Karlsruhe Institute of Technology
Communications Engineering Lab

Cognitive Relay: Detecting Spectrum Holes in a Dynamic Scenario

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Introduction and Motivation

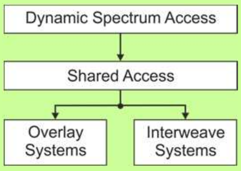
Dynamic Spectrum Access (DSA) is one of the many applications of cognitive radio.

Main tasks for a DSA operating as Secondary User (SU):

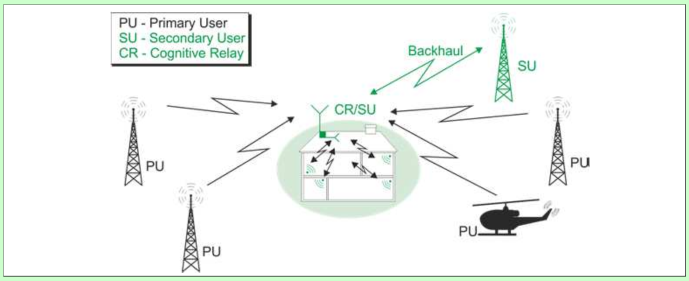
- Sensing (*Learning*) and intelligent access (*Act*)
- Avoid interference to the Primary User (PU)

Purpose of this work:

- Realize the cognitive concepts over the hardware
- Use sophisticated algorithms to reduce the time constraints and computational complexity
- Demonstrate the radio in a real scenario



Scenario



Cognitive Relay (CR) is a network element of the SU system

- Supports wireless services for devices operating indoor
- Enables dynamic access to increase spectral efficiency

System Model

Cross layer optimization

- Receiver model

$$Y[n] = X[n] + W[n]$$

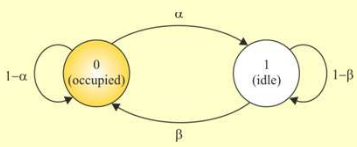
Energy detection

$T(\mathbf{Y})$ test statistics
K number of samples
$Y[n]$ received waveform
$X[n]$ transmitted waveform
$W[n]$ noise waveform
γ threshold, determined using constant false alarm

$$T(\mathbf{Y}) = \frac{1}{K}\sum_{n=0}^{K-1}|Y[n]|^2 \underset{\mathcal{H}_1}{\overset{\mathcal{H}_0}{\gtrless}} \gamma$$

Learning

Modelling channel access as discrete time discrete state Markov process

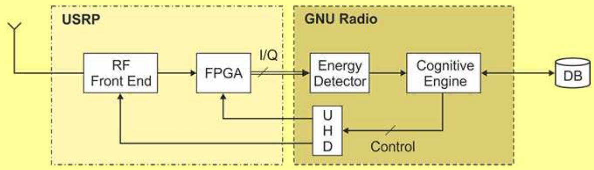


- PU subchannels N
- Multiband sensing through scanning
- State transition probabilities (α, β)
- Utilization probability u

$$u = \mathbb{P}(z(t) = 0) = \frac{\alpha}{\alpha+\beta}$$

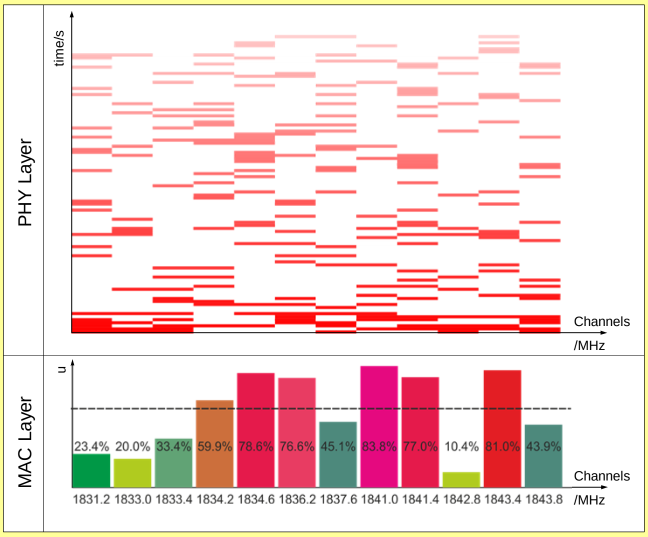
Implementation and User Interactions

Demonstrator Setup



Test scenario	GSM channels at 1800 MHz
Shared Access	Interweave
Hardware	USRP N210
Multiband sensing Software defined architecture	GNU Radio

Analysis



Detection of spectral holes	Time slots
Estimation of model parameters ($\hat{\alpha}$, $\hat{\beta}$)	Maximum likelihood estimation
Channel ranking	$\mathbf{u} = [u^1, u^2, ..., u^N]$

Conclusion and Future Work

- Cognitive radio implementation in a dynamic scenario
- Potential to sense non-contiguous multiple band simultaneously over low cost hardware
- Capable to learn and interact with its environment
- Considering other scenarios such as Overlay Systems
  – Spatial separation of the PU and SU systems (transmission power control)
- Cooperation with the other CRs