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Title: Comparative Link Performance of SC-FDMA and OFDMA

Source:
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Abstract:
We present first results on SC-FDMA vs OFDMA. From these first results, with ideal channel estimation and MMSE equalization, SC-FDMA shows a performance disadvantage of up to 1 dB compared to OFDMA. Various effects of frequency selectivity of the channel and operating SINR are shown. Link performance is of course not an indication of system performance. Unfortunately, link results even with non-ideal channel estimation are too uninformative compared to what is really required: System-level simulations with realistic models of PA (with dynamic backoff) and the cell radius and transmit PSD update rate as parameters.

Uplink SC-FDMA vs. OFDMA

- MAC inflexibility: OFDMA can flexibly assign resources (tiles) which are disjoint for a given user. SC-FDMA can only perform assignments of a contiguous chunk of bandwidth (tiles that are contiguous).
- SC-FDMA needs to transmit the signaling information inband for all persistently allocated services such as VoIP. This means that every time signaling needs to be transmitted, the code rate for traffic must be increased, impacting latency and, more importantly, latency variance.
- The SC-FDMA PAPR benefits at the system level are questionable under dynamic backoff assumptions commonly implemented in modern OFDMA systems.
- Layered Superposition with $L = 2$ layers can boost throughput in many scenarios on top of any UL MIMO gains. It also solves the (inherent) to orthogonal uplink fairness issues. SC-FDMA would require a far more complicated receiver as compared to OFDMA.

