Successive Refinement with Decoder Cooperation

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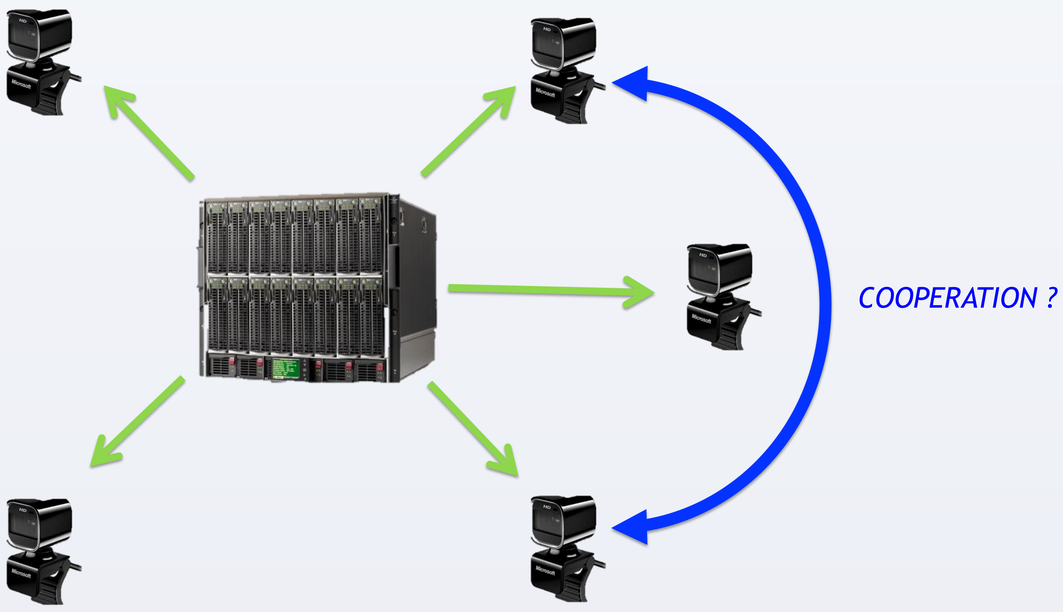
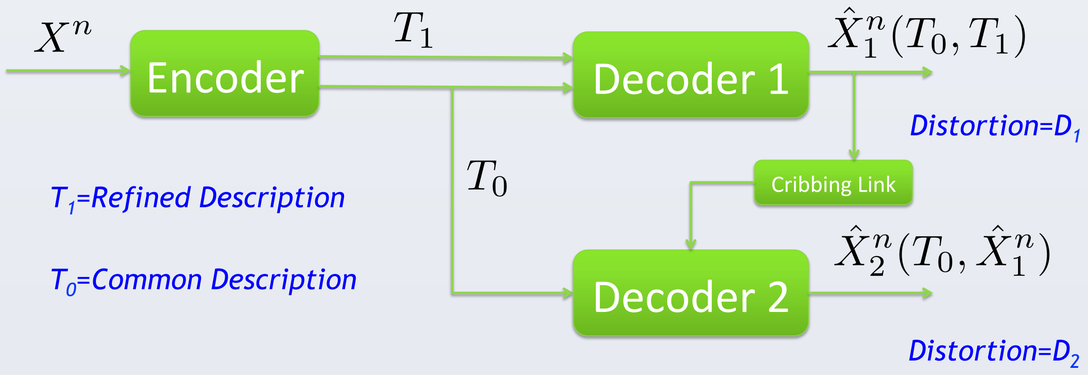
Model of Cooperation

Distributed Compression



Cooperation via "Cribbing"



