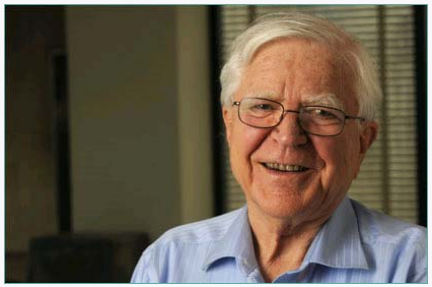
What to do about Hard Problems That Don't Go Away

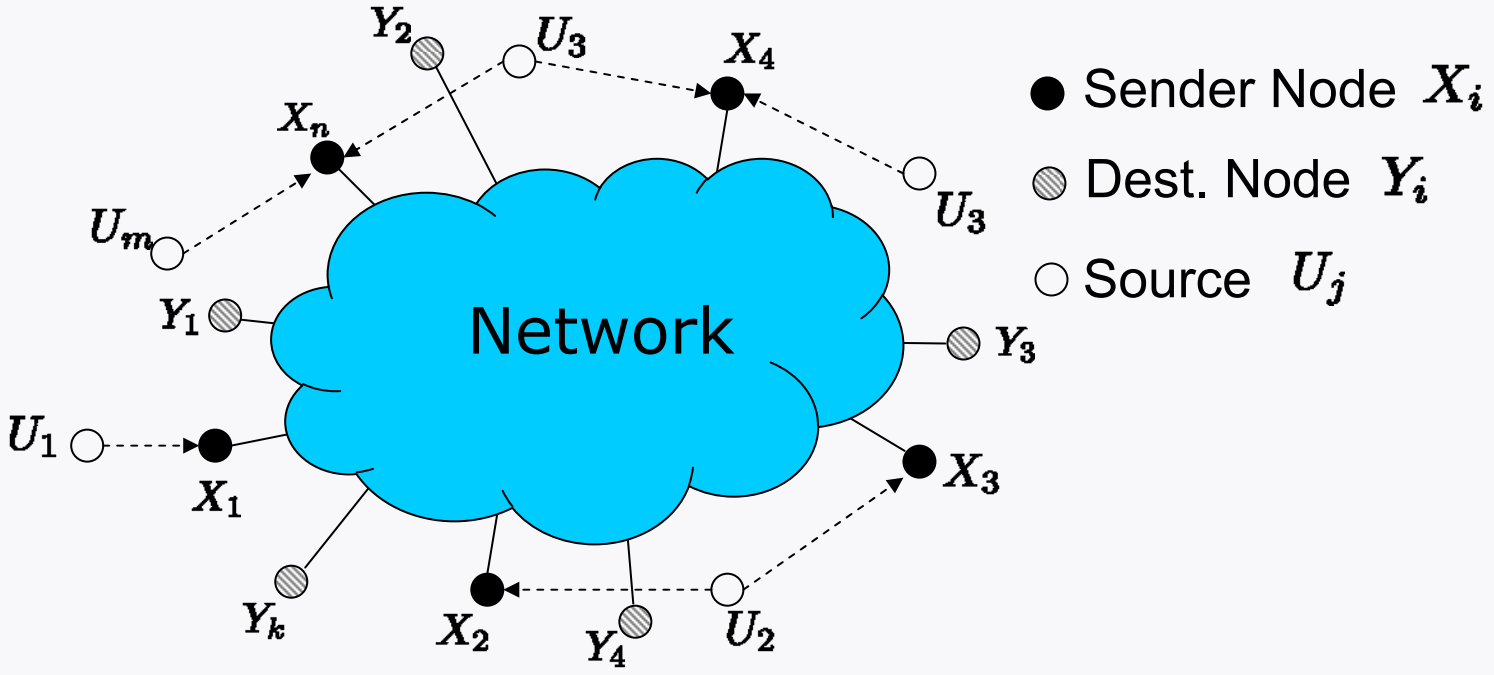


David Tse

U.C. Berkeley

Thanks to Anant Sahai for discussions.

