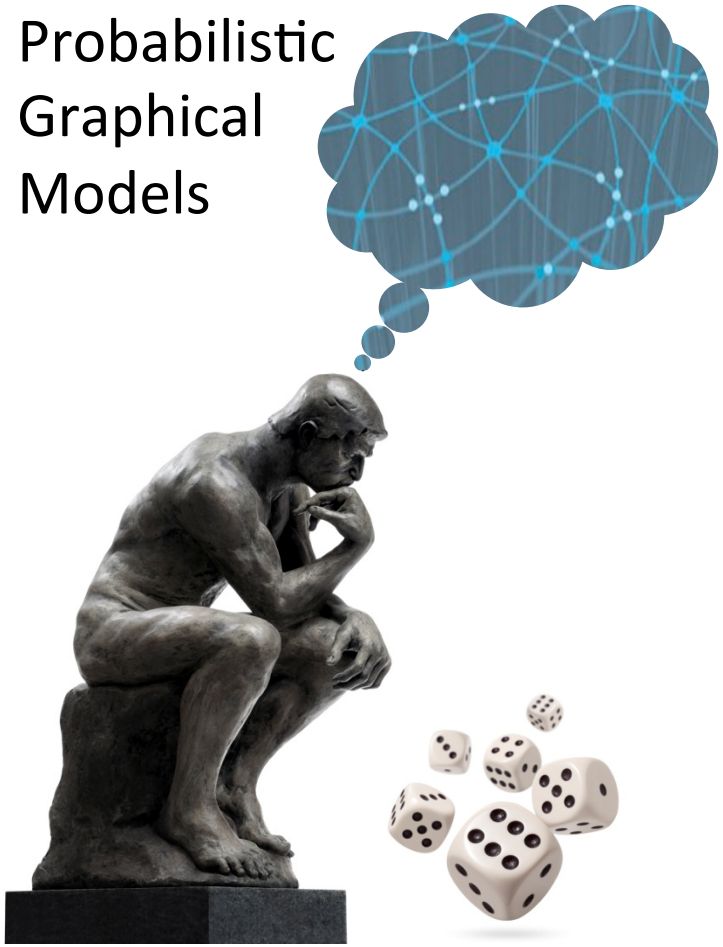
Probabilistic Graphical Models

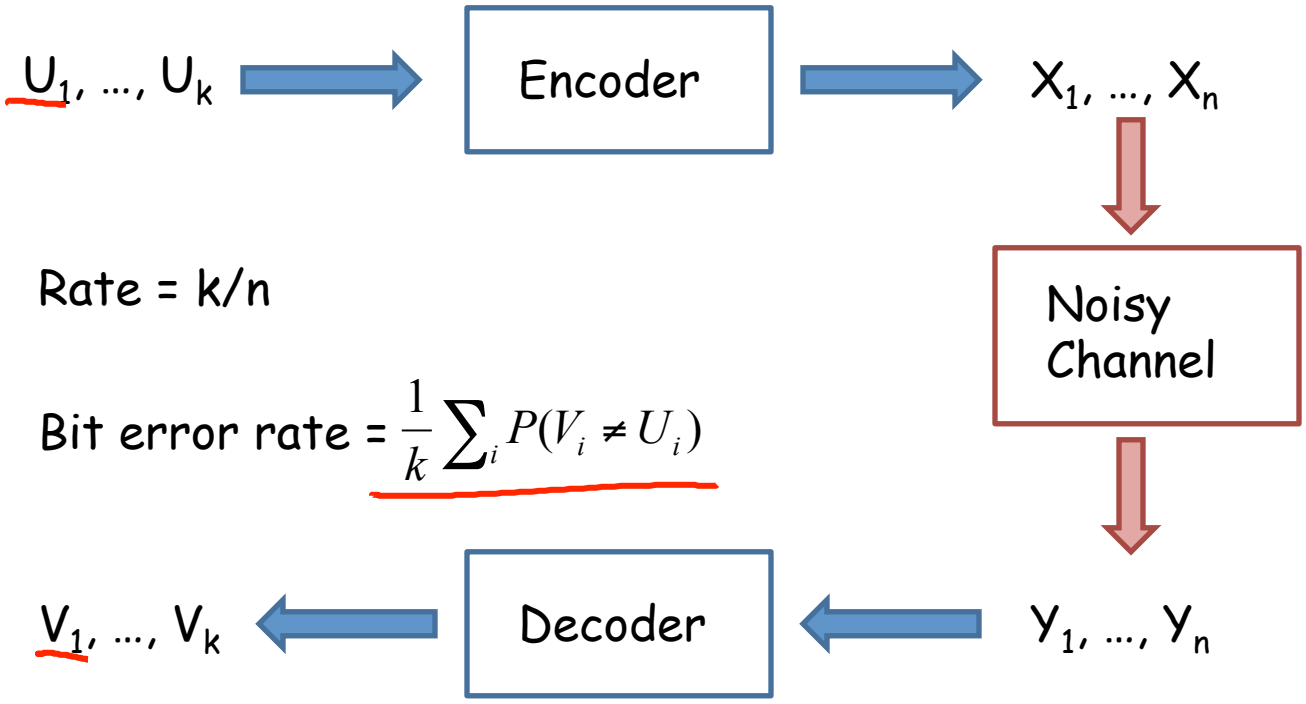


Inference

Message Passing

Loopy BP and Message Decoding

Message Coding & Decoding



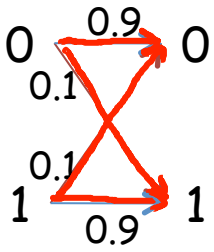
Rate = k/n

