Opportunistic Wireless Relay Channels

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Abstract

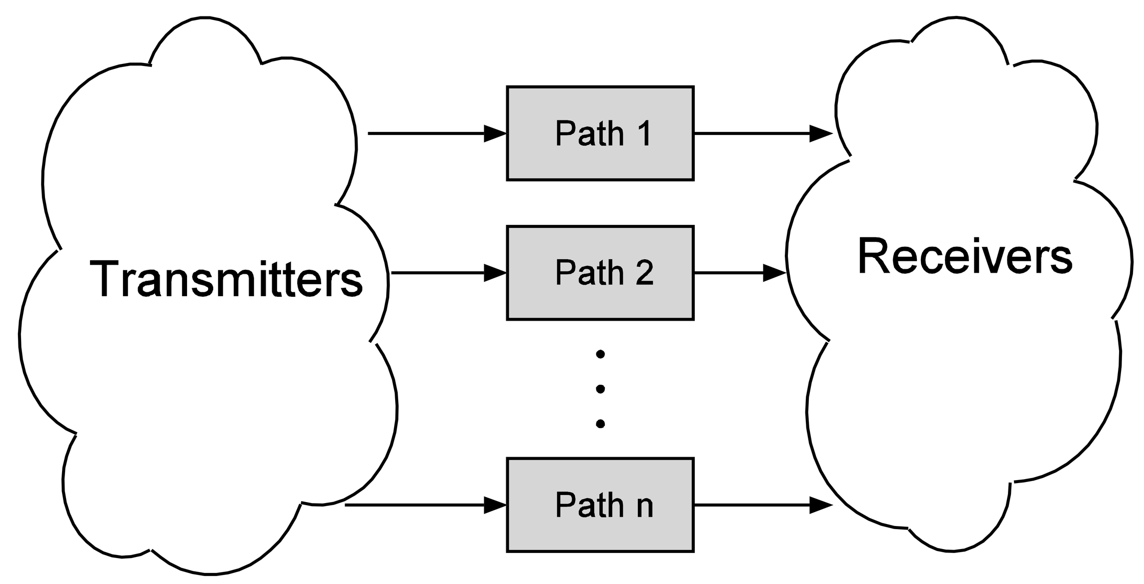
Relays has been widely used to increase the transmission rates, extend the coverage area of a wireless network and at the same time maintain a required quality of service. Opportunistic communication is known to increases capacity compared to open-loop systems, removes the effect of interference and allows simpler encoding and decoding. We investigate various relay networks in the opportunistic mode. This study is in part motivated by the advances in multi-user diversity in uplink or downlink channels, where instead of superposition of interfering users, the best user at each time is serviced.

In this work we study the multiple access relay channel as an example. Specifically we explores the effect of multiuser diversity on the diversity multiplexing trade-off (DMT) performance of the MARC. A new opportunistic channel access communication scheme is proposed where the user selection depends only on the source-destination channels coefficients. This is proven to be DMT optimal. Both non-orthogonal and orthogonal relay transmission are studied under various cooperation protocols. This work does not assume CSI at the transmitters and assumes only 1-bit feedback from the destination to the sources.

Opportunistic Access over Wireless Networks

Definition 1: ***Opportunistic communication*** is defined as a strategy where different message streams in the network do not interfere. The target message stream may originate from a source, a relay, or both and more than one message as long as no interference is introduced.

Definition 2: ***An opportunistic communication mode or access mode*** is the set of active transmitters, receivers, and respective links in the network during a given transmission interval.



Lemma 1: Consider a system that opportunistically switches between *n* access modes. The overall DMT is bounded by:

$$d(r) \le d_1'(r) + d_2'(r) + \cdots + d_n'(r),$$

where $d_i'(r)$ is defined as

$$d_i'(r) = \lim_{\rho \to \infty} \frac{\log \mathrm{P}(e_i \mid e_{i-1}, \cdots, e_n)}{\log \rho}$$

and $\mathrm{P}(e_i \mid e_{i-1}, \cdots, e_n)$ is the probability of error in access mode *i* given that all the previous access modes are in error.

Lemma 2: A DMT upper bound for opportunistically switching between *n independent* access modes is given by

$$d(r) \le d_1(r) + d_2(r) + \cdots + d_n(r),$$

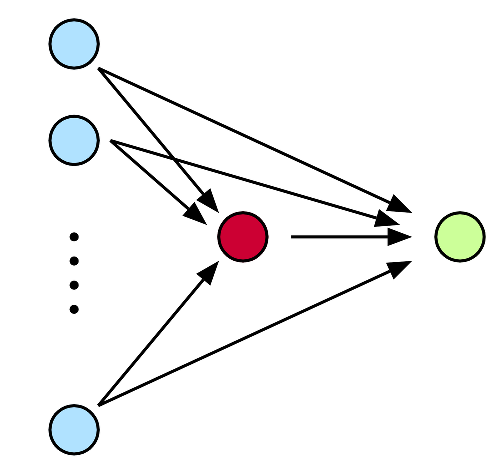
where $d_i(r)$ is the DMT of the subsystem i.

