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A Jointly Cooperative Scheme for Secondary Spectrum Access

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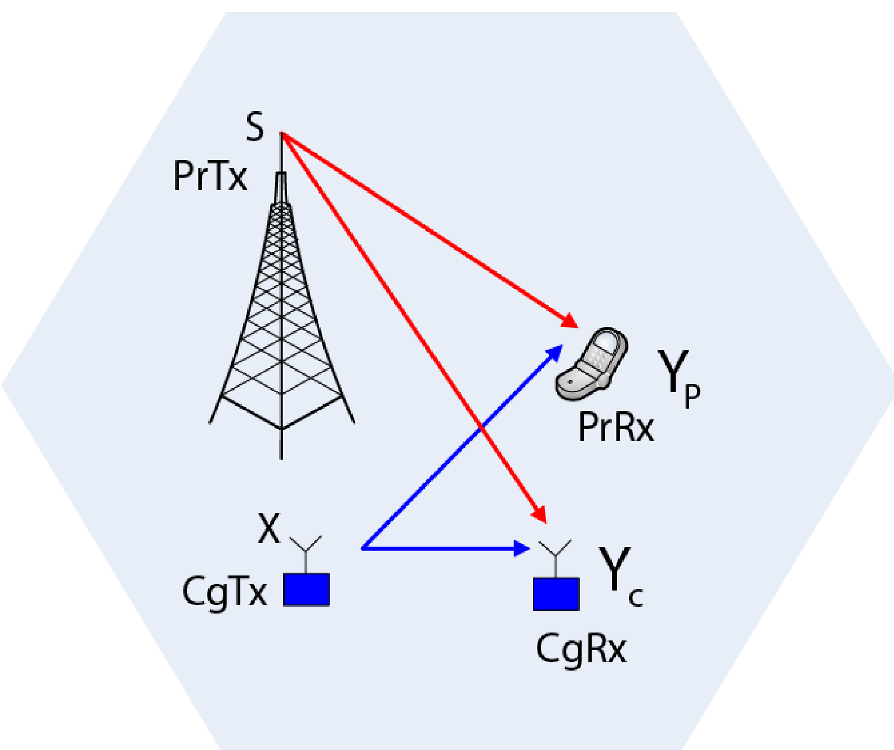
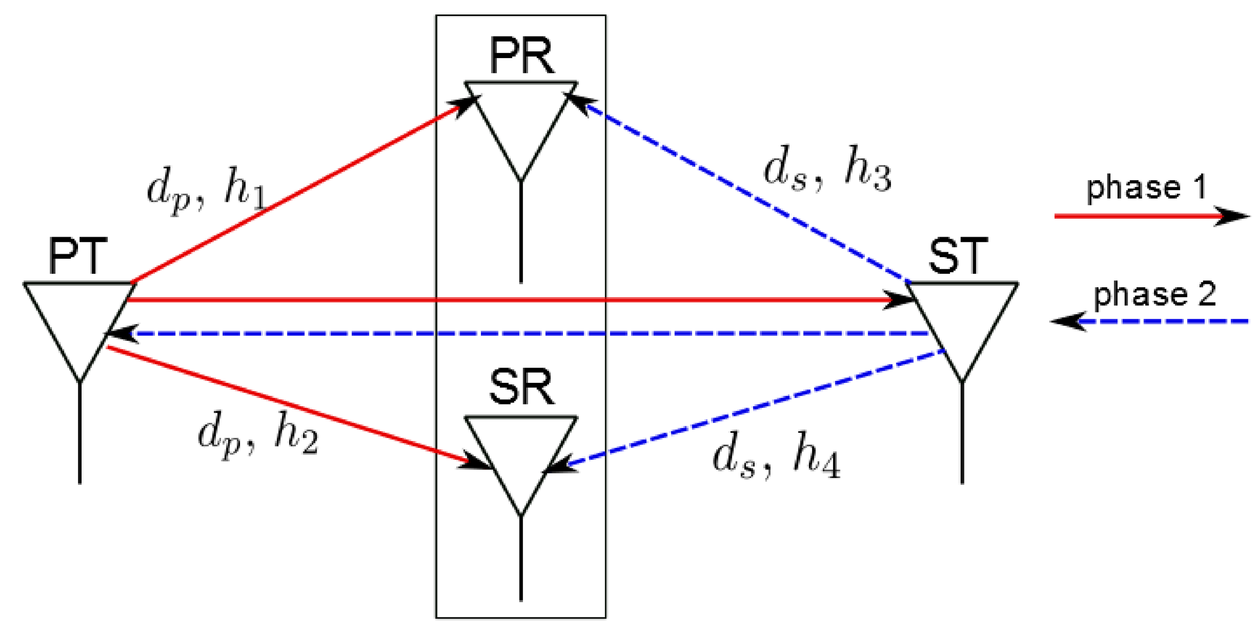