SC-FDMA Signal Flow

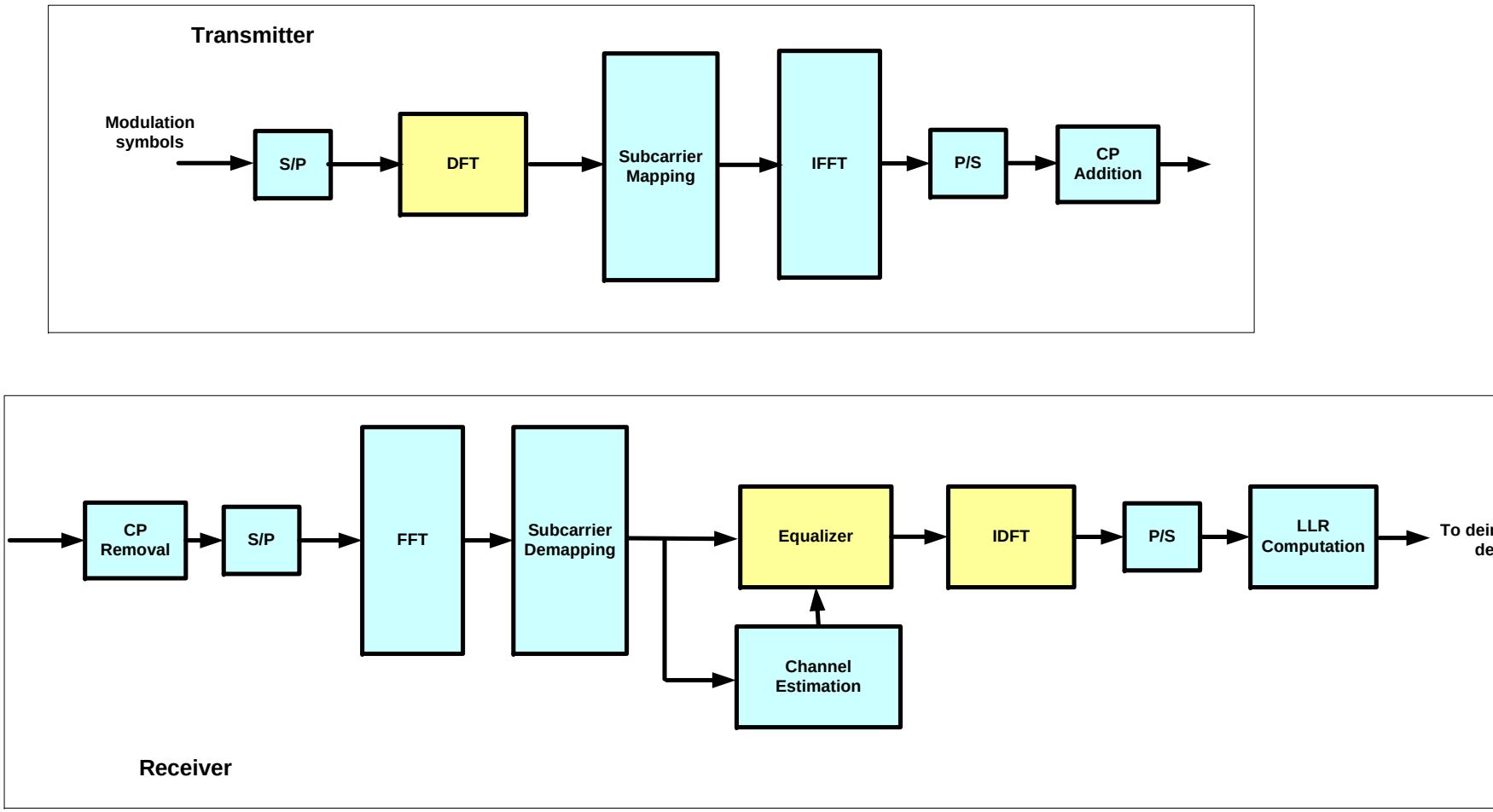

Figure: SC-FDMA Signal Processing Flow

MMSE Equalizer

- In SC-FDMA, when the assigned bandwidth exceeds the channel coherence bandwidth, each modulation symbol sees a frequency selective channel, which causes intersymbol interference (ISI) and hence requires equalization
- Because of CP transmission, equalization can easily be carried out as a single-tap frequency domain equalizer (FDE) Zero-forcing (ZF) and MMSE equalizers are two options MMSE is preferred as it strikes an optimal balance between ISI reduction and noise enhancement

SC-FDMA Performance

- For a frequency non-selective channel, OFDMA and SC-FDMA have the same link performance (because there is no ISI for SC-FDMA)
- As the frequency selectivity of the channel increases (i.e. increased dispersion), SC-FDMA degrades in performance compared to OFDMA
  - For low to medium SINRs, SC-FDMA and OFDMA have similar link performance, because thermal noise dominates residual ISI for SC-FDMA
  - For high SINRs, OFDMA outperforms SC-FDMA due to residual ISI of SC-FDMA with MMSE-FDE.
  - Turbo Equalization techniques can be used with SC-FDMA to further suppress the residual ISI, and close the gap with OFDMA even in channels with high frequency selectivity and at high SINRs
- The link performance curves on the remaining slides compare SC-FDMA with MMSE-FDE with no turbo equalization to OFDMA, assuming ideal channel estimation and localized subcarrier allocation.