Lemma 3: The upper bound above is tight if the following two conditions are asymptotically satisfied:

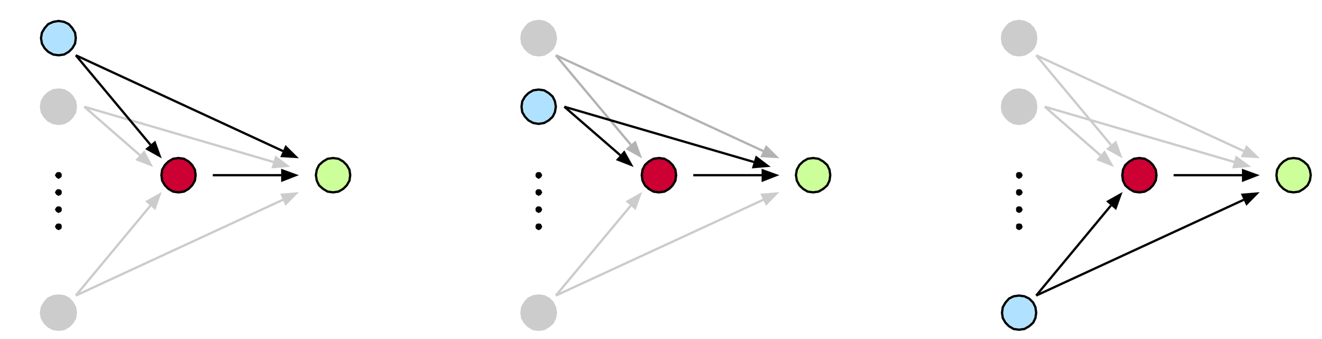
1) The selection criterion is such that the system is in outage only when all subsystems are in outage.

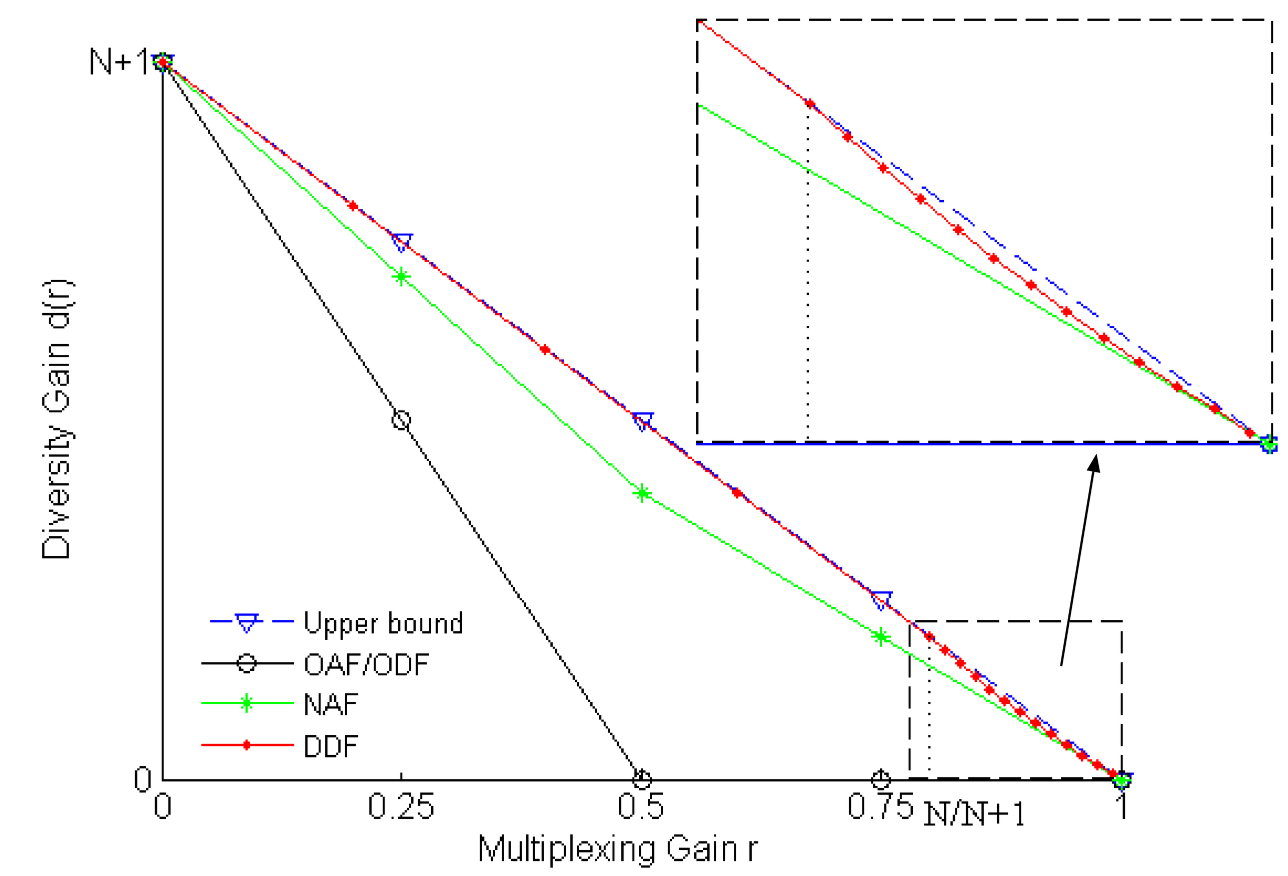
2) Each selected subsystem uses codebooks that achieve its individual DMT conditioned on its selection.

Example: Multiple Access Relay Channel



- Simple selection scheme based on the source-destination link gains is DMT optimal.
- Dynamic decode and forward relaying approaches the upper bound as the number of users grows.
- Compress and Forward relaying achieves the upper bound.





Future Work

Results have been calculated for various Relay networks including:

- The interference relay channel.
- The X-relay channel.
- The shared relay channel.
- The broadcast relay channel.
- The Gateway channel.