Holy Grail of Network Information Theory



What is the optimal achievable performance?

Point-to-Point Communication

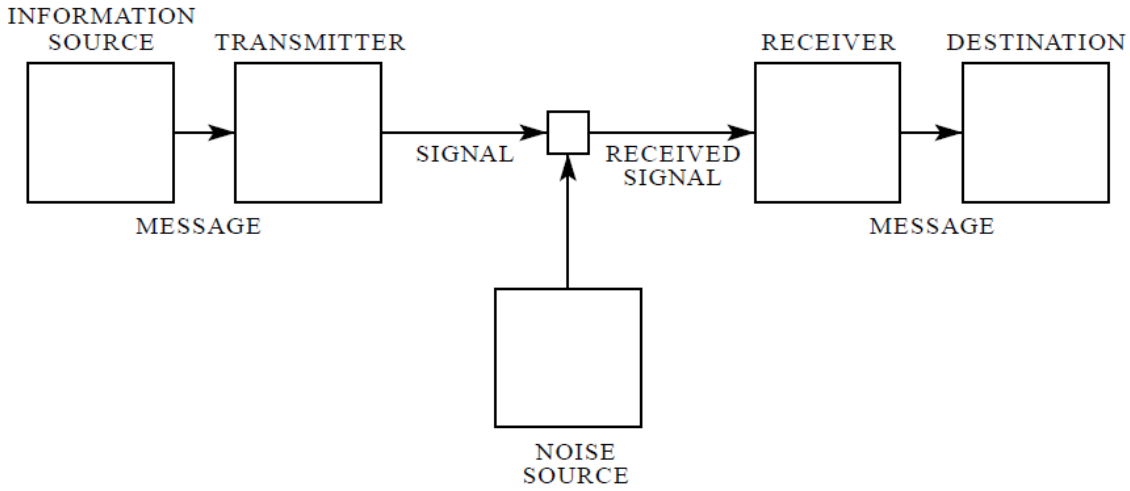


Fig. 1—Schematic diagram of a general communication system.

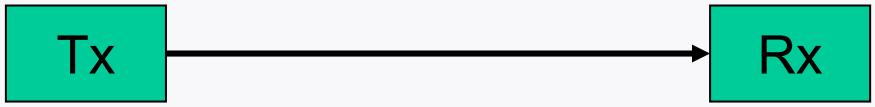
Shannon 48

$$C = \max_{p_X} I(X;Y) \qquad R(D) = \min_{p_{\hat{X}|X}, E[\rho(\hat{X},X)] \le D} I(\hat{X};X)$$

Target distortion D is achievable iff $R(D) < C$.

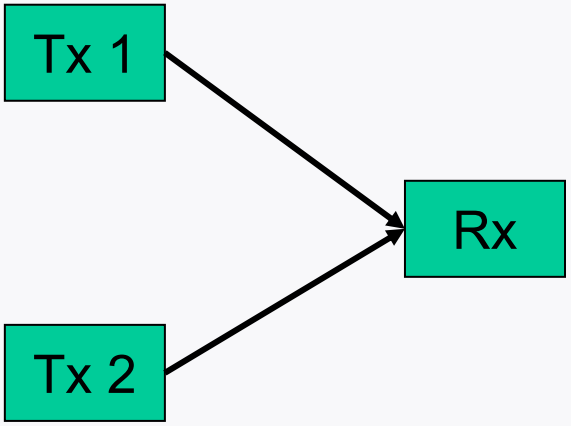
This result is remarkable but also sets a high bar for us.

