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

Conferência Sobre Sistemas Mveis e Ubiquos (CSMU'06)

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Outline

Motivation

Related Work

Approaches to Improve Cooperation in Open MANETs

Improve fairness

Monitor and punish misbehavior

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

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

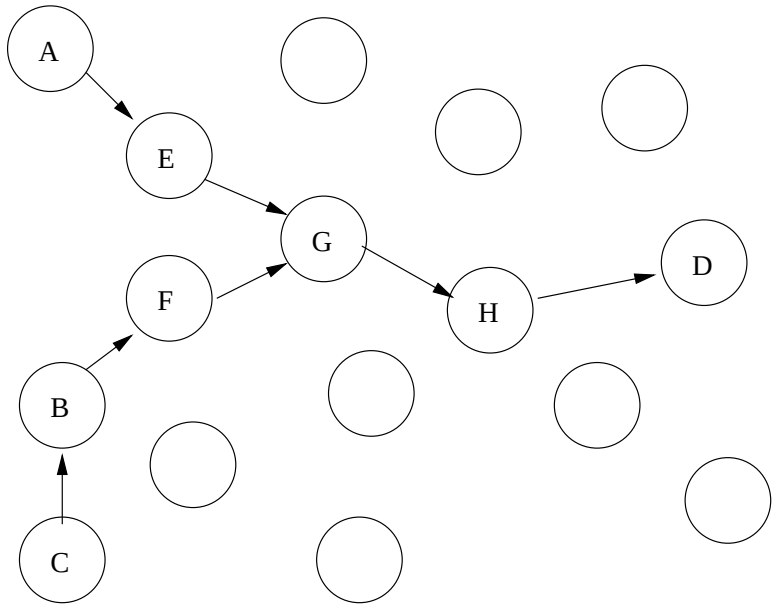
- The generalisation of MANETs
- No central authority
- Participants do not share a common goal
- Each user administers his device
- Scenarios
  - Airports
  - Shopping molls
  - Conferences
- Applications
  - Internet access
  - Games
  - Chat

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

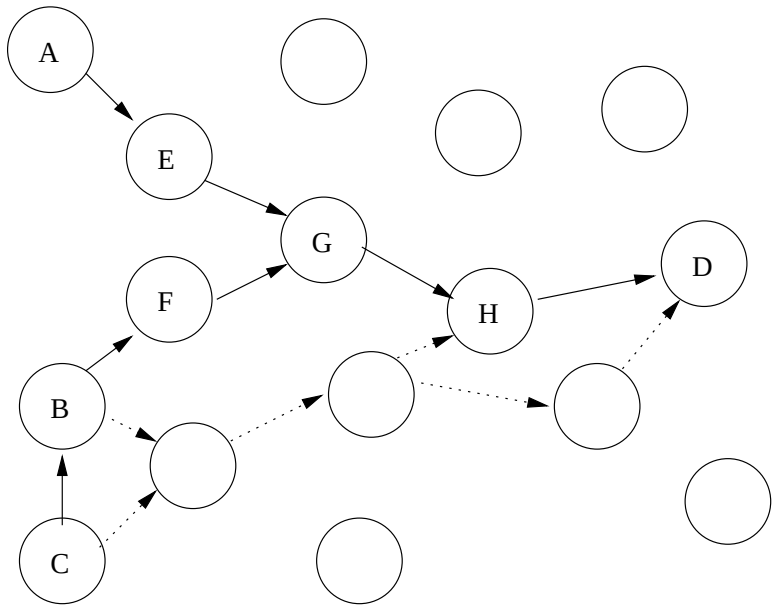
Unfairness Example: DSR

- 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

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- 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 Φ_i is given by:

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

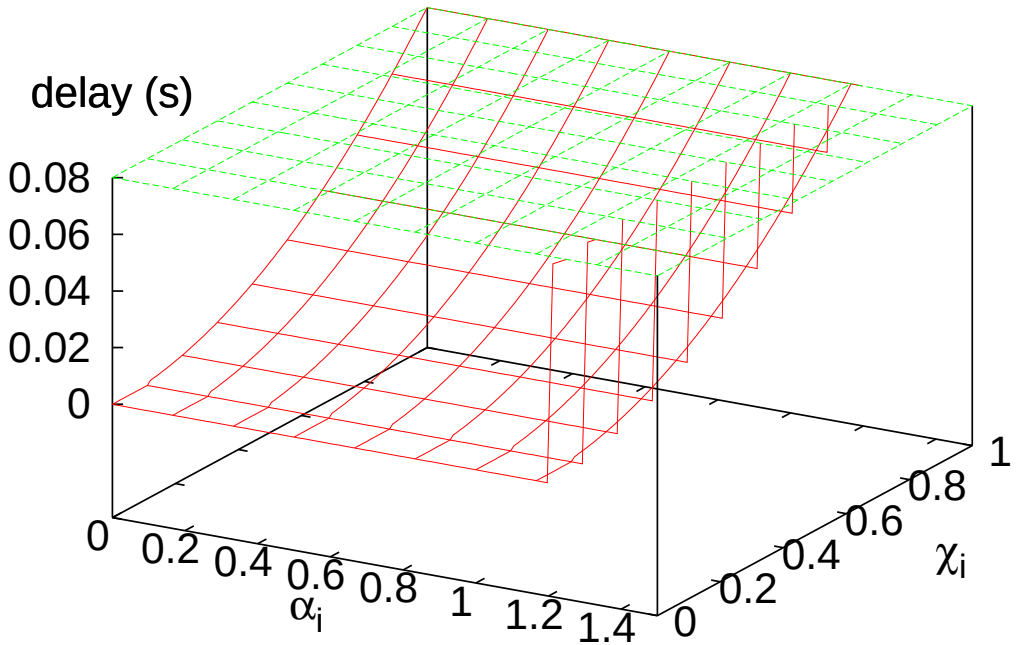
- Where:

k_α, k_χ	Constants
α_i	Relative Regional Load
χ_i	Regional Congestion

- Φ_i grow with the unfairness and/or congestion on node i

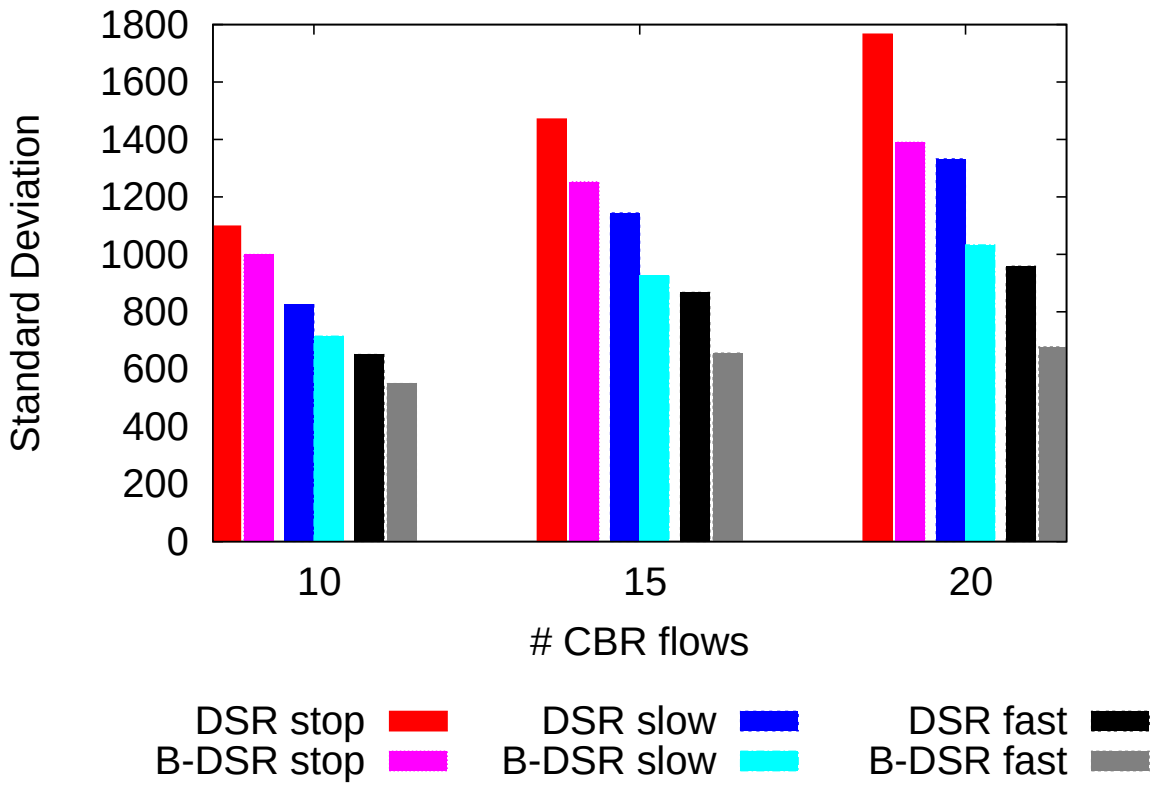
Delay of Route Requests

- 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:

- Confirme that other nodes provide the services they have requested
- Periodically advertise the status of their relationship with their neighbours

  friends_p The set of nodes to whom he is willing to provide services

  foes_p The set of nodes to whom he refuses to provide services

  selfish_p The set of nodes that lied to him, by declaring him as friend
- Nodes rate their neighbours by crossing the information received
- 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:

$$\frac{\sharp friends_p^q}{\sharp friends_p^q + \sharp foes_p^q}$$

  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