MASTER THESIS

SCALABLE ROUTING MECHANISM IN AD HOC NETWORKS

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Espoo, Finland

Thesis Topic:	Scalable Routing Mechanism in Ad Hoc networks
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Outline

- Introduction
- Objective
- SARP simulation analysis
- SARP implementation
- SARP testing
- Conclusions and future work

Introduction

- Ad Hoc networks
  - An emerging technology
  - There is no commercial demand
    - But they are perfectly suited for disaster scenarios, search-and-rescue operations
  - Nodes create Ad Hoc network dynamically without any fixed infrastructure
  - Every node in the Ad Hoc network act as a router
  - As nodes move around, routes to other nodes in the Ad Hoc network need to be discovered and maintained
  - All nodes cooperate in carrying network traffic

Introduction

- Routing
  - Fundamental aspect of network establishment
  - The process of exchanging route information from one node to other in a network
- Ad Hoc networks routing
  - It is a problem because there is no fixed infrastructure
  - Existing Internet routing protocols do not work very well in Ad Hoc networks
    - Because they are designed considering that network has a fixed infrastructure
  - Power constraints
    - Low powered nodes do not produce ideal conditions for better route discovery and maintenance

Introduction

- Ad Hoc network routing protocols
  - Proactive routing protocols
    - Maintain routing tables filled with the whereabouts of the other nodes
    - Use routing algorithms to periodically exchange link information
    - Consume more power and bandwidth
    - OLSR, DSDV
  - On-demand routing protocols
    - Form the routes between nodes when needed
    - Consume less power, but still consumes unnecessary amounts of bandwidth
    - AODV, DSR, TORA
  - Hybrid routing protocols
    - Combine advantages of proactive and on-demand routing protocols, thus obtaining better performance
    - However, consume more memory and power, thus special precautions are necessary on the nodes
    - ZRP

Objective

- To propose a new routing mechanism for Ad Hoc networks
  - Scalable Ad Hoc Routing Protocol (SARP)
    - Hybrid solution
      - Combines on-demand and proactive routing protocols in the same node
      - Two routing protocols can share eachother's routing information
      - Power constraints of the node are checked periodically to decide activation of proactive routing protocol or not for more efficient power consumption
      - Supports external QoS module (optional)

Objective

- SARP
  - Main target is to reduce the time spent in the route discovery
  - Proactive routing stores link information
    - It eliminates time spent in the route discovery by on-demand routing protocols
    - This operation consumes more power but can be managed
      - If the node is able to decide activation or deactivation of proactive routing, excess power consumption can be managed and routing efficiency is increased
  - Nodes are classified into two groups
    - Smart nodes
      - Nodes running simultaneously on-demand and proactive routing protocols
    - Ordinary nodes
      - Nodes running only on-demand routing protocols