Linear Quadratic Gaussian Networks

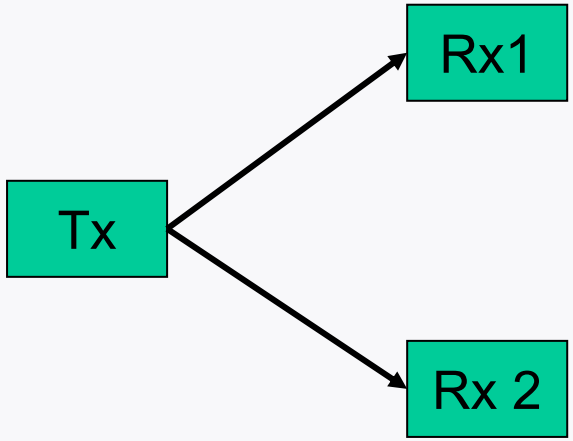


point-to-point (Shannon 48)

$$C = \log_2(1 + \text{SNR})$$



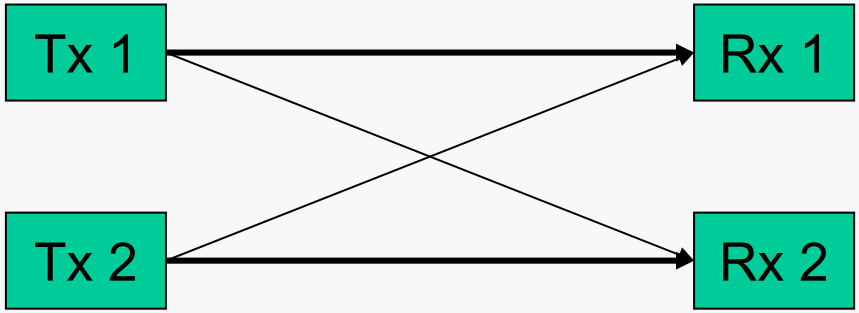
multiple-access
(Alshwede, Liao 70's)



broadcast
(Cover, Bergmans,Gallager 70's)

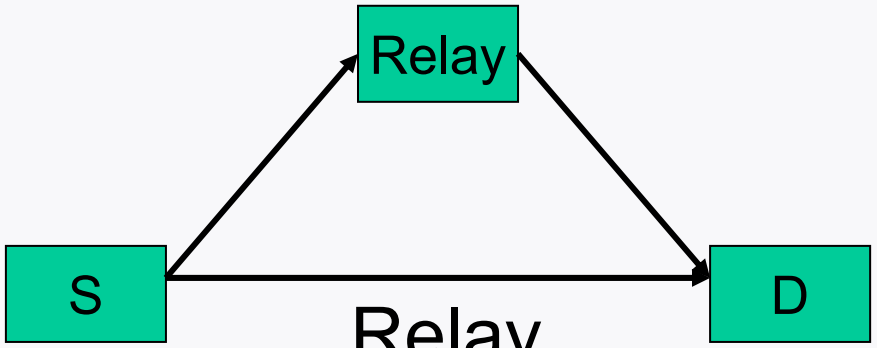
What We Don't Know

Unfortunately we don't know the capacity of most other Gaussian networks.



Interference

(Best known achievable region: Han & Kobayashi 81)



Relay

(Best known achievable region: El Gamal & Cover 79)

30 Years Have Gone by…..

We are still stuck.

How to make progress?

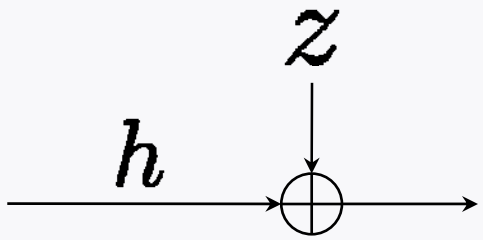
Approximate.

But how to approximate?

