Cross-layer design for bee-inspired routing in mobile ad hoc networks

Alexandros Giagkos

Intelligent Robotics Group, Aberystwyth University

May 31, 2011

Supervised by Dr Myra S. Wilson and Mr David E. Price

Open Systems Interconnection model (OSI model)

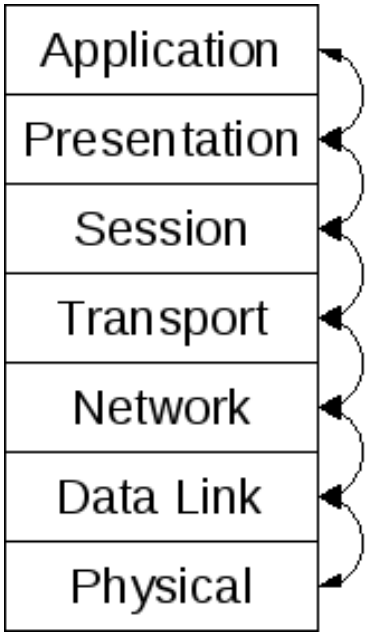

Fig. 1. *Traditional way*

Open Systems Interconnection model (OSI model)

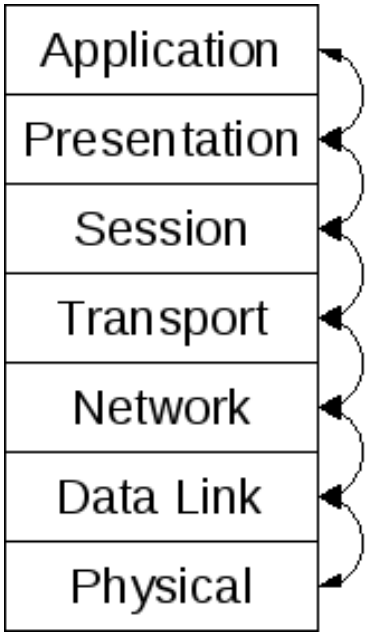

Fig. 1. *Traditional way*

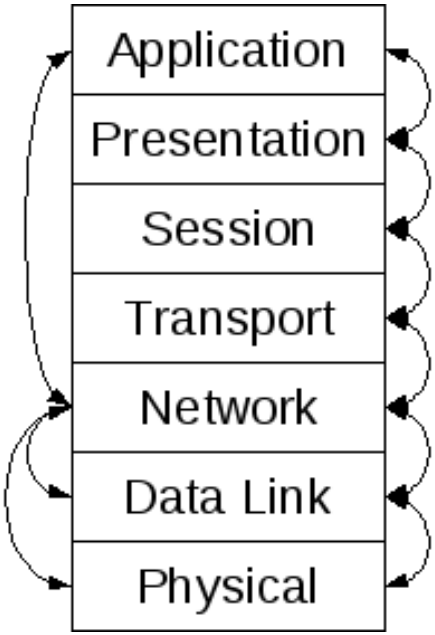

Fig. 2. *Cross-layering*

Presentation plan

Background

Protocol's design

Experimental results

Conclusion and next steps

Background

Routing problems and needs

- Mobility, resource constraints, terrain changes
- Adaptation, optimality, scalability, speed

Literature findings

- Too many Internet-inspired protocols compete with each other
- Nature-inspired:
  - 2004: AntHocNet, and a number of improvements
  - 2005: BeeAdHoc

Presentation plan

Background

Protocol's design

Experimental results

Conclusion and next steps

Artificial bees in networks

- Scouts:
  - Sent to discover new paths (broadcast)
  - Introduces neighbouring nodes
- Ack_scouts:
  - Acknowledges successful paths, marks them with unique IDs
  - **Calculates the path quality and reports back to source**
- Forager
  - Encapsulates 'real data' in the form of payload
  - Is given a path ID and a next hop
- Ack_forager (similar to foragers, plus)
  - **Calculates the path quality and reports back to source**

Understanding the quality

Question: "How is the quality of the path calculated?"

In Nature:

- Scout and forager bees consider some quality factors:
  - sweetness of sugar solution, type of flower, quantity,
  - ease of obtaining, distance, weather, dangers, etc.
- They report the quality back to their hive by "dancing"
- Their dance triggers fellow bees:
  - to be recruited or,
  - avoid the particular finding

Understanding the quality (cont.)

