Technische Universität München

A Leaner Carrier for the New 5G Air Interface

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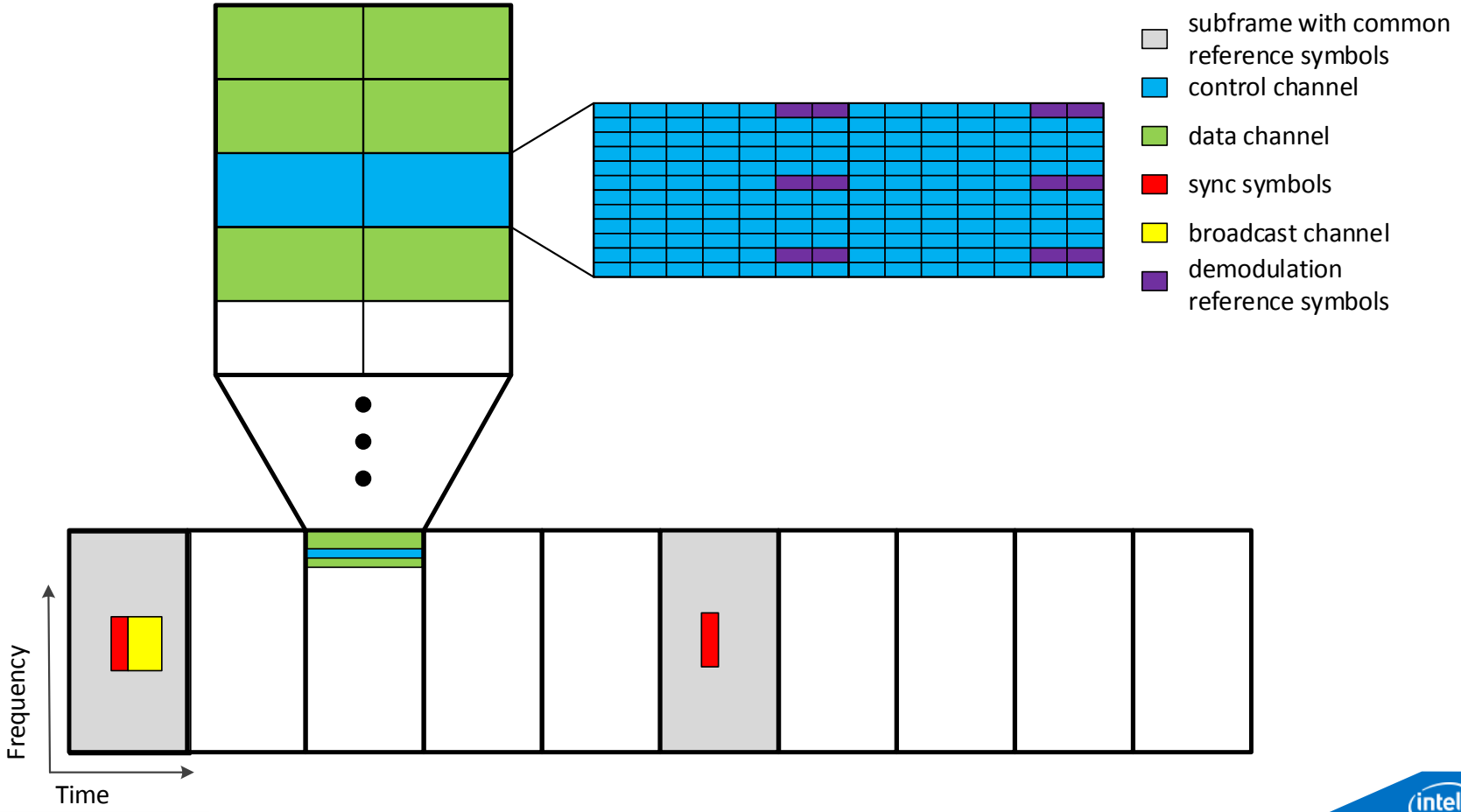
Motivation of a leaner carrier

- Improved spectral efficiency and cell edge throughput
  - More flexible control channel allocation
  - Reduced reference overhead
- Reduced interference
  - Reduced common reference symbols
  - Improved base-station interference coordination
- Reduced base-station power consumption
  - Micro-sleep of RF front-end possible
- Possible evolutionary solution for 5G waveform