An Abstraction of an Abstraction

Transmit a real number

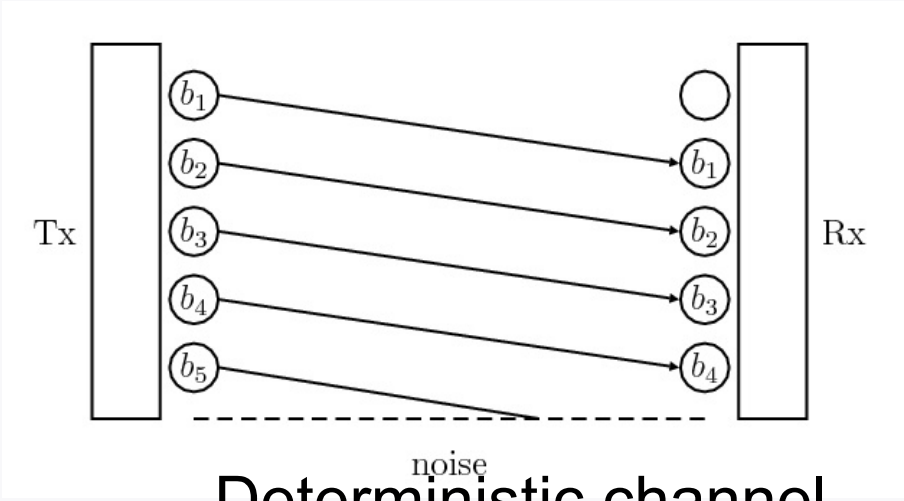
$$x = 0.b_1 b_2 b_3 b_4 b_5$$



Gaussian channel

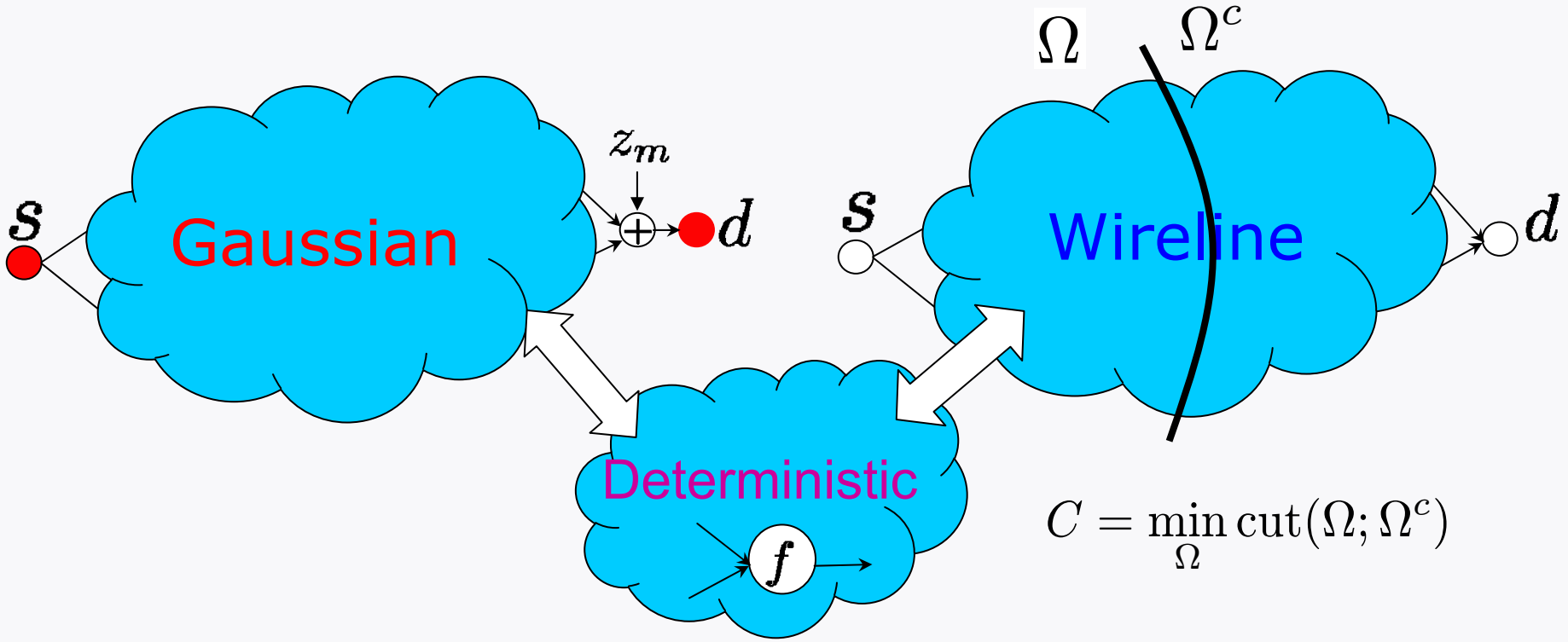
$$b_1 b_2 \cdots b_n . b_{n+1} \cdots$$

Least significant bits are truncated at noise level.



