Reliable Communication for the Internet

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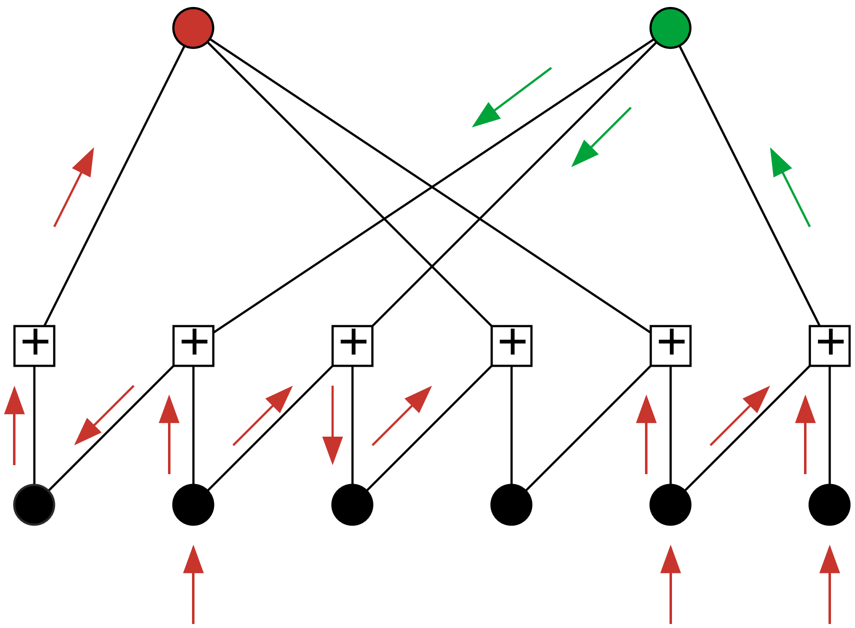
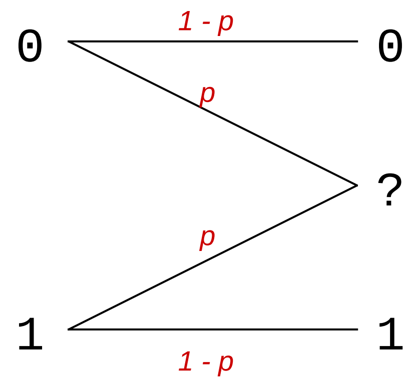


Lee Center for Advanced Networking

Pasadena, California, May 16, 2001

The Binary Erasure Channel: A Model for Internet Traffic



- Packets are "erased" with probability p but never received in error.

- The capacity of the BEC is $C = 1 - p$, which is easy to achieve with feedback.

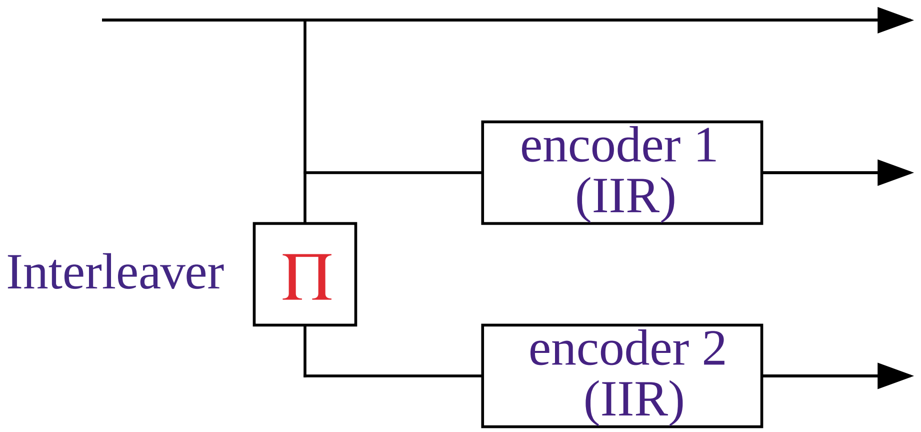
- Without feedback, the classical complexity of communicating at a fraction $1 - \epsilon$ of capacity is $O(1/\epsilon^4)$, obtained by solving linear equations for the erased positions. ▪

We can Do Much Better with Iterative Message-passing (Turbo) Decoding

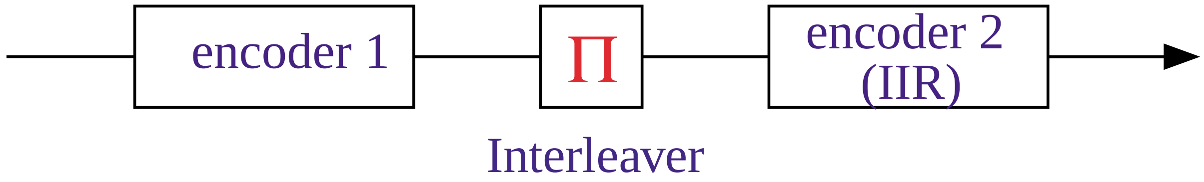
A Low-Complexity Approximation To “Exact” Decoding.

Codes that can be Decoded in the "Turbo-Style"

- Classical turbo codes:

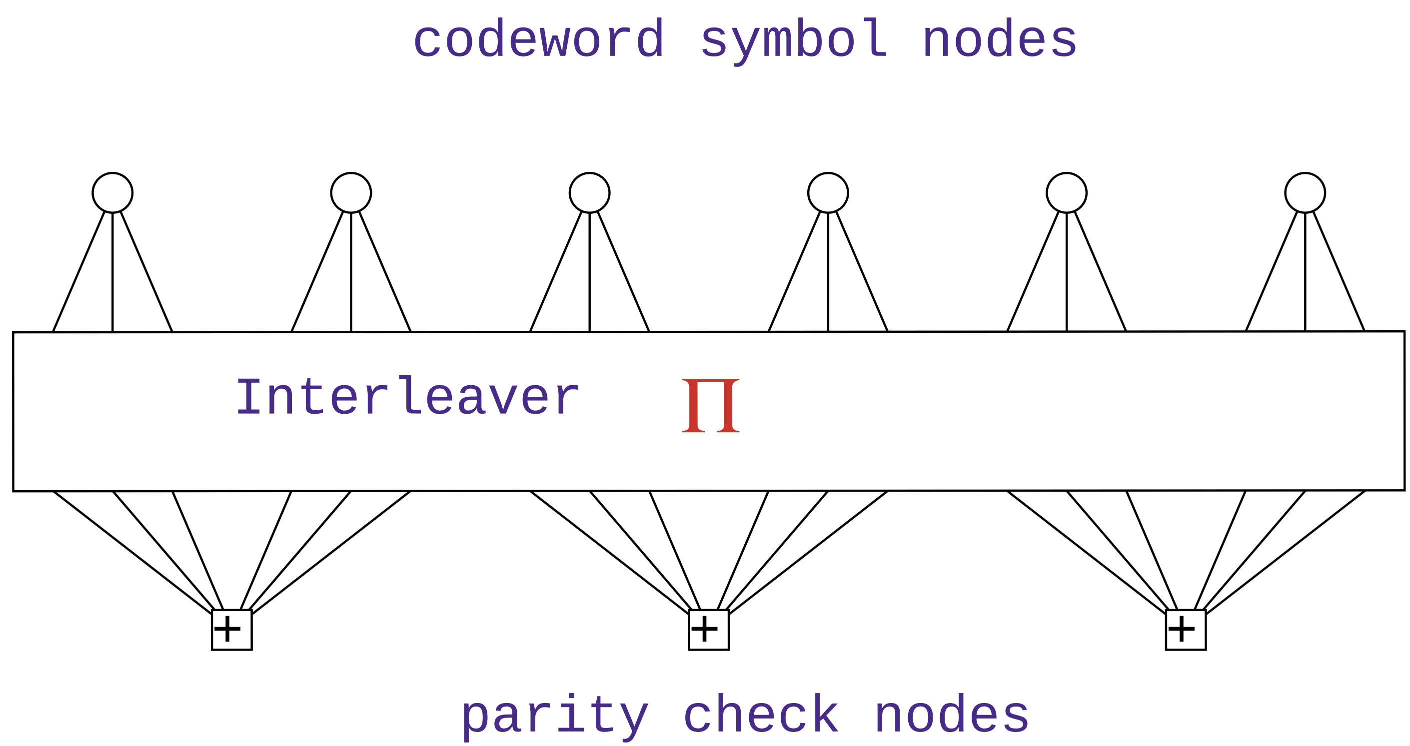


- "Serial" turbo codes:



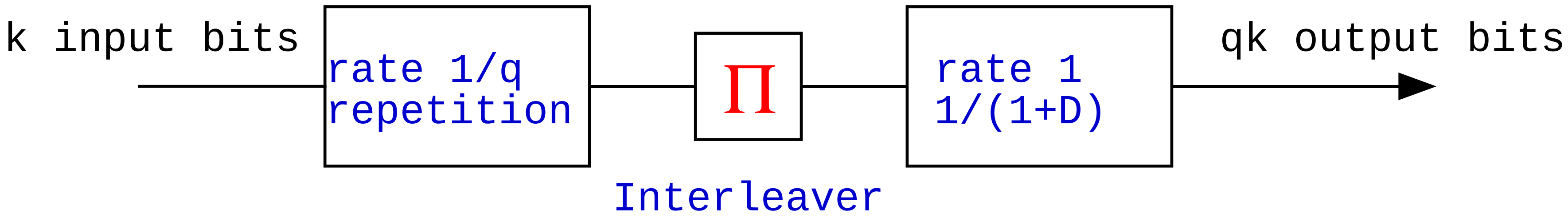
Codes that can be Decoded in the "Turbo-Style"

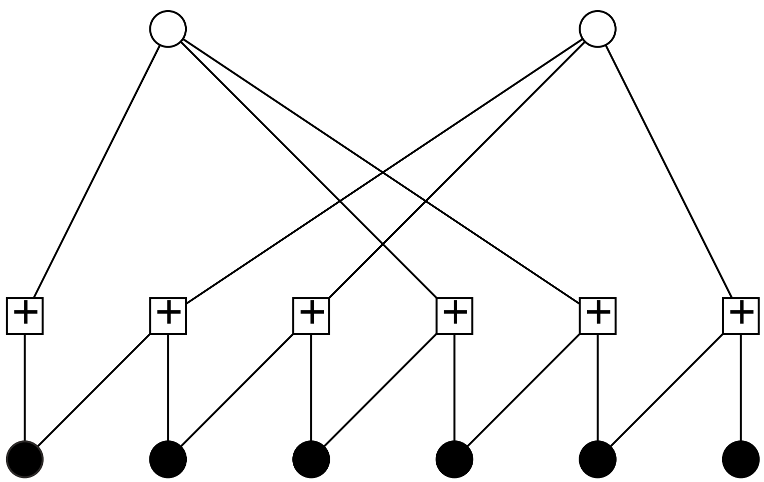
• Gallager codes (Low-Density Parity-Check), regular and irregular:



And . . .

Repeat-Accumulate (RA) Codes



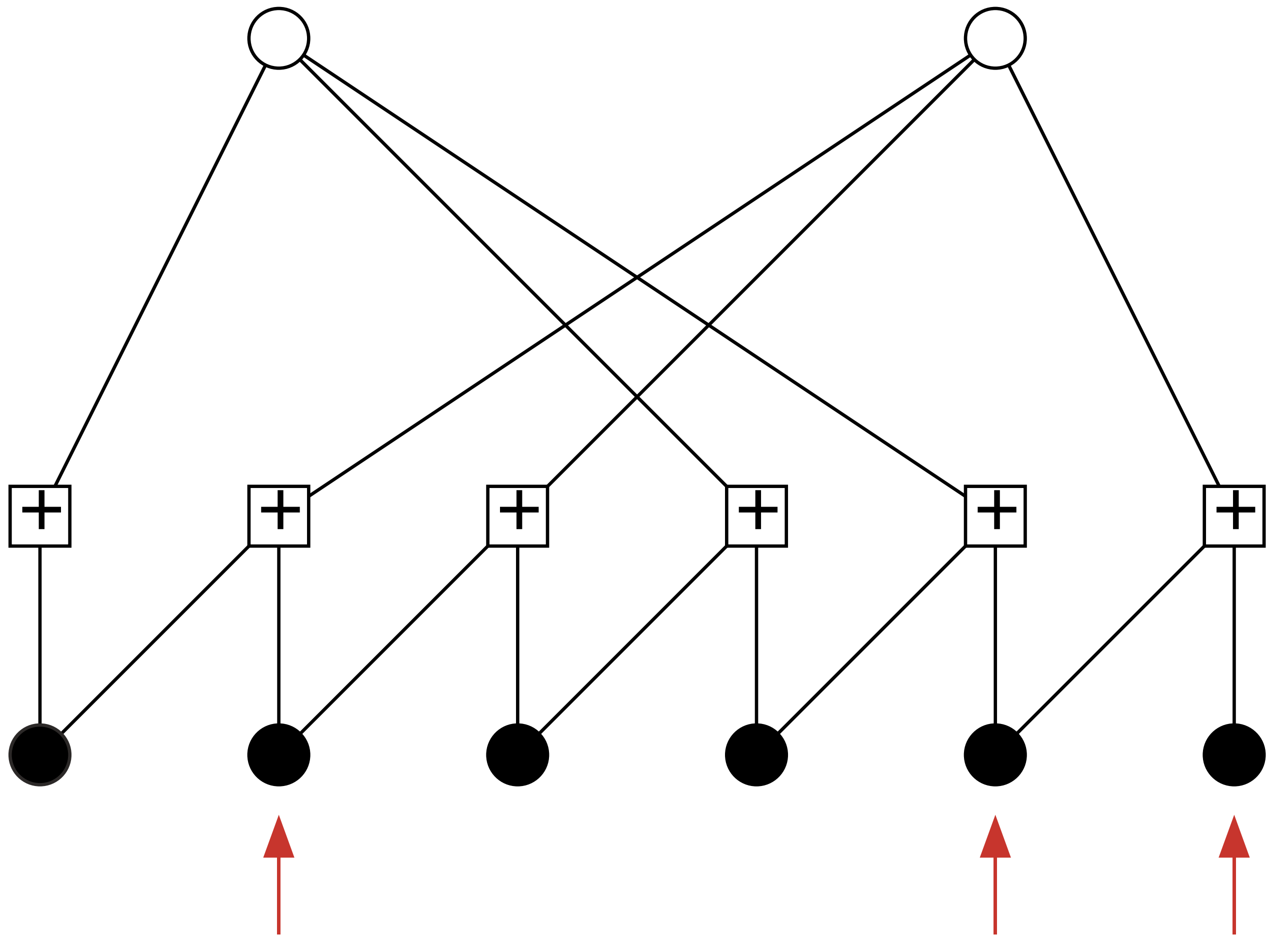


Tanner Graph

$(k = 2,\ q = 3)$

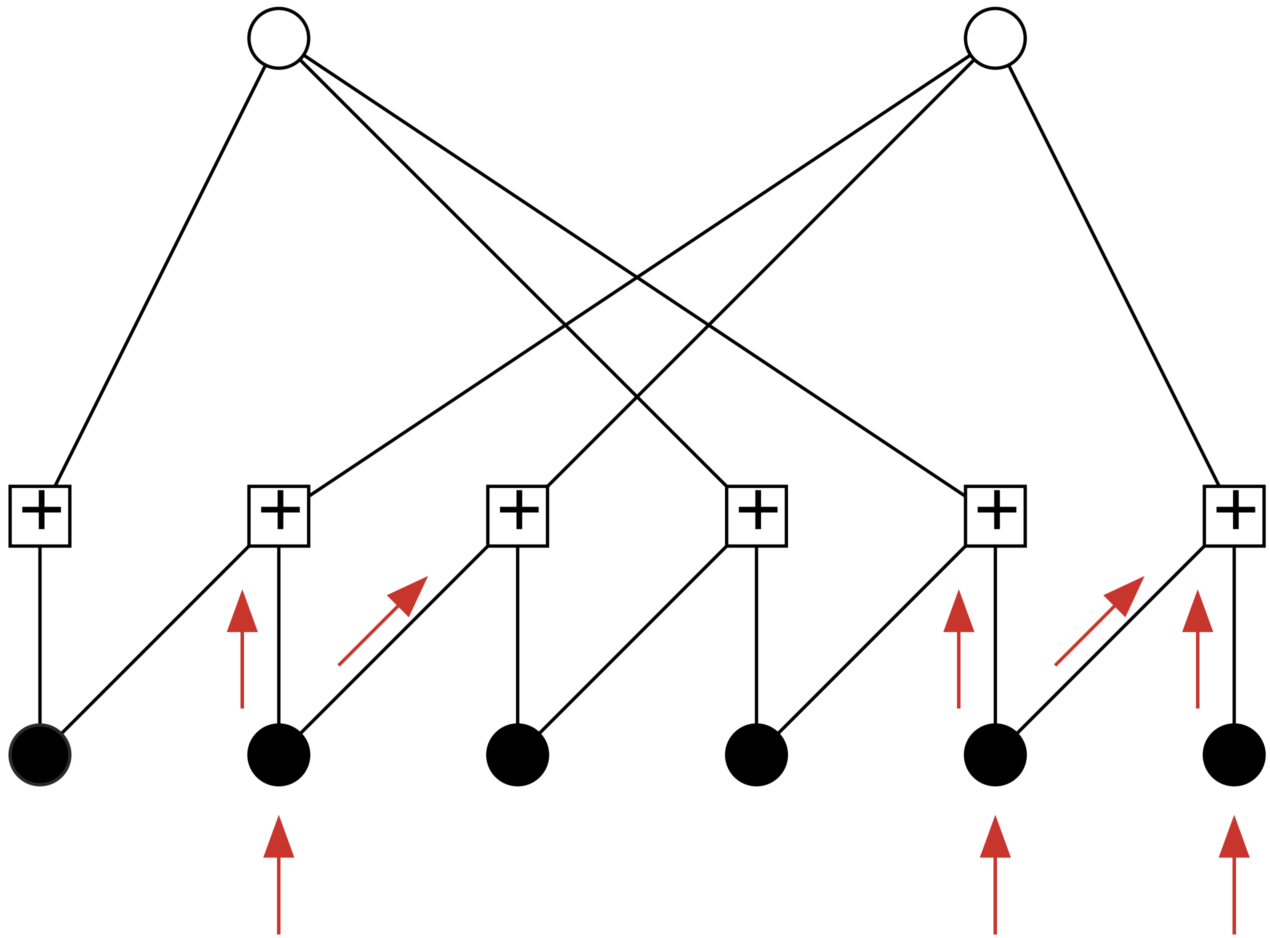
Decoding an RA Code on the BEC Using Message Passing

