Journal Watch
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SPCOM Lab, IISc
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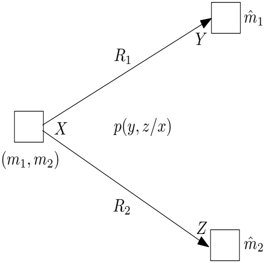
On Marton's Inner Bound and Its Optimality for Classes of Product Broadcast Channels

Authors: Geng, Y. ; Gohari, A. ; Nair, C. ; Yu, Y.



Inner bound (Marton)

$R_1 \leq I(U, W : Y)$

$R_2 \leq I(V, W : Z)$

$R_1 + R_2 \leq \min[I(W;Y), I(W;Z)] + I(U;Y|W)I(V;Z|W) - I(U;V|W)$

$(U, V, W) \rightarrow X \rightarrow (Y, Z)$

$|\mathcal{U}|, |\mathcal{V}| \leq |\mathcal{X}| \qquad |\mathcal{W}| \leq |\mathcal{X}| + 4$ → Recent result (Gohari, Ananthram)

Outer bound (Nair, El-Gamal)

$R_1 \leq I(U;Y)$

$R_2 \leq I(V;Z)$

$R_1 + R_2 \leq I(V;Z) + I(X;Y|V)$

$R_1 + R_2 \leq I(U;Y) + I(X;Z|U)$

$(U, V) \rightarrow X \rightarrow (Y, Z)$

$|\mathcal{U}|, |\mathcal{V}| \leq |\mathcal{X}| + 1$ → Recent result (Nair, Gohari, Ananthram)

Product BC

$p(y_1, y_2, z_1, z_2|x_1, x_2)$

$= \quad q_1(y_1, z_1|x_1)\; q_2(y_2, z_2|x_2)$

$\mathcal{X} = (\mathcal{X}_1, \mathcal{X}_2) \;\; \mathcal{Y} = (\mathcal{Y}_1, \mathcal{Y}_2) \;\; \mathcal{Z} = (\mathcal{Z}_1, \mathcal{Z}_2)$

Reversely semideterministic BC

$q_1(y_1|x_1), q_1(z_2|x_2) \in \{0, 1\}$

$q_1(z_1|x_1), q_1(y_2|x_2) \in \{0, 1\}$

Reversely more capable BC

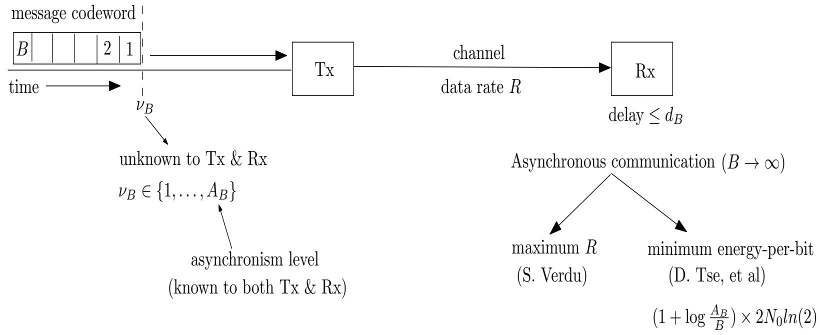
$I(X_1;Y_1) \geq I(X_1;Z_1) \& I(X_2;Z_2) \geq I(X_2;Y_2)$

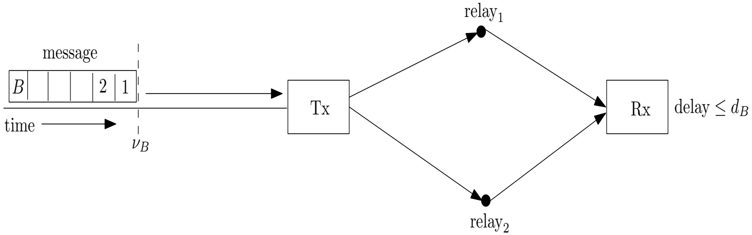
$I(X_1;Z_1) \geq I(X_1;Y_1) \& I(X_2;Y_2) \geq I(X_2;Z_2)$

→ Bounds are tight

Diamond Networks With Bursty Traffic: Bounds on the Minimum Energy-Per-Bit

Authors: Shomorony, I. ; Etkin, R.H. ; Parvaresh, F. ; Avestimehr, A.S.


message codeword
B
2
1
time
ν_B
Tx
channel
data rate R
Rx
delay $\leq d_B$
unknown to Tx & Rx
$\nu_B \in \{1, \ldots, A_B\}$
asynchronism level
(known to both Tx & Rx)
Asynchronous communication $(B \to \infty)$
maximum R
(S. Verdu)
minimum energy-per-bit
(D. Tse, et al)
$(1 + \log \frac{A_B}{B}) \times 2N_0 ln(2)$

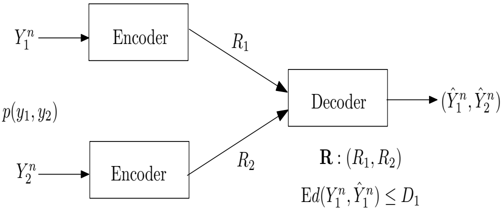

message
B
2
1
time
ν_B
Tx
relay_1
relay_2
Rx
delay $\leq d_B$

Main results

- $(1 + \log \frac{A_B}{B}) \times 2N_0 \ln(2)$ can be achieved by *separating synchronization and communication*:
  - As soon as the message arrives at time ν_B, Tx informs the Rx that a message bit is about to be transmitted.
  - If synchronization is successful, communication proceeds under the synchronous setting.
- For the diamond network:
  - Separation coding is optimal. Inference: employ relay_1, or relay_2, or both relay_1 and relay_2. This is in contrast to the synchronous case, where the optimal scheme is to employ as many relays as possible.
  - In the highly asynchronous regime, the separation-based scheme achieves the minimum energy-per-bit to within a constant fraction of 1 bit.
- Applicable for scenarios where communications is bursty.

