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Temporal Cognitive UWB Medium Access

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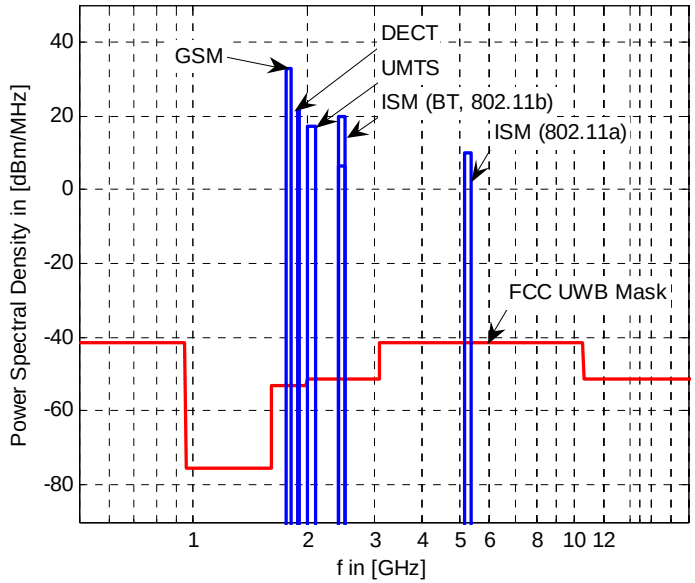
Outline

- Introduction
- Background Interference
- Burst Interference in Vicinity of the UWB Receiver
- Temporal Cognitive UWB Medium Access
- Conclusions

Introduction

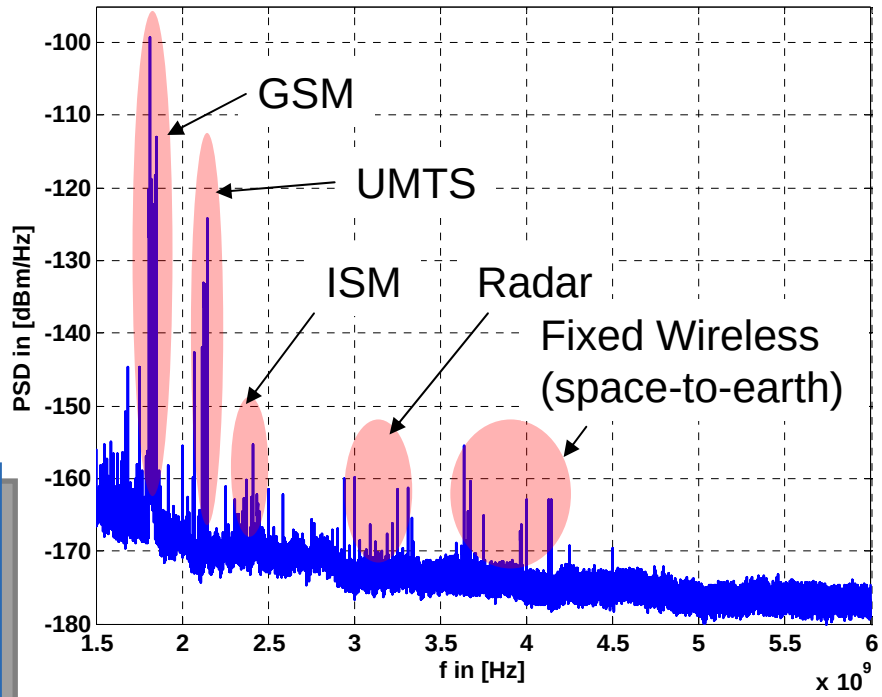
- UWB receiver have to cope with interference from existing wireless services
  - Very low transmit power
  - Huge bandwidth



- Importance of interference mitigation
- Consideration of 2 types of interferers
  - Continuous background interference
  - Burst interferers in close vicinity to the UWB receiver

Background Noise

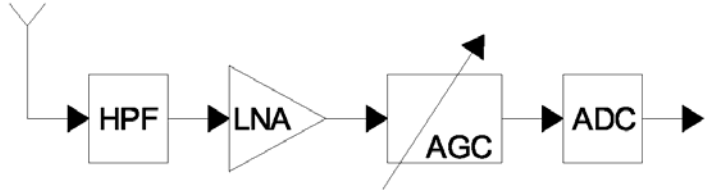
- Spectrum analyzer measurement (resolution bandwidth 30kHz)
- Increase of frequency resolution by doing subsequent measurements of 20MHz
- Mean over different day times
- GSM and UMTS basestations dominant



