A Two-Side Perspective on Cooperation in Mobile Ad Hoc Networks

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Presentation Outline

1. Motivation
   ▶ MANETs
   ▶ Open MANETs
   ▶ Motivations for uncooperative behaviour
   ▶ The need for cooperation in Open MANETs

2. Related Work

3. Approaches to Improve Cooperation in Open MANETs
   ▶ Improve fairness
   ▶ Monitor and punish misbehaviour

4. Conclusions
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Outline
- Motivation
- Related Work
- Approaches to Improve Cooperation in Open MANETs
- Improve fairness
- Monitor and punish misbehavior

MANETs

- Mobile Ad Hoc Networks
- Networks exclusively composed by the devices of the participants
  - No infra-structure
  - All services must be provided by the participants
- Scenarios
  - Search-and-rescue operations
  - Military operations
- Hybrid/Mesh networks
  - Only some of the participants access the infra-structure
Open MANETs

- The generalisation of MANETs
- No central authority
- Participants do not share a common goal
- Each user administers his device

- Scenarios
  - Airports
  - Shopping malls
  - Conferences

- Applications
  - Internet access
  - Games
  - Chat
Selfish Behaviour of the Users

▶ Why cooperate?
  ▶ Fair resource consumption is the “price to pay” from the benefits collected
  ▶ A MANET composed only of selfish users is useless

▶ Why be selfish?
  ▶ Devices are not carried for altruistic purposes
  ▶ Power reserves of the devices is limited
    ▶ Wireless networking is one of the most relevant sources of power consumption of the devices
  ▶ Network protocols are not fair
    ▶ Fairness conflicts with energy saving
Unfairness Example: DSR

- A issues a Route Request to D
- F snoops the Route Reply
- B issues a Route Request to D
- F replies with the snooped route
- C snoops route usage by B
Unfairness Example: DSR

- A issues a Route Request to D
- F snoops the Route Reply
- B issues a Route Request to D
- F replies with the snooped route
- C snoops route usage by B
- No alternative routes are discovered
  - G and H become unfairly overused
A Two-Side Perspective

- Develop more fair protocols
  - Able to better distribute the load by the devices
A Two-Side Perspective

- Develop more fair protocols
  - Able to better distribute the load by the devices
- Penalise selfish users
  - Preventing them from accessing the services provided by others
A Two-Side Perspective

- Develop more fair protocols
  - Able to better distribute the load by the devices
- Penalise selfish users
  - Preventing them from accessing the services provided by others
- Without significantly impacting
  - Performance
  - Power consumption
Related Work

Power-aware/load balancing routing protocols Rely on the information provided by each node about his state

Reputation systems Do not provide load balance

Economic models Too complex for ad hoc networks
A Fairness Monitoring Service

Goal:
- To evaluate the effort of each participant in a MANET
- Make this information available to applications and middleware services

Requirements:
- Light-weight
  - Memory
  - Computational power
  - Energy consumption
  - Number of messages
Network Monitoring

- Nodes keep a record of the messages recently broadcasted by its neighbours
- This allows them to derive different metrics:
  - **Relative Regional Load**: the relation between i’s number of messages and the average on the neighbourhood
  - **Regional Congestion**: bandwidth usage in the neighbourhood
Application - Biased DSR

- An effort metric $\Phi_i$ is given by:

$$\Phi_i = k_\alpha \cdot \alpha_i + k_\chi \cdot \chi_i$$

- Where:
  
  $k_\alpha, k_\chi$ Constants
  
  $\alpha_i$ Relative Regional Load
  
  $\chi_i$ Regional Congestion

- $\Phi_i$ grows with the unfairness and/or congestion on node $i$
Delay of Route Requests

- Route requests are delayed proportionally to the effort
  - Increases the chances of route discovery even if using congested nodes
  - Route replies using less congested nodes will be delivered faster
  - Promotes the use of routes using less congested nodes
- Route requests are still dropped in extreme situations
Unfairness Mitigation

- Evaluated from the standard deviation of the number of link layer frames sent by each node
  - Accounts with retransmissions due to collisions

- Standard deviation in Biased DSR is 9% to 30% lower than baseline DSR
A Framework to Detect and Punish Selfish Nodes

Nodes:

- Confirm that other nodes provide the services they have requested
- Periodically advertise the status of their relationship with their neighbours
  - $\text{friends}_p$: The set of nodes to whom he is willing to provide services
  - $\text{foes}_p$: The set of nodes to whom he refuses to provide services
  - $\text{selfish}_p$: The set of nodes that lied to him, by declaring him as friend
- Nodes rate their neighbours by crossing the information received
- $\text{credits}_p^q$ keeps the balance between the services provided to and requested by $q$
Who’s Selfish?

- Decision is taken locally. Node $q$ with the ratio:

$$\frac{\#friends^q_p}{\#friends^q_p + \#foes^q_p}$$

bellow an acceptable threshold will be considered selfish by $p$.

- Load balancing: it is acceptable to have foes, as long as they are not too much.
Conclusions and Future Work

- Ad hoc networks require the cooperation of the nodes
- Nodes may not feel motivated to cooperate
  - Protocols are unfair
  - Users do not share a common goal or respond to some authority
- This paper as presented:
  - A fairness monitoring service to help protocols to be more fair
  - A selfishness detection service to alert nodes about selfish behaviour
- Future work
  - To develop a framework combining both services
  - To address the limitations exhibited by both protocols