Multiterminal Source Coding Under Logarithmic Loss

Authors: Courtade, T.A. ; Weissman, T.



$\mathbf{R} : (R_1, R_2)$

$\mathrm{E}d(Y_1^n, \hat{Y}_1^n) \leq D_1$

$\mathrm{E}d(Y_2^n, \hat{Y}_2^n) \leq D_2$

Settled problems

$D_1 = D_2 = 0$ (Slepian, Wolf)

$D_1 = 0, D_2 = D_{\max}$ (Ahlswede, Korner)

Y_2 at decoder (Wyner, Ziv)

D_1 arbitrary, $D_2 = 0$ (Yeung, Berger)

$p(y_1, y_2)$ Gaussian; (D_1, D_2) arbitrary (Wagner, Viswanath)

$d(y_i, \hat{y}_i) = \log(\frac{1}{\hat{y}_i(y_i)}), i = 1, 2$

$d(y_i, \hat{y}_i) = D(\{Y_i = y_i\} || \hat{y}_i), i = 1, 2$

$p(y_1, y_2)$ arbitrary

Inner bound

$R_1 \geq I(Y_1; U_1 | U_2, Q)$

$R_2 \geq I(Y_2; U_2 | U_1, Q)$

$R_1 + R_2 \geq I(U_1, U_2; Y_1, Y_2 | Q)$

$D \geq H(X | U_1, U_2, Q)$

Outer bound

$R_1 \geq H(Y_1 | Y_2) - D$

$R_2 \geq H(Y_2 | Y_1) - D$

$R_1 + R_2 \geq H(Y_1, Y_2) - D$

$D \geq H(Y_1, Y_2 | U_1, U_2, Q)$

$X \sim \text{Bernoulli}\left(\frac{1}{2}\right)$

$P(Y_i = X) = 1 - \alpha, \alpha > 0$

Open problems

Characterize $\mathbf{R}$

D_1 arbitrary, $D_2 = D_{\max}$

$p(y_1, y_2)$ arbitrary

Characterize $\mathbf{R}$

$p(y_1, y_2)$ arbitrary

D arbitrary

Signal Estimation With Additive Error Metrics in Compressed Sensing

Authors: Tan, J; Carmon, D; Baron, D.

- $\boldsymbol{w} = \boldsymbol{\Phi x}$; $\boldsymbol{x} \in \mathbb{R}^N$ and i.i.d.; $\boldsymbol{\Phi} \in \mathbb{R}^{M\times N} (M < N)$ is sparse and known.
- $\boldsymbol{w}$ is passed through a channel $f(\boldsymbol{y}|\boldsymbol{w}) = \prod_{i=1}^{M} f(y_i|w_i)$; $f(y_i|w_i)$ is not restricted to follow a particular distribution.
- Estimate $\boldsymbol{x}$ from $\boldsymbol{\Phi}$ and $\boldsymbol{y}$.
- Error function: $D(\hat{\boldsymbol{x}}, \boldsymbol{x}) = \sum_{j=1}^{N} d(\hat{x}_j, x_j)$.
- Contributions:
  - A Bayesian estimation algorithm that minimizes the error metric is shown to be optimal;
  - Information-theoretic performance limits of estimation given an error metric (mean absolute error, mean support error, mean weighted-support error).
- $\hat{\boldsymbol{x}}_{\text{opt}} = \arg\min_{\hat{\boldsymbol{x}}} \mathbb{E}[D(\hat{\boldsymbol{x}}, \boldsymbol{x})|\boldsymbol{q}]$; $\boldsymbol{q} = \boldsymbol{x} + \boldsymbol{v}$, where $v_j \sim \mathcal{N}(0, \mu_j)$, $j = 1, \dots, N$.
- $D(\hat{\boldsymbol{x}}_{\text{opt}}, \boldsymbol{x})$ is the fundamental information-theoretic performance limit of an algorithm, i.e., no estimation algorithm can outperform this algorithm.

- Nir Lev, Ron Peled, and Yuval Peres, “Separating signal from noise”, http://arxiv.org/pdf/1312.6843.pdf
- Omer Melih Gul, and Elif Uysal-Biyikoglu, “UROP: A Simple, Near-Optimal Scheduling Policy for Energy Harvesting Sensors”, http://arxiv.org/pdf/1401.0437.pdf
- Ritesh Kolte, Urs Niesen, and Piyush Gupta, “Energy-Efficient Communication over the Unsynchronized Gaussian Diamond Network”, http://arxiv.org/pdf/1401.1711.pdf