SC-FDMA Performance

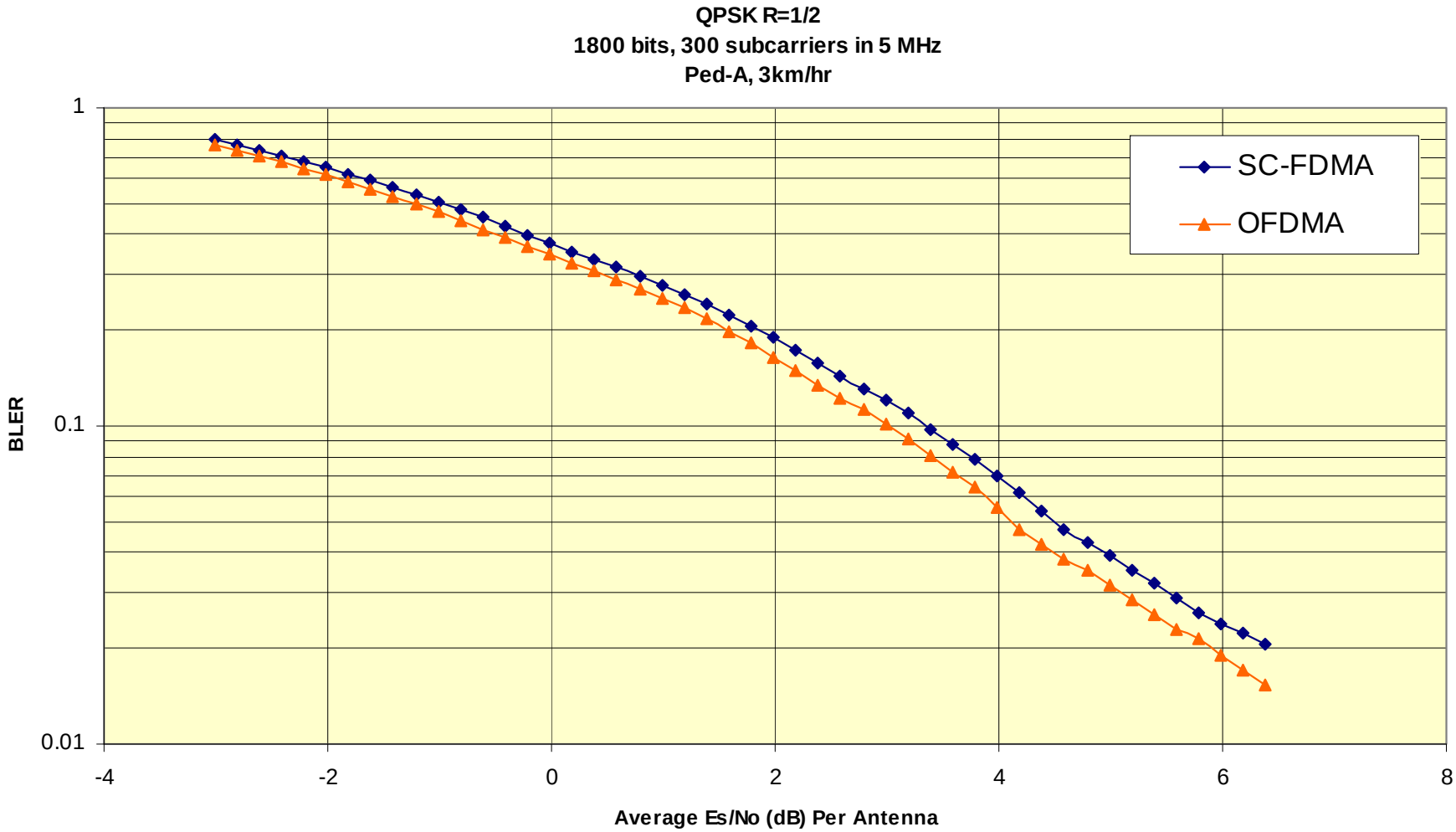

Figure: Low frequency selectivity and low required SINR means that SC-FDMA and OFDMA perform similarly.

