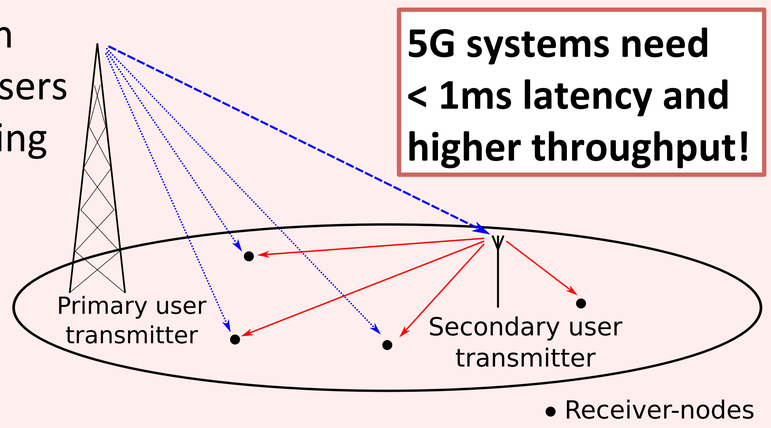
Concurrent Spectrum Sensing and Transmission for Cognitive Radio using Self-Interference Cancellation

Andrew Austin, Orion Afisiadis, Alexios Balatsoukas-Stimming, Andreas Burg

Spectrum-Sensing in Cognitive Radio

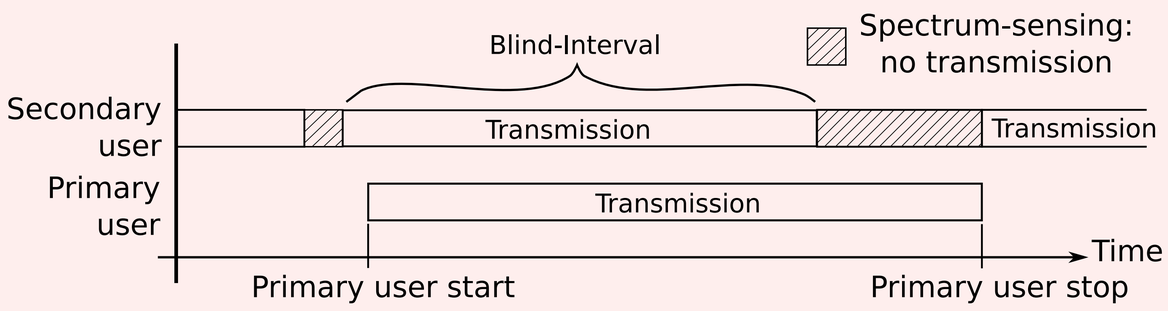
Secondary users (SU) can only sense for primary users (PU) while not transmitting

5G systems need < 1ms latency and higher throughput!



Blind-intervals: PU transmissions not detected by the SU until the next sensing period

- Increases **latency** and causes interference to PU
- Reduces **throughput**: sensing more often increases overhead



Concurrent Spectrum Sensing and Transmission

Self-interference overwhelms the sensing-circuit

Solution: **suppress** SI using full-duplex RF and digital cancellation

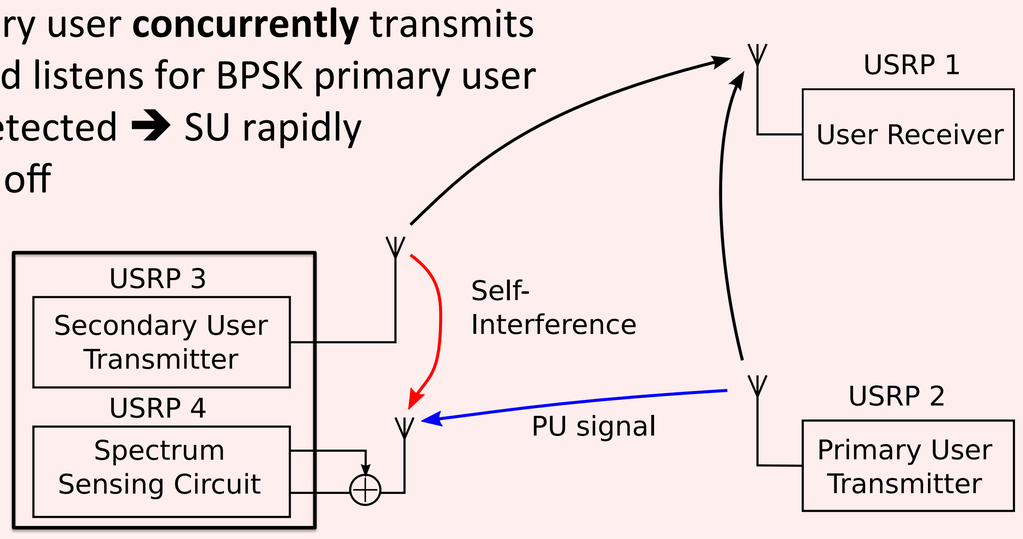
- In principle, the transmitted signal is "known", so we can subtract the self-interference

