On the capacity of the Gaussian Cognitive S channel

Stefano Rini, Daniela Tuninetti and Natasha Devroye

Some Literature for the Gaussian cognitive interference channel

- Capacity in weak interference \( b < 1 \)
- Capacity in very strong interference \( a \geq b \)
- Outer bound in strong interference \( b > 1 \)
- A constant gap of less than 2 bits for the whole parameter region

We remove the "a" link from the Gaussian cognitive interference channel.

Outer bounds

- Sato type outer bound
- Gaussian MIMO BC outer bound
- Gaussian MIMO broadcast channel outer bound

The intersection of the two outer bounds is:

\[
\begin{align*}
R_1 &\leq C(1 + \alpha P_1) \\
R_2 &\leq C \left( 1 + P_2 + \frac{P_1(1-\alpha) \sqrt{1-\alpha P_1 P_2}}{1+\alpha P_1 P_2} + 2\sqrt{1-\alpha P_1 P_2} \right) \\
R_1 + R_2 &\leq C(1 + P_2 + b^2 P_1 + 2\sqrt{(1-\alpha) P_1 P_2})
\end{align*}
\]

Intersection is tight

MIMO BC outer bound is tight

b^2 ≤ P_2 + 1
b^2 ≥ P_2 + 1 + 2b√P_1 P_2

Achievability

- Weak interference:
  - Both messages are private
  - Enc. 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
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- A constant gap of less than 2 bits for the whole parameter region: S. Rini, D. Tuninetti, and N. Devroye, "The capacity region of Gaussian cognitive radio channels to within 1.87 bits," Information Theory Workshop, Cairo. 2010.

Gaussian MIMO broadcast channel outer bound

The intersection of the two outer bounds is: MIMO BC outer bound is tight

Weak Interference:
- Both messages are private
- Tx 1 performs DPC
- Rx 2 treats interference as noise
- Enc. 1 message is public, Enc. 2 private.
- Tx 1 treats interference as noise
- Rx 2 decodes the primary message

Intersection is tight

A genie provides:

Maximum distance of 1 bit
Achievable region

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

Intersection is tight

1 bit gap (new)