Open aspects of 3GPP discussion

- Sufficient tracking performance in challenging scenarios
  - Frequency offset tracking
  - Timing offset tracking
- Standalone operation
  - Broadcast channel transmission scheme
  - Channel estimation broadcast channel
  - Control channel resource allocation
  - Uplink HARQ ACK/NACK

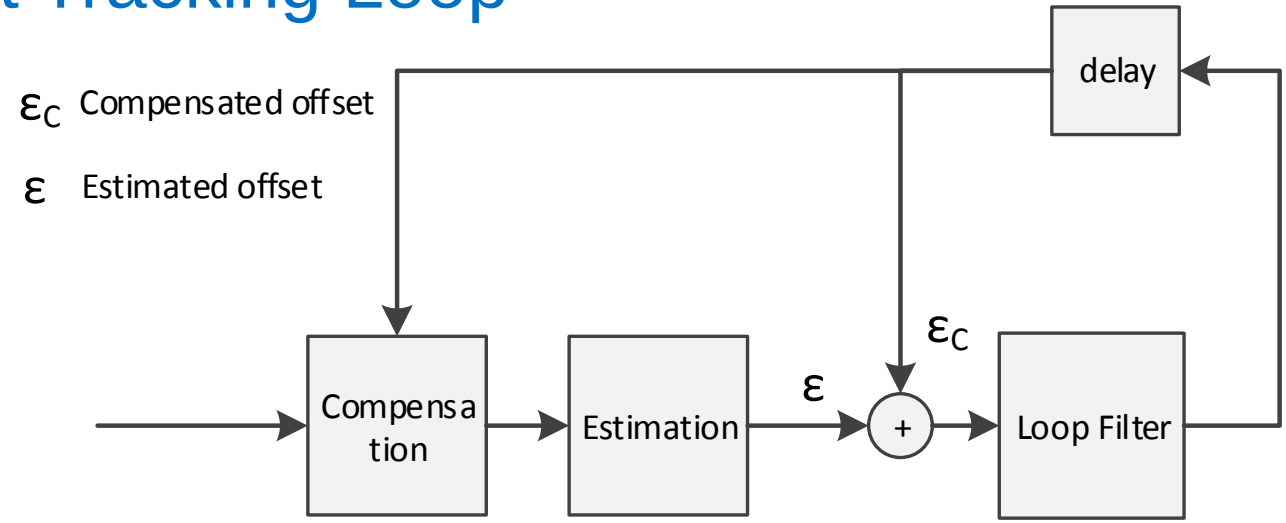
Lean carrier frame structure



Timing and frequency offset estimation

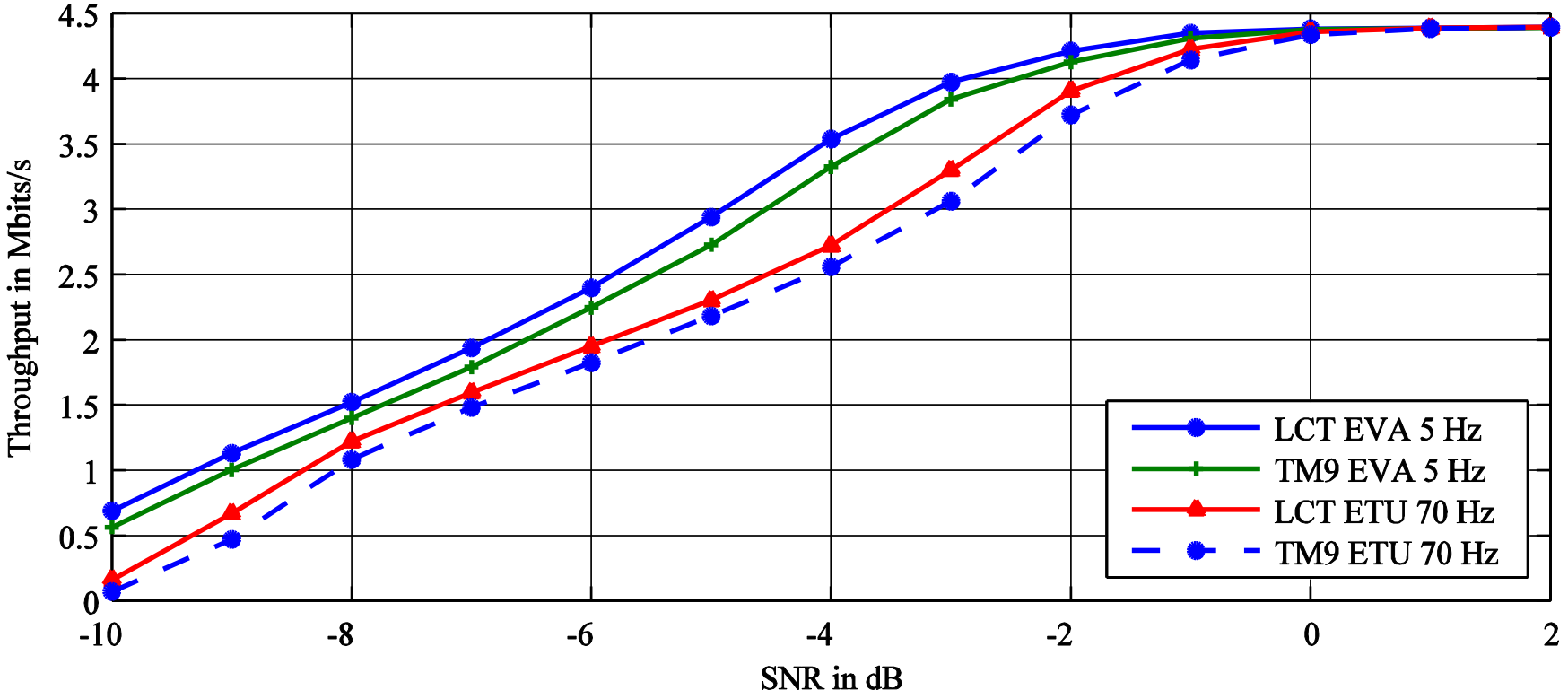
- Estimation of frequency and timing offset
  - Based on correlation of reference symbols
  - Common reference symbols and synchronization symbols
- Demodulated reference symbol
  - $D_{k,l} = e^{j\varphi_l(\varepsilon_f)} e^{j\varphi_k(\varepsilon_t)} H_{k,l} + W_{k,l} X^*_{k,l}$
  - $\varphi_l(\varepsilon_f) = 2\frac{\pi l \varepsilon_f (N+N_g)}{N}, \qquad \varphi_k(\varepsilon_t) = -\frac{2\pi k \varepsilon_t}{N}$
- Symbol correlation
  - $\varepsilon_f = \frac{<(\sum D_{k,l} D^*_{k,l+L})}{-2\pi L(1+\frac{N_g}{N})}, \qquad \varepsilon_t = \frac{<(\sum D_{k,l} D^*_{k+K,l})}{-2\pi K/N}$