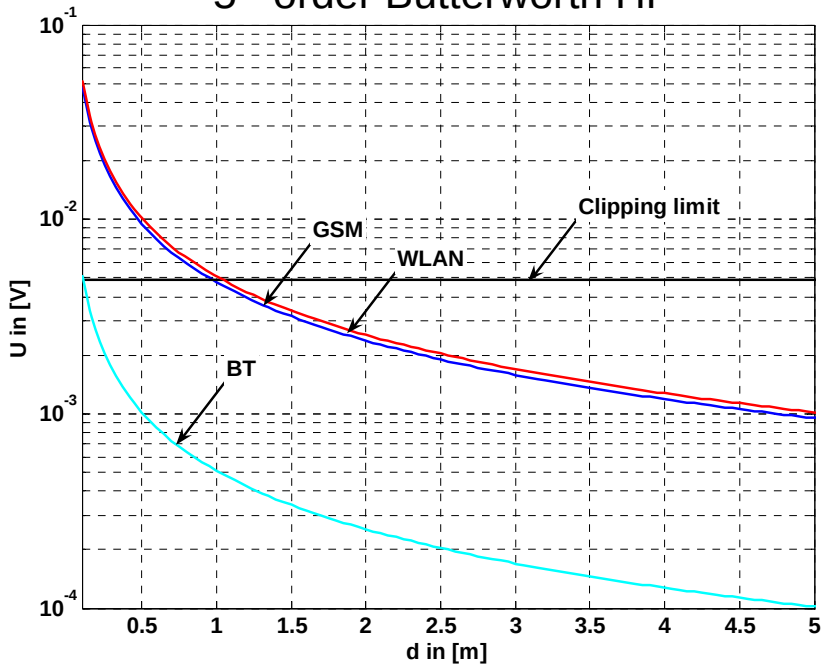
- Filtering can be used to reduce background interference

Interference in Close Vicinity

- HPF filters background interfercence
- LNA and AGC assumed to be perfect
- AGC amplifies desired signal such that it fits best in the desired 3bit range of the ADC
- ADC with 6 bit resolution
  - 3 bit for signal +
    3 bit reserve until clipping
  - Assume expected UWB signal
    -50dBm = 0.7mV @ 50Ω
  - ⇨ Clipping if interferer > 4.9mV



5th order Butterworth HP

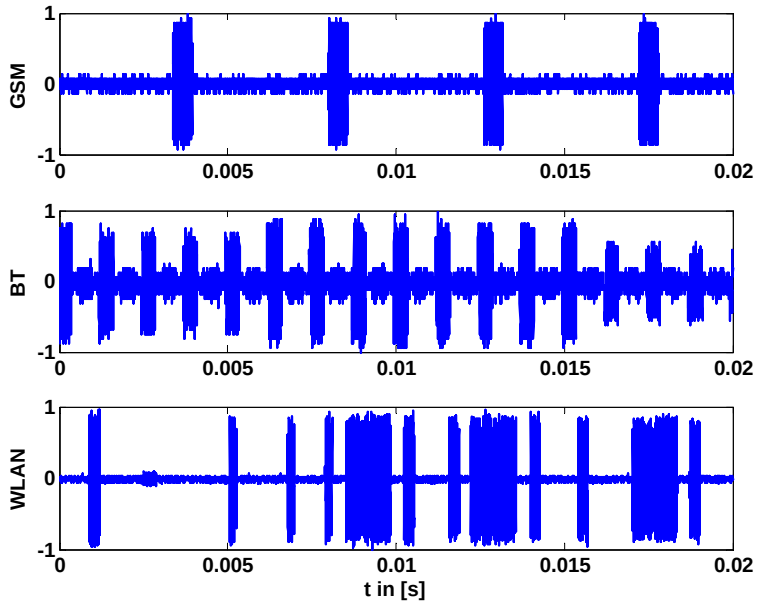


⇨ Clipping for distances below 1m

⇨ Further interference mitigation required

Burst Interferers in Close Vicinity of the UWB RX

- Time domain measurement with oscilloscope
- Burst wise transmission of GSM, BT, and WLAN