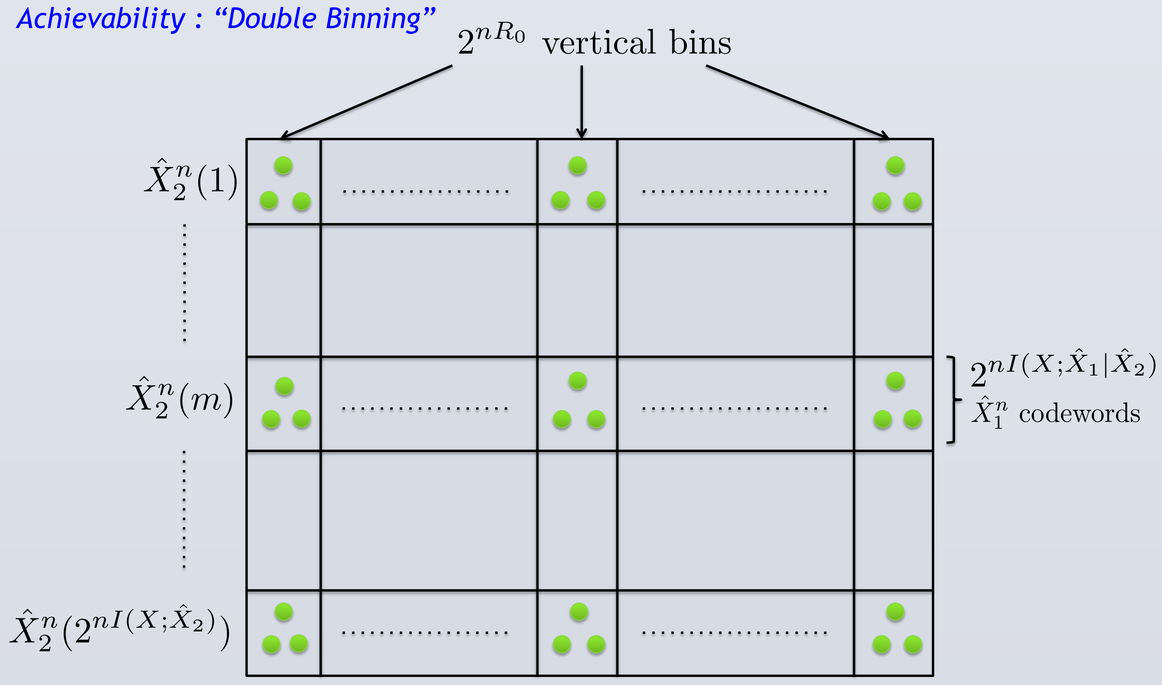
- Source estimate of a decoder uses the estimate of another decoder, *"crib"*.
- Non-causal, strictly-causal, causal cribbing.

Non-causal Cribbing

Rate Region

$$\mathcal{R}_{nc}(D_1, D_2) = \begin{cases} R_0 \geq \{I(X;\hat{X}_1,\hat{X}_2) - H(\hat{X}_1)\}^+ \\ R_0 + R_1 \geq I(X;\hat{X}_1,\hat{X}_2) \\ \text{p.m.f. : } P(X,\hat{X}_1,\hat{X}_2) \\ \text{s.t. } \mathbf{E}[d_i(X,\hat{X}_i)] \leq D_i,\ i=1,2 \end{cases}$$

Achievability : "Double Binning"



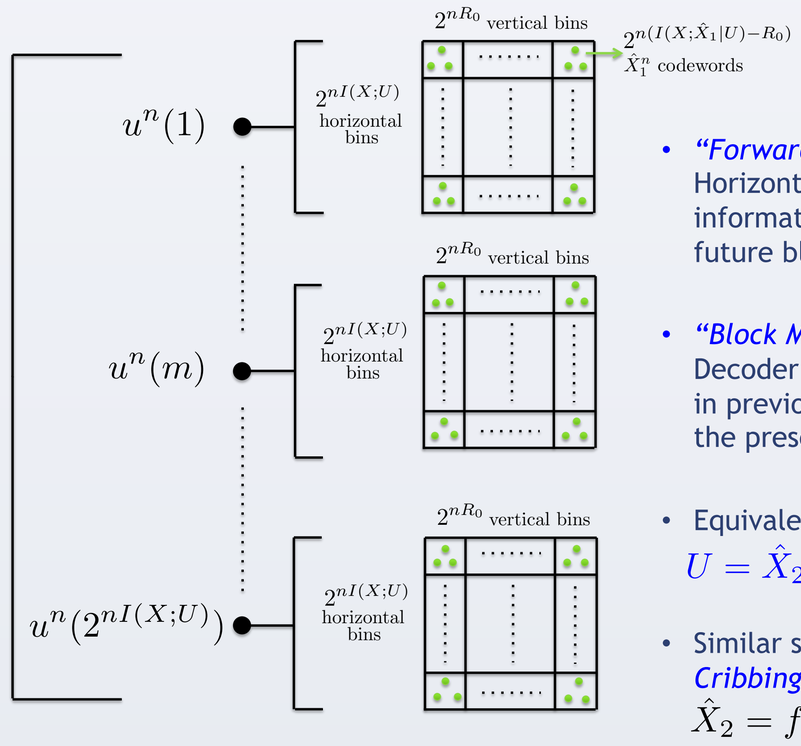
- Decoding at Decoder 1 requires ⟹ $R_0 + R_1 \geq I(X;\hat{X}_1,\hat{X}_2)$
- Decoder 2 finds the unique bin "m" in which "crib" lies ⟹ $H(\hat{X}_1) \geq I(X;\hat{X}_1,\hat{X}_2) - R_0$

