Friends & Foes: Preventing Selfishness in Mobile Ad Hoc Networks

Hugo Miranda and Luís Rodrigues

hmiranda@di.fc.ul.pt

Universidade de Lisboa

DIAL-NP - LaSIGE

Outline

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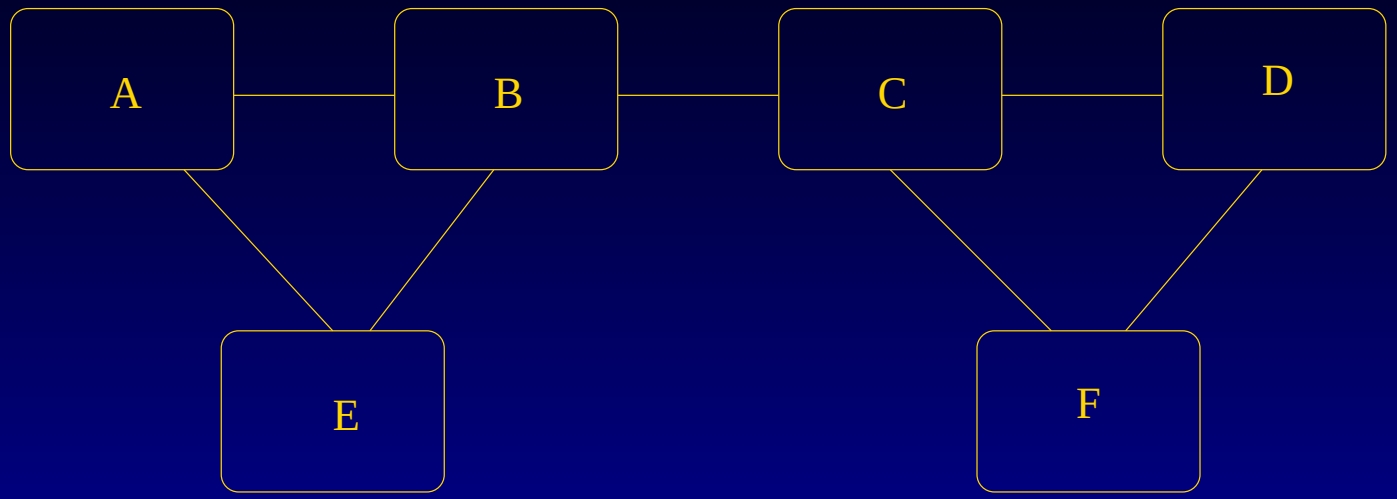
  - Selfishness prevention
- Protocol overview
- Load balancing evaluation
- Conclusions

Motivation

- Mobile Ad Hoc Networks (MANETs) depend of the individual behavior of the nodes
- Open MANETs users may be “resource selfish”
- Routing protocols may exacerbate the problem if routes remain static

Dynamic Source Routing (DSR)



- 3 routing message types: requests, replies and errors
- Data messages include the route to be followed
- To minimize routing messages:
  - learn routes in data messages
  - if a route is known, reply to route requests

Load-balancing in DSR

Two scenarios with:

- 36 nodes, on a 6×6 matrix
- nodes reach each of their neighbors
- no node movement
- no transmission errors
- each node (i, j) sends 20 UDP datagrams to:

  Scenario #1 Node (j, i)