$\longrightarrow = 1$, $\longrightarrow = 0$



Decoding an RA Code on the BEC
Using Message Passing

$\longrightarrow = 1$, $\longrightarrow = 0$



Decoding an RA Code on the BEC Using Message Passing

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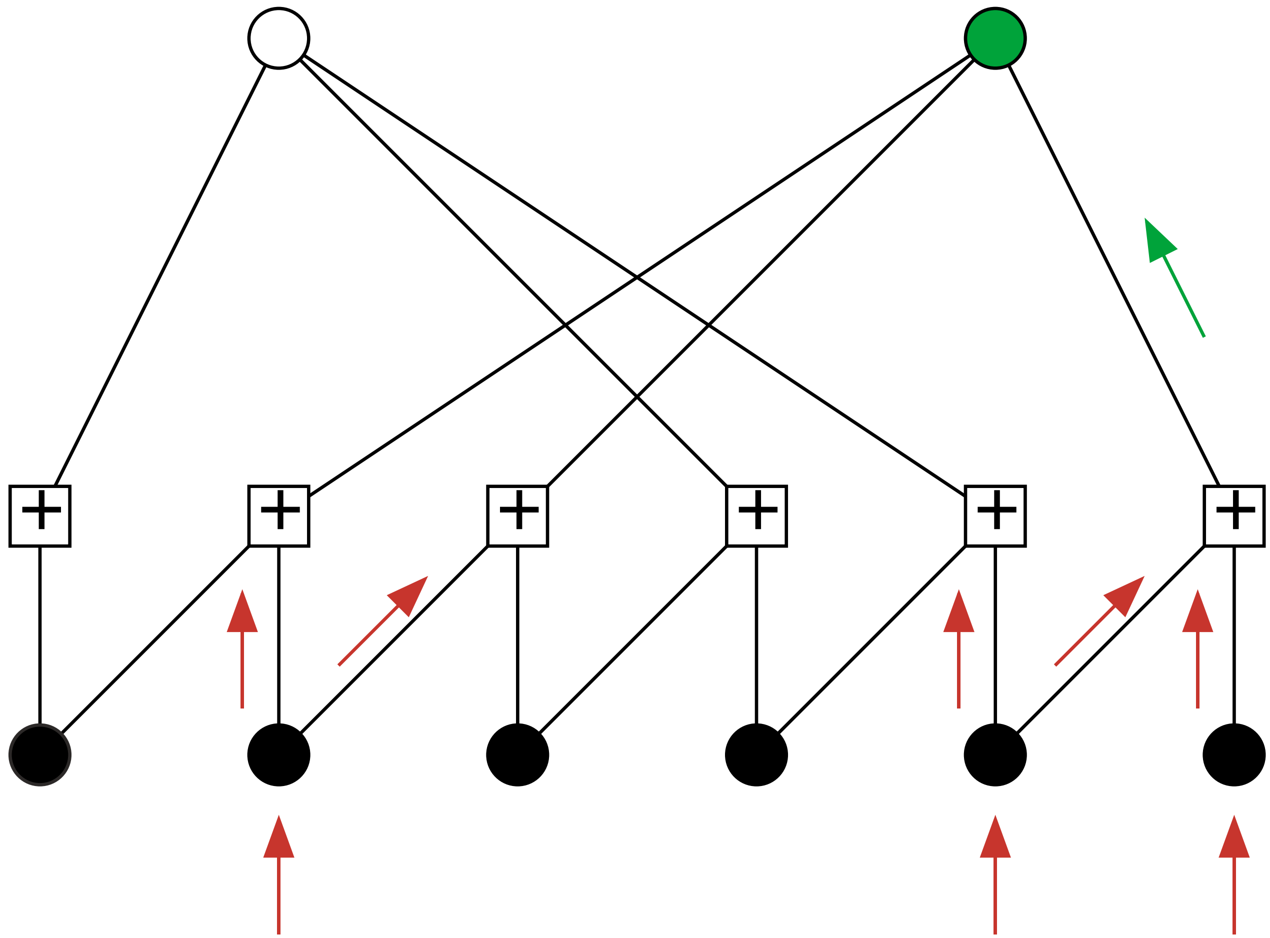

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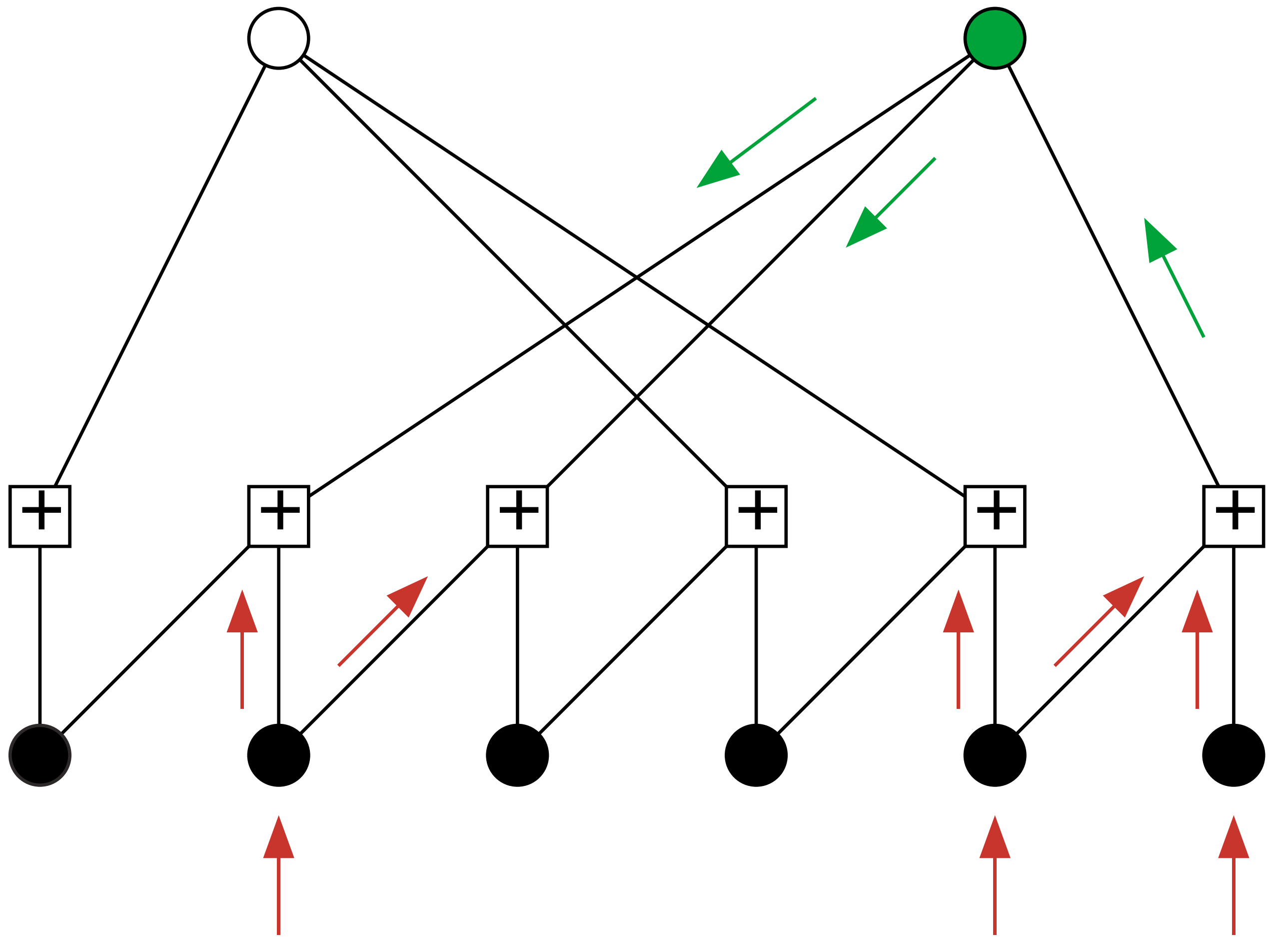

