Maximise Through-put with Buffer-Aided Relay in a Two-Hop Full Duplex Wireless Network

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Introduction

- There is an exponentially growing demand for higher data rates being placed on wireless networks.
- To satisfy these demands there is a need to develop new wireless communication schemes.
- Buffer-aided has been proposed as a viable means to improve data rates for wireless networks.
- So far buffer-aided relaying has only been proposed for half-duplex relays, which are unable to send and transmit a the same time.
- Full-Duplex relays (FD), which are able to both transmit and receive at the same time have been largely ignored due to self-interference associated with FD communication.
- However, recently developed technologies have shown that the self-interference can be suppressed significantly, thus allowing for FD systems to become feasible in practice.
- Motivated by these results, in this research, we develop new buffer-aided relaying schemes for FD relays.
- Our results show that the proposed FD buffer-aided relaying schemes can significantly outperform conventional (i.e., non-buffer-aided) FD relaying schemes.

System Model and Problem

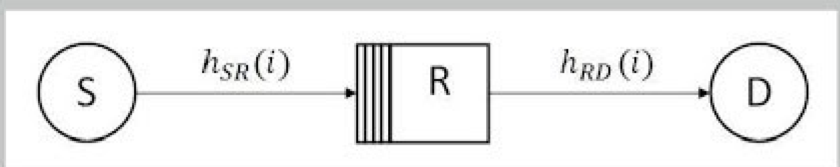

Figure 1: Block Model of system

- The systems model shows a two-hop FD buffer-aided relay network.
- Source sends codewords to destination only via the relay.
- The relay has a buffer in which it can store the received information.
- If the relay transmits a codeword to the destination successful, then it removes this information from its buffer.
- The transmission time is divided into infinite equal length timeslots, N.

$$C(i) = \log_2\left(1 + \frac{P_S h^2}{\sigma^2}\right)$$

- C represents the capacity of the channel.
- P_s is the power at which the codewords are sent.
- h is the attenuation from fading.
- σ^2 is the variance of the additive white Gaussian Noise.
- In each timeslot the source and relay transmit codewords that span an entire timeslot and are fixed rates from a discrete and finite list sorted in ascending order

$$\mathcal{S} = \{S_1, S_2, ..., S_K\} \text{ and } \mathcal{R} = \{R_1, R_2, ..., R_L\}$$

- To show successful transmission, outage indicators need to be defined.
- To this end, let $O_{SR_k}(i)$ and $O_{RD_l}(i)$ detonate successful transmission indicators, such that $O_{SR_k}(i) = 1$ and $O_{SR_k}(i) = 0$ if $S_k \leq C_{SR}(i)$ and $S_k > C_{SR}(i)$, respectfully and $O_{RD_l}(i) = 1$ and $O_{RD_l}(i) = 0$ if $R_l \leq C_{RD}(i)$ and $R_l > C_{RD}(i)$, respectfully.

$$\max_{a_k(i), b_k(i)} \tau_{RD} = \lim_{N \to \infty} \frac{1}{N} \sum_{i=1}^{N} \sum_{l=1}^{L} O_{RD_l}(i) b_l(i) R_l$$

subject to:

C1: $a_k(i) \in \{0,1\}$

C2: $b_l(i) \in \{0,1\}$

C3: $\sum_{k=1}^{K} a_k(i) \in \{0,1\}$

C4: $\sum_{l=1}^{L} b_l(i) \in \{0,1\}$

C5: $\lim_{N \to \infty} \frac{1}{N} \sum_{i=1}^{N} \sum_{k=1}^{L} O_{SR_k}(i) a_k(i) S_k = \lim_{N \to \infty} \frac{1}{N} \sum_{i=1}^{N} \sum_{l=1}^{L} O_{RD_l}(i) b_l R_l$

Problem Continued

- To maximize the throughput, we need to select the transmission rates at source and relay optimally.
- To this end, let $a_k(i)$ and $b_l(i)$ denote rate selection variables, such that $a_k(i) = 1$ and $a_k(i) = 0$ if rate S_k is selected and not selected, respectively, and $b_l(i) = 1$ and $b_l(i) = 0$ if rate R_l is selected and not selected, respectively.
- The maximisation of system throughput can be simplified to τ_{RD} due to C5.