Bit error rate = $\frac{1}{k}\sum_i P(V_i \neq U_i)$

Noisy Channel

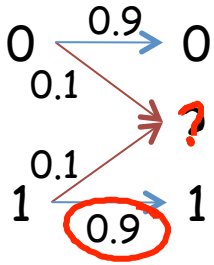
Channel Capacity

Binary symmetric channel

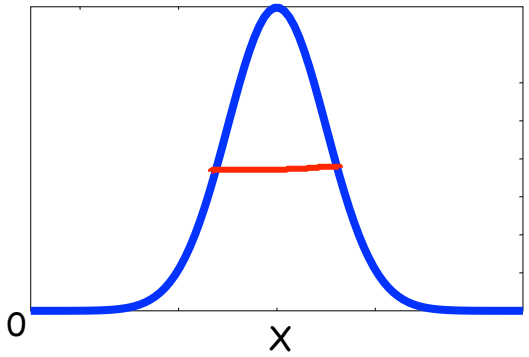


capacity = 0.531

Binary erasure channel



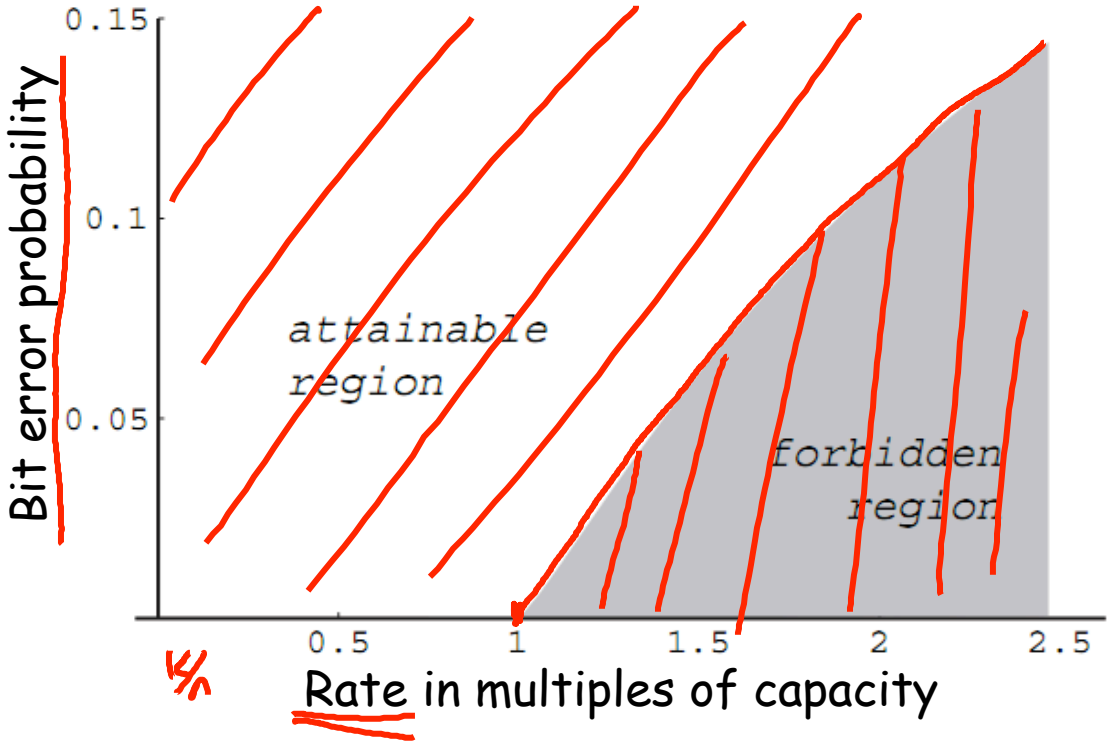