- primary Tx is transmitting to the primary Rx
- cognitive Tx wants to transmit to cognitive Rx through the same spectrum with primary user

Two phase transmission scheme



- 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

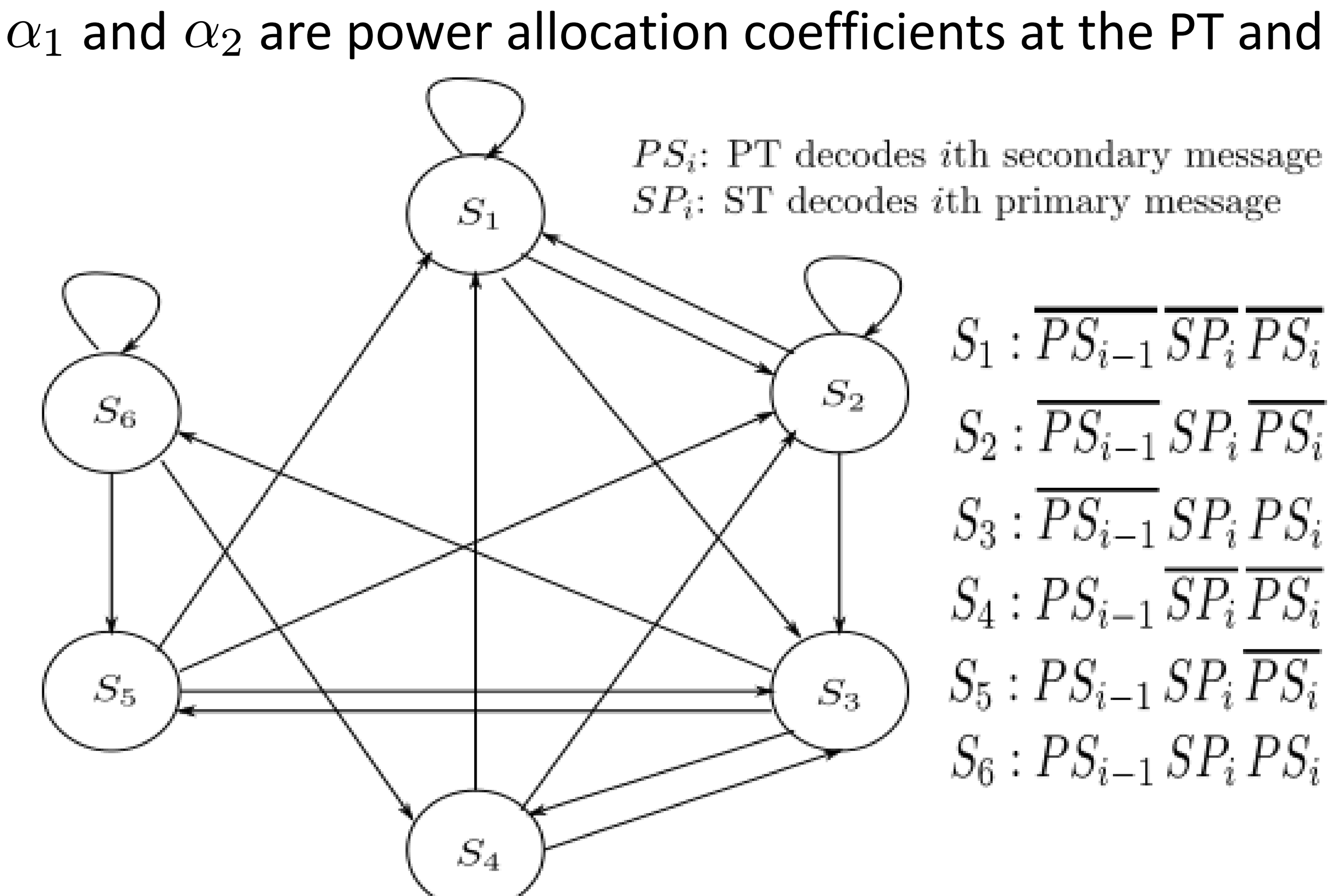
Transmitted signals for time frame i

		PT	ST
phase 1	PT decodes $x_{s(i-1)}$	$\sqrt{\alpha_1 P_p}x_{pi}+\sqrt{(1-\alpha_1)P_p}x_{s(i-1)}$	silent
	else	x_{pi}	silent
phase 2	ST decodes x_{pi}	silent	$\sqrt{\alpha_2 P_s}x_{pi}+\sqrt{(1-\alpha_2)P_s}x_{si}$
	else	x_{pi}	silent