Simulation and Discussion

- The solution of the optimization problem can be explained as follows:
  - The Source and/or relay are silent only when an outage occurs on their respective channels for all available transmission rates.
  - Otherwise, the source and/or relay will transmit at the highest rate that still results in successful transmission.

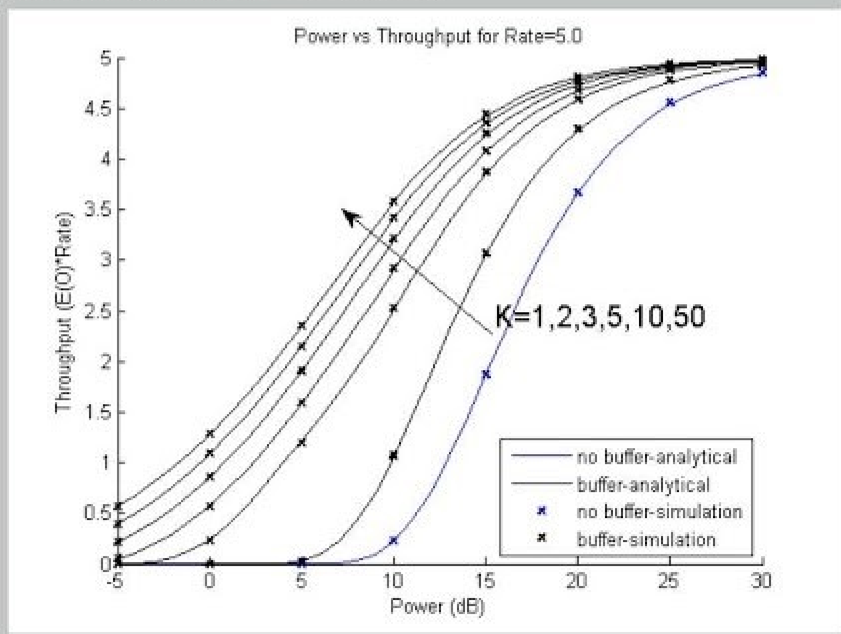

Figure 2: Throughput vs Power for rate of 5

- The numerical simulations are performed by fixing the rates such that $\mathcal{S} = \mathcal{R}$, $S_k = R_l = mR$, for $k = l$ and $m = 1, 2, ...K$ where mR is fixed, simply the rates to choose from are the same for source and relay.
- For the our simulation $mR = 5$.
- The benchmark is a FD system that does not use a buffer-aided relay
- The other plots show a buffer-aided system where K is altered.
  - $K = 1$ allows transmission at rate mR or silent (no transmission),
  - $K = 2$ allows transmission of rate $0, \frac{mR}{2}, mR$.
- The use of a buffer (with only 1 rate option) allows for the same throughput and lower power consumption (up to 3dB).
- With more choice of rates, less power is required.
- For $K > 10$ the improvements become more negligible.

Conclusion

- We have developed a new FD buffer-aided relaying protocol for the two-hop FD relay channel with discrete transmission rates.
- Our results show that the proposed FD buffer-aided relaying scheme can significantly outperform conventional (i.e., non-buffer-aided) FD relaying schemes.

References

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[2] S. Hong, J. Brand, J. Choi, M. Jain, J. Mehlman, S. Katti, and P. Levis. "Applications of Self-Interference Cancellation in 5G and Beyond," *IEEE Communications Magazine*, Vol. 52(2), pp.114-121,Feb. 2014

Acknowledgements

- This research was made possible with the supervision and guidance of Nikola Zlatanov