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Design and Performance Trade-offs in Parallelized RF SDR Architecture

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Outline

- Parallel RF SDR platform for LTE and WLAN (UE)
- Holistic RF platform design
  - effect on RX and TX front-end filters
- Multi-radio opportunities
  - we show system-level data throughput opportunities by RF resource sharing (simulation results)

Parallel RF SDR Architecture

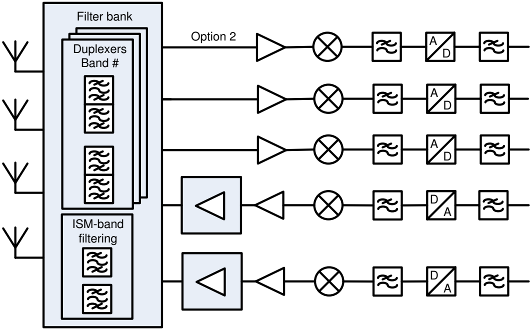


Figure: Archetype of a parallel multi-standard RF transceiver. The number of RX and TX pipes may be varied.

In-device RF Interference

- We analyse how the RX noise floor is accumulated from different sources
  - receiver noise figure
  - TX signal spilling to RX frequencies due to TX non-linearities
  - TX signal transferred to RX noise due to RX non-linearities
- By setting the allowed desensitization threshold, we can determine RX and TX filter requirements
- Focus on a difficult case
  - WLAN 2.4-GHz (2400–2483.5 MHz)
  - LTE Band 7 (TX: 2500–2570 MHz, RX: 2620–2690 MHz)

RX Filter Requirements

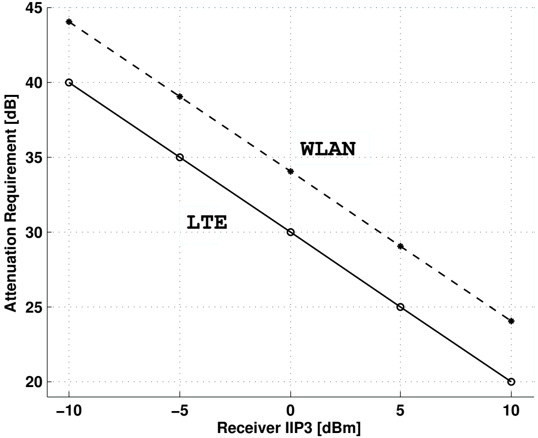


Figure: TX blocker attenuation requirement vs. IIP3 of the receiver to achieve 1 dB sensitivity loss

TX Filter Requirements

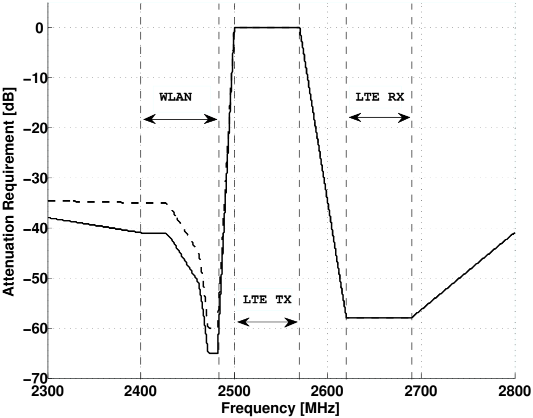


Figure: TX stopband attenuation requirement for LTE band 7 for sensitivity losses of 1 dB and 3 dB in 2.4-GHz WLAN receiver

Multi-radio Opportunities

- Non-dedicated RF resources
- Two approaches for sharing
  - more performance in the average case (high-end)
  - less hardware for same functionality (low-end)
- Sharing requires favourable conditions, *e.g.*, discontinuous modes in use
  - high-end approach is currently more feasible

RF Resource Scheduling

- The fundamental idea
  - when one radio does not need full HW capabilities, use spare resources to boost another radio
  - all radios maxed out is not the common case
- Some techniques
  - semi-static scheduling: SISO vs MIMO
  - dynamic scheduling: fine-grain traffic shaping
    i.e., “TDM of chip resources”

LTE and WLAN on Shared Resources

- Assume discontinuous modes
  - LTE: DRX
  - WLAN: powersave
- The idea
  - LTE reserves the resources first
  - WLAN uses what is left
    - PS-Poll enables fine-grained traffic shaping for RX
- In experiments, we assume
  - bandwidths are 20 MHz ($\approx$ 150 Mbps)
  - device has control on SISO vs MIMO
    - MCS & RI feedback

LTE and WLAN: Performance Estimation (1/2)

