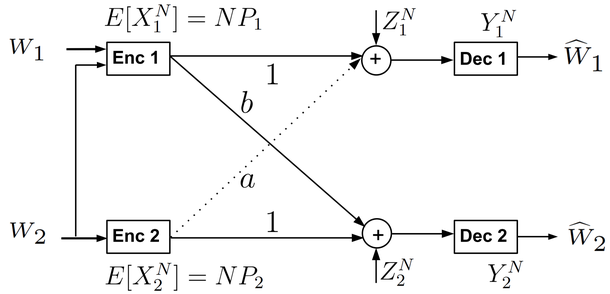
On the capacity of the Gaussian Cognitive S channel

Stefano Rini, Daniela Tuninetti and Natasha Devroye

Channel Model & Existing results

Channel Model



We remove the '*a*' link from the Gaussian cognitive interference channel

Some Literature for the Gaussian cognitive interference channel

•Capacity in weak interference $b \leq 1$
W. Wu, S. Vishwanath, and A. Arapostathis, "Capacity of a class of cognitive radio channels: Interference channels with degraded message sets," Information Theory Transactions. 2007.

•Capacity in very strong interference $\approx$ $a \geq b$
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•Outer bound in strong interference $b \geq 1$
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•A constant gap of less than 2 bits for the whole parameter region
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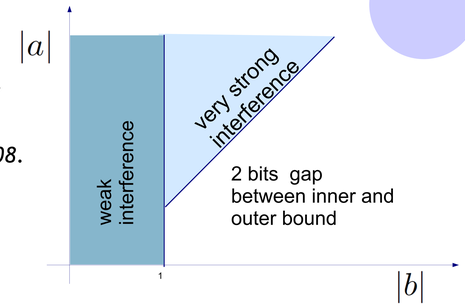
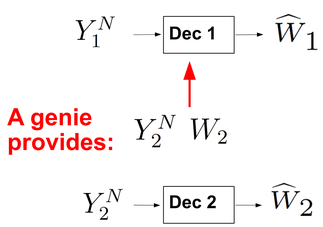
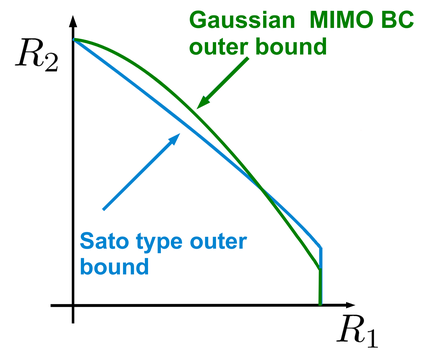


Outer bounds

Sato type outer bound



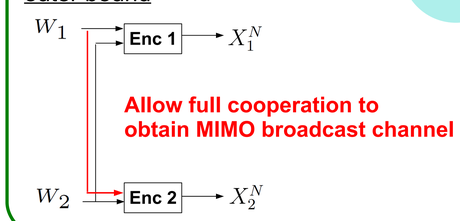


The intersection of the two outer bounds is:

Union over $\alpha \in [0,1]$

$$\left\{ \begin{array}{ll} R_1 & \leq \mathcal{C}(1+\alpha P_1) \\ R_2 & \leq \mathcal{C}\left(1+P_2+\frac{b^2 P_1(1-\alpha)}{1+\alpha P_1}+2b\sqrt{\frac{(1-\alpha)P_1P_2}{1+\alpha P_1}}\right) \\ R_1+R_2 & \leq \mathcal{C}(1+P_2+b^2P_1+2\sqrt{(1-\alpha)P_1P_2}) \end{array} \right\}$$

Gaussian MIMO broadcast channel outer bound

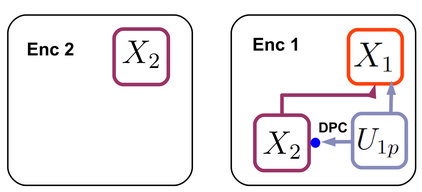


b^2

$b^2 \leq P_2 + 1$ $\qquad$ $b^2 \geq P_2 + 1 + 2b\sqrt{P_1P_2}$

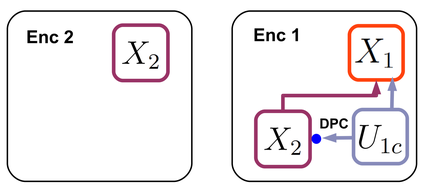
Sato type outer bound is tight			Intersection is tight	MIMO BC outer bound is tight
Capacity (Wu et al.)	Capacity (new)	1 bit gap (new)	1 bit gap (new)	Capacity (new)
$b^2 \leq 1$	$b^2 \leq P_2 + 1 - \frac{P_1P_2}{P_1+1}$			