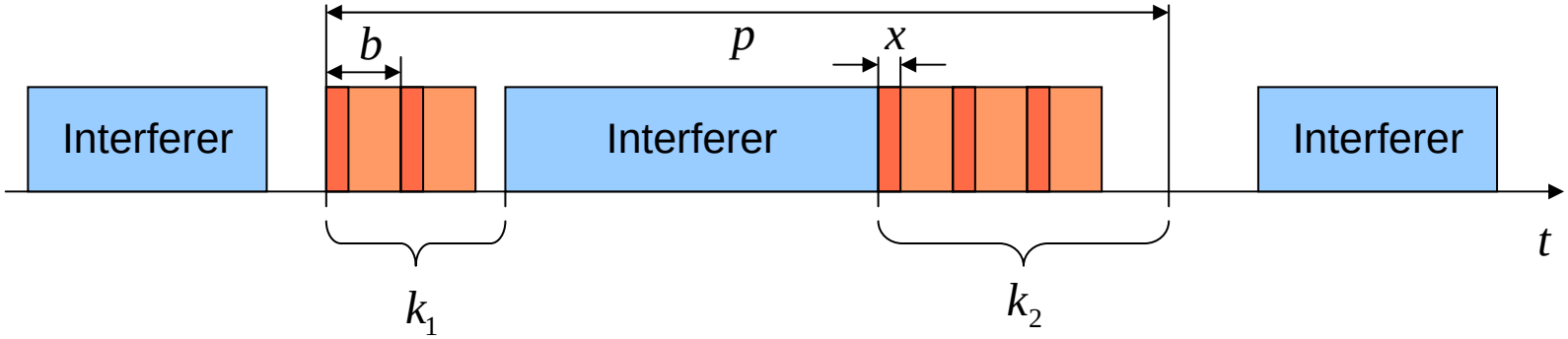


⇨ UWB transmission between interferer bursts

⇨ Temporal Cognitive UWB Medium Access

Temporal Cognitive UWB Medium Access

- Listen for Interference
  - Receiver waits if interference is present
  - UWB transmission during *N* interferer idle time-slots of duration k_i, …, k_N
  - Each UWB packet has duration *b* including a preamble of duration *x*



- 1pulse/µs in peak power limit
- Colliding packets are discarded

⇨ Pulse rate *r* in a given latency time *p*

$$r(b) = \frac{b-x}{p} \cdot \mathrm{E}\left\{\sum_{i=1}^{N} \left\lfloor \frac{k_i}{b} \right\rfloor\right\}$$

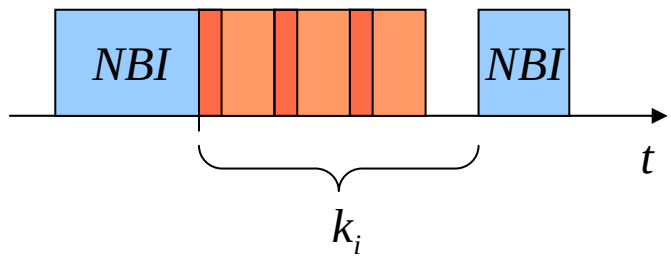
Packet Length

- Strong impact of packet length *b* on the data rate
- Increase of packet length *b*:
  - Increase of payload *b-x*
  - Decrease of number of UWB packets per idle slot

⇨ Optimum packet length

- Pulse rate: $r(b) = \frac{b-x}{p} \cdot \mathrm{E}\left\{\sum_{i=1}^{N} \left\lfloor \frac{k_i}{b} \right\rfloor\right\}$

