BRA: A Bidirectional Routing Abstraction for Asymmetric Mobile Ad Hoc Networks

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Outline

- Introduction
- BRA Bidirectional Routing Abstraction
- Routing With BRA
- Evaluation
- Conclusion
A problem in mobile ad hoc networks is asymmetry.

Several reasons cause asymmetry
- Devices transmitting with different powers
- Noise sources near a device
- Environmental conditions affect signal propagation
Network asymmetry adversely affects routing in several different ways

- Link-layer Services: sending ACKs will fail for unidirectional links
- Connectivity: some route can’t be found
Introduction

- How the well-known routing protocols deal with network asymmetry.
  - **Proactive Distance-Vector Protocols:**
    - Broadcast over multiple hops
  - **On-Demand Protocols:**
    - AODV
      - Blacklist
    - DSR
      - Sending the RREPs on a separate route back to the source.
Introduction

• BRA improved connectivity and routing performance in asymmetric networks.

• The central feature of BRA is to maintain reverse routes for unidirectional links.
BRA: BIDIRECTIONAL ROUTING ABSTRACTION

- Distributed Bellman-Ford Algorithm
  - Distance vector algorithm

Routing table is updated

B broadcasts the new routing information to his neighbors
It fails in the presence of unidirectional link

- If A->B but not B->A

- A would never receive the message from B and thus will never be able to discover the shortest path to C
BIDIRECTIONAL ROUTING ABSTRACTION

- Reverse distribute Bellman-Ford Algorithm
  - Idea: Each node find the shortest distance from other nodes to itself, rather than from itself to other nodes.

- Ex:
  - C→B→A
  - B→A
  - A→B
  - C→B
  - A→B→C
  - B→C
BRA: BIDIRECTIONAL ROUTING ABSTRACTION

Reverse Route: B → C → A

Update Format: Source; #hops; First-hop
BRA : BIDIRECTIONAL ROUTING ABSTRACTION

- Each node needs to maintain the reverse route to its in-neighbor

- The first-hop entry in the distance vector is used to find the reverse route

Reverse Route: B → C → A
BRA: BIDIRECTIONAL ROUTING ABSTRACTION

- Reverse Route Maintenance
  - Proactive
  - `update_interval`
    - Send only the changes in the route information

- `Complete_update_interval`
  - Send complete information

- `update_loss`
  - Not receiving update from the neighbor
Dynamic BRA

- There may be asymmetric links with no reverse routes in the network.

- BRA reduces the overhead of reverse route maintenance by restricting the spread of distance vectors.

- Radius
  - radius 1 means the reverse routes found are all of one-hop length.

- Each node independently sets the radius.
BRA:
BIDIRECTIONAL ROUTING ABSTRACTION

- **Local Criterion**
  - If a node does not have reverse routes to more than `asymmetry_tolerance_threshold` percentage of in-neighbors, it chooses the `max_radius`.
  - Otherwise, it chooses a radius of the maximum reverse route length of A’s in-neighbors.

- **Global Criterion**
  - Make sure the node help other nodes succeed in reverse route discovery.
Routing with BRA

- Reverse route forwarding
  - When B receives a control packet for node A
  - BRA computes the reverse route, appends an IP option containing the reverse route to the packet, and transmits the packet to the next node on the reverse route.
  - Intermediate nodes cannot always compute the reverse route.
Routing with BRA

- Combine AODV with BRA
  - RREQ: the same as bidirectional network
  - RREP and RERR: using BRA reverse route forwarding

- Benefit
  - Find additional routes not present in the bidirectional view of the network
  - It does not require the *blacklisting mechanism*
Evaluation

**Setup**
- The simulations were implemented on GloMoSim
- Transmission range randomly $[N+D/2 ; N-D/2]$
  - $N=220m$, Diversity $0,80,160,240,280,300$ (m)
- $1300m \times 1300m$ for 80 nodes
- update_interval 500 ms
- complete_update_interval 4500 ms
- update_loss 3
- asymmetry_tolerance_threshold 15%
- max_radius 8
Evaluation

Connectivity:
Evaluation

High-speed mobility

Low-speed mobility.
Evaluation
This paper presented a bidirectional routing abstraction BRA to handle unidirectional links that arise frequently in mobile ad hoc networks.

BRA can combine with the typical routing protocol, such as the well-known AODV.