An Achievable Rate Region for the Two-Way Two-Relay Channel

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Problem Statement and Motivation

An information theoretic analysis of the TWTRC is limited by two obstacles:

- **no unidirectional flow of information,** relays cannot subtract "downstream" interference,
- **the failure of backward decoding** due to deadlock, each relay must decode both sources before the other relay.

We make progress on this state of affairs through two ways:

- **an additional constraint** resolves the deadlock problem,
- **an offset-encoding strategy** resolves the flow of information problem.

Main Result

The "multiple access" or "backward-decoding" rate region is achievable provided at least one of the following constraints hold:

$$R_1 < I(X_1; Y_2 | X_2, X_3)$$
$$R_4 < I(X_4; Y_3 | X_2, X_3)$$
$$R_1 + R_4 < \max\{I(X_1, X_4; Y_2 | X_2, X_3),\ I(X_1, X_4; Y_3 | X_2, X_3)\}$$

These constraints ensure some relay can decode *at least one* source before the other relay. The symmetry of the inequalities yields two disjoint cases:

- **Case 1** some relay decodes *exactly one* source before the other relay,
- **Case 2** some relay decodes *both* sources before the other relay.

Conclusions and Future Work

- The additional constraint and the offset encoding technique together resolve the deadlock problem in the TWTRC.
- We are working on extending these results to the two-way multiple-level relay channel.

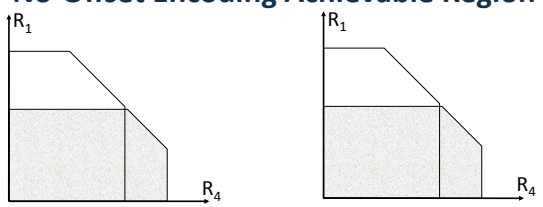
A No-offset Encoding Scheme

Node	Block b	Block b+1	Block b+2
1	$x_1(w_{1,b})$	$x_1(w_{1,b+1})$	$x_1(w_{1,b+2})$
2	$x_2(w_{1,b-2}, w_{4,b-1})$	$x_2(w_{1,b}, w_{4,b-1})$	$x_2(w_{1,b+1}, w_{4,b})$
3	$x_3(w_{1,b-1}, w_{4,b-1})$	$x_3(w_{1,b-1}, w_{4,b})$	$x_3(w_{1,b}, w_{4,b+1})$
4	$x_4(w_{4,b})$	$x_4(w_{4,b+1})$	$x_4(w_{4,b+2})$

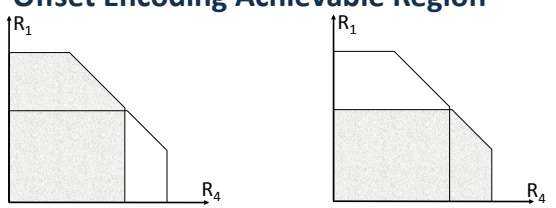
An Offset Encoding Scheme

Node	Block b	Block b+1	Block b+2	Block b+3
1	$x_1(w_{1,b})$	$x_1(w_{1,b+1})$	$x_1(w_{1,b+2})$	$x_1(w_{1,b+3})$
2	$x_2(w_{1,b-2}, w_{4,b-1})$	$x_2(w_{1,b-1}, w_{4,b})$	$x_2(w_{1,b}, w_{4,b+1})$	$x_2(w_{1,b+1}, w_{4,b+2})$
3	$x_3(w_{1,b-3}, w_{4,b-1})$	$x_3(w_{1,b-2}, w_{4,b})$	$x_3(w_{1,b-1}, w_{4,b+1})$	$x_3(w_{1,b}, w_{4,b+2})$
4	$x_4(w_{4,b})$	$x_4(w_{4,b+1})$	$x_4(w_{4,b+2})$	$x_4(w_{4,b+3})$

No-Offset Encoding Achievable Region



Offset Encoding Achievable Region



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