Deterministic channel

Deterministic Bridge

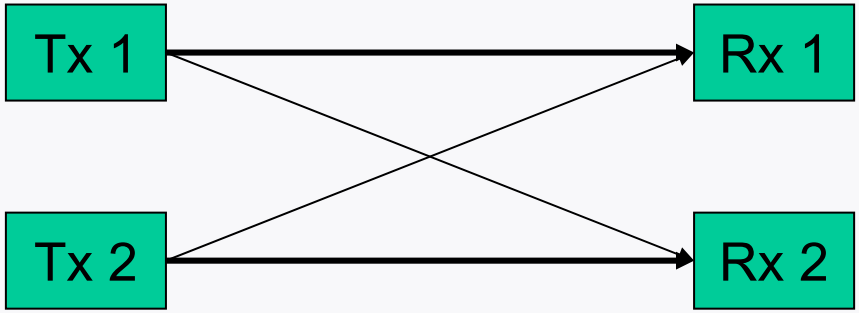


Approximate max-flow min-cut

Generalized max-flow min-cut

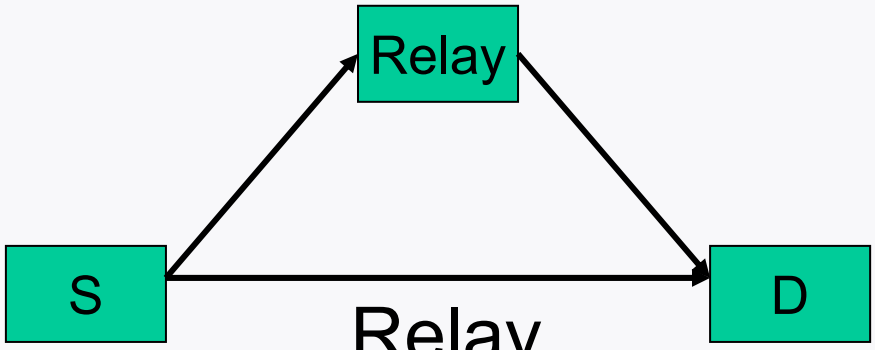