SC-FDMA Performance

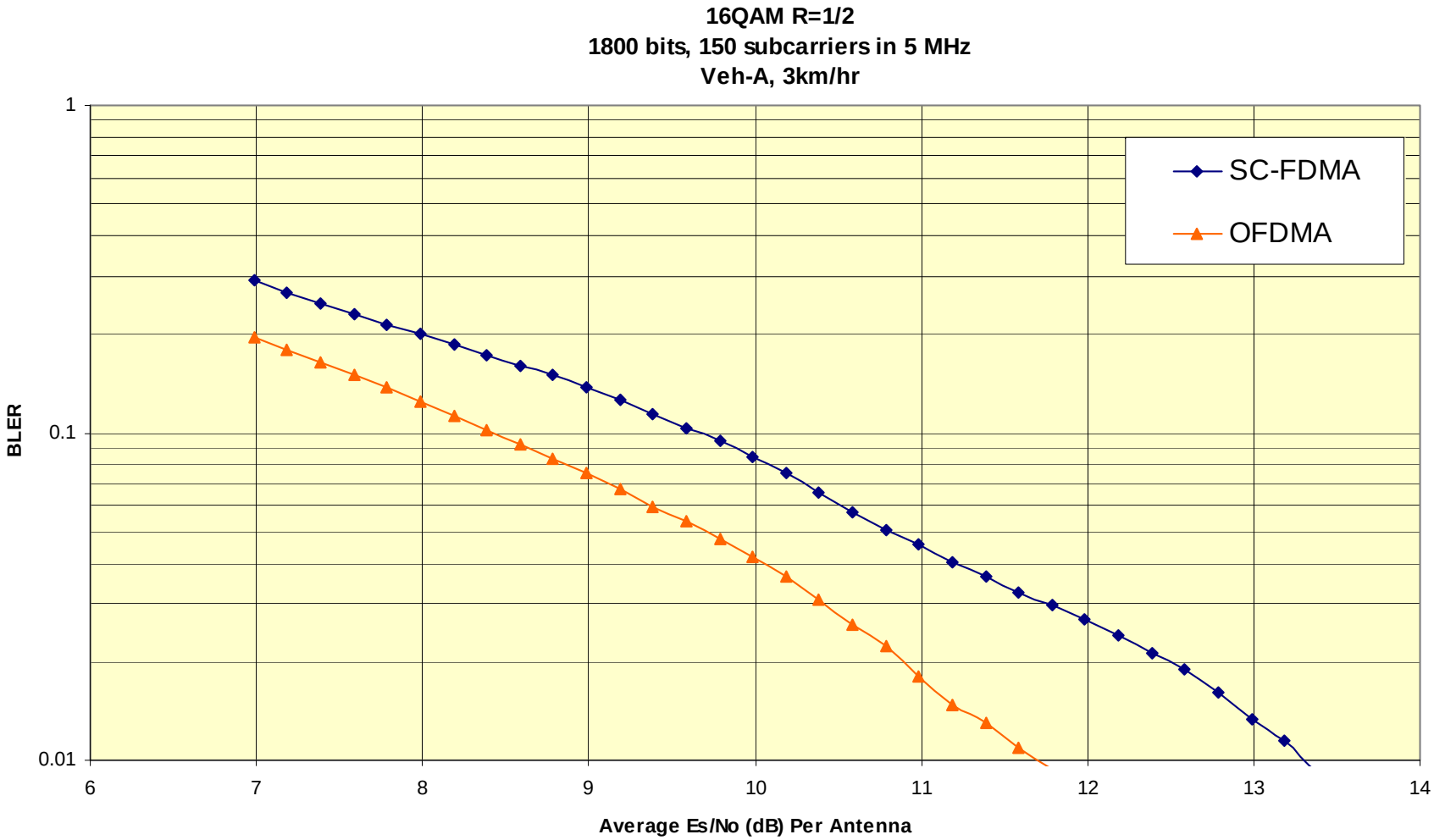

Figure: Moderate frequency selectivity but high required SINR causes a growing gap between SC-FDMA and OFDMA.