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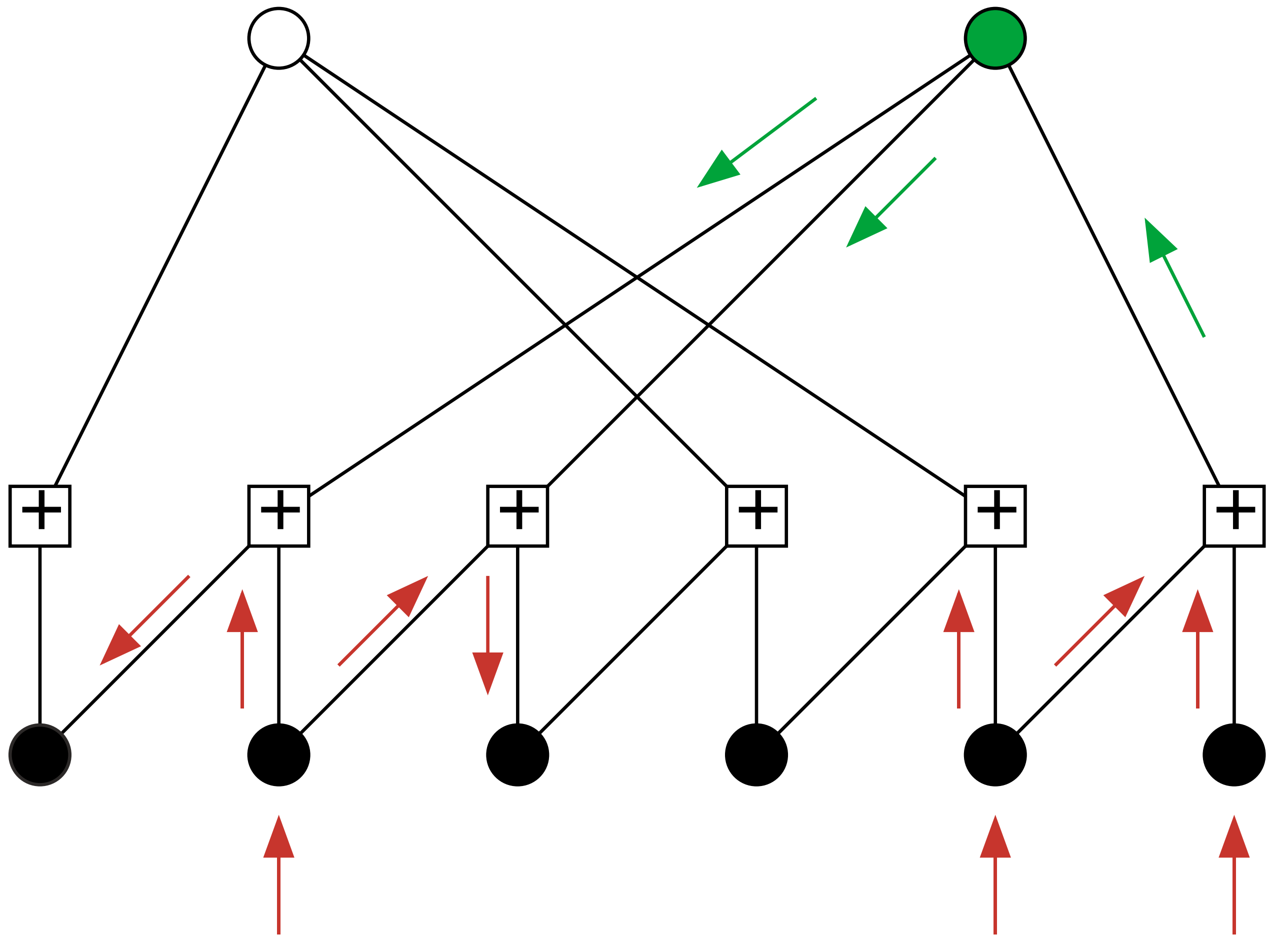

Decoding an RA Code on the BEC
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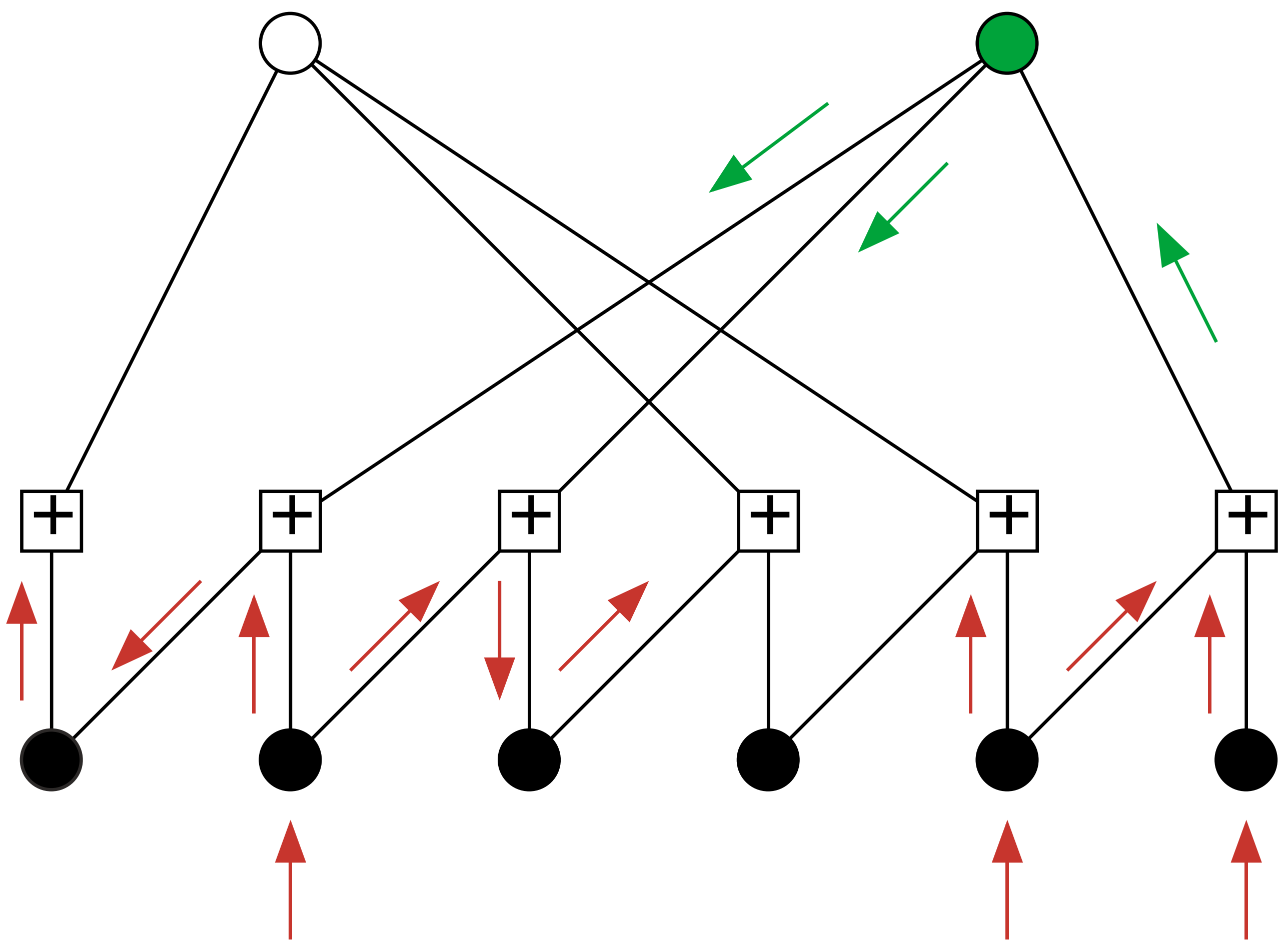

