Performance evaluation and enhancement of WLAN

(CMPT885 / ENSC835)

Jiaqing (James) Song
songs@acm.org
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Introduction to WLAN

IEEE 802.11
- Defines both PHY layer and MAC layer
- Data rate: 1M, 2M, 5.5M, 11M
- Access model: DCF and PCF (optional)
- Adopts CSMA/CA as DCF
- Adopts RTS/CTS as PCF

Some Problems of WLAN
- Media is error prone
- Carrier sensing is difficult
- Hidden terminal problem
Introduction to WLAN
- WLAN Components: Independent BSS
Introduction to WLAN
- Independent BSS Data Link

Independent BSS

wlan workstation 1  wlan server 1

wlan workstation 2  wlan workstation 3
Introduction to WLAN
- WLAN Components: Infrastructure BSS
Introduction to WLAN
- Infrastructure BSS Data Link
Introduction to WLAN
Introduction to WLAN
- OPNET Model: WLAN Station
Introduction to WLAN
- OPNET Model: WLAN Workstation/Server
Introduction to WLAN
- OPNET Model: WLAN Router

Access Point (wlan router)

Diagram showing network topology with various nodes and connections.
Performance enhancement
- Survey of Methods

- Physical layer characteristics (slot time, SIFS)
- Tune up the WLAN parameters (Fragmentation threshold, RTS threshold, ...)
- Adaptive back-off protocol on MAC layer
- Proxy approach (snoop, SMART snoop protocol)
  - Reliable link-layer approach (AIRMAIL)
  - Split-connection approach (I-TCP, M-TCP)
Implementation with OPNET

Part 1: PHY Characteristics

- Analyze the effect of PHY characteristics
- PHY characteristics provided by OPNET model: Frequency Hopping, Direct Sequence, Infra Red
- OPNET does not provide customized PHY characteristics
- Add Slot Time, Sifs Time, Minimum Contention Window, Maximum Contention Window parameters into the OPNET node model
Implementation with OPNET
Part 1: PHY - Settings

(Wireless LAN Parameters) Table

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rts Threshold (bytes)</td>
<td>None</td>
</tr>
<tr>
<td>Fragmentation Threshold (bytes)</td>
<td>None</td>
</tr>
<tr>
<td>Data Rate (bps)</td>
<td>11 Mbps</td>
</tr>
<tr>
<td>Physical Characteristics</td>
<td>Customized</td>
</tr>
<tr>
<td>Short Retry Limit (slots)</td>
<td>7</td>
</tr>
<tr>
<td>Long Retry Limit (slots)</td>
<td>4</td>
</tr>
<tr>
<td>Access Point Functionality</td>
<td>Disabled</td>
</tr>
<tr>
<td>Channel Settings</td>
<td>(...)</td>
</tr>
<tr>
<td>Buffer Size (bits)</td>
<td>256000</td>
</tr>
<tr>
<td>Max Receive Lifetime (secs)</td>
<td>0.5</td>
</tr>
<tr>
<td>Large Packet Processing</td>
<td>Drop</td>
</tr>
<tr>
<td>BSS Identifier</td>
<td>Not Used</td>
</tr>
<tr>
<td>Slot Time</td>
<td>2E-05</td>
</tr>
<tr>
<td>Sifs Time</td>
<td>1E-05</td>
</tr>
<tr>
<td>Min Contention Window</td>
<td>15</td>
</tr>
<tr>
<td>Max Contention Window</td>
<td>1023</td>
</tr>
</tbody>
</table>

Frequency Hopping
- Direct Sequence
- Infra Red
- Customized
Implementation with OPNET
Part 1: PHY - Scenario
Implementation with OPNET
Part 1: PHY – Results 1
Implementation with OPNET
Part 1: PHY – Results 2

![Graph showing Average of Delay (sec) over time]

- Physical characteristic: customized
- Physical characteristic: standard

Time: 0m, 0m 20s, 0m 40s, 1m, 1m 20s, 1m 40s, 2m

Y-axis: 0.0000 to 0.0008

Graph indicates the average delay over time for different physical characteristics.
Implementation with OPNET

Part 2: WLAN Parameters

- Two important parameters: Fragmentation threshold, RTS/CTS threshold
- Proper fragmentation threshold can improve the wlan performance if the media error rate is high
- Too small fragmentation threshold will make the packet header occupy too much bandwidth

- RTS/CTS is used to deal with the hidden terminal problems
### Implementation with OPNET

Part 2: WLAN Parameters – PEG

![Image of OPNET settings window]

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Error Mode</td>
<td>Bit Error Mode</td>
</tr>
<tr>
<td>Bit Error Rate (bits per error)</td>
<td>10,000</td>
</tr>
<tr>
<td>Packet Error Rate (packets per error)</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Mode Options:
- Mode Disabled
- Bit Error Mode
- Packet Error Mode
**Implementation with OPNET**

Part 2: WLAN Parameters – Settings

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start Time (seconds)</td>
<td>constant (2)</td>
</tr>
<tr>
<td>ON State Time (seconds)</td>
<td>constant (100)</td>
</tr>
<tr>
<td>OFF State Time (seconds)</td>
<td>constant (0)</td>
</tr>
<tr>
<td>Packet Generation Arguments</td>
<td>(...)</td>
</tr>
<tr>
<td>Stop Time (seconds)</td>
<td>Never</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interarrival Time (seconds)</td>
<td>exponential (0.01)</td>
</tr>
<tr>
<td>Packet Size (bytes)</td>
<td>exponential (1024)</td>
</tr>
<tr>
<td>Segmentation Size (bytes)</td>
<td>No Segmentation</td>
</tr>
</tbody>
</table>
Implementation with OPNET
Part 2: WLAN Parameters – Results 1

Bits Error Rate = 1/50,000
Implementation with OPNET
Part 2: WLAN Parameters – Results 2

Bits Error Rate = 1/10,000
Implementation with OPNET

Part 3: Adaptive Backoff

- Named Distributed Contention Control (DCC)
- Can be executed on the top of pre-existent access scheduling protocol (DCF)
- For the adaptive reduction of contention in WLAN networks
- Estimate the channel’s congestion level from the slots utilization rate
- High congestion level \(\rightarrow\) Trigger the virtual congestion procedure \(\rightarrow\) Do the Backoff without the cost of a collision
Implementation with OPNET

Part 3: Adaptive Backoff

Immediate access when medium is free >= DIFS

DIFS

Busy Medium

DIFS

PIFS

SIFS

Contention Window

Backoff-Window

Next Frame

Slot time

Deferred Access

Select Slot and Decrement Backoff as long as medium is idle
Implementation with OPNET
Part 3: Adaptive Backoff – Modified Model
Implementation with OPNET
Part 3: Adaptive Backoff - Scenario
Implementation with OPNET
Part 3: Adaptive Backoff - Settings
Implementation with OPNET
Part 3: Adaptive Backoff – Results 1

![Graph showing wireless lan throughput over time with adaptive backoff and standard backoff compared.](image-url)
Implementation with OPNET
Part 3: Adaptive Backoff – Results 2
TCP-aware link-layer scheme
Makes the lossy link appear as a higher quality link with a reduced effective bandwidth
Based on the Snoop protocol
Use SMART strategy (Simple Method to Aid Retransmissions, it combines the best feature of Go-Back-N and Selective-Ack)

Still in progress …
References
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[16] Rodrigo Garces, J. J. Garcia-Luna-Aceves, "Collision avoidance and resolution multiple access with transmission queues", Wireless Networks March 1999 Volume 5 Issue 2

Thanks!

(April 2, 2002)