capacity = 0.9



capacity = $\frac{1}{2}\log\left(1+\frac{E(X^2)}{\sigma^2}\right)$

McEliece

Shannon's Theorem



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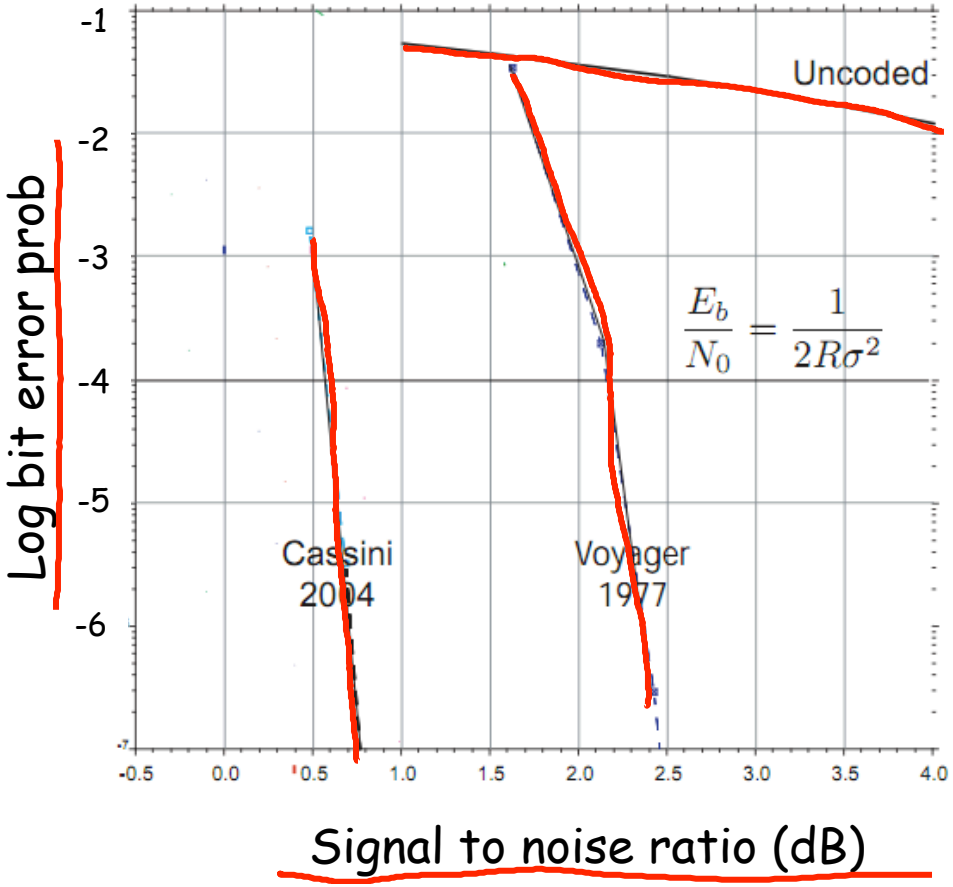
McEliece

How close to C can we get?