Offset Tracking Loop

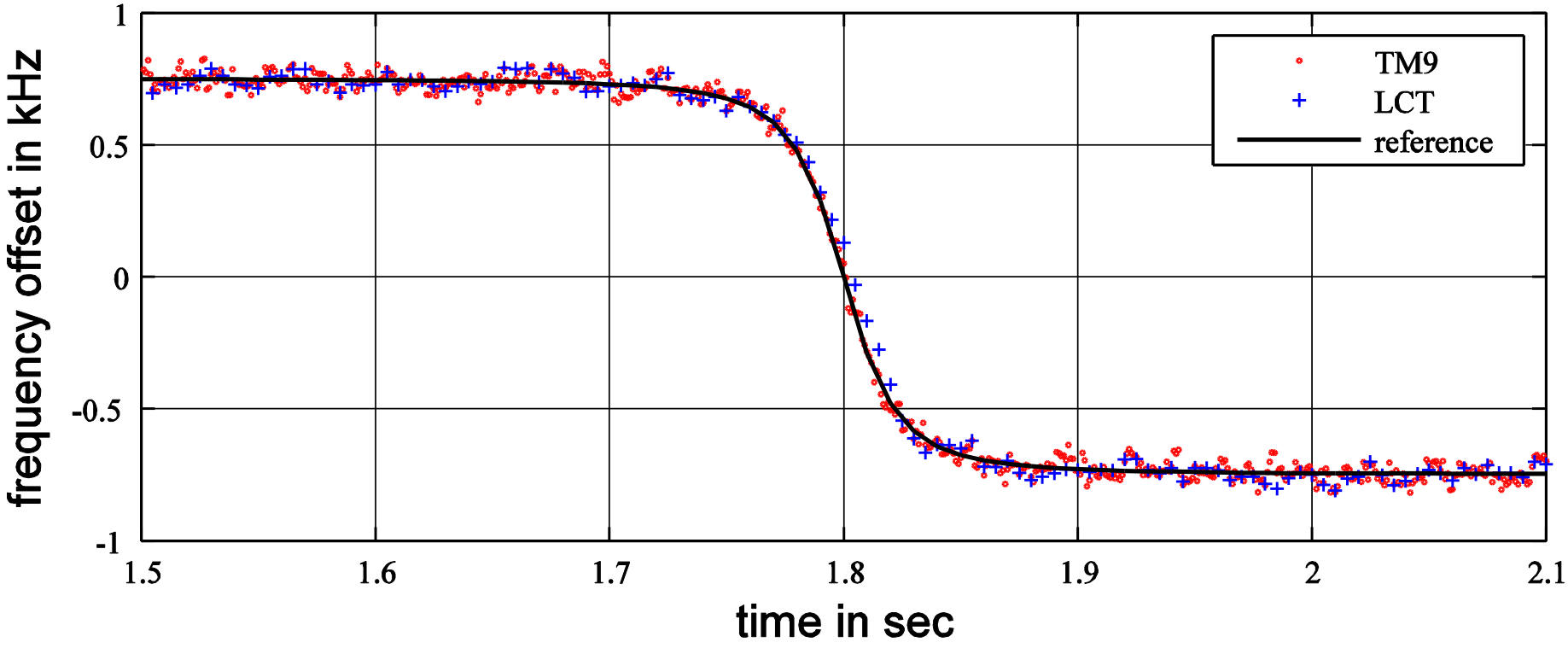


- Different loop filters possible
  - FIR filter
  - IIR filter
  - Adaptive filter or other algorithms possible
