Diagnosing and improving 802.11 Wireless Networks

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http://sysnet.ucsd.edu/wireless/
Wireless Internet at UCSD CSE

Why is SSH so slow!? ...

I get disconnected every 5 minutes! ...

Couldn’t connect in the last hour! ...

...
Why is it hard to figure out?

- Problems can be:
  - Caused by various, interacting protocols
  - Transient or persistent
  - Interference (example: microwaves)
- Manual diagnosis is extremely time consuming!

Sysadmin
Automating diagnosis

- **Jigsaw**: monitor the whole wireless network
  - Overlay existing WiFi with passive monitors
  - Create a single unified trace

- **Shaman**: expert system that diagnoses problems
  - Models costs of connecting to wireless
  - Models per packet delay and loss causes (TCP)
  - Models impact of contention from other users (e.g. VoIP, in progress)
(Re-)connecting to wireless

1. Scan for APs
2. Associate with AP
3. Get IP address (DHCP)
4. Check IP address and locate the gateway (ARP)
5. Access the Internet

Critical path to connectivity
Connecting often takes forever

<table>
<thead>
<tr>
<th>Step</th>
<th>Majority clients</th>
<th>Worst 20% clients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total time to connect</td>
<td>&gt;10s</td>
<td>&gt;20s</td>
</tr>
<tr>
<td>Scan for APs</td>
<td>&gt;7.5s</td>
<td>&gt;10s</td>
</tr>
<tr>
<td>Association</td>
<td>&gt;2.5ms</td>
<td>&gt;7.5ms</td>
</tr>
<tr>
<td>DHCP</td>
<td>&gt;0.1s</td>
<td>&gt;2.5s</td>
</tr>
<tr>
<td>ARP</td>
<td>&gt;1s</td>
<td>&gt;5s</td>
</tr>
</tbody>
</table>

Note: these are successful cases

Interfering APs
Bad client implementation
Unresponsive DHCP server
Check IP address
Unresponsive gateway

[sigcomm 2007]
Shaman expert system

• Want to help sysadmin to diagnose specific problem cases
• Given a trouble ticket, Shaman:
  – Analyzes critical path to wireless connectivity, TCP delays, …
  – Assigns blame for problem to DHCP server, microwave, client itself, etc.
Shaman time series

ARP

DHCP

Assoc

1st ARP

1st DHCP

1st assoc

repeatedly re-associates

12:25:00 12:30:00 12:35:00 12:40:00 12:45:00 12:50:00
The diagnosis

"Your DHCP has problems due to no server response"

Break-down of critical path

<table>
<thead>
<tr>
<th>Protocol</th>
<th>spent</th>
<th>caused</th>
</tr>
</thead>
<tbody>
<tr>
<td>DHCP</td>
<td>222.05s</td>
<td>222.05s</td>
</tr>
<tr>
<td>Wireless Association</td>
<td>9.81s</td>
<td>9.81s</td>
</tr>
<tr>
<td>ARP (to gateway)</td>
<td>0.01s</td>
<td>0.01s</td>
</tr>
</tbody>
</table>

Time period diagnosed

12:15:00 to 12:45:00 (2007-01-25)
Using jigsaw to analyze VoIP

• Voice-over-IP: telephony over Internet
• Increasingly important
• Analyze performance problems of VoIP over wireless
Potential problems with VoIP

• Poor call quality due to jitter, delay, loss
  – 802.11e standard addresses this for wireless

• Impact of VoIP on other users of wireless
Scaling VoIP

- What happens if more people make calls?
  - How many can the wireless medium support?
  - What is the impact on e.g. web users?
Measuring the impact on TCP

- Testbed with:
  - N VoIP stations
  - a TCP station
- TCP receives or sends at max available throughput
- Gradually activate each VoIP station
- Measure TCP throughput
- Expect: gradual decline of TCP throughput
Degradation of TCP

- Expected from size of VoIP packets
- Measured (802.11b)
- VoIP very inefficient
Can anything be done?

- Emulation of our solution
- Current (measured)
- Our solution (calculated)
Current status

• Shaman/Jigsaw online, answering tickets
• Working on implementation for reducing VoIP impact
• Integrating VoIP into shaman:
  – Diagnose VoIP call quality
  – Diagnose cases where other users suffer from VoIP impact

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