Classical max-flow min-cut

Back to Canonical Problems



Interference

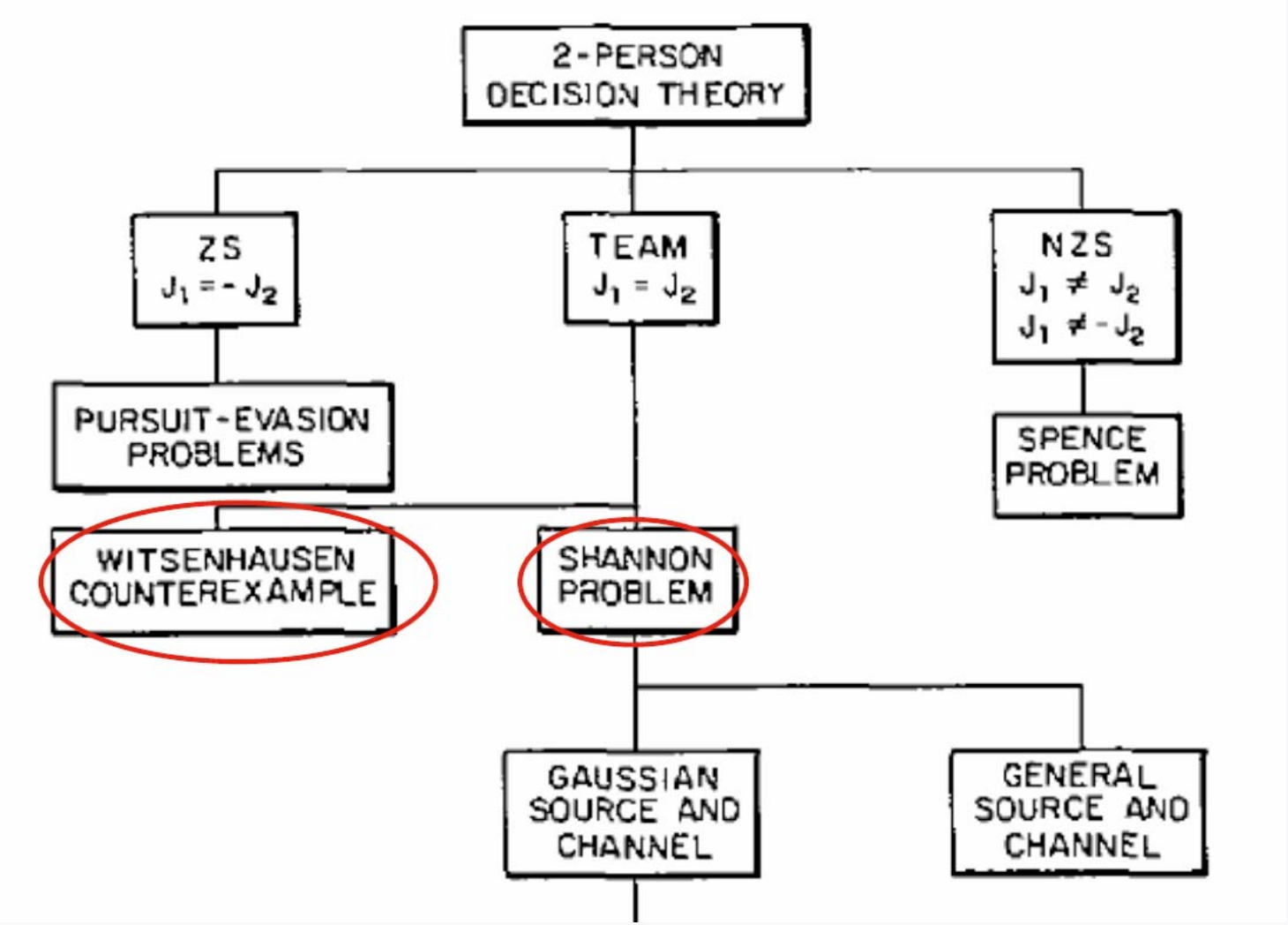
Capacity to within 1 bit (Etkin, T. & Wang 06)