No blind-interval: significantly reduces latency (decision made every sample) and increases throughput

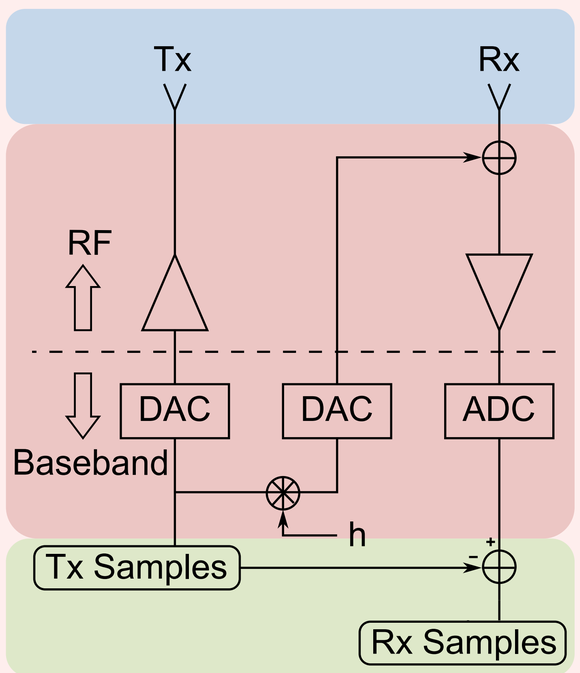
Implementation on NI-USRP Platform

Secondary user **concurrently** transmits QPSK and listens for BPSK primary user

- PU detected ➔ SU rapidly turns off



Different Suppression Stages



Passive Suppression:

- 15-40 dB isolation between Tx and Rx circuits

Active Analog Suppression:

- Add a cancellation signal in the analog domain (before the ADC)
- 30-60 dB depending on transmit power and bandwidth

Digital Domain Suppression:

- Remove residual interference

Detecting the Primary User

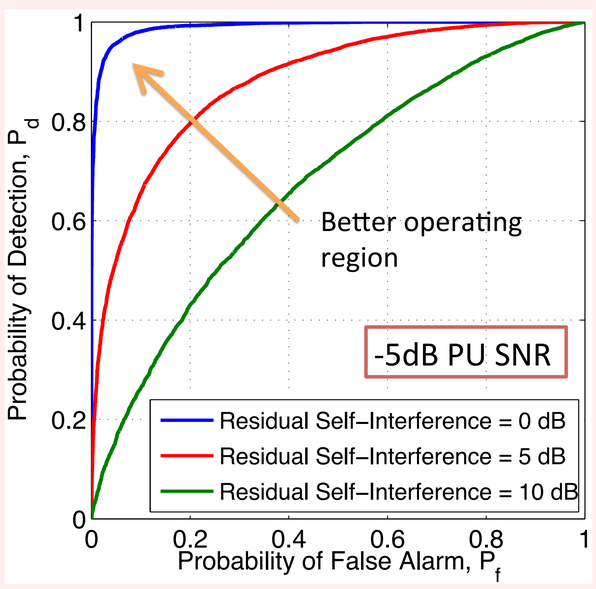
Energy Detection: measure received energy ➔ compare against threshold to determine if a PU is present

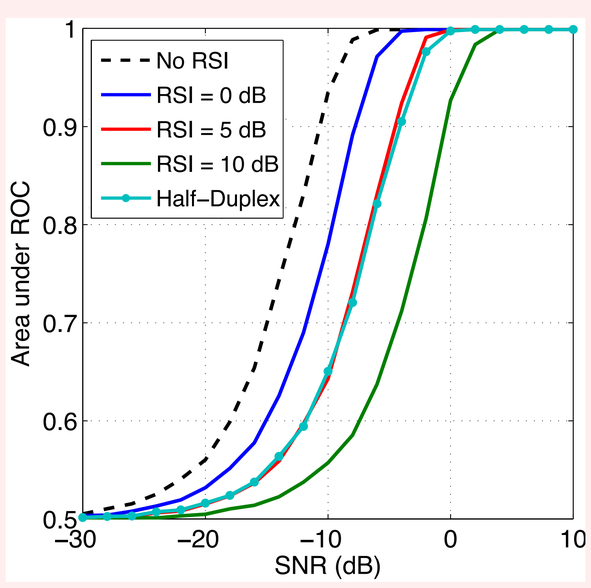
- **Conventional spectrum-sensing:** can only measure energy during short sensing intervals
- **Concurrent spectrum-sensing:** can use the entire frame as a sensing interval and make decisions every sample