Strictly-causal Cribbing

Rate Region

$$\mathcal{R}_{sc}(D_1, D_2) = \begin{cases} R_0 \geq \{I(X;\hat{X}_1,U) - H(\hat{X}_1|U)\}^+ \\ R_0 + R_1 \geq I(X;\hat{X}_1,U) \\ \text{p.m.f. : } P(X,\hat{X}_1,U)\mathbf{1}_{\{\hat{X}_2 = f(U)\}} \\ \text{s.t. } \mathbf{E}[d_i(X,\hat{X}_i)] \leq D_i,\ i=1,2 \end{cases}$$

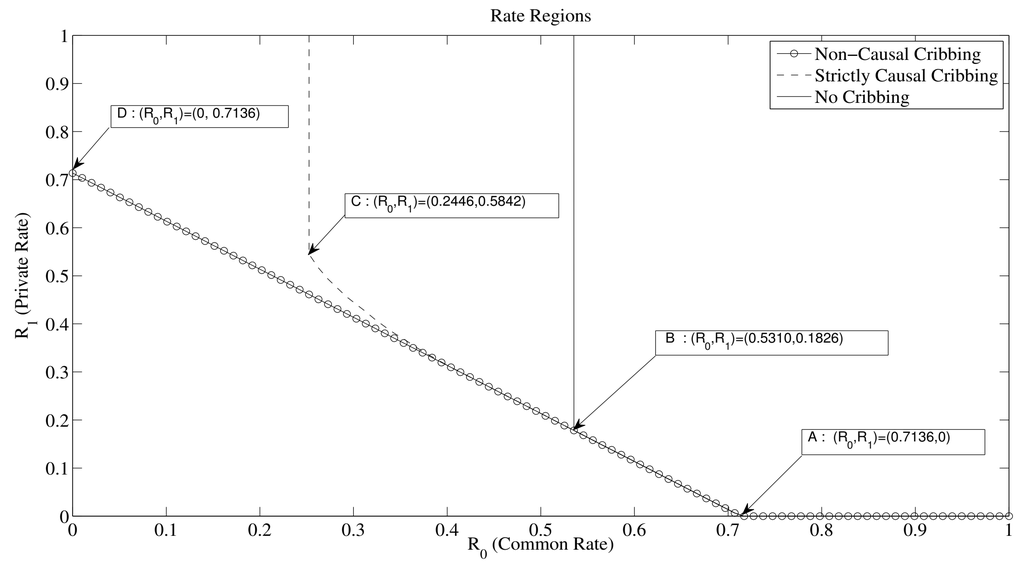
Achievability : "Forward Encoding and Block Markov Decoding"



- *"Forward Encoding"* : Horizontal bin index, stores information about the source in future block.
- *"Block Markov Decoding"* : Decoder 2 uses decoded indices in previous block to decode in the present block.
- Equivalent Rate Region with $U = \hat{X}_2$.
- Similar scheme for *"Causal Cribbing"*, with reconstruction $\hat{X}_2 = f(\hat{X}_1, U)$.

Numerical Example

X ~ Bern (0.5), Hamming Loss, (D_1, D_2)=(0.05,0.1)



Extensions

- The results can be extended to the setting where *"crib"* is a deterministic function of the source reconstruction.
- Cooperation via "*conferencing*" or rate-limited link.
- Dual channel coding setup : Multiple Access Channel (MAC) with common message and "*cooperating*" encoders.

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