Decoding an RA Code on the BEC Using Message Passing

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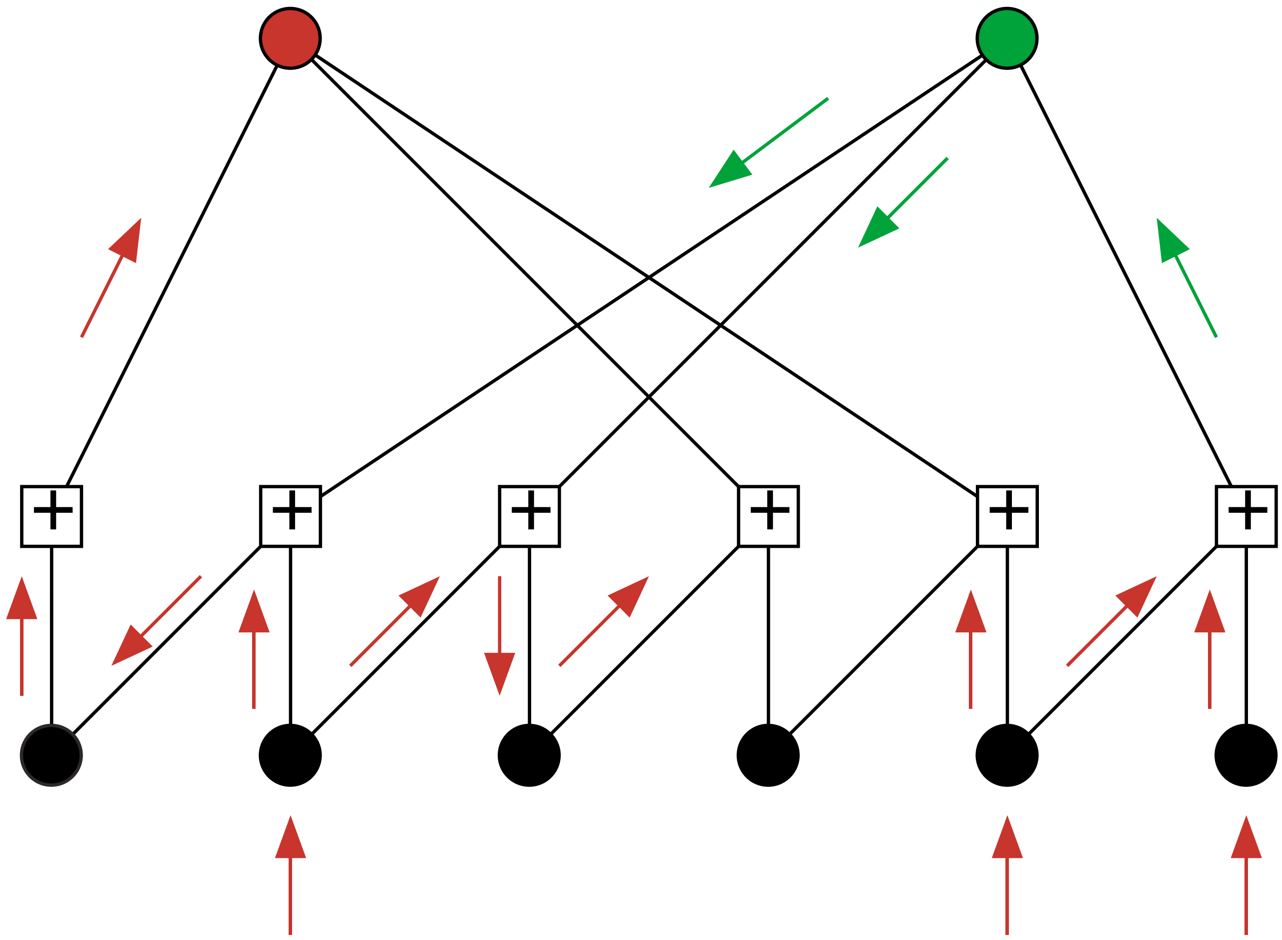
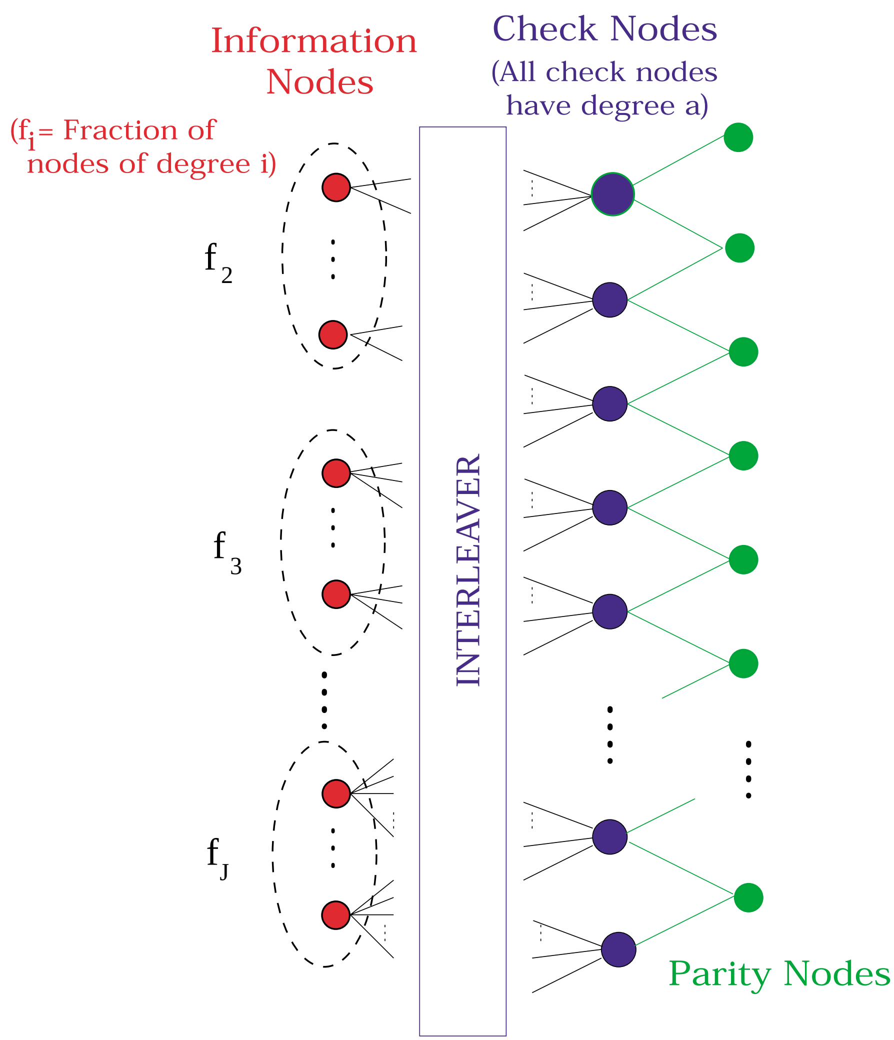
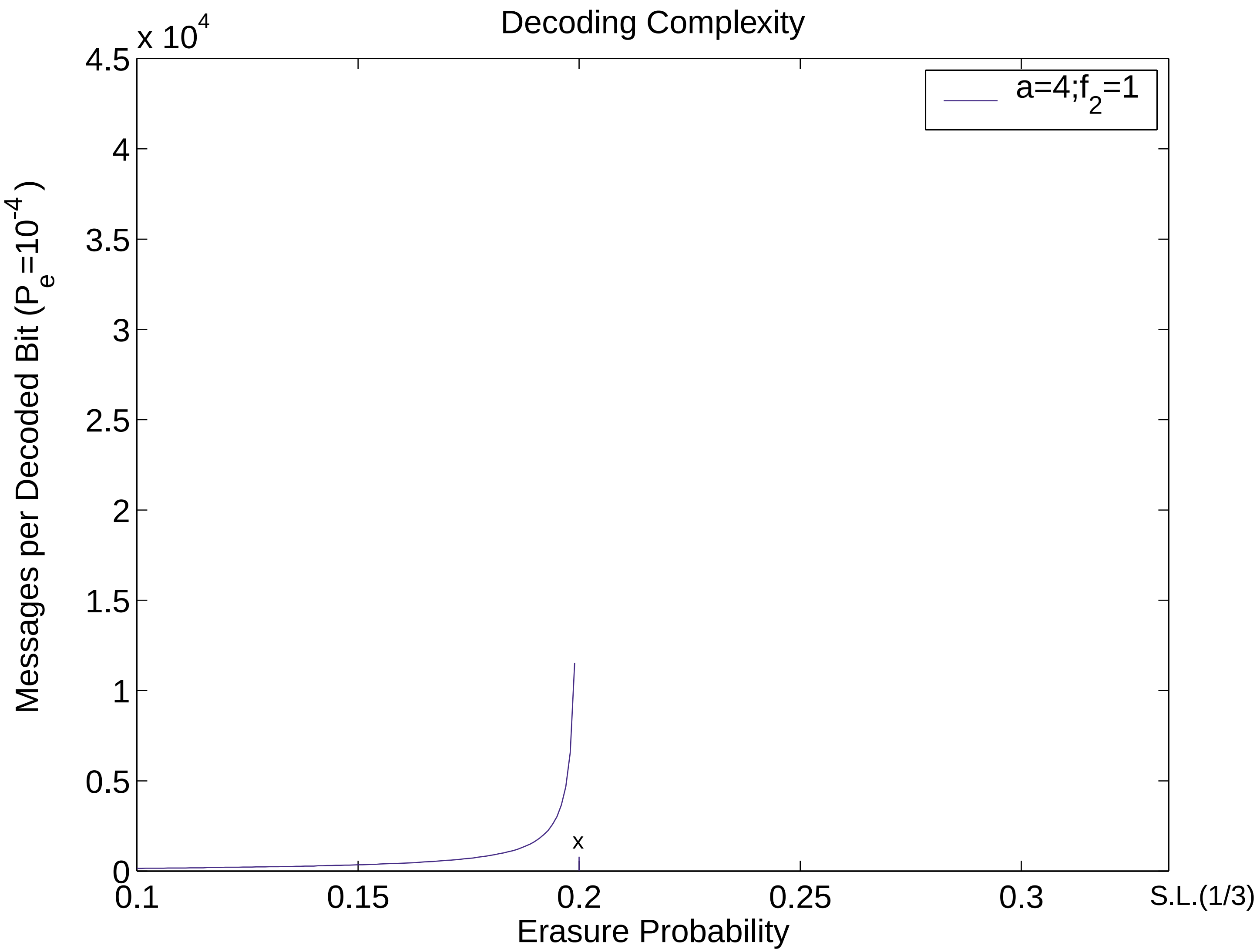