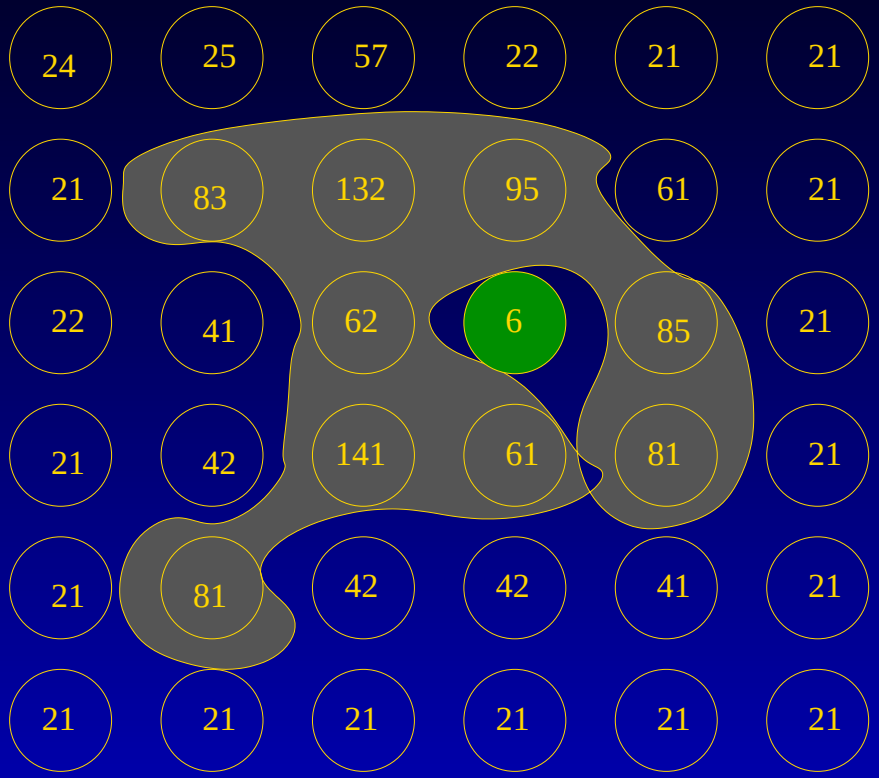
  Scenario #2 Node $(2, 3)$

Scenario #1

- $3468(2997 + 471)$ MAC frames sent
- 9 (25%) of the nodes sent 1802 (52%) of the frames
- 3 (8%) of the nodes sent 773 (22%) of the frames

- 50 routes used (12 of them once)
- Node $(2, 3)$ sent 337 frames in 24 routes

Scenario #2



- $1561 (1496 + 65)$ MAC frames sent
- 42 routes used (2 of them once)

- The 8 nodes surrounding $(2, 3)$ have sent 90 frames on average. Standard deviation: 31.5

Therefore. . .

- MANET routing protocols privilege efficiency over load balancing
- Some nodes may unfairly exhaust their resources serving others
- The lack of load balancing mechanisms and the absence of consequences from selfish behavior, motivates users for being “resource selfish”

Related Work

- Path rater
  - Notifies routing protocols to avoid selfish nodes
  - Selfish nodes may freely use the network
- Confidant
  - Nodes refuse to forward messages from those with a bad reputation
  - Nodes are always forbidden to be selfish (no fairness)

Related Work - cont.

- Terminodes
  - Virtual currency possibly mapped in real money
  - Each hop of a message would charge some *nuglets* (*beans*)
  - Tamper-proof device prevents frauds
  - Requires PKI
- Power-aware routing
  - Different metrics
  - Rely on the information provided by each node

Desirable Properties

- Fair selfishness, if some node becomes highly loaded
  - Nodes should remember the past behavior of other nodes
- The protocol should be optional
- Low overhead

Selfishness Prevention Protocol

- Fair selfishness: improves load balancing
- Excludes selfish nodes
  - Node reintegration
- Charges per message
- Requirements
  - A route composed of only non-selfish nodes must exist between any two selfish nodes
  - Selfish nodes do not cooperate between them

Algorithm overview

Periodically, each node p broadcasts:

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 neighbors by crossing the information received

Internal data structures

Each node p keeps a record for each of his neighbors q with:

credits$_p^q$ Messages forwarded on behalf of q

maxCredits$_p^q$ Acceptable number of credits

friends$_p^q$ Nodes to whom q provides services

foes$_p^q$ Nodes to whom q refuses to provide services

deadbeat$_p^q$ Evaluates if q is still in the neighborhood

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.

- Selfish nodes will only be able to send messages until their credits reach 0

Other considerations

- Re-integration;
- Protocol transparency;
- Subverting the protocol;
- Integration with routing protocols
  - Do not forward route discovery messages issued by foe nodes
  - Send route errors for messages to be forwarded to foe neighbors

Evaluation # 1

- $3559(3060 + 499)$ MAC frames sent [3468]
- 9 (25%) of the nodes sent 1721 (48%) of the frames [1802]
- 3 (8%) of the nodes sent 687 (19.3%) of the frames [773]

- 53 [50] routes used (12 of them once)
- Node $(2, 3)$: 285 [337] frames in 23 [24] routes

Evaluation # 2

- $1632(1553 + 79)$ MAC frames sent [1561]
- 84 [42] routes used (20 of them once)

- The 8 nodes surrounding $(2, 3)$ are closer to average. Standard deviation: 19.7 [31.5]

Summary of Evaluation

- Slightly increase on:
  - Number of frames
  - Number of routes
- New routes alleviate overloaded nodes

Future Work

- How to make the protocol more robust;
- Validation of the protocol;
- Investigate the use of other metrics;

Conclusions

- When nodes remain in the same position, routing protocols may present unfair load distribution
- Selfishness prevention in MANETs is a relatively new subject
- A new algorithm that enhances load balancing while banning selfish users from the MANET was presented