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Turbocodes (May 1993)

NEAR SHANNON LIMIT ERROR - CORRECTING CODING AND DECODING : TURBO-CODES (1)

Claude Berrou, Alain Glavieux and Punya Thitimajshima

Claude Berrou, Integrated Circuits for Telecommunication Laboratory

Alain Glavieux and Punya Thitimajshima, Digital Communication Laboratory

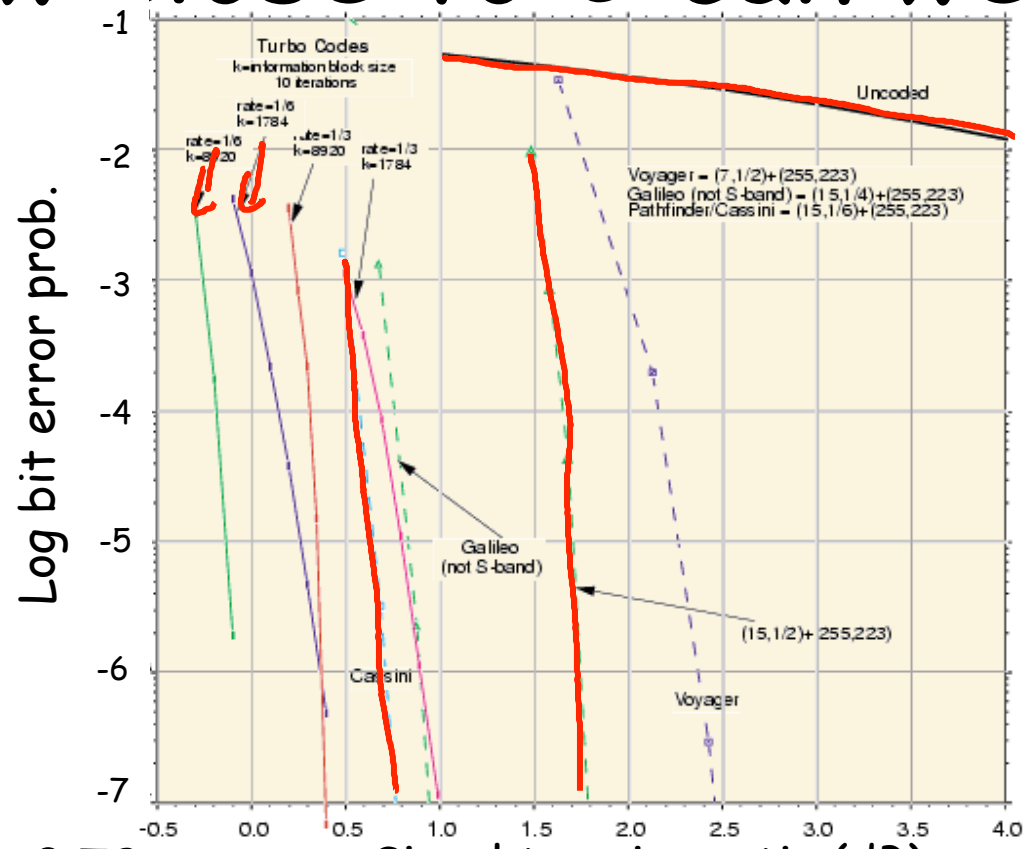
Ecole Nationale Supérieure des Télécommunications de Bretagne, France

(1) Patents N° 9105279 (France), N° 92460011.7 (Europe), N° 07/870,483 (USA)

Daphne Koller

McEliece

How close to C can we get?