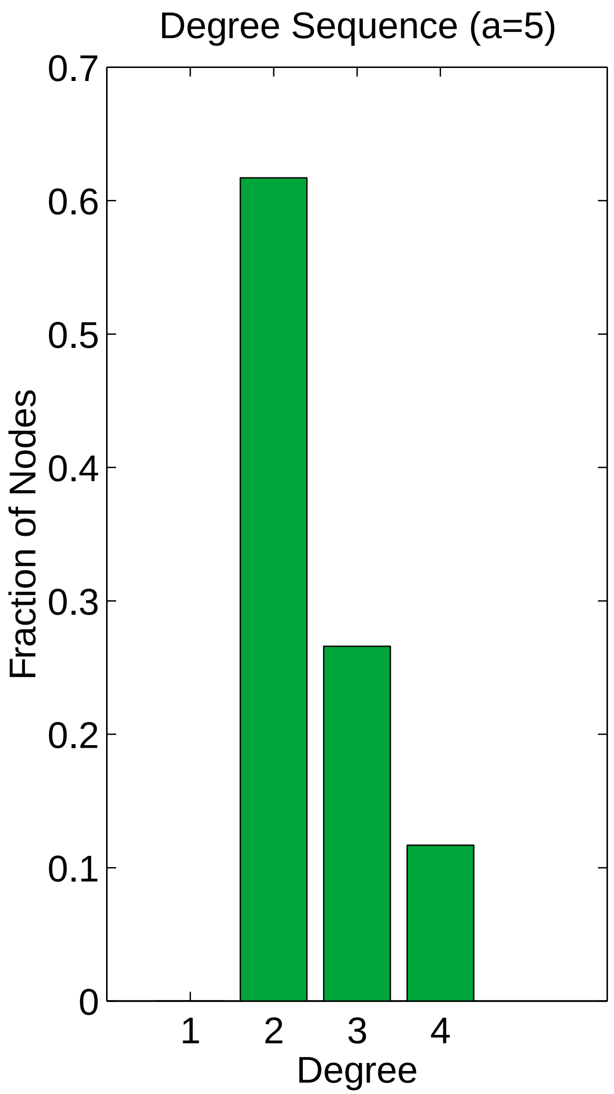
We Can Do Still Better with "Irregular" Repeat-Accumulate Codes

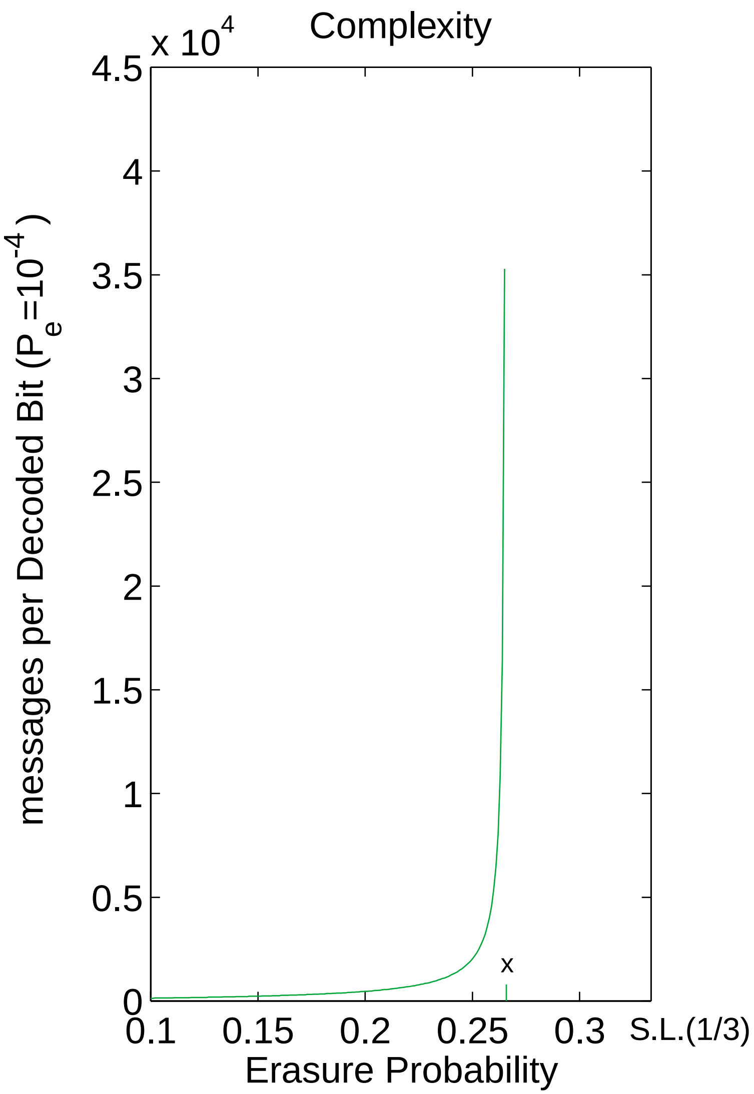


$R = 2/3$ IRA Codes for the Binary Erasure Channel



$R = 2/3$ IRA Codes for the Binary Erasure Channel





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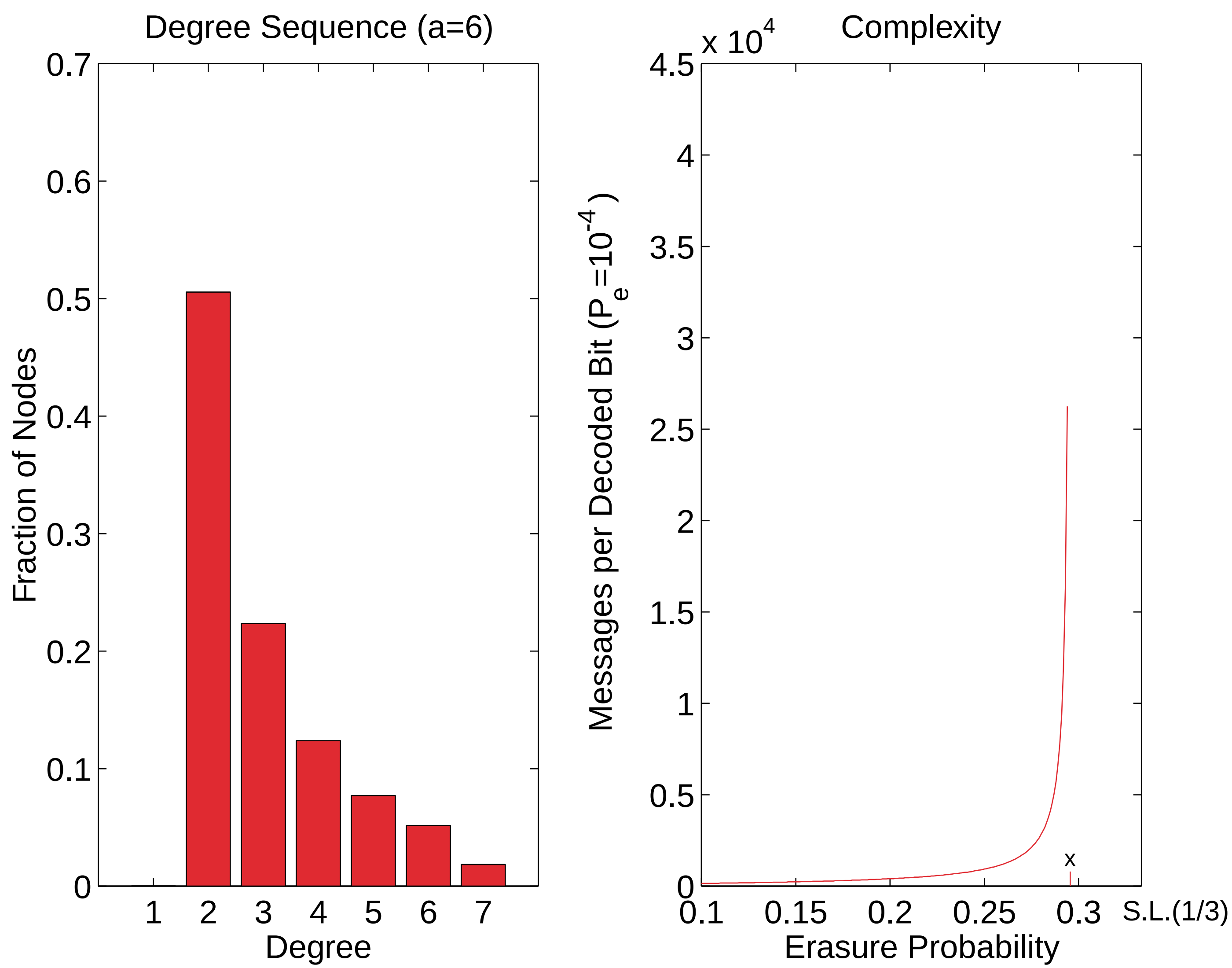