SC-FDMA Performance

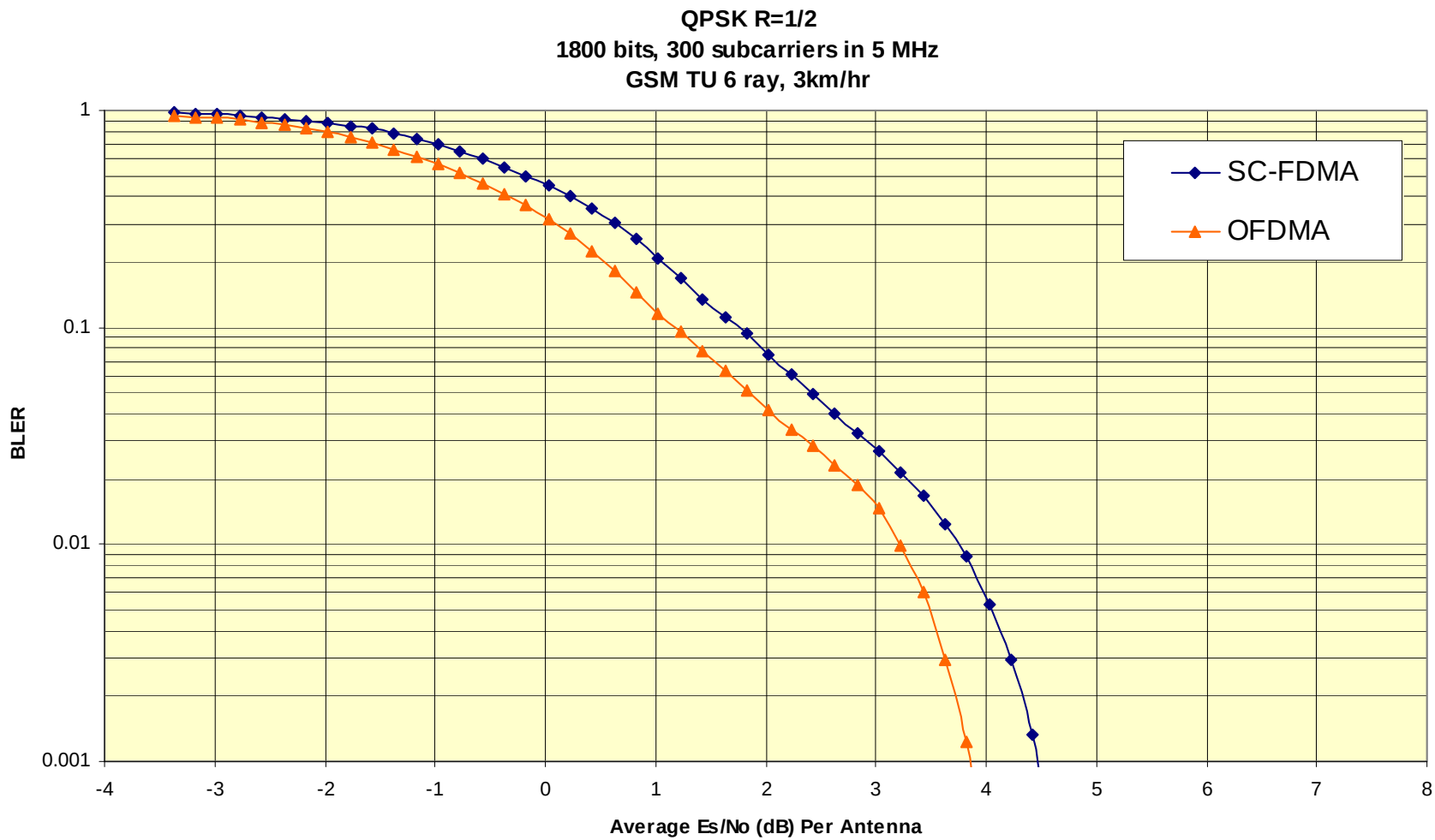

Figure: High frequency selectivity and low required SINR also causes a gap between SC-FDMA and OFDMA.

Conclusions

- First results on SC-FDMA vs OFDMA. Non-ideal channel estimation structure will be detailed in the next version of this contribution.
- From these first results, SC-FDMA shows a performance disadvantage of up to 1 dB compared to OFDMA. Various effects of frequency selectivity of the channel and operating SINR are shown. It is imperative to repeat these simulations with a realistic non-ideal channel estimator.
- **Link performance is of course not an indication of system performance**. Unfortunately, link results even with non-ideal channel estimation are too informative compared to what is really required: System-level simulations with realistic models of PA (with dynamic backoff) and the cell radius and transmit PSD update rate as parameters.