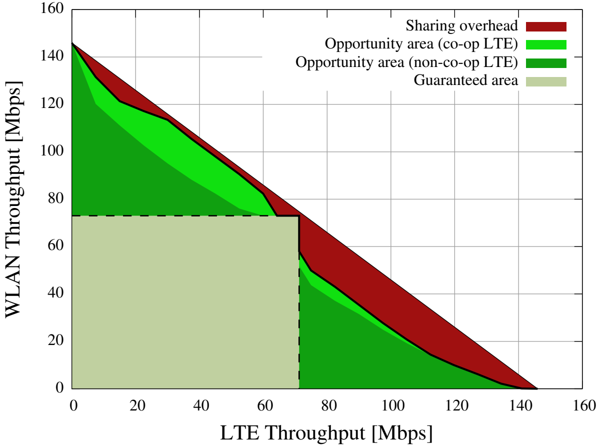


Figure: Performance estimation for 2 shared receivers

LTE and WLAN: Performance Estimation (2/2)

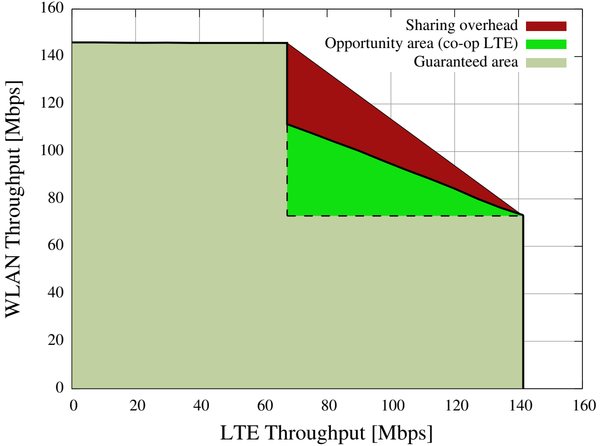


Figure: Performance estimation for 3 shared receivers

Conclusions

- RF systems must be designed as a whole, not only per-protocol
  - *e.g.*, additional filter requirements
- Parallel SDR approach brings new opportunities
  - Resource sharing for better system-level throughputs
  - Is there even a fundamental reason for dedicated RF pipes?
  - Cognitive radio connection:
    Don't share only the spectrum, share the resources too
- Resource sharing calls for further protocol work
  - We want better flexibility and predictability
    - ongoing in-device coexistence work helps in this
- Ultimately, we'd like to see general-purpose RF platforms
  - think CPUs, GPGPUs, FPGAs, ...

Bonus Slides

Resource Schedule Example

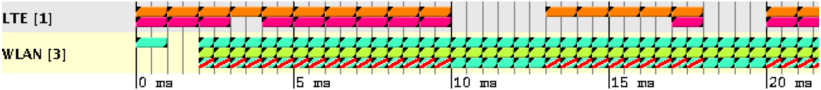
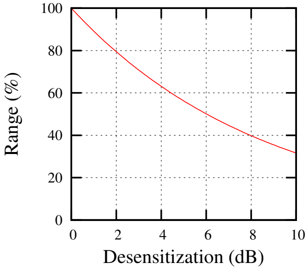
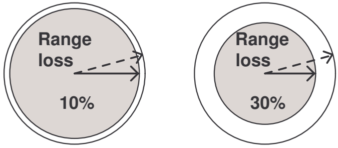


Figure: A resource schedule for LTE and WLAN on 2 RX + 2 TX platform. LTE allocates resources with higher priority.

Effect of Desensitization



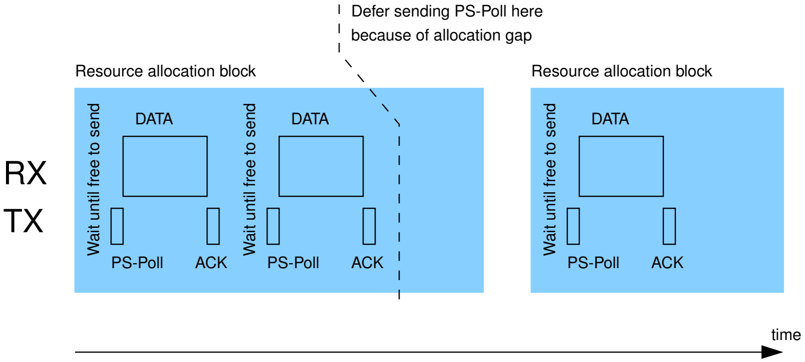
Relation of desensitization and range loss



Visualization for 1 dB and 3 dB desensitization

Figure: Desensitization as range loss in free space

WLAN Frame Scheduling



Multi-radio Resource Schedule Example

- External PNG slides