Communication Efficient Data Exchange Among Multiple Nodes

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Introduction

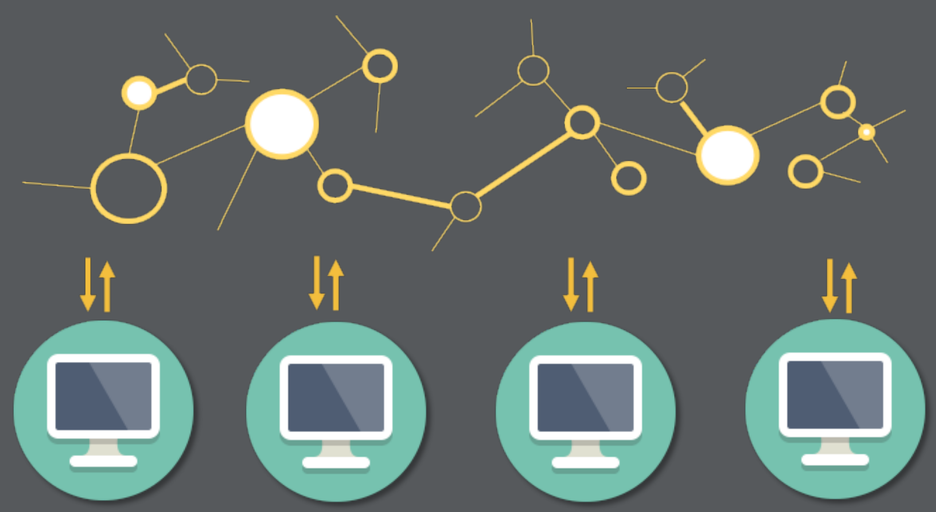

Figure 1: Multiparty Data Exchange.

Multiple parties observing correlated data seek to recover each other's data. How can they accomplish this using minimum communication?

- In practice, algorithms like r-sync are used for data exchange.
  - Uses *one* guess.
  - Does not exploit the correlation between the data.
  - Needs more communication.
- In theory, Slepian-Wolf compression is the optimal solution.
  - Difficulties in implementation of SW coding.
    - Search is over an exponential list in decoding.
    - Knowledge of $P_{X|Y}$ required.
- Suggested approach.
  - Use structured channel codes, in particular *Polar codes*, for implementation of SW compression [1].
  - Achieve universality using a *Recursive Data Exchange protocol* (RDE) [2].
  - Realise the RDE using H-ARQ based on polar codes.

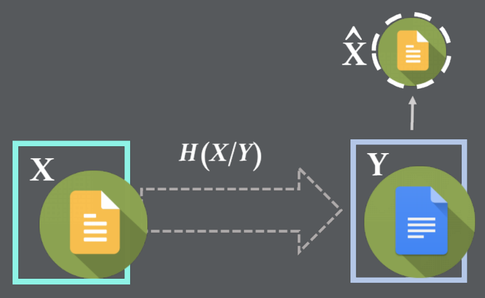

Figure 2: Slepian-Wolf Compression.

HARQ based on Polar Codes

- Polar Codes for error control. N indentical and independent channels W are converted to a second set of channels which have probability of error tending to 0 or 1. Information is sent over the channels which have high reliability. Other channels are *frozen* with known bits.
- Hybrid-ARQ is instrumental when underlying channel W is unknown.
  - In H-ARQ, initially *MSG+ Error Detection Code* is sent to receiver. On unsuccessful recovery, *Error Correction Code (FEC)* is communicated iteratively.
- Incremental freezing HARQ [3].
  - Initiates assuming a high reliability channel.
  - Decoding failure is detected after each iteration at the decoder.
  - In case of failure more unreliable bits are frozen by retransmission.