Performance Evaluation for Concurrent Sensing

- Noise and residual self-interference (RSI) limit performance
- Concurrent sensing with low RSI ➔ outperforms conventional

Ideally: $P_{detection} = 1$ & $P_{false\text{-}alarm} = 0$ ➔ area under P_d/P_f (ROC) curve = 1



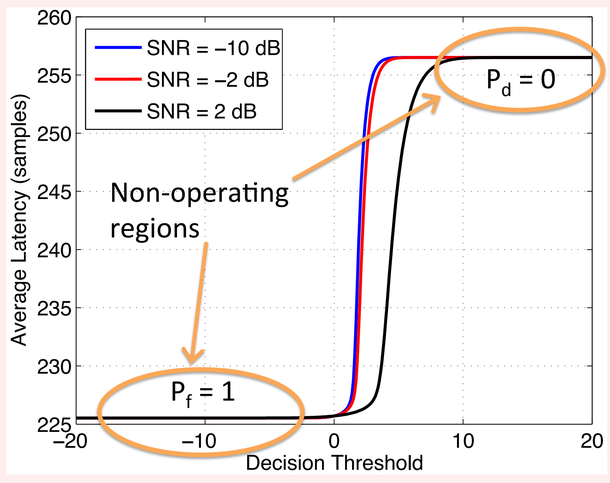


Decreasing RSI ➔ better sensing performance

Latency Analysis

Conventional Sensing

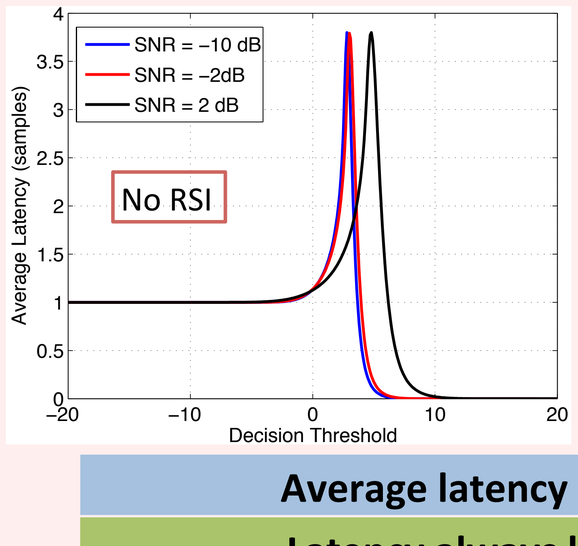
Conventional spectrum sensing: average latency is approximately half the frame ➔ due to blind-interval

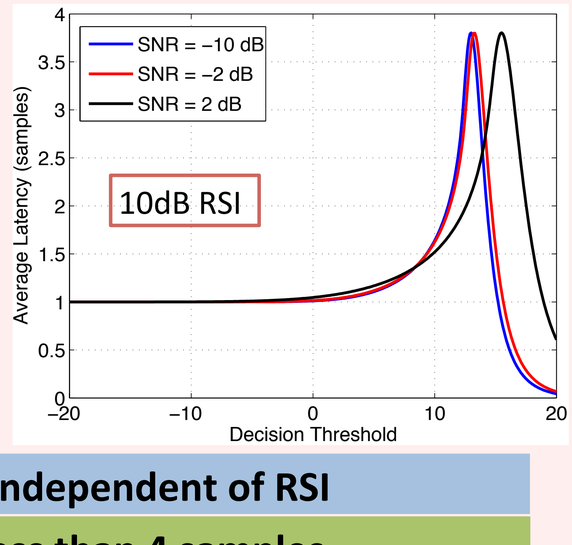


For 32 sensing samples and a frame size of 512, the system is blind for 93.75% of the time

Average latency never less than **225 samples**

Concurrent Sensing





Average latency independent of RSI

Latency always less than 4 samples

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

Telecommunications Circuits Laboratory