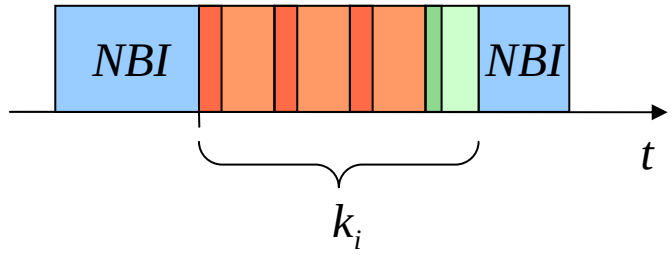
$$\left\lfloor \frac{k_i}{b} \right\rfloor = \frac{k_i}{b} - c; \quad c \in [0,1)$$



Bounds and Approximation for Pulse Rate

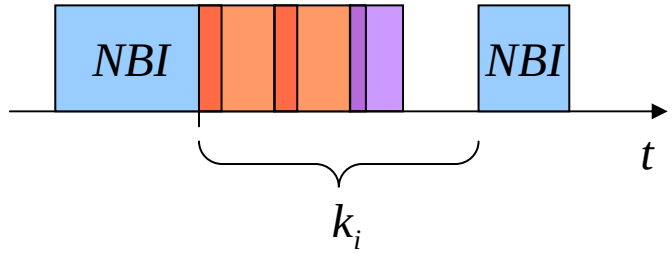
- Max.: $c = 0$

$$\Rightarrow r_{\max}(b) = \frac{b-x}{p} \cdot \mathrm{E}\left\{\sum_{i=1}^{N}\left(\frac{k_i}{b}\right)\right\}$$



- Min.: $c = 1$

$$\Rightarrow r_{\min}(b) = \frac{b-x}{p} \cdot \mathrm{E}\left\{\sum_{i=1}^{N}\left(\frac{k_i}{b}-1\right)\right\}$$



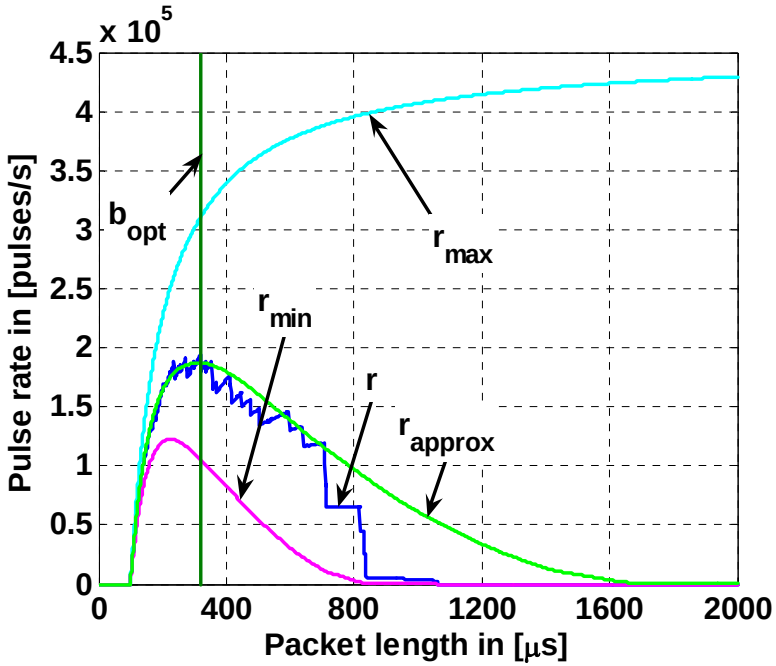
- Approx.: c uniformly distributed $\Rightarrow \mathrm{E}\{c\} = \frac{1}{2}$

$$\Rightarrow r_{approx}(b) = \frac{b-x}{p} \cdot \mathrm{E}\left\{\sum_{i=1}^{N}\left(\frac{k_i}{b}-\frac{1}{2}\right)\right\}$$

$$\Rightarrow b = \sqrt{2E\{k_i\}x}$$

Achievable Data Rate

- Simultaneous transmission of GSM, BT, and WLAN
- x = 100µs, p = 2ms, k_i from measurements



- b_{opt} = 318µs
- About 190 kpulses/s for optimum packet length
- Approximation and real pulse rate match well

Conclusions

- Measurement of background interference
  - GSM and UMTS basestations dominant
- Background interference can be handled by filtering
- Measurement of burst interference
  - Long idle periods observable
- Temporal cognitive UWB medium access is well suited to avoid burst interference

Thank you for your attention