Extended ZRP: a Routing Layer Based Service Discovery Protocol for Mobile Ad Hoc Networks

Christopher N. Ververidis & George C. Polyzos
Mobile Multimedia Laboratory
Department of Computer Science
Athens University of Economics and Business
Athens 10434, Greece
{chris,polyzos}@aueb.gr
http://mm.aueb.gr/
Tel.: +30 210 8203 650, Fax: +30 210 8203 686

Outline
- Service Discovery in MANETs
- E-ZRP: Routing Layer based Service Discovery
- Simulation Results
  - Proactive part
  - Reactive part
  - Service Availability
- Conclusions

Service Discovery in MANETs
- Service Discovery in fixed networks
  - Assumes reliable communication
  - Mainly centralized approaches
  - Includes: (UDDI, Salutation, JINI, SLP, SDP)
- Service Discovery in MANETs
  - Needs to be distributed-decentralized
  - Needs to be scalable
  - Needs to minimize energy consumption
  - SANDMAN and DEAPspace
    - Power savings only by allowing nodes to go into ‘sleep’ mode
    - What if continuous connectivity is mandatory?

Routing Layer Based Service Discovery: Motivation
- If Service Discovery is implemented above the routing layer then
  - Two message producing processes coexist:
    - One for communicating service information among nodes
    - One for communicating routing information among nodes
  - Hence a node is forced to perform the battery-draining operation of receiving and transmitting packets multiple times
- A Routing Layer based Service Discovery protocol: E-ZRP
  - Integration of routing with service discovery
  - Cross-layer optimization
  - An idea proposed by Koodli and Perkins

Review: Zone Routing Protocol (ZRP) – Haas et al.
- Combines reactive and proactive routing approaches
- ZRP actually consists of 3 parts:
  - Neighbor Discovery Protocol (NDP)
  - Intra-Zone Routing Protocol (IARP)
    - Responsible for proactively maintaining route records for nodes located inside a node’s routing zone (e.g. records for nodes located up to 2-hops away)
  - Inter-Zone Routing Protocol (IERP)
    - Responsible for reactively creating routes for nodes located outside a node’s routing zone (e.g. records for nodes located further than 2-hops away)

Extended ZRP (E-ZRP)
- Our goal
  - To provide an experimental assessment of energy savings obtained by implementing service discovery at the routing layer
- Our approach
  - Select interesting, appropriate MANET routing protocol
  - Explore the capability of acquiring service information along with routing information
  - We modified the Zone Routing Protocol
    - By piggybacking service information into routing messages
  - Services are described using UUIDs (Unique Universal Identifiers), in order to keep packet lengths of routing messages small
Flooding takes a long time to "scan" the network since it imposes significant delays. Since IERP uses the mechanism of bordercasting, it can efficiently and quickly "scan" distant areas of the network to find the requested service. Flooding takes a long time to "scan" the network since it relies on hop-by-hop broadcasting.

Extended Comparison
Proactive Part
- optimal configuration for application-based service discovery scheme (restricted zone updates)
  - service discoverability is equal to or better than that achieved by a routing layer based approach
  - no mobility, 250 nodes, 1000 s simulation time
  - vertical and horizontal blue dotted lines: E-ZRP with a broadcast interval of 10 s
  - Flooding broadcast interval x 4 = Service deletion interval
  - messages are shorter for Flooding than for ZRP/E-ZRP
  - Flooding performs better than E-ZRP in terms of service discoverability for broadcast intervals higher than 40 s, but Energy consumption is increased by > 30%
  - longer intervals mean fewer messages transmitted
  - nodes receive less services information

Extended Comparison, Proactive part—cont.
- 250 Nodes, 1000 s simulation time
- Low Mobility: min. speed 0 m/s, max. speed 0.5 m/s and pause time 30 s
- High Mobility: min. speed 0 m/s, max. speed 12.5 m/s and pause time 30 s
- dotted lines: E-ZRP with a broadcast interval of 10 s

Service Availability
- Service Availability Duration (SAD): decreases when speed increases
- Average Transaction Duration (ATD): for a node, for any service
- Tradeoff between
  - average SAD
  - number of discovered services

Simulation Results
Proactive part, Fixed topology
- E-ZRP vs. a traditional Flooding application-layer service discovery protocol
  - Flooding radius equals E-ZRP Zone radius
  - a message in E-ZRP contains info about the sending node's service and also about the services of its intra-zone neighbors
- Flooding imposes significant delays
- longer intervals mean fewer messages transmitted
- nodes receive less services information

Simulation Results
Proactive part, Mobility
- random waypoint model with the following parameters:
  - Min. Speed = 0 (m/s)
  - Max. Speed = 0.5 m/s, 1 m/s, 2 m/s, 5 m/s, 7.5 m/s, 10 m/s and 12.5 m/s
- Tradeoff between
  - average SAD
  - number of discovered services

Reactive Part
- Flooding imposes significant delays for discovering out of zone services
  - IERP: node needs 10 - 50 ms
  - Flooding: node needs 200 - 800 ms

Since IERP uses the mechanism of bordercasting, it can efficiently and quickly "scan" distant areas of the network to find the requested service.

Flooding takes a long time to "scan" the network since it relies on hop-by-hop broadcasting.

Simulation Results
Reactive Part
- Flooding imposes significant delays for discovering out of zone services
  - IERP: node needs 10 - 50 ms
  - Flooding: node needs 200 - 800 ms

Each point on the diagram is an average obtained over 20 service discovery requests between different node pairs at the same distance.

Service Availability
- Service Availability Duration (SAD): decreases when speed increases
- Average Transaction Duration (ATD): for a node, for any service
- Tradeoff between
  - average SAD
  - number of discovered services
Service Availability Results

- Average SAD actually decreases when speed increases
- High mobility (max. speed ~ 14 m/s): highest # of services discovered
- High ATD: the discovery protocol would perform better in a low mobility setting
- Low ATD: a high mobility setting would be ideal for the discovery protocol
- In high density cases, the average SAD is decreased
  - despite the existence of multiple paths and providers
  - because of higher contention
- The total number of services discovered is higher in denser environments

Conclusions

- E-ZRP leads to significantly smaller energy consumption (approximately 50% less), but also, in certain cases, it achieves higher service discoverability
- Favoring the application layer based service discovery protocol with larger flooding intervals in order to become more economic in terms of energy consumption (savings of 3%), had a detrimental effect in service discoverability, reducing it by 22% or more, compared to the proposed routing layer based approach
- Our experiments for out-of-zone services revealed that E-ZRP consumes 5% more energy than Flooding but achieves one order of magnitude smaller delay for discovering services
- We introduced a new metric, Service Availability Duration (SAD) for measuring the “quality” of discovered services
  - examined the implications of network density and node mobility on the availability of services discovered with E-ZRP

Thanks!

George C. Polyzos
Joint work with my Ph.D. student
Christopher N. Ververidis

Email: chris@aueb.gr or polyzos@aueb.gr

Mobile Multimedia Laboratory
Department of Computer Science
Athens University of Economics and Business
http://mm.aueb.gr/