- Simple IIR filter optimized for each scenario separately is used

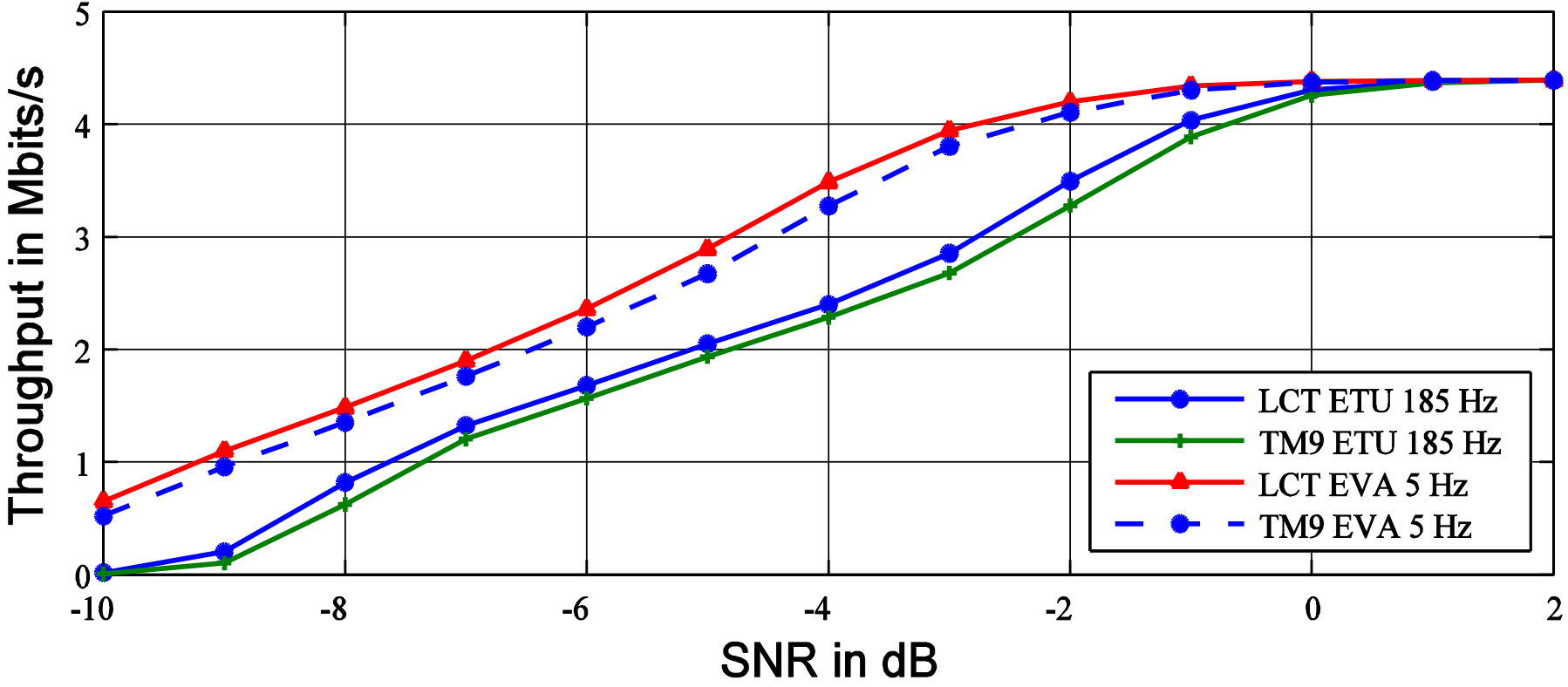
Frequency offset tracking fixed offset 200 Hz