Relay

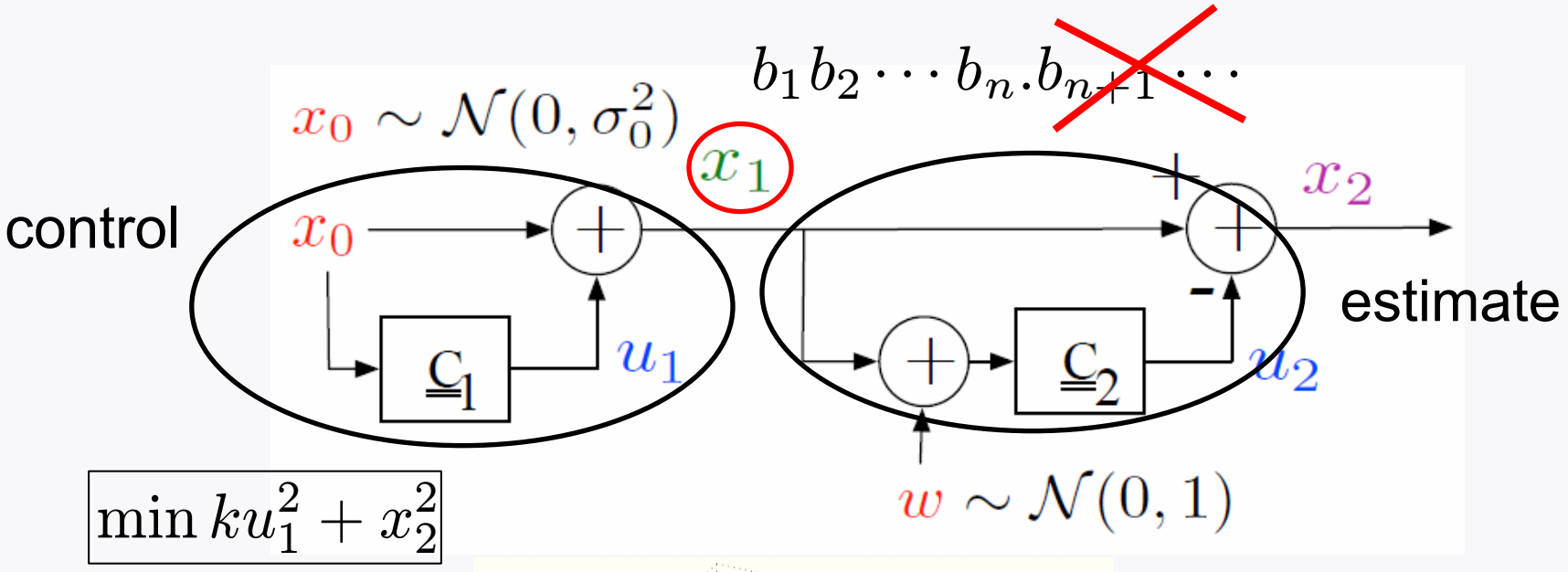
Capacity to within 1 bit (Avestimehr,Diggavi & T. 08)

From Information to Control

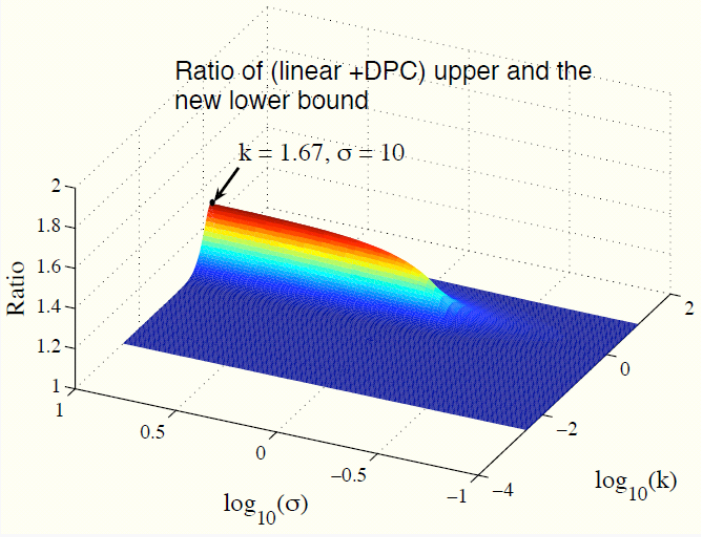


(Ho, Kastner & Wong 78)

Witsenhausen Counterexample Revisited



$$\min k u_1^2 + x_2^2$$



Constant-factor optimality.
(Park,Grover & Sahai 09)

Lessons Learnt

- Don’t be obsessed with a specific model.
- Don’t be obsessed with exact solutions.
- Be obsessed with basic phenomena in one’s field.
- Making progress on core problems can yield side benefits.
- Making progress on core problems in one’s field can lead to connections with other fields.