Shannon limit = -0.79

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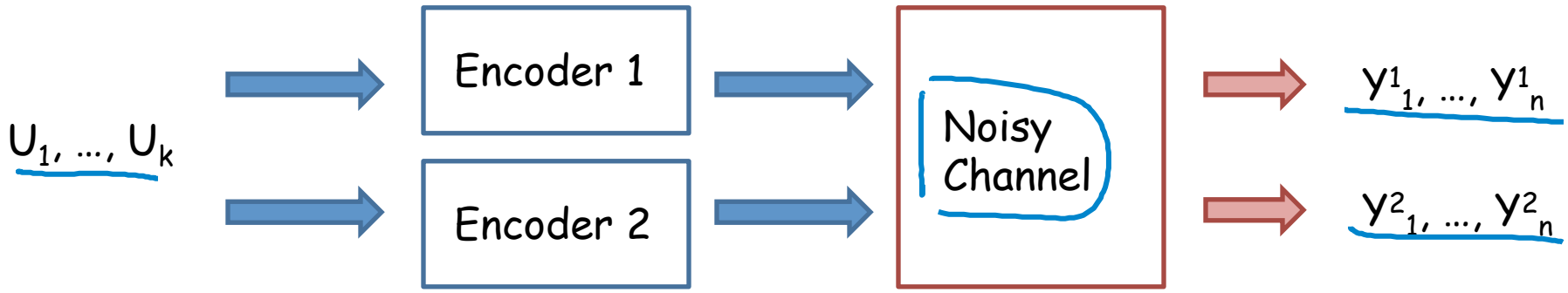
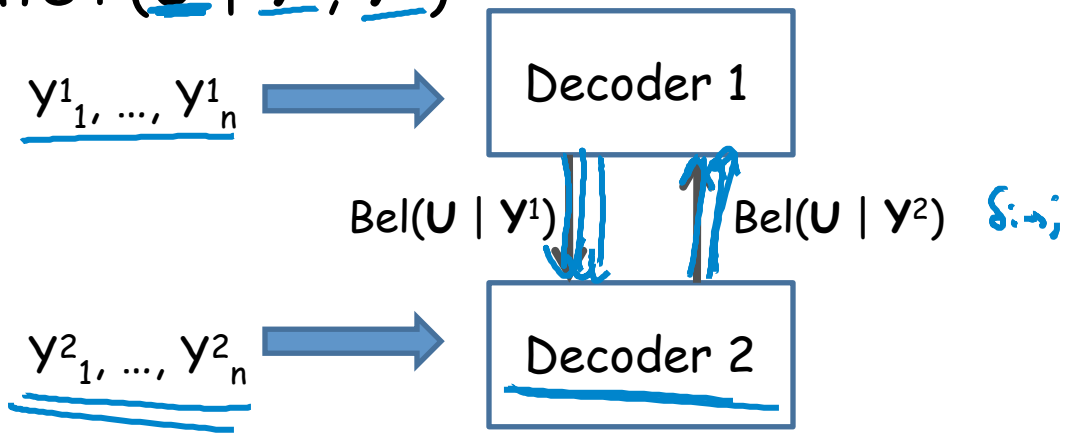
Turbocodes: The Idea