Question: "How is the quality of the path calculated?"

In networks:

- Ack_scout & ack_forager bees calculate the quality based on:
  - pkt's signal strength (dbm), sender's battery life (J),
  - sender's current speed (m/s) and interface queue size (b),
  - and finally transmission delay (s)

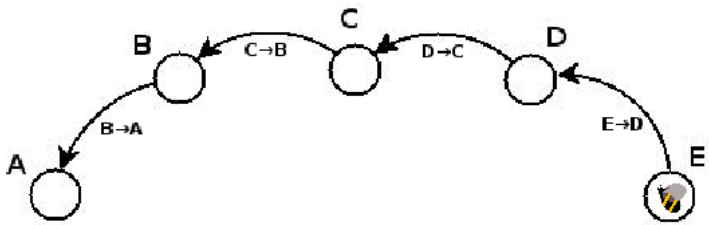

Fig. 3. *A path example*

Understanding the quality (cont.)

Question: "How is the quality of the path calculated?"

In networks:

- Ack_scout & ack_forager bees calculate the quality based on:
  - pkt's signal strength (dbm), sender's battery life (J),
  - sender's current speed (m/s) and interface queue size (b),
  - and finally transmission delay (s)

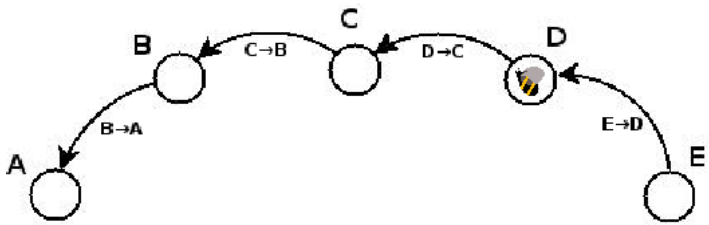

Fig. 3. *A path example*

Understanding the quality (cont.)

Question: "How is the quality of the path calculated?"

In networks:

- Ack_scout & ack_forager bees calculate the quality based on:
  - pkt's signal strength (dbm), sender's battery life (J),
  - sender's current speed (m/s) and interface queue size (b),
  - and finally transmission delay (s)

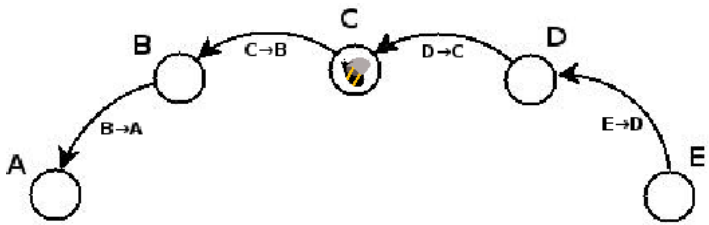

Fig. 3. *A path example*

Understanding the quality (cont.)

- Report the overall quality to the source node

$$quality_{link} = pow' * w_{pow} + energy' * w_{energy} + speed' * w_{speed} + qd' * w_{qd} + txd' * w_{txd} \quad (1)$$

$$quality_{path} = \sum_{n=1}^{m-1} (quality_{link_{N_{n+1} \rightarrow N_n}}) \quad (2)$$

where, m is the number of nodes in the path, the primes are the normalized parameters,

and w's are the weights representing the importance of each parameter.

Understanding the quality (cont.)

- Report the overall quality to the source node

$$quality_{link} = pow' * w_{pow} + energy' * w_{energy} + speed' * w_{speed} + qd' * w_{qd} + txd' * w_{txd} \quad (1)$$

$$quality_{path} = \sum_{n=1}^{m-1} (quality_{link_{N_{n+1} \rightarrow N_n}}) \quad (2)$$

where, m is the number of nodes in the path, the primes are the normalized parameters,

and w's are the weights representing the importance of each parameter.

