Liveliness Evaluation of a Cooperation and Accounting Strategy in Hybrid Networks

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Introduction

• Multi-hop Cellular Networks
  – Combine dynamics of mobile ad hoc networks and reliability of infrastructured wireless networks
  – Compared to single-hop
    • Increased coverage area
    • Dynamic adaptation of network topology
Motivation

• New context to deal with weaknesses of mobile ad hoc networks such as
  – Routing
  – Security
  – Cooperation

• Stimulate cooperation without threat of punishment

• Make cooperation a rewarding alternative to selfishness
CASHnet Concept

- Every time a node wants to transmit a self-generated packet, it has to pay with *Traffic Credits* (TC)
- Every time a node forwards a packet, it gets *Helper Credits* (HC)
- Traffic Credits can be bought for real money or traded for Helper Credits at service stations
Architecture

• Assumptions
  – Tamper resistant device which allows safe execution of CASHnet functions and maintains two accounts
  – Distance (in hop counts) to gateway provided by routing protocol
  – Sufficient processing power on the node
• Security mechanisms are based on public key cryptography
  – Nodes authenticate themselves using certificates with short life time issued by the provider
  – Transmitted messages are digitally signed ensuring non-repudiation (data integrity and data origin authentication)
Operation

Smart Card

Operation Gateway Provider's Backbone Gateway Provider's Backbone

-4 TC +1 HC +1 HC +1 HC +1 HC -3 TC

Gateway

Service Station

Provider's Backbone

-20 HC -10 RM +20 TC

Gateway

+1 HC +1 HC -3 TC
Simulation Scenarios

Parameter | Value
---|---
Initial Traffic Credits account state | 100 TC
Initial Real Money account state | 500
Traffic Helper Credits exchange rate | 1:1
Exchange threshold at Service Stations | 10 HC
Distance threshold to Service Stations | 50 m
## Simulation Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area</td>
<td>1500 m x 800 m</td>
</tr>
<tr>
<td>Number of nodes</td>
<td>40</td>
</tr>
<tr>
<td>Transmission range</td>
<td>250 m</td>
</tr>
<tr>
<td>Mobility model</td>
<td>random waypoint</td>
</tr>
<tr>
<td>Speed</td>
<td>u. d. between 1 and 10 m/s</td>
</tr>
<tr>
<td>Pause time</td>
<td>u. d. between 0 and 20 s</td>
</tr>
<tr>
<td>Packet generation rate</td>
<td>1, 0.2, 0.1 pkt/s</td>
</tr>
<tr>
<td>Number of Service Stations</td>
<td>1, 2, 9, 12</td>
</tr>
<tr>
<td>Simulation time</td>
<td>900 s</td>
</tr>
</tbody>
</table>
Starvation Periods

- Starvation: a node is unable to transmit self-generated packets because of missing TCs

CASHnet, 5 s packet interval, 2 service stations, run 0

CASHnet, 5 s packet interval, 12 service stations, run 0
Starvation Events/Duration Category

CASHnet, 1 s packet interval, 1 service station

1 s packet interval
1 service station

CASHnet, 1 s packet interval, 12 service stations

1 s packet interval
12 service stations

CASHnet, 10 s packet interval, 1 service station

10 s packet interval
1 service station

CASHnet, 10 s packet interval, 12 service stations

10 s packet interval
12 service stations
Results

- Duration and frequency of starvation events correlates with
  - Number of Service Stations
  - Location of Service Stations
- Simulation results affected by mobility model
  - Random waypoint movement paths behave centric (2 service stations worse than 1 centered)
- Per packet charging lets nodes run out of Traffic Credits/Real Money quickly
Summary & Outlook

- Highly decentralized accounting and security architecture
- Selfish nodes are allowed, but cooperation is encouraged via rewards
- Cost sharing between sender & receiver
- Evaluation of starvation property through simulations
  - Compare with other cooperation schemes
  - Use different mobility models, e.g. restricted random waypoint
  - Study effects of possible extensions (e.g. charging for ad hoc only traffic, deposit payment for receiving traffic, increasing granularity)
- Specify charging/remuneration relation
Implementation

- ns-2 [Vint Project], Wireless and Mobility extensions [Rice] and AODV+ [Hamidian]
- Class CashnetNode inherits from MobileNode
- Agent at ns2 src/sink does rewarding
- Class CMUTrace extended for CASHnet events