Frequency-offset tracking High Speed Train (HST)



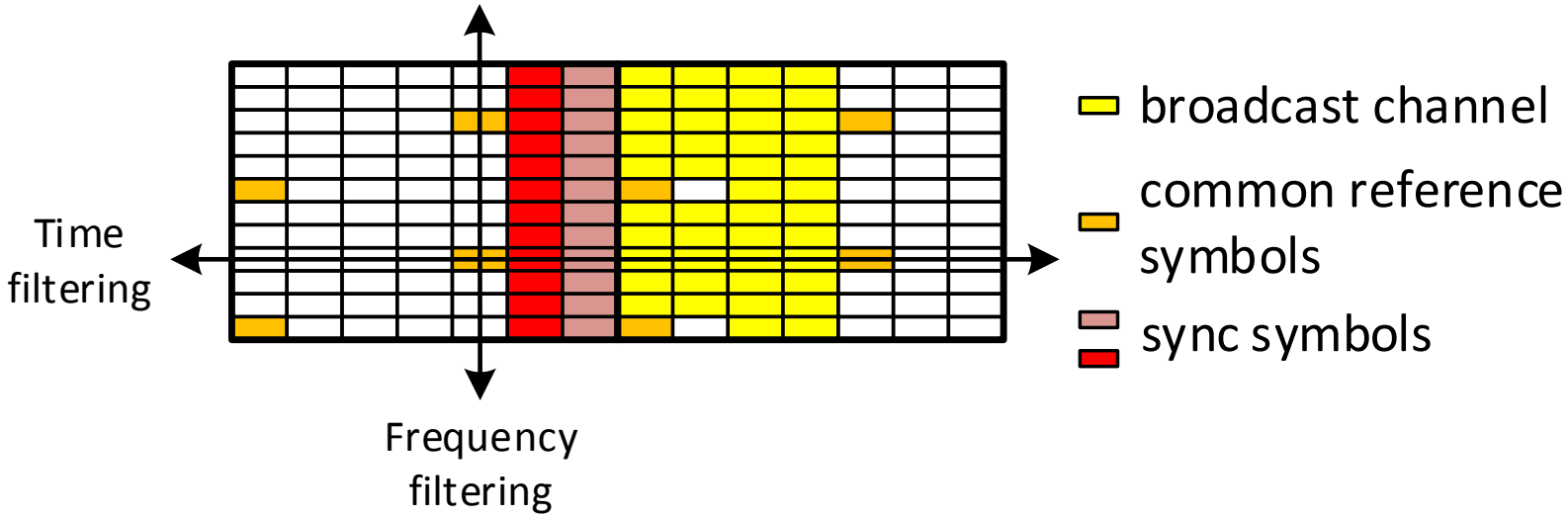
Timing offset tracking fixed offset 1µs



Broadcast Channel Description

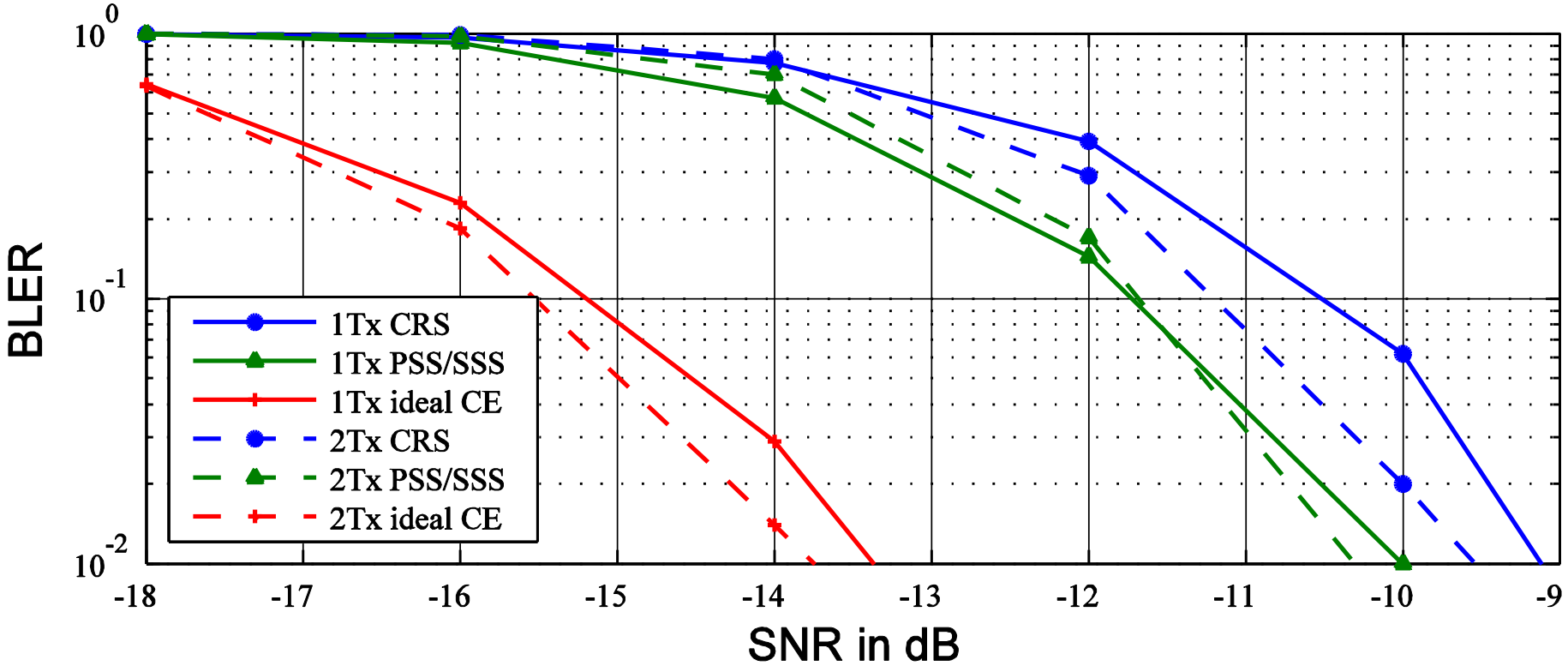
- Purpose of Broadcast channel
  - Primary channel to access system information
  - Enable initial cell access
- Assumptions
  - Same payload
  - Same reserved area
- Design challenges in LCT
  - No Tx-Div possible
  - No channel estimation averaging across subframes

Broadcast channel CE options



- CE based on common reference symbols and/or sync symbols
- Synchronizations symbols CE advantages
  - More reference symbols
  - Simpler and less MMSE filters

Broadcast channel BLER ETU 70Hz low correlation

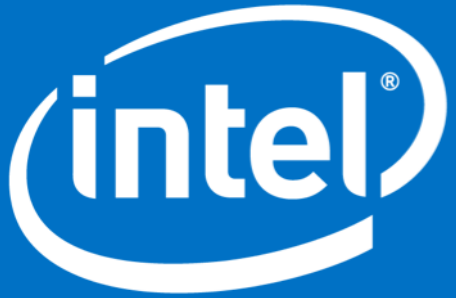


Standalone Lean carrier aspects

- Resource allocation of control channel
  - Flexibility simplicity tradeoff
  - Common search space allocation limited by broadcast information bits
  - Allocation should enable base-station control channel interference coordination
- Uplink HARQ ACK/NACK in control channel
  - Reduced overhead because HARQ bits not protected by FEC

Conclusion

- Parameter estimation for a lean carrier
  - Frequency offset tracking feasible
  - Timing offset tracking feasible
- Minor impact of reduced reference symbols
- Throughput performance equal improvement compared to LTE
  - More flexible control overhead
  - Reduced reference overhead
- Broadcast channel performance
  - BLER comparable to LTE/LTE-A
  - Improvement by synchronization symbols usage possible
- Possible candidate for a 5G waveform



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Control channel resource allocation