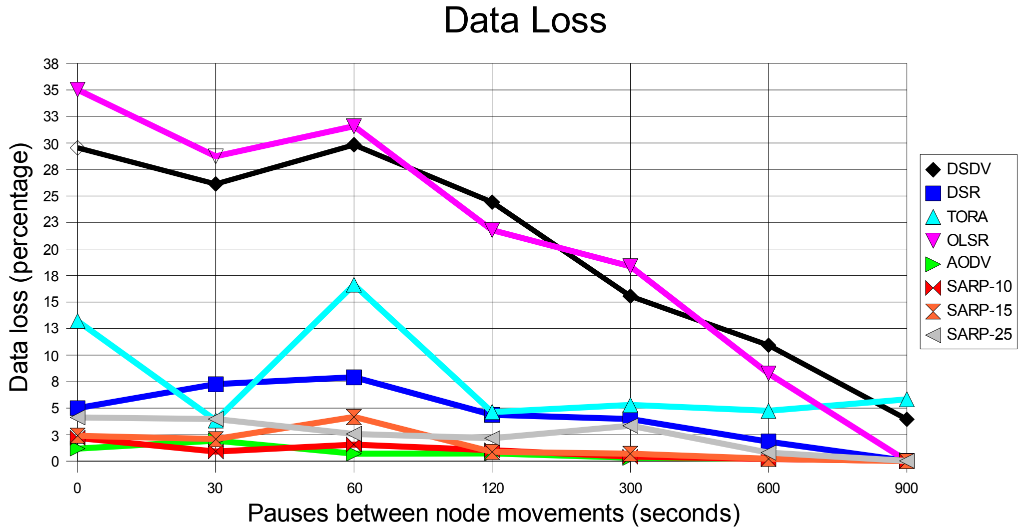
Objective

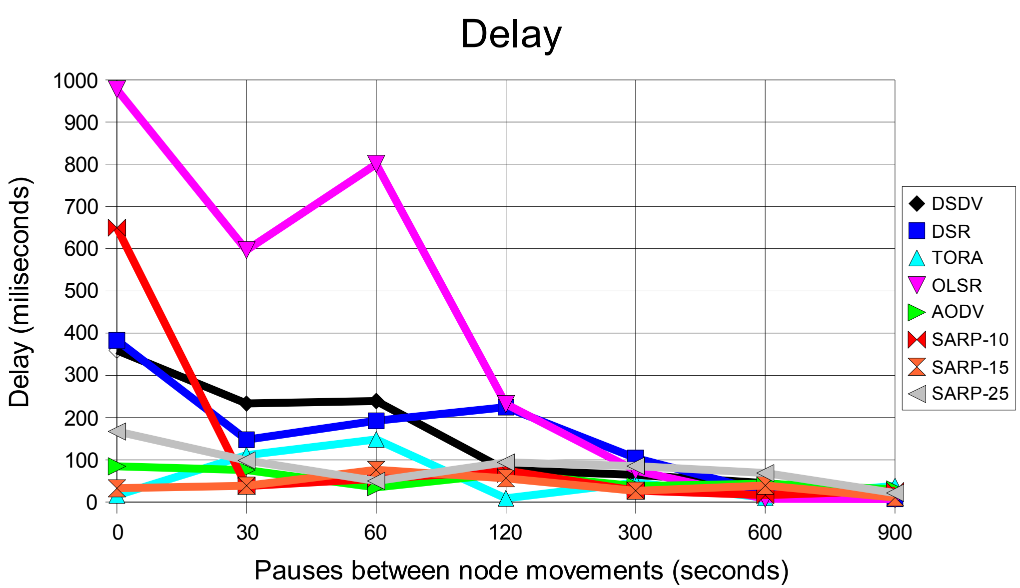
- SARP
  - Each smart nodes decides to be smart or ordinary node by checking its power level
    - If node's battery power level is greater than predefined power threshold, node is *"Smart".*
  - Smart nodes will communicate between them using proactive routing protocol
    - This will create so called a *virtual backbone of smart nodes*
  - Smart nodes will communicate with ordinary nodes using on-demand routing protocol
    - On-demand routing protocol should be always active on the smart nodes
  - Ordinary nodes will communicate between them and with smart nodes using on-demand routing protocol

SARP Simulation Analysis

- Performance comparison of SARP with state of the art routing protocols
- Necessary for correctly verification of SARP
- Simulation environment
  - NS-2 running in Linux
  - SARP implemented for NS-2 using C++
- Simulation results
  - Data loss
  - Delay
  - Routing data size
  - Throughput
  - Overhead

SARP Simulation Analysis - I





Simulation parameters

- SARP, AODV, OLSR, DSR, DSDV, TORA
- 50 nodes
- 5, 10, 25 smart nodes for SARP
- 1500 meters width, 300 meter height
- 7 different mobility levels at X-axis
- Results are at Y-axis
- 30 CBR traffic connection
  - 64 bytes UDP packets
  - Duration: 12,5 seconds
  - Rate: 8 packets/second
- Radio range: 250 meters

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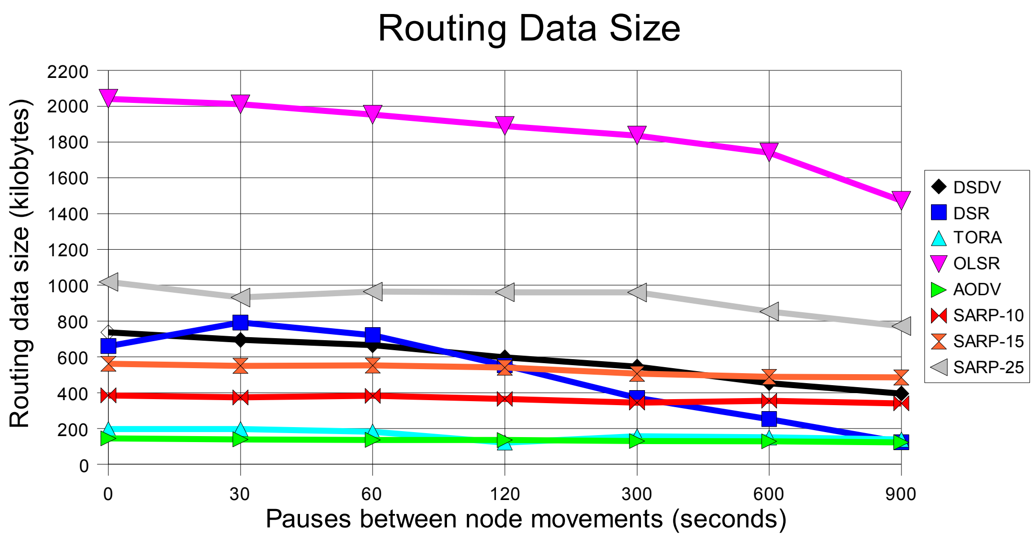

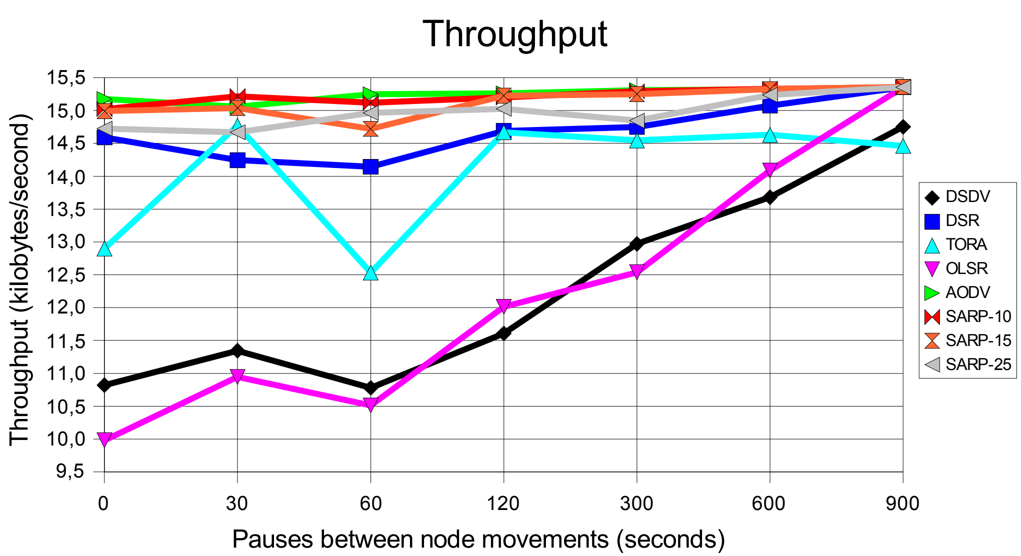

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