A Jointly Cooperative Scheme for Secondary Spectrum Access

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Two phase transmission scheme

- primary Tx is transmitting to the primary Rx
- cognitive Tx wants to transmit to cognitive Rx through the same spectrum with primary user
- Orthogonal scheme (only one of PT and ST is transmitting in one phase)
- phase 1 and 2 have equal length

Joint cooperation

- ST and PT are both willing to spare part of their own transmit power to relay the others’ message
- decode-and-forward relaying is applied at PT and ST in alternating phases

System Markov chain

- transmitted signals determined by results of decoding others’ message at PT and ST
- signals from 3 phases needed to decode $x_{pi}$ and $x_{si}$ at receivers
- the whole system is in one of 6 states defined by decoding results at transmitters

Separate decoding

- PR and SR do not talk to each other and try to decode interested messages separately

Performance evaluation

- $1.8$ dB
- $20$ dB

Joint decoding

- PR and SR antennas form a virtual antenna array (a two-user SIMO MAC)
- received signal for state k:

$$y(k) = H_{pi}(k)x_{pi} + H_{si}(k)x_{si} + H_{p(i+1)}(k)x_{p(i+1)} + H_{s(i-1)}(k)x_{s(i-1)} + w$$

- “one shot” decoder (no memory)
- expect a better performance than decoding separately

Capacity and outage

rate pair for state k, $\{R_p(k), R_s(k)\}$:

$$R_p(k) \cdot \log_2 \left(1 + \frac{\mathbb{E}_k \left| H_{pi}(k) H_{si}^H(k) \right|^2}{\mathbb{E}_k \left| H_{pi}(k) H_{si}^H(k) \right|^2 + \sigma^2} \right), \forall S \subseteq \{p, s\}$$

$H_{pi}$: Channel vector of $i$th message after whitening noise

individual outage probabilities for state k:

$$P_o(\text{out}|k) = \Pr \left[ r_j > R_j(k) \right], \quad j \in \{p, s\}$$

$P_o$: target rate
- exact expressions or tight approximations for both primary and secondary outage probabilities in all six states are derived