Communication Efficient Data Exchange Among Multiple Nodes

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Introduction

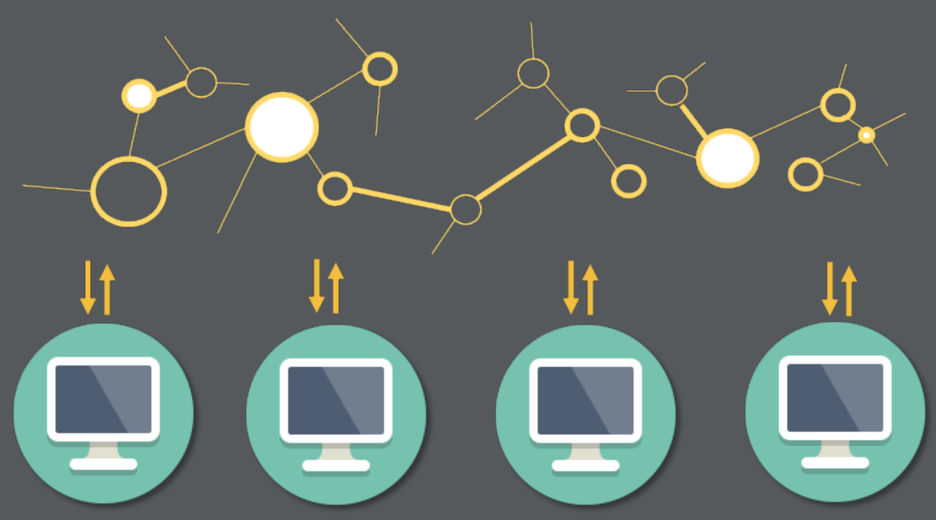

Figure 1: Multiparty Data Exchange.

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.
  - Fast and low complexity.
- In theory, Slepian-Wolf compression is the optimal solution.

Implementation of Slepian-Wolf Compression

- Difficulties in implementation of SW coding.
  - Search is over an exponential list in decoding.
  - Knowledge of $P_{X|Y}$ required.

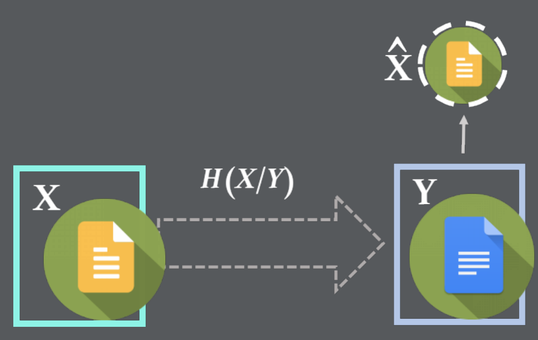

Figure 2: Slepian-Wolf Compression.

- Suggested approach.
  - Use of 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.

Polar Codes for Data Exchange

- Polar Codes for error control.
  - N indentical and independent channels W are converted to a second set of channels which have probility of error either 0 or 1.
  - Low complexity.

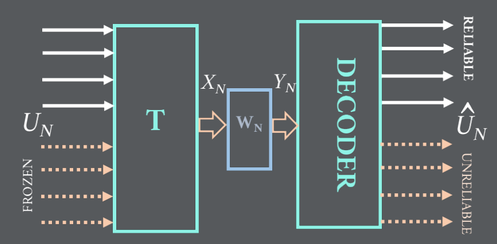

Figure 3: Polar Coding.

- Polar Codes for SW Compression.

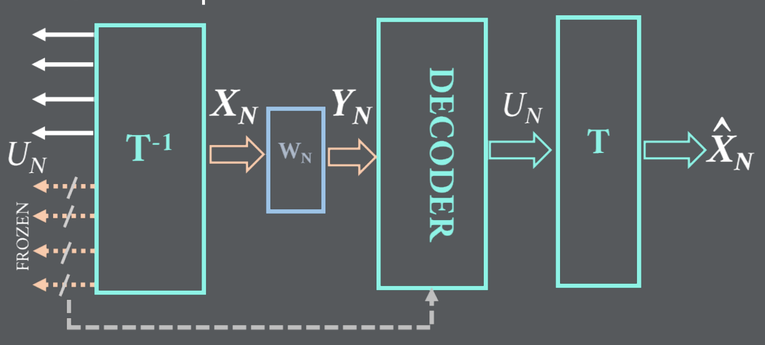

Figure 4: Polar Coding for SW Compression.