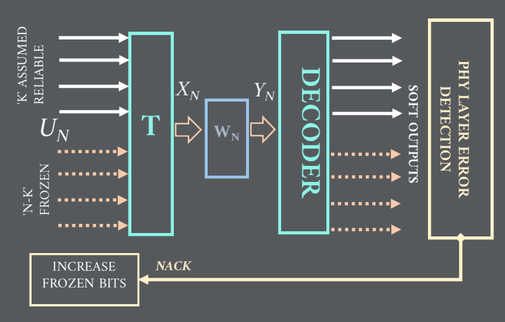

Figure 3: Incremental Freezing.

Decoding failure Detection

- Repeat-Top Polar Code (RT-Polar)
  - The scheme retransmits the t message bits sent over the most reliable polarized good channels over the least reliable good channels.
  - These two t-bit strings are decoded and compared to detect an error.
- Loglikelihood Threshold Polar (LT-Polar)
  - In a successful transmission a high percentage of the Log-Likehood Ratios (LLR) of the bit-channels clear the threshold with high probability.

Iterative SW Compression using

- Polar Codes for SW Compression.
  - Here, X_N and Y_N are correlated. The bits that are to be sent for estimation of X_N from Y_N are decided by inverse Arikan transform, 'T^{-1}', and are communicated error-free.

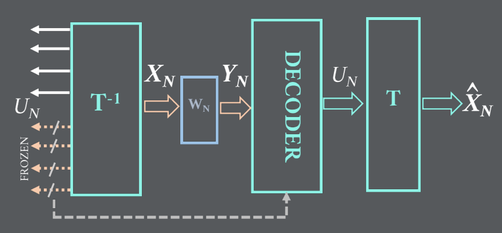

Figure 4: Polar Coding for SW Compression.

- The RDE scheme iteratively communicates in steps until the data exchange is completed. This can be practically implemented by Hybrid ARQ.
- Error detection using CRC is not feasible in SW compression.

Results

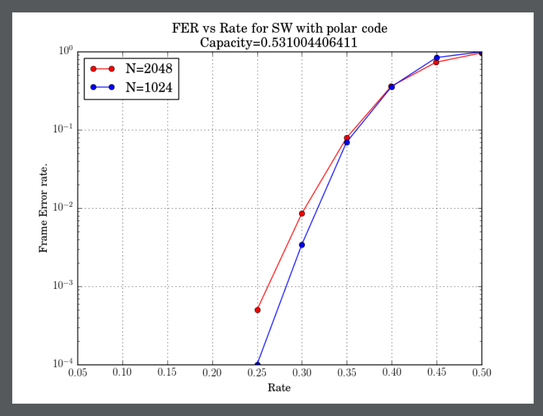

Figure 5: FER for SW compression.

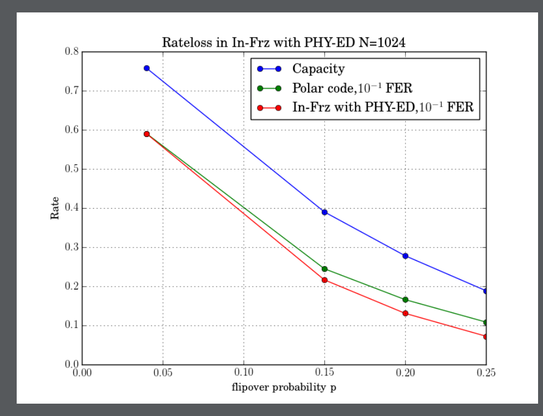

Figure 6: Rateloss for BSC.

Analytic t

- The proposed scheme reduces communication among nodes.
- The CRC-free universal polar code promises considerable rate gain for communication using short packet lengths.
- Future work.
  - Extensive performance analysis and theoritical analysis of proposed error detection scheme as a RB-HARQ for polar codes.
  - Implementation of the scheme for multiparty data exchange.

Conclusion and future work

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References

[1] Polar Codes for Nonasymetric Slepian-Wolf coding, Saygun Onay,2012.

[2] Universal Multiparty Data Exchange and Secret Key Agreement,Himanshu Tyagi and Shun Watanabe, Information Theory (ISIT), 2016 IEEE International Symposium.

[3] Capacity-Achieving Rateless Polar-Codes, Bin Li et al. 2015.

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