Simulation of an Adaptive Cooperative Diversity Algorithm for Ad-hoc Networks

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***Abstract*—We implement a cross-layer design utilizing a cyclic redundancy check (CRC) on the transport layer to detect poor channel state and Alamouti's space-time block code on the link layer for retransmission. Diversity nodes are selected at the transport layer, rather than the link layer, reducing the channel quality estimation to a CRC. We also simulate different methods of selecting retransmission nodes by taking into account likelihood of retransmission.**

***Keywords*—Cooperative diversity, cross-layer design, CRC, Alamouti's code, ad-hoc networks**

I. Introduction

WIRELESS ad-hoc networks have recently become a topic of research as they can be deployed quickly in locations lacking the infrastructure required for typical wireless networks. Compared to the transmitters and receivers in traditional wireless networks, the nodes in an ad-hoc network may be much smaller and possibly mobile. This discourages the use of many techniques for increasing capacity, most notably the use of multiple antennas at the transmitter for obtaining a diversity gain. A diversity strategy is proposed in [1] that creates a virtual antenna array by utilizing inactive neighboring nodes in transmitting with an orthogonal space-time block code.

II. Adaptive Cooperative Diversity

A cooperative diversity algorithm was described in [1] and was used as a basis for the simulation.

A. Diversity Strategy

If we consider an ad-hoc network consisting of many separate devices, it can be assumed that some of these nodes will be idle and available for data transmission. These inactive nodes can be utilized for transmission with an orthogonal space-time block code. To limit unnecessary use of other nodes, the transmission only falls back to cooperative diversity if the destination node fails the CRC from the source-only transmission. A simple implementation of this process can be seen in Figure 1.

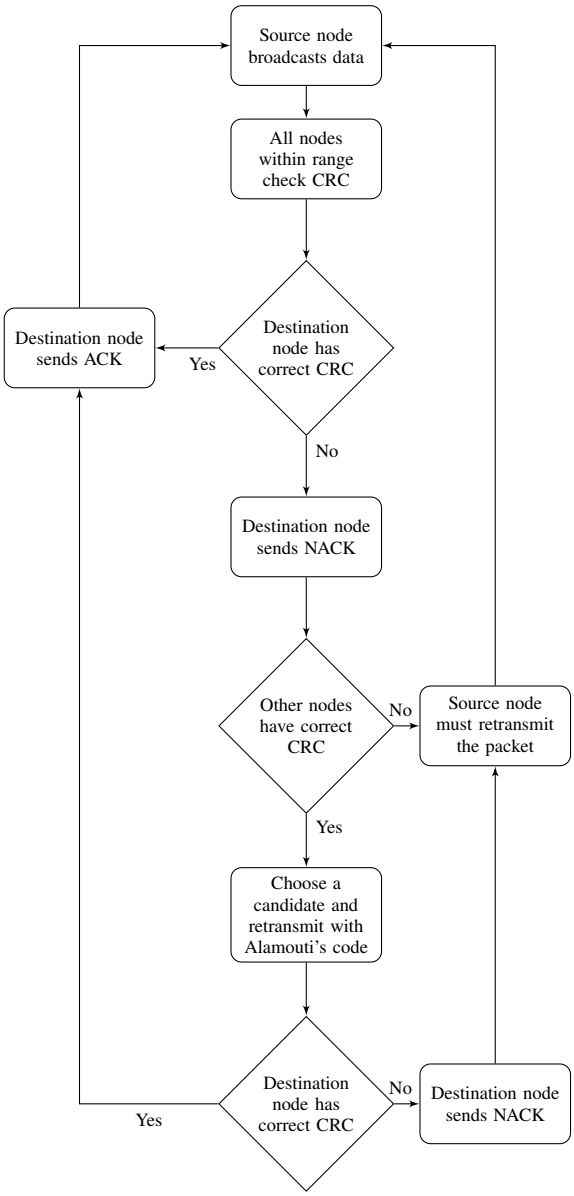

Fig. 1. Flowchart of the simulated algorithm.

