A MAC and Routing Protocol in Ad Hoc Wireless Networks with Directional Antenna

2003/09/25
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Outline

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Introduction

- The goal of CSMA/CA is to have a node transmit a packet *if and only if* there will be no collisions [4].
  - Not only should it *be blocked* if there will *be a collision*, but it should *also not be blocked* if there will *be no collision* [4].

- CSMA/CA meets this goal admirably in ad hoc networks when omni-directional antennas are used. However, with directional transmissions, this is not true [4].
Problem Definition

- **MAC Issues**
  - The Deafness Problem [1][3]
  - The Hidden Terminal Problem [1][3]

- **Routing Issues**
  - Route Coupling Problem [4]
Problem Definition (MAC Issues)

Invalid transmissions but allowed
Valid transmissions but denied
Problem Definition (Routing Issues)
The Control Messages Shared between Proposed MAC and Routing Protocol

- Circular Directional Control Message
  - Directional Link State Advertisement
  - Location Table [3]
  - Communication State Advertisement (which is combined with link state advertisement) [4]
  - Active Node Table [4]
Directional Link State Advertisement

HELLO from neighbors
All nodes should construct the location table which contains the location of its neighbors.

<table>
<thead>
<tr>
<th>Me</th>
<th>Neighbor</th>
<th>My Beam</th>
<th>Neighbor’s Beam</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>B</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>A</td>
<td>C</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>A</td>
<td>D</td>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>
Communication State Advertisement

- The hello message of link state advertisement must contain the communication state of the node.
- The possible state of all the nodes in the network could be 0(inactive) or 1(active).
Active Node Table

All node should construct the active node table which contains *the perception about communication activities* in the entire network.

<table>
<thead>
<tr>
<th>Nodes</th>
<th>n₁</th>
<th>n₂</th>
<th>...</th>
<th>nₙ</th>
</tr>
</thead>
<tbody>
<tr>
<td>State</td>
<td>0(inactive)</td>
<td>1(active)</td>
<td>...</td>
<td>0(inactive)</td>
</tr>
</tbody>
</table>
The Proposed MAC Protocol

- Preceding Tone [4]
- Circular Directional RTS [3] and CTS
- D-NAV [2][3][4]
Preceding Tone

- In order to enable the receiver decoding the received signal correctly, each control packet is transmitted with a preceding tone with a duration such that *in this period the receiver can track the best possible direction of receiving the signal.*
Circular Directional RTS and CTS

SILENCE

SILENCE
The Proposed Routing Protocol

Routing Protocol with Maximally Zone Disjoint Shortest Path [4]

- Step 1: Find out all paths between s-d pair with numbers of hop less than $H_{max}$.
- Step 2: Consult the active node table for finding out the nodes involved in ongoing communications at that point of time for computing route correlation factor $\eta$.
- Step 3: Choose the lowest $\eta$ path as routing path.
Conclusions

- *Preceding tone* help the receiver quickly track the correct direction of the transmitter.
- *Circular directional RTS and CTS* fully exploit the coverage of smart antenna, at the same time, it solves the problem of hidden terminal.
- *D-NAV* refines the spacial reuse of WLAN, for this reason, it can improve the capacity of WLAN drastically. D-NAV also solves the deafness problem.
- *Maximally Zone Disjoint Shortest Path Routing* can resolve the route coupling problem which degenerate the end-to-end delay of route.
References


