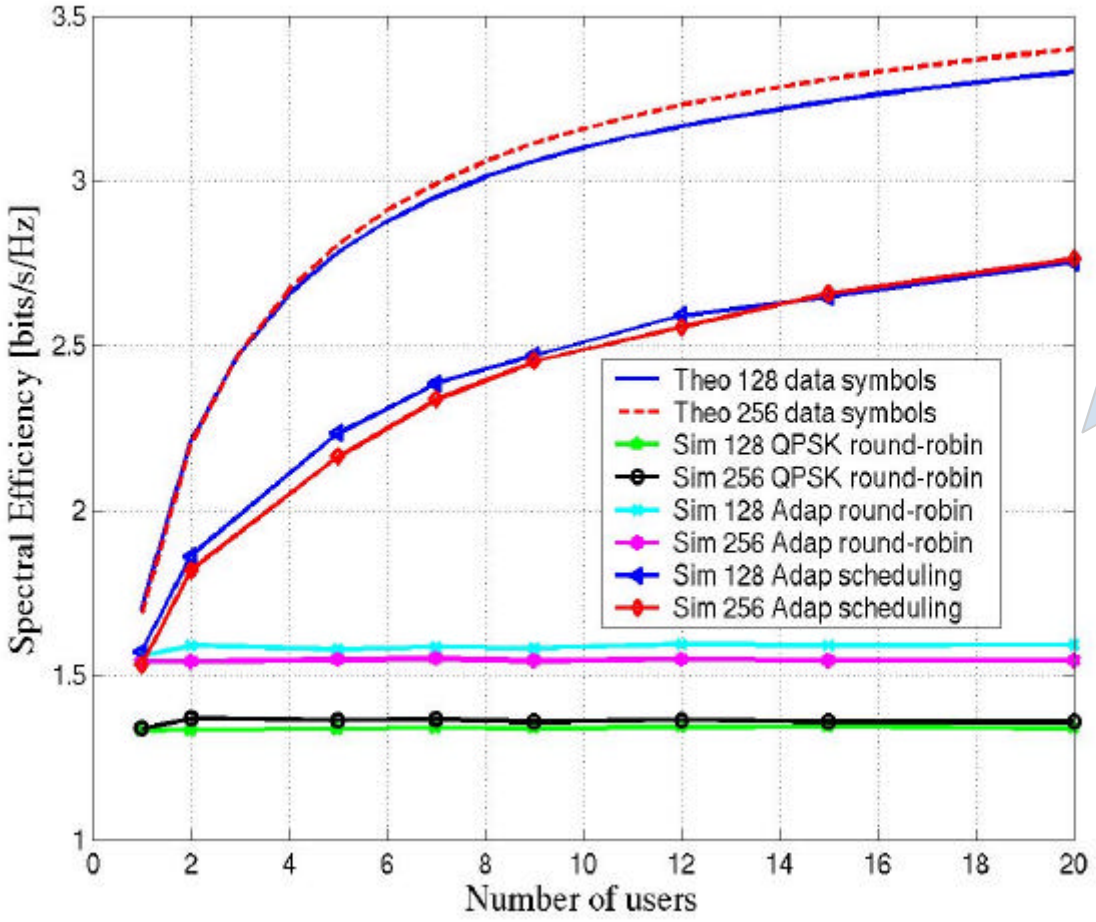
- The ITU-IV channel A PDP only has 4 taps due to a lower sampling rate in the 1MHz channel.
- The speed of the terminals is 50 km/h.
- Received SNR=16dB

Results — usage of modulation formats



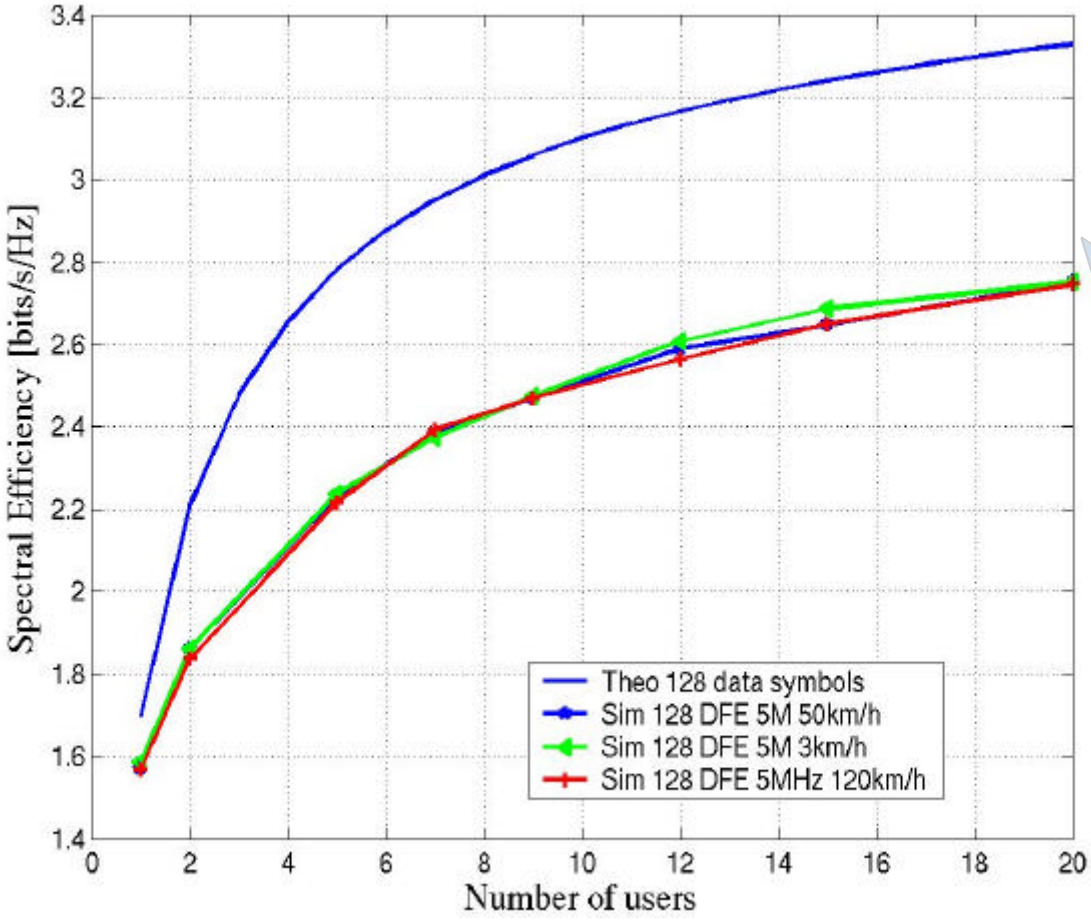
Probability of using rate k_i in a single user case with both 1 Mhz and 5 MHz bandwidth

Results — spectral efficiency in QPSK round-robin



- The round-robin case has the same amount of overhead as the adaptive TDMA.
- Received SNR=16dB
- QPSK is used in the round-robin case.
- The speed of the terminals is 50 km/h.

Results — spectral efficiency in different speeds



- Three different speeds:
  - 3 km/h
  - 50 km/h
  - 120 km/h
- Received SNR=16dB
- The coherence time is more than a time-block even at 120 km/h.

Conclusions

- The equalized channels are more time-variable in a narrow-band single-carrier system.
- The multiuser diversity gain is limited in a wideband system.
- An OFDM-based uplink seems to be more potential when ignoring the non-linearity and synchronization issues.