Compute $P(U \mid y^1, y^2)$



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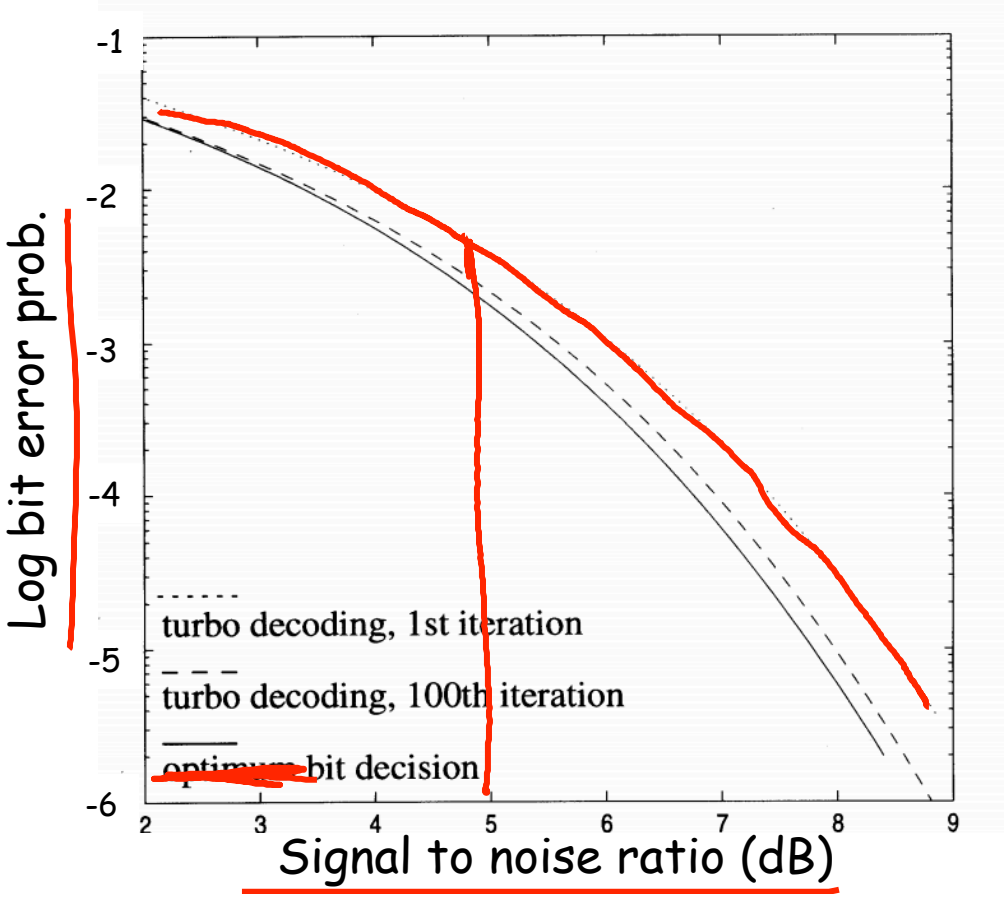
McEliece

Iterations of Turbo Decoding



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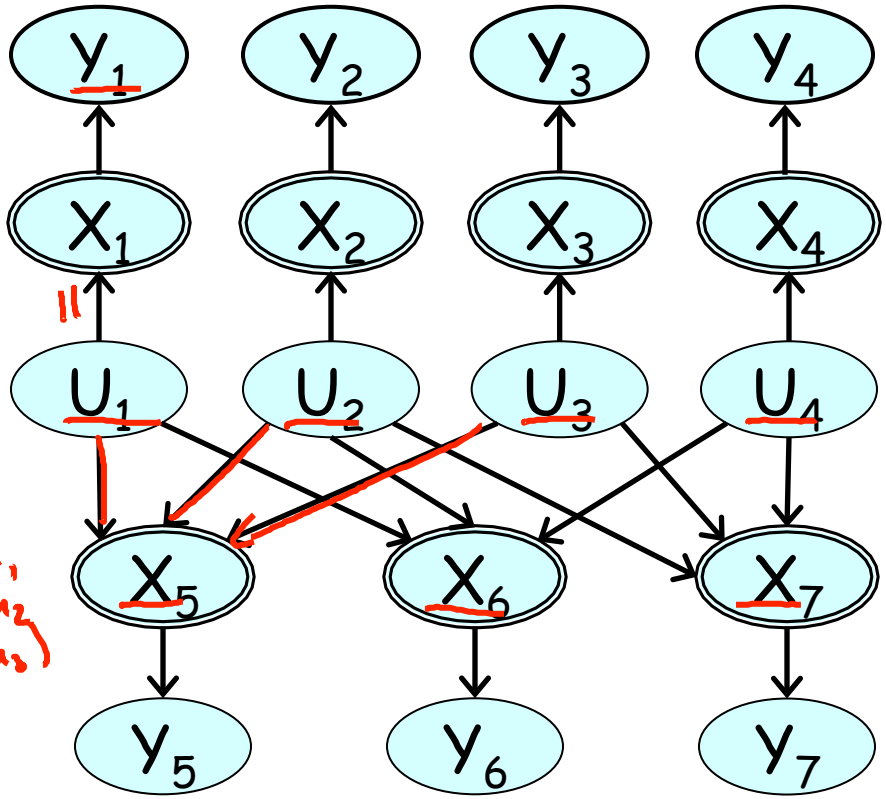
Low-Density Parity Checking Codes