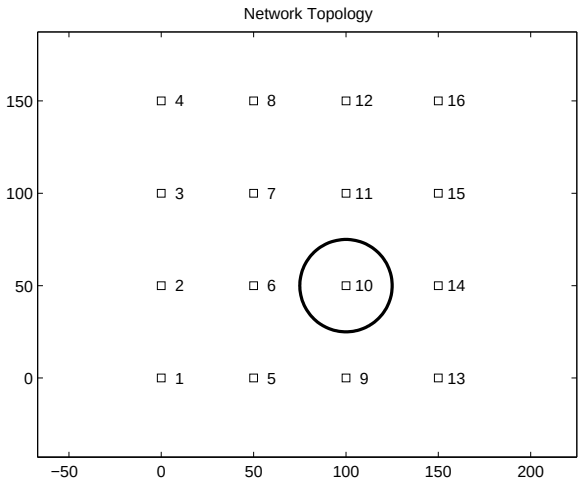

Fig. 2. Topology of a 4x4 grid network.

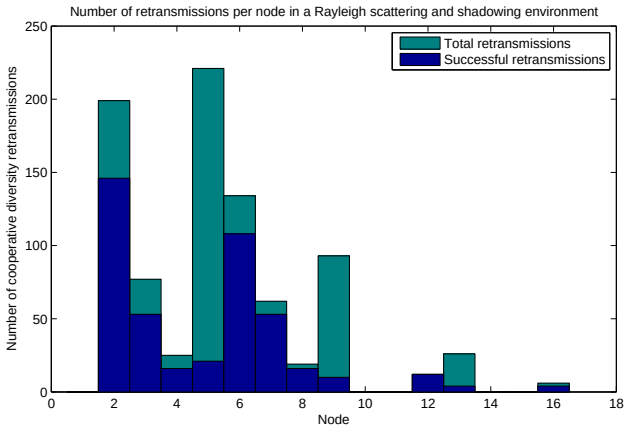

Fig. 3. Histogram of retransmissions at each node in a network.

B. Distance and Shadow Fading Considerations

Simply picking a diversity node at random from the list of nodes that passed the CRC is not the most efficient method. Consider the network topology shown in Figure 2. Assume that the circle around node 10 is a building introducing significant shadowing to the channels passing through it. Consider that node 1 is attempting to transmit data to node 11. While nodes 2 and 5 will pass the CRC equally often, a cooperative diversity transmission with node 2 is much more likely to be successful than one with node 5. The same is true for nodes 3 and 9. Figure 3 contains the results of 1000 packet transmissions where the diversity nodes where chosen from a uniform random distribution. While nodes 2 and 5 were selected for diversity about the same number of times, node 5 was obviously not a good choice for cooperative diversity. To account for this, Algorithm 1 was developed. When the node enters the network, it assumes that all nodes have an equal probability of performing a successful transmission as a diversity node. As transmissions are made, the node keeps track of the probability of transmission and selects the diversity nodes based on which of the diversity candidate nodes has the highest probability of transmission.

Algorithm 1 Algorithm for selecting diversity nodes by transmission likelihood

Let N be the set of all other nodes in the ad-hoc network.
Let Q be the subset of N that passed the CRC.
Let Q' be the subset of Q that has the highest probability of success as a diversity node.
Let P_{ij} be the likelihood of transmission to node j if node i is selected as the diversity node.

for all $i, j \in N$ **do**
  Initially assume all nodes have perfect transmission likelihood.
  $P_{ij} \leftarrow 1$
  $n_{ij} \leftarrow 1$
end for
loop
  Transmit without diversity from i to j.
  if $\{j$ passes CRC$\}$ **then**
    Send next packet.
  else
    Let $Q = \{a \mid \forall a \in N, a$ passes CRC$\}$
    Let $Q' = \{b \mid \forall b, c \in Q, P_{bj} \geq P_{cj}\}$
    if $|Q'| > 1$ **then**
      $m \sim U(1, |Q'|)$
      $k \leftarrow Q'_m$
    else
      $k \leftarrow Q'_1$
    end if
    Retransmit from i to j with k selected as diversity node.
    if $\{j$ passes CRC$\}$ **then**
      $P_{kj} \leftarrow \frac{P_{kj} n_{kj} + 1}{n_{kj} + 1}$
      Send next packet.
    else
      $P_{kj} \leftarrow \frac{P_{kj} n_{kj}}{n_{kj} + 1}$
      Requeue packet for retransmission without diversity.
    end if
  end if
end loop

III. Conclusion

The conclusion goes here.

References

[1] L. Dai and K. Letaief, "Throughput maximization of ad-hoc wireless networks using adaptive cooperative diversity and truncated arq," *Communications, IEEE Transactions on*, vol. 56, no. 11, pp. 1907–1918, November 2008.

[2] S. Alamouti, "A simple transmit diversity technique for wireless communications," *Selected Areas in Communications, IEEE Journal on*, vol. 16, no. 8, pp. 1451–1458, Oct 1998.