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On exploiting spatial reuse in wireless ad hoc networks

Ziguang Yan

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On Exploiting Spatial Reuse in Wireless Ad Hoc Networks

A thesis submitted in partial fulfillment of the requirements for the award of the degree

Master of Engineering by Research

From

UNIVERSITY OF WOLLONGONG

By

Ziguang Yan

School of Electrical, Computer and Telecommunications Engineering

March 2008
Statement of Originality

I, Ziguang Yan, declare that this thesis, submitted in partial fulfillment of the requirements for the award of Master of Engineering - Research, in the School of Electrical, Computer and Telecommunications Engineering, University of Wollongong, is wholly my own work unless otherwise referenced or acknowledged. The document has not been submitted for qualifications at any other academic institution.

Ziguang Yan

March 2008
Abstract

Wireless ad hoc networks have been increasingly popular in recent years with the development of mobile devices. However, both theoretical and simulation works show that the capacity of wireless ad hoc networks is bounded due to its nature of distributed and multihop. Spatial reuse is a promising technology to increase the capacity of wireless ad hoc networks by allowing more transmissions to occur simultaneously. In this thesis, we enhance 802.11 performances by exploiting the benefits of spatial reuse in wireless ad hoc networks which is achieved by transmission power control (TPC) and directional antennas.

We first propose spatial TPC based on basic TPC to fully exploit the benefits of spatial reuse achieved by transmission range control. Simulation results show that spatial TPC achieves higher throughput and lower power consumption compared to 802.11 and basic TPC. We also develop four schemes of directional MAC protocols with the intention of overcoming the new hidden node problem faced by directional antennas. By extensive simulations under different topologies and traffic patterns, we find the directional RTS/CTS (DD) scheme outperforms 802.11 as well as other three schemes by fully exploiting the benefits of spatial reuse achieved by directional antennas.

Keywords:
Wireless ad hoc networks, MAC, CSMA, 802.11 DCF, Spatial reuse, Power control, Directional antennas, OPNET simulation.
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Abbreviations

ACK    acknowledgement
AoA    angle of arrival
AP     access point
ATIM   announcement traffic indication message
BEB    binary exponential backoff
BER    bit error rate
BSS    basic service set
CCA    clear channel assessment
CFP    contention free period
CP     contention period
CS     carrier sense
CSMA   carrier sense multiple access
CTS    clear to send
CW     contention window
DCF    distributed coordination function
DIFS   distributed (coordination function) interframe space
DPSK   differential phase shift key
DMAC   basic directional MAC protocol
DNAV   directional network allocation vector
EIFS   extended interframe space
FSM    finite state machine
GPS    global positioning system
IFS    interframe space
LoS    line of sight
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>MAC</td>
<td>medium access control</td>
</tr>
<tr>
<td>MSDU</td>
<td>MAC service data unit</td>
</tr>
<tr>
<td>NAV</td>
<td>network allocation vector</td>
</tr>
<tr>
<td>PCF</td>
<td>point coordination function</td>
</tr>
<tr>
<td>PCS</td>
<td>physical carrier sensing</td>
</tr>
<tr>
<td>PLCP</td>
<td>physical layer convergence protocol</td>
</tr>
<tr>
<td>PS</td>
<td>power saving</td>
</tr>
<tr>
<td>RTS</td>
<td>request to send</td>
</tr>
<tr>
<td>RTT</td>
<td>round trip time</td>
</tr>
<tr>
<td>SIFS</td>
<td>shortest interframe space</td>
</tr>
<tr>
<td>SISO</td>
<td>single in single out</td>
</tr>
<tr>
<td>SNR</td>
<td>signal to noise ratio</td>
</tr>
<tr>
<td>STA</td>
<td>station</td>
</tr>
<tr>
<td>TPC</td>
<td>transmission power control</td>
</tr>
<tr>
<td>ToA</td>
<td>time of arrival</td>
</tr>
<tr>
<td>VCS</td>
<td>virtual carrier sensing</td>
</tr>
<tr>
<td>WLAN</td>
<td>wireless local area network</td>
</tr>
<tr>
<td>WM</td>
<td>wireless medium</td>
</tr>
</tbody>
</table>
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