- Every $quality_{path}$ value describes **one single flight**
- Collect data from 10 (default) previous flights
- Regression analysis for variables: time and $quality_{path}$
- Using Pearson's correlation coefficient, we calculate r
- Threshold -0.8 to reduce recruits, +0.8 to give extras

Next hop selection

At the source node:

- Candidates with at least 1 recruited forager available
- Decision depends on desired behaviour, default is smallest half-RTT
- Other metrics can be applied, e.g.
  - number of hops in path, min(remaining energy of links),
  - ..

At the intermediate nodes:

- Based on path ID and direction

At the destination node:

- FIFO fashion

Presentation plan

Background

Protocol's design

Experimental results

Conclusion and next steps

Simulation setup

- BeeIP implementation for ns-2 network simulator
- Compared with:
  - Ad-hoc On-Demand Distance Vector (AODV)
  - Destination-Sequenced Distance Vector Routing (DSDV)
  - Dynamic Source Routing (DSR)
- 50 mobile nodes in 1500x300m terrain for 10 minutes
- Random energy (200 to 1500 J), and speed (1 to 20 m/s)
- PHY layer set up to work as 914MHz Lucent WaveLAN
- Pause times: 0, 60, 120, 300, 600 seconds (constant)
- TCP source/TCP sinks, 30 active sources

