Routing Protocol Performance in MANETs

Outline

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Introduction

- To judge the merit of a routing protocol, metrics are needed to measure its suitability and performance.

- Routing protocol characteristics:
  - Operates over a wide range of mobile networking contexts
  - Reacts efficiently to topological changes and traffic demands

- Qualitative metrics. Desirable properties of MANET routing protocols as distributed operation, loop-freedom,...

- Quantitative metrics. Measurable parameters can be used to assess the performance of any routing protocol as throughput, delay,..

Introduction. Network Context

- Network size--measured in the number of nodes
- Network connectivity-- the average number of neighbors of a node
- Topological rate of change--the speed with which a network's topology is changing
- Mobility--when, and under what circumstances, is temporal and spatial topological correlation relevant to the performance of a routing protocol? In these cases, what is the most appropriate model for simulating node mobility in a MANET?
Qualitative metrics

- Distributed operation
- Loop freedom. Avoid a small fraction of packets spinning around in the network for arbitrary time periods
  - TTL Solutions
- Demand-based operation. Adapt the routing protocol to the traffic pattern on a demand to optimize network energy and bandwidth resources
  - Internet access
- Energy conversation
  - Accomodate inactive nodes
- Unidirectional link support
- Security

Quantitative metrics

- How well does the protocol work?
- Throughput
- End to end delay
- Routing Acquisition Time. Time required to establish route when requested for on-demand routing protocols.
- Percentage out-of-order delivery.
- Average hop count
- Average number of data bits transmitted/data bit delivered.
- Average number of control bits transmitted/data bit delivered.
  - Control bits = routing control packets + header data packets
- Average number of control and data packets/data packet delivered.
Quality-aware metrics I

- When nodes are not mobile, high quality routes can be found.
  - The stationary topology in WMN benefits from routes with more capacity or less error probability.

- ETX (Expected Transmission count). Expected number of transmissions a node requires to successfully transmit a packet to a neighbor.
  - The chosen route is the one with the lowest sum of ETX
  - How to calculate ETX?
    - In a link \( \text{ETX} = 1 / (d_{\text{forward}} + d_{\text{reverse}}) \)
    - \( d_{\text{forward}} = \text{Received probes from A}/\text{Sent probes from A} \)
    - \( d_{\text{reverse}} = \text{Received probes from B}/\text{Sent probes from A} \)
    - Each node periodically broadcasts probes containing the number of received probes from each neighbor.

Quality-aware metrics II

- ML (Minimum Loss).
  - The chosen route is the one with the lowest end to end loss probability. \( \text{ML}_{\text{end-to-end}} = \text{ML}_{\text{link1}} \times \text{ML}_{\text{link2}} \times \ldots \times \text{ML}_{\text{linkn}} \)
  - How to calculate ML?
    - In a link \( \text{ML} = 1 / (d_{\text{forward}} + d_{\text{reverse}}) \)
    - \( d_{\text{forward}} = \text{Dropped probes from A}/\text{Sent probes from A} \)
    - \( d_{\text{reverse}} = \text{Dropped probes from B}/\text{Sent probes from A} \)
    - Each node periodically broadcasts probes containing the number of received probes from each neighbor.
  - The multiplication to find \( \text{ML}_{\text{end-to-end}} \) reduces the number of route changes

- Drawbacks:
  - ETX and ML do not take into account different bandwidth links and data packet sizes
  - They may not follow the link variations because they are based on average values computed on a time-window interval.
ETT (Expected Transmission Time) is the time a data packet requires to be transmitted successfully to each neighbor.

- ETT adjusts ETX to different PHY rates and data-packet sizes.
- The chosen route is the one with the lowest ETT
- How to calculate ETT?
  - \( \text{ETT} = \text{ETX} \times t \) where \( t \) is the average time a single data packet requires to be delivered
  - \( t \) can be calculated as data-packet size/ estimated Bandwidth
  - To estimated Bandwidth depends on the firmware.

To periodically estimate it through this process:
- the node sends two packets (a small and a large packet).
- Each neighbor measures the interarrival time and reports back to the sender.
- Bandwidth = large packet size/(minimum interarrival time)

References