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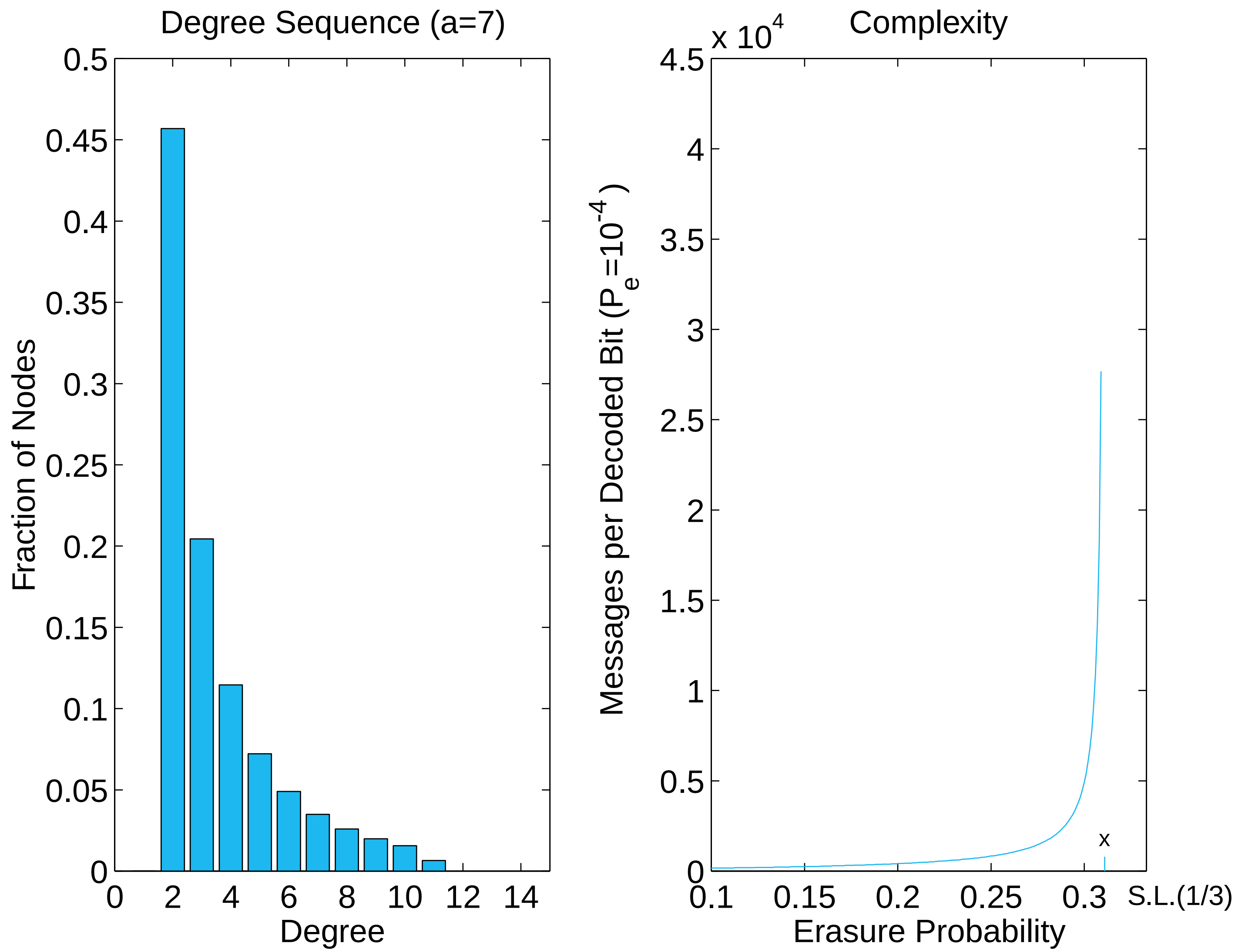

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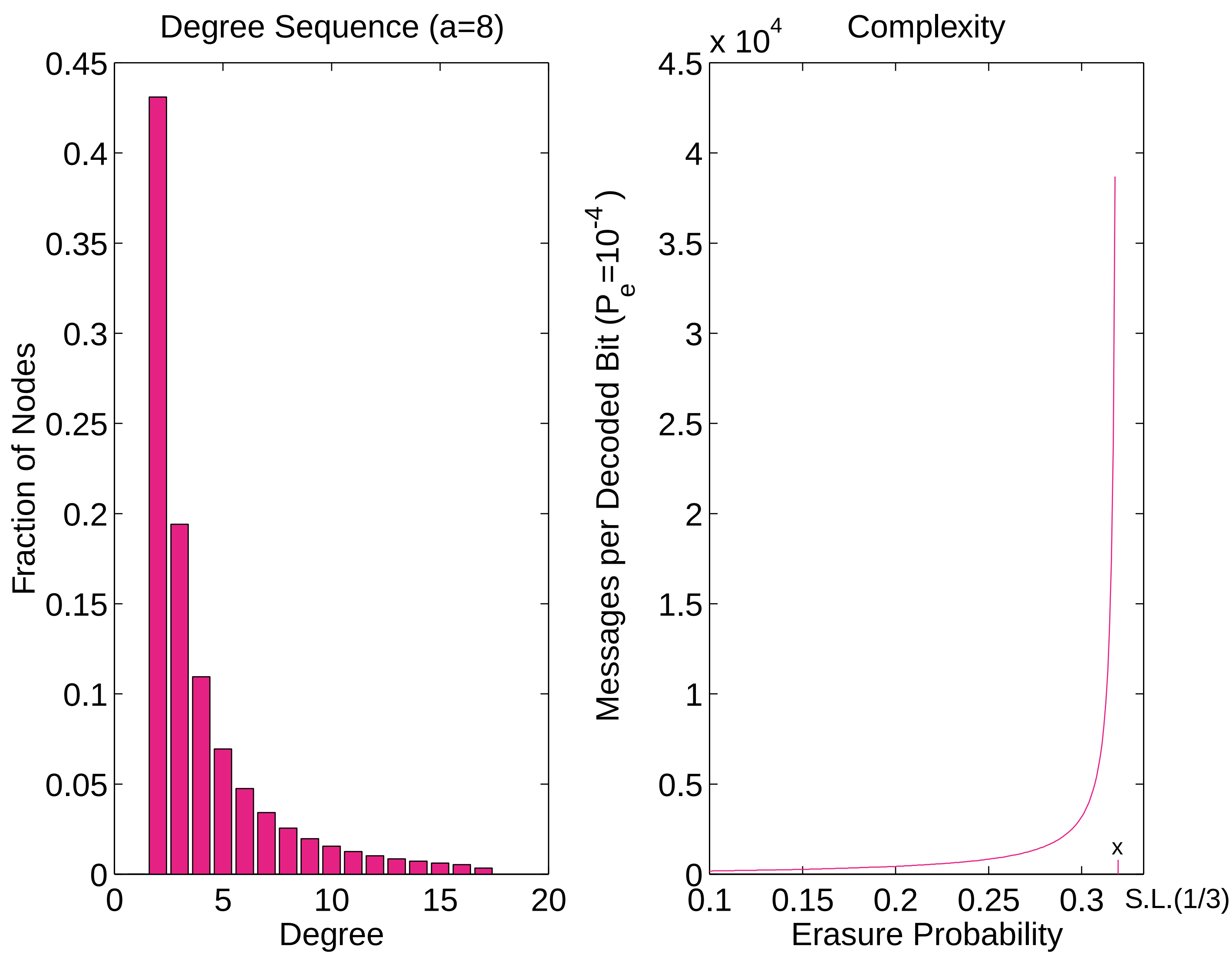