rate 4/7



noisy bits received

original message bits

Invented by Robert Gallager in 1962!

parity(u_1, u_2, u_3)

parity bits

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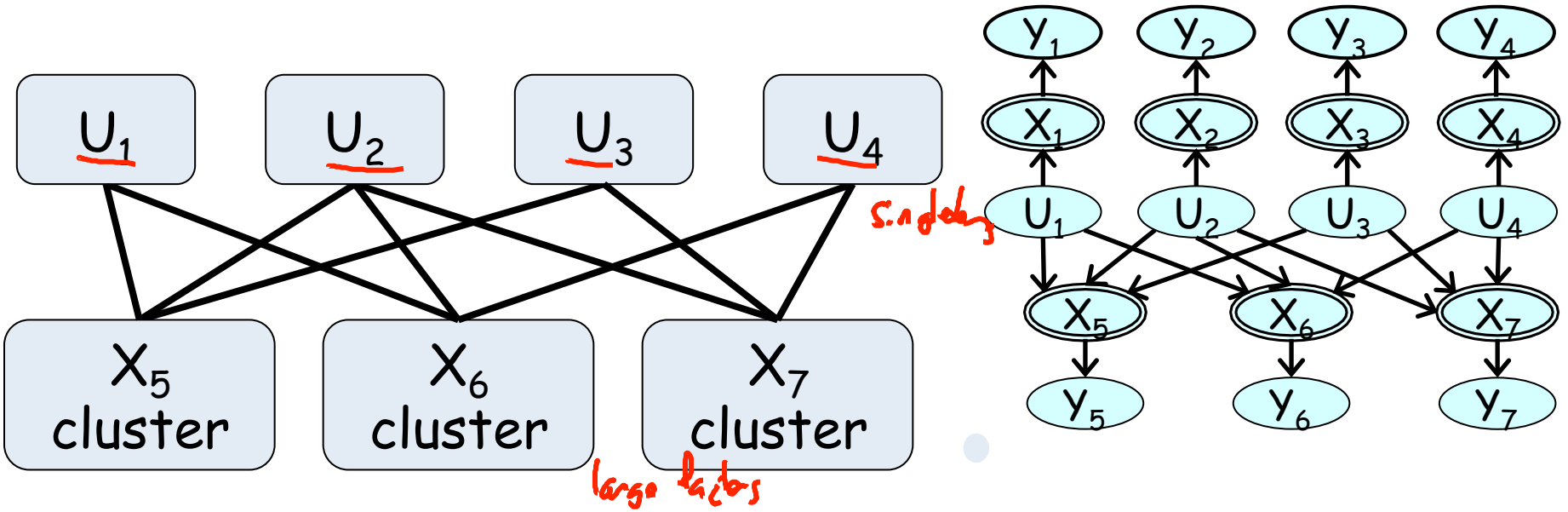
Decoding as Loopy BP



Turbo-Codes & LDPCs

- 3G and 4G mobile telephony standards
- Mobile television system from Qualcomm
- Digital video broadcasting
- Satellite communication systems
- New NASA missions (e.g., Mars Orbiter)
- Wireless metropolitan network standard

Summary

- Loopy BP rediscovered by coding practitioners
- Understanding turbocodes as loopy BP led to development of many new and better codes
  - Current codes coming closer and closer to Shannon limit
- Resurgence of interest in BP led to much deeper understanding of approximate inference in graphical models
  - Many new algorithms