Packet delivery ratio

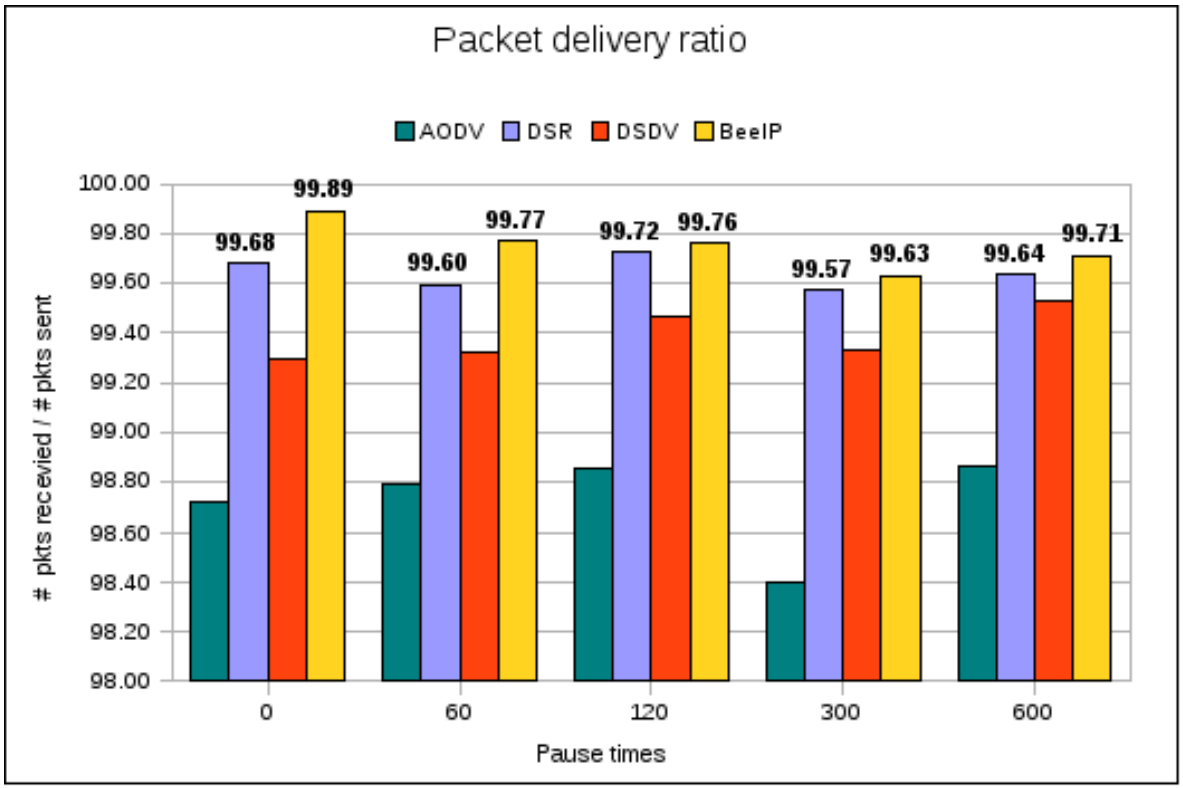

Fig. 4. *Packet delivery ratio for 30 sources*

Control overhead

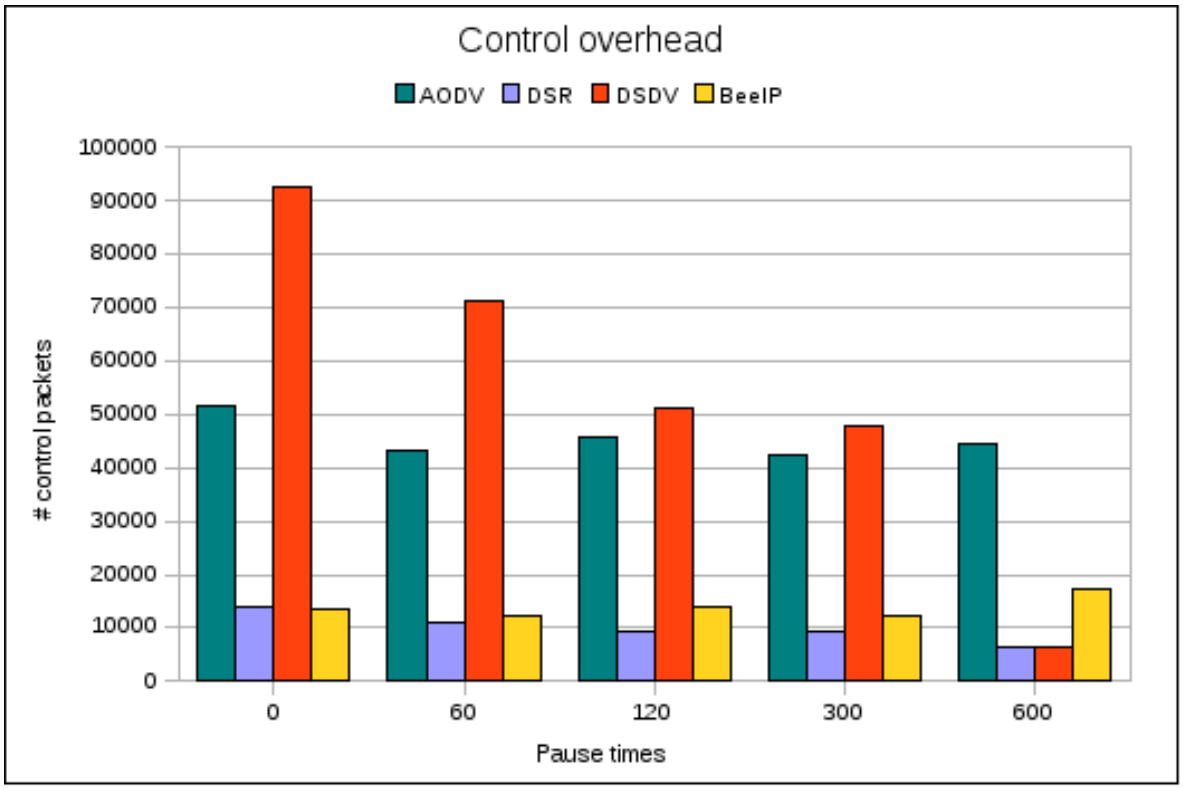

Fig. 5. *Control overhead for 30 sources*

Presentation plan

Background

Protocol's design

Experimental results

Conclusion and next steps

Conclusion

- Background in the area of routing for MANETs
- Presented a new design for bee-inspired routing
  - focuses on monitoring the quality of paths
  - supports different next hop metrics
- Comparison with state-of-the-art protocols
  - Better packet delivery ratio than AODV, DSDV, competes DSR
  - Less and balanced control overhead than AODV, DSDV

Next steps

Research future work:

- Change the next hop metric on (application's) demand
- Add UDP support (bee swarming)
- Apply model to real-world applications

.. towards the degree:

- Conducting final experiments (in progress..)
- Analyzing results (in progress..)
- Preparing a journal paper
- Thesis write up (in progress) and submission

Any questions?

"The bee's life is like a magic well: the more you draw from it, the more it fills with water" – Prof. Karl von Frisch (1886–1982)