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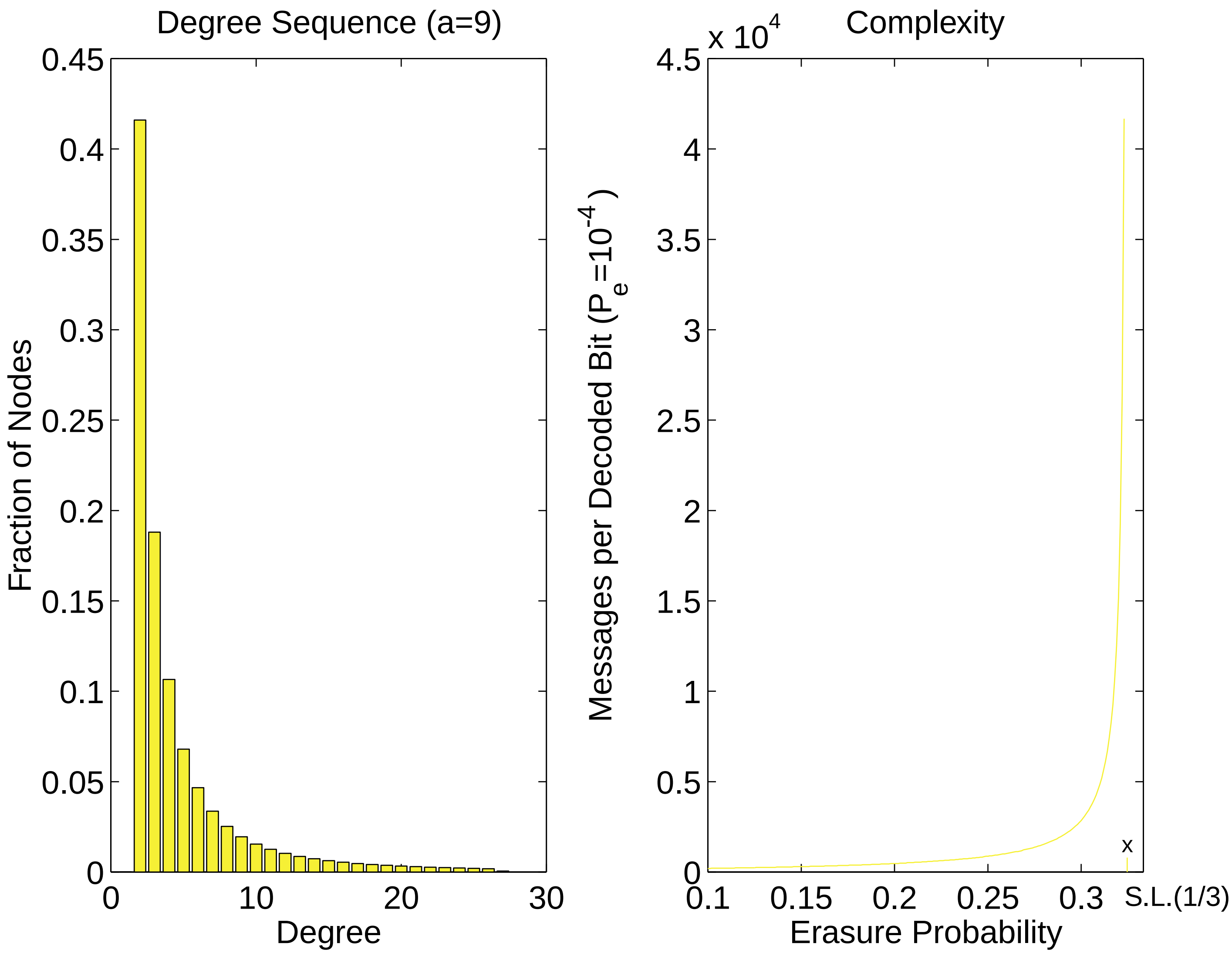
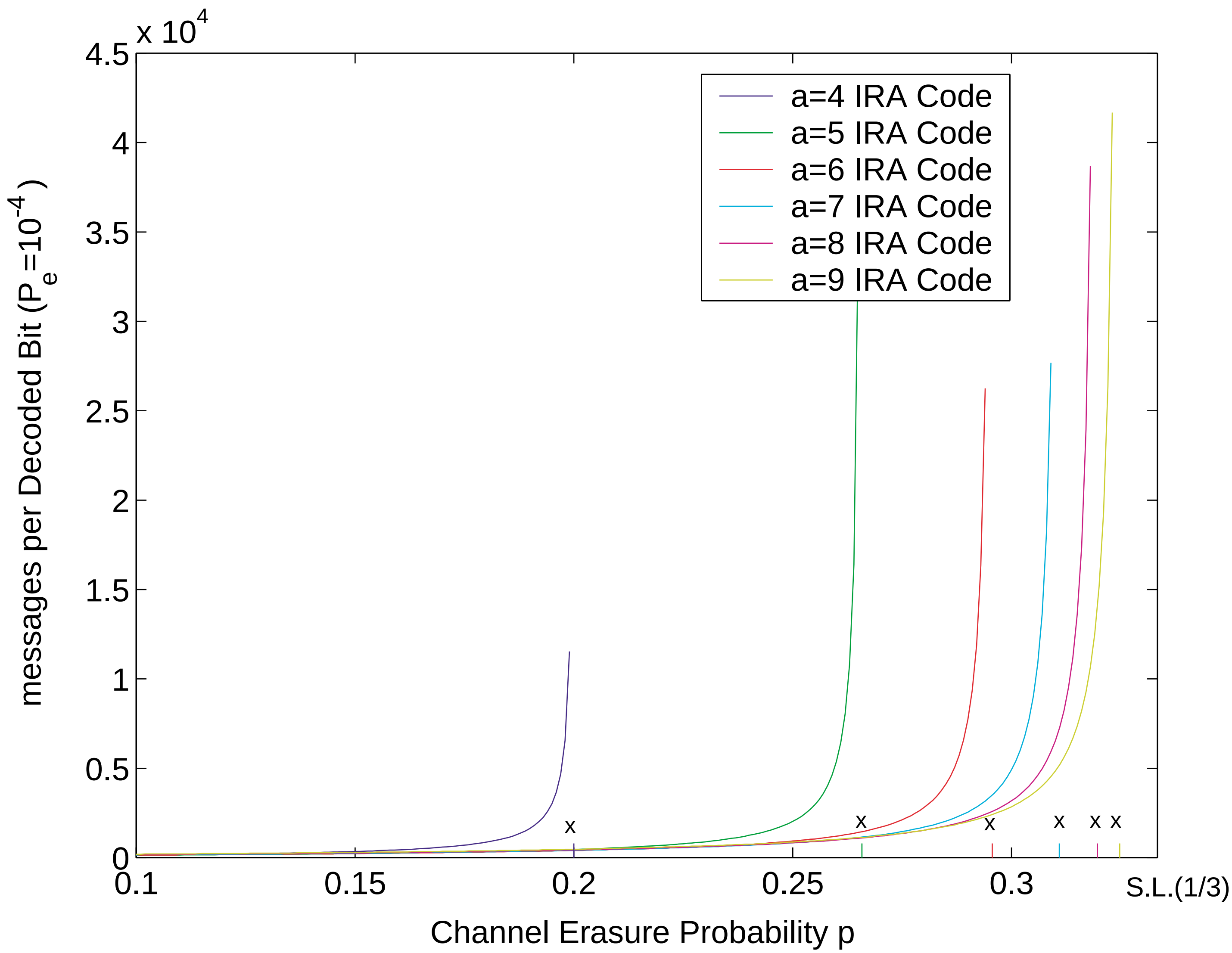


$R = 2/3$ IRA Codes for the Binary Erasure Channel



A New Result

Theorem C. *For the binary erasure channel, for IRA codes, the complexity of communicating at a rate equal to* $1 - \epsilon$ *of capacity is*

$$\overline{\chi}_D(\epsilon) = O(\frac{1}{\epsilon^2} \log \frac{1}{\epsilon})$$

Conjecture D. *For the binary erasure channel, for IRA codes, in fact*

$$\overline{\chi}_D(\epsilon) = O(\frac{1}{\epsilon} \log \frac{1}{\epsilon})$$

Note: We can prove that $\overline{\chi}_D(\epsilon) = O(\frac{1}{\epsilon} \log \frac{1}{\epsilon})$ for irregular LDPC codes.