- α_1 and α_2 are power allocation coefficients at the PT and ST respectively

System Markov chain

- transmitted signals determined by results of decoding other's 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

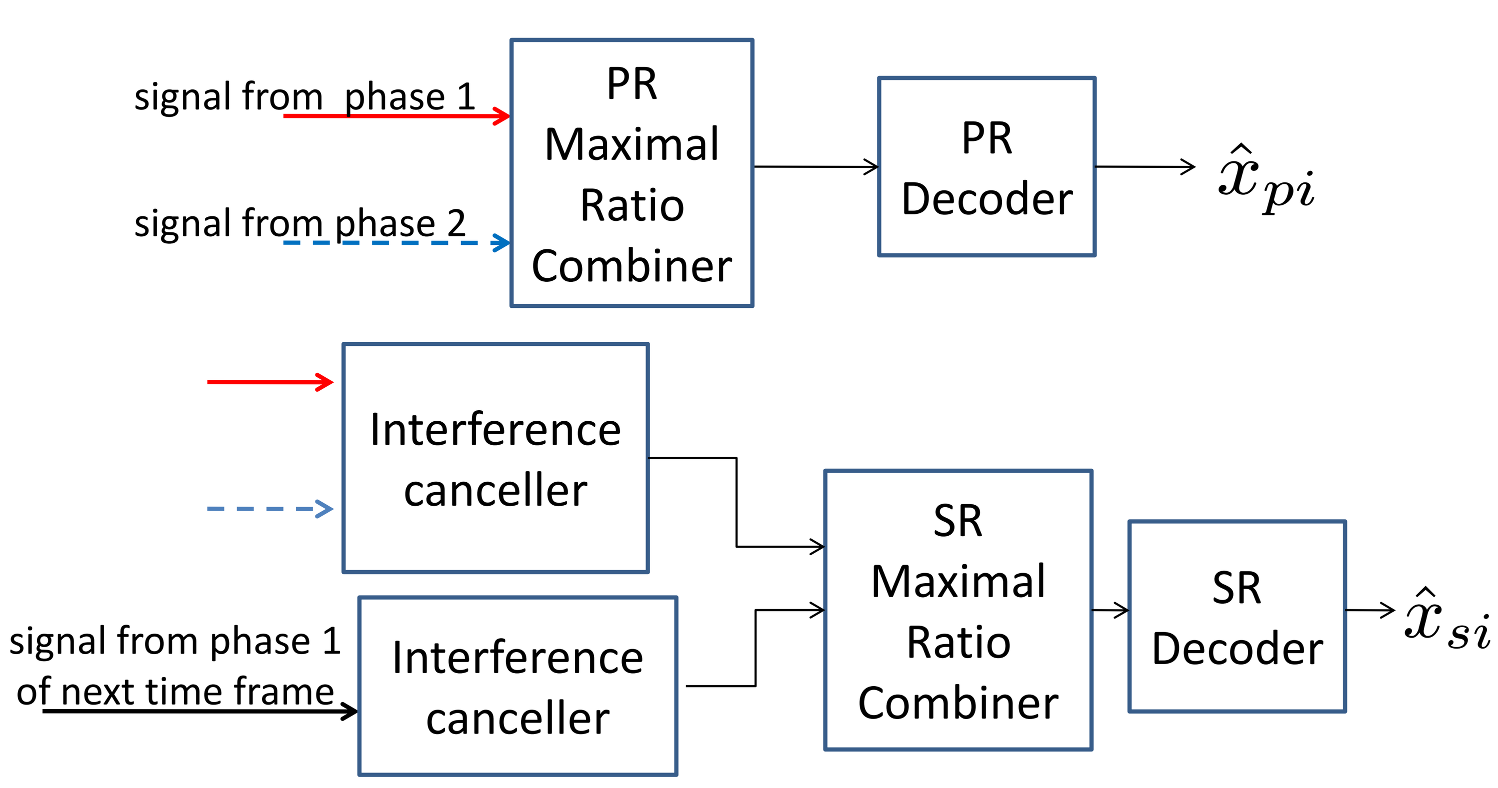


$S_1 : \overline{PS_{i-1}}\,\overline{SP_i}\,\overline{PS_i}$
$S_2 : \overline{PS_{i-1}}\,SP_i\,\overline{PS_i}$
$S_3 : \overline{PS_{i-1}}\,SP_i\,PS_i$
$S_4 : PS_{i-1}\,\overline{SP_i}\,\overline{PS_i}$
$S_5 : PS_{i-1}\,SP_i\,\overline{PS_i}$
$S_6 : PS_{i-1}\,SP_i\,PS_i$

- closed form expressions for probability transition matrix and stationary distribution

Separate decoding

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



Joint decoding

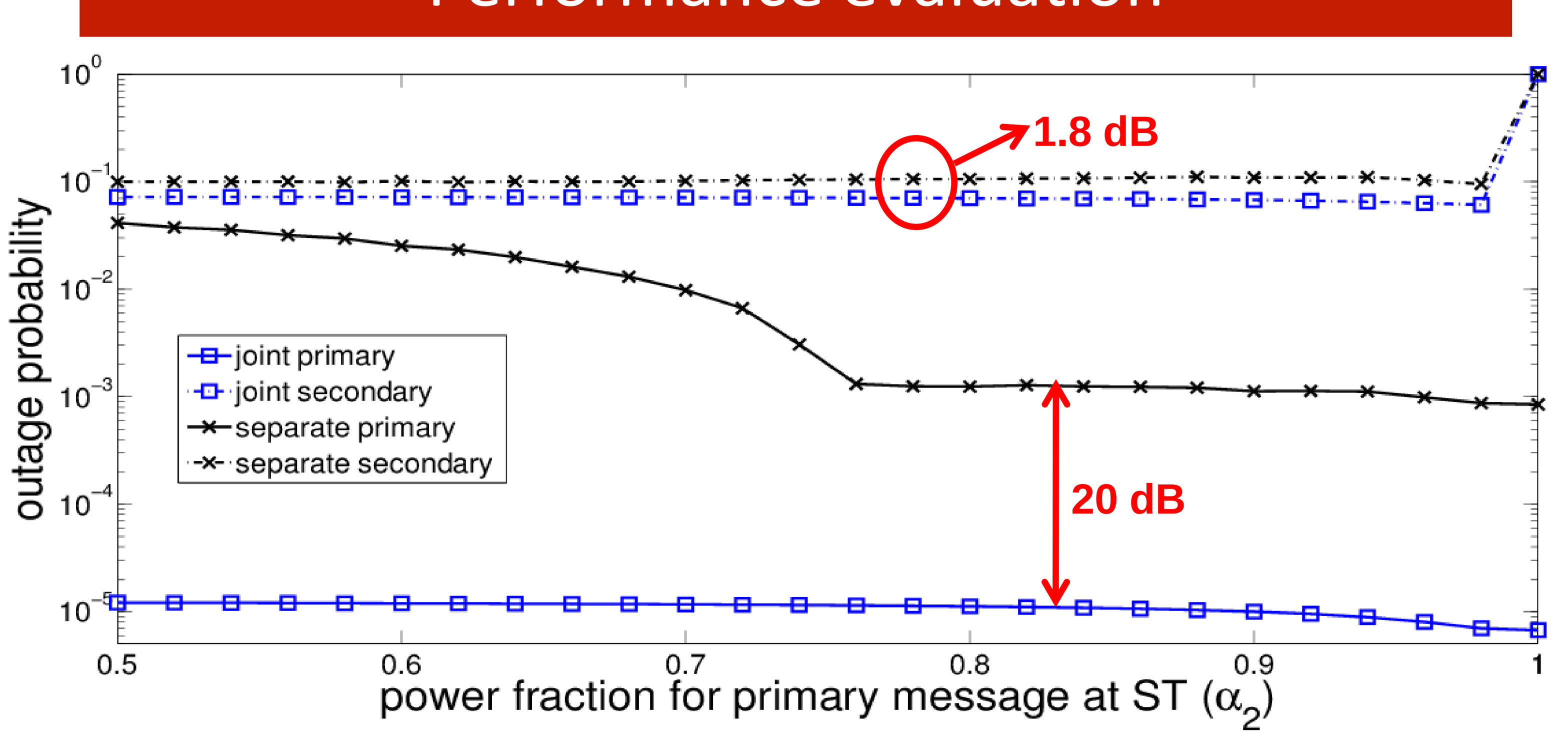
- PR and SR antennas form a virtual antenna array (a two-user SIMO MAC)
- received signal for state k:

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

information symbols — try to decode and cancel — treated as noise

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

Performance evaluation



Capacity and outage

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

$$\sum_{j\in S}R_j(k)\cdot\frac{1}{2}\log\left[\det\left(\mathbf{I}+\sum_{j\in S}\widetilde{H_{ji}}(k)\,\widetilde{H_{ji}}(k)^T\right)\right],\forall S\subseteq\{p,s\}.$$

$\widetilde{H_{ji}}$: Channel vector of ith message after whitening noise

individual outage probabilities for state k:

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

r_j: target rate

- exact expressions or tight approximations for both primary and secondary outage probabilities in all six states are derived

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