Achievability



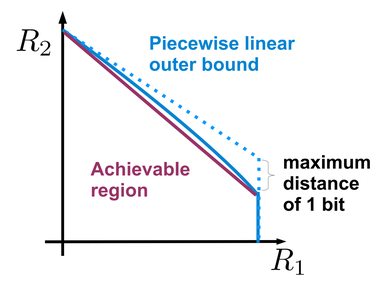
Weak Interference:

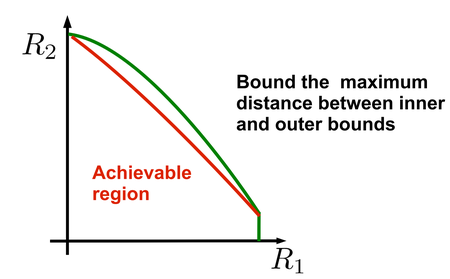
•Both messages are private
•Tx 1 performs DPC
•Rx 2 treats interference as noise

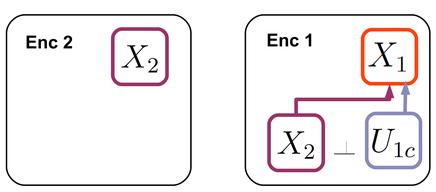


Primary decodes cognitive + DPC

•Enc. 1 message is public, Enc. 2 private.
•Tx 1 performs DPC
•Rx 2 decodes the primary message







Primary decodes cognitive, no DPC

•Enc. 1 message is public, Enc. 2 private.
•Tx 1 treats interference as noise
•Rx 2 decodes the primary message

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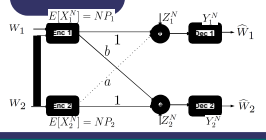

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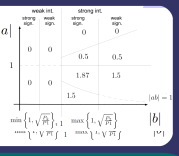
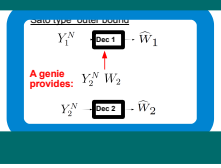
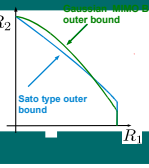


Outer bounds



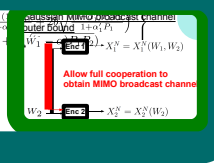
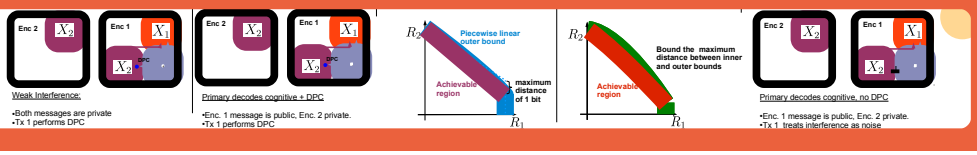


The intersection of the two outer bounds is:

$$\mathcal{R}^{(S\ G.MIMO\ BC)} = \bigcup_{\alpha \in [0,1]} \left\{ \begin{array}{ll} R_2 & \leq \mathcal{C}\left(1 + P_2 + \frac{b^2 P_1 (1-\alpha)}{1+\alpha P_1}\right) \\ R_1 + R_2 & \leq \mathcal{C}(1 + P_2 + b^2 P_1 + \ldots \end{array} \right\}$$

Union over

$$\left\{ \begin{array}{ll} R_1 & \leq \mathcal{C}(1 + \alpha P_1) \\ R_2 & \leq \mathcal{C}\left(1 + P_2 + \frac{b^2 P_1 (1-\alpha)}{1+\alpha P_1} + 2b\sqrt{\frac{(1-\alpha) P_1 P_2}{1+\alpha P_1}}\right) \\ R_1 + R_2 & \leq \mathcal{C}(1 + P_2 + b^2 P_1 + 2\sqrt{(1-\alpha) P_1 P_2}) \end{array} \right\}$$



Achievability