  - 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.

Iterative SW Compression using Incremental Freezing

- The RDE scheme iteratively communicates in steps until the data exchange is completed. This can be practically implemented by Hybrid ARQ.
- In H-ARQ, initially *MSG+ Error Detection Code* is sent to receiver. On unsuccessful recovery, *Error Correction Code (FEC)* is communicated incrementally.
- Adaptation of H-ARQ for RDE.
  - In Incremental Freezing, unreliable channels are chosen and information present in these channels are commmunicated [3] incrementally.
  - Error detection using CRC is not feasible in SW compression.Hence a PHY layer error detection scheme is proposed.
- PHY layer Error Detection for Incremental freezing.
  - Incremental freezing initiates assuming a high reliability channel.
  - Log-Likehood Ratios (LLR) of the bit-channels are compared to a threshold.
  - In a successful transmission a high percentage of the LLRs clear the threshold with high probability.
  - Otherwise more unreliable bits are frozen.

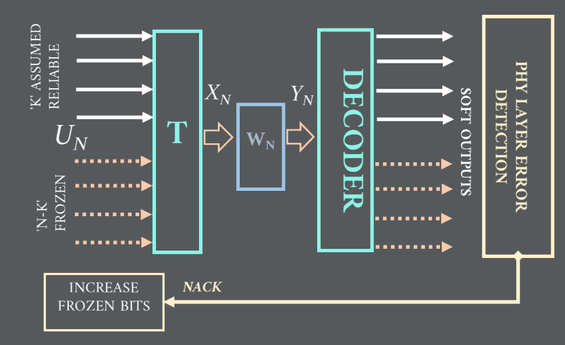

Figure 5: H-ARQ for RDE.

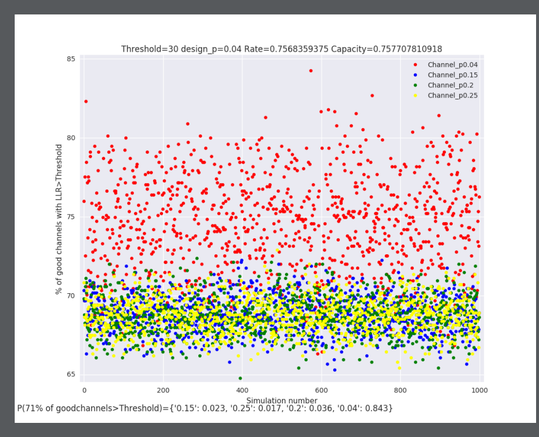

Figure 6: Choice of threshold for BSC.

Results

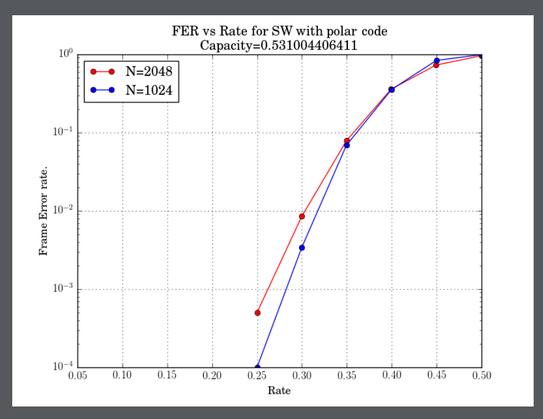

Figure 7: FER for SW compression.

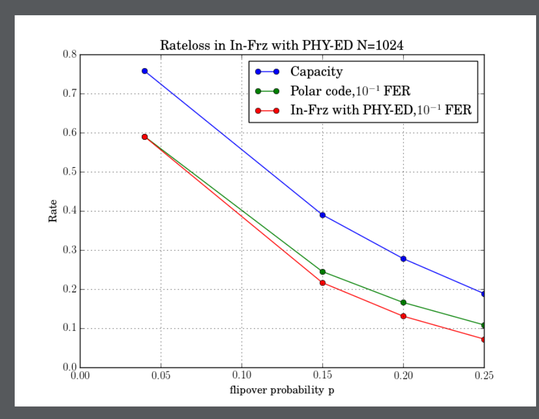

Figure 8: Rateloss for BSC.

Conclusion and future work

- 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.

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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