Selfish MAC Layer Misbehavior in Wireless Networks

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ECE 299, Karthik Balasubramanian
February 8, 2007
The problem: a game theory approach

Need incentive structure to prevent cheating

<table>
<thead>
<tr>
<th></th>
<th>Cheat</th>
<th>Don’t Cheat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cheat</td>
<td>1, 1</td>
<td>3, 0</td>
</tr>
<tr>
<td>Don’t cheat</td>
<td>0, 3</td>
<td>2, 2</td>
</tr>
</tbody>
</table>
Review: contention schemes

**Point Contention Function (PCF)**
- Centralized controller required
- No ad-hoc networks
- 802.11 optional feature

**Distributed Contention Function (DCF)**
- Suitable for ad-hoc networks
- Suitable for fluctuating number of nodes and hosts
- Uses Carrier Sense Multiple Access/Collision Avoidance
- What paper focuses on
• Randomly choose backoff value $B$ in range $[0,CW]$
  - $CW$ is the Contention Window

• Count down backoff by 1 every idle slot
Cheating

What if I always choose B=1?

Misbehaving node

Well-behaved node

B1 = 1  B1 = 1
Transmit  Transmit

wait  wait

B2 = 20  B2 = 19

Good for me, bad for you

Source: Pradeep Kyasanur and Nitin Vaidya, UIUC
Goal 1: detect cheating

• Method: Sender backoff data collection
  - Measure actual backoff durations of individual nodes
  - If backoff from skewed distribution, cheating suspected

• Method weaknesses
  - Cheating cannot be immediately diagnosed
  - High chance for misdiagnosis if small sample size
  - Requires significant computation

Current 802.11 not sufficient for good detection
802.11 modification: B selected by receiver

1. R provides backoff B to S in ACK
   B selected from \([0, \text{CW}_{\text{min}}]\)

2. S uses B for backoff

Source: Pradeep Kyasanur and Nitin Vaidya, UIUC
Detection

- Receiver counts number of idle slots $B_{\text{obsr}}$

**Condition for detecting deviations:**

$$B_{\text{obsr}} < \alpha B \quad 0 < \alpha \leq 1$$

Source: Pradeep Kyasanur and Nitin Vaidya, UIUC
Goal 2: punish cheating

- Punishment
  - Must be effective deterrent
  - Must not hinder overall throughput

- If $\sum$(deviations) > threshold, cheater identified
  - Pass on to higher layers: “telling Daddy on you”
  - Appropriate action can be taken
When $B_{\text{obsr}} < \alpha B$, penalty $P$ added:
- $P$ proportional to $\alpha B - B_{\text{obsr}}$
- Total backoff assigned = $B + P$

Source: Pradeep Kyasanur and Nitin Vaidya, UIUC
Simulation Setup

Source: Pradeep Kyasanur and Nitin Vaidya, UIUC
Diagnosis

Percentage of Misbehavior (of misbehaving node)

Source: Pradeep Kyasanur and Nitin Vaidya, UIUC
Throughput

Source: Pradeep Kyasanur and Nitin Vaidya, UIUC
Throughput with no misbehavior

Source: Pradeep Kyasanur and Nitin Vaidya, UIUC
Discussion/Limitations

- Requires 802.11 modification for efficient detection
- Breakdown at high cheating levels
- No enforcement mechanism presented

- Questions?