Paranoid Secondary: Power Control for a Bursty Cognitive Interference Channel

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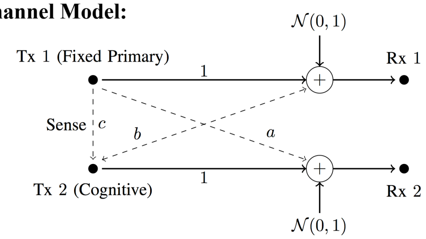
MOTIVATION

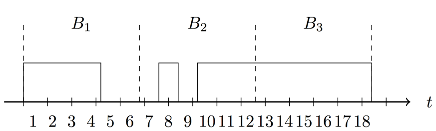
- Underutilized spectrum
  - Rate margin due to burstiness of data
  - Interference margin due to channel
- Compatibility with legacy systems

Aim: To maximize the secondary rate while satisfying the interference and average power constraints.

Channel Model:



BLOCK SWITCHING MODEL



Primary Model:
- Fixed decoder and interference margin
- Bursty traffic – one state switch per block

$$R_1 = \mathcal{C}\left(\frac{\text{SNR}_1}{1+\text{INR}_{\text{gap}}}\right)$$

Effective secondary channel:

$$Y_2^{(t)} = X_2^{(t)} + Z^{(t)}(s)$$

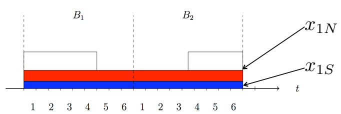
$$Z^{(t)}(s) = \begin{cases} \mathcal{N}(0,1) & \text{if } s_t = 0 \\ \mathcal{N}(0, 1+\sqrt{\text{INR}_2}) & \text{if } s_t = 1 \end{cases},$$

Scheme: SENSE and SEND
Sense at the beginning of each block and then send

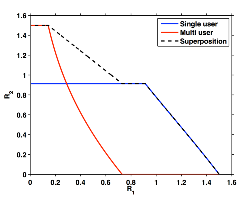
BOUNDS

No-sensing scheme:

- Treat primary as noise (x_{1N})
- Decode off primary and eliminate interference (x_{1S})
- Do both (mixture codeword)

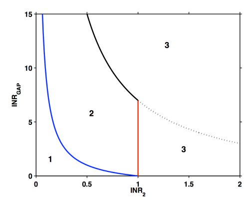


Rate region for the three no-sensing schemes



INR_{gap}=5, a,b=0.5

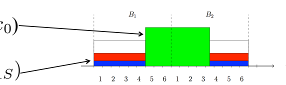
Components of the mixture codeword



INR_1=1, a,b=0.5

Genie-aided sensing scheme:

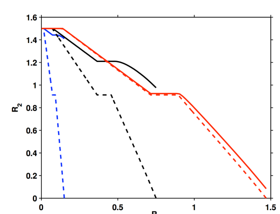
- When primary is off send (x_0)
- When primary is on use a mixture codeword (x_{1N}, x_{1S})



Tightness of Bounds

Less burstiness implies less to make use of using a genie-aided scheme.

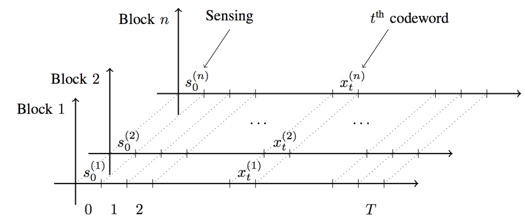
a=0.5, b=0.5
Blue: beta=0.1
Black: beta=0.5
Red: beta=0.98
Beta = fraction of time primary is on



When the primary data is very bursty, the no-sensing scheme performs as well as the genie-aided scheme.

PERFECT SENSING

Multiplexed Codewords



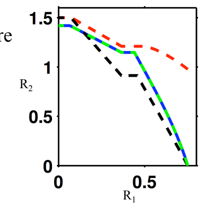
$$C = \frac{1}{T+1}\sum_{d=1}^{T} \max_{p(X^{(d)}|S_0)} I(X^{(d)}; Y^{(d)}|S_0, S^{(d)})$$

Rate region

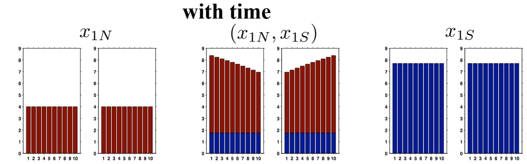
When R_1 is small, i.e. there is more unused spectrum, no sensing out-performs sense-and-send.

a=0.5, b=0.5
INR_{gap}=5, SNR1=3.5, SNR2=3.5, beta=0.5

Blue: Perfect sensing
Black: No-sensing
Red: beta=Genie-aided sensing



Power Profile: Effective channel becomes noisier with time



a=0.5, b=0.5, SNR1=3.5, SNR2=3.5

CONCLUSION

- Performance of no-sensing, genie-aided sensing and perfect sensing
  - Multiplexed codewords achieve capacity
  - Mixture codewords (N+SIC)
- When channel utilization is small, there is no gain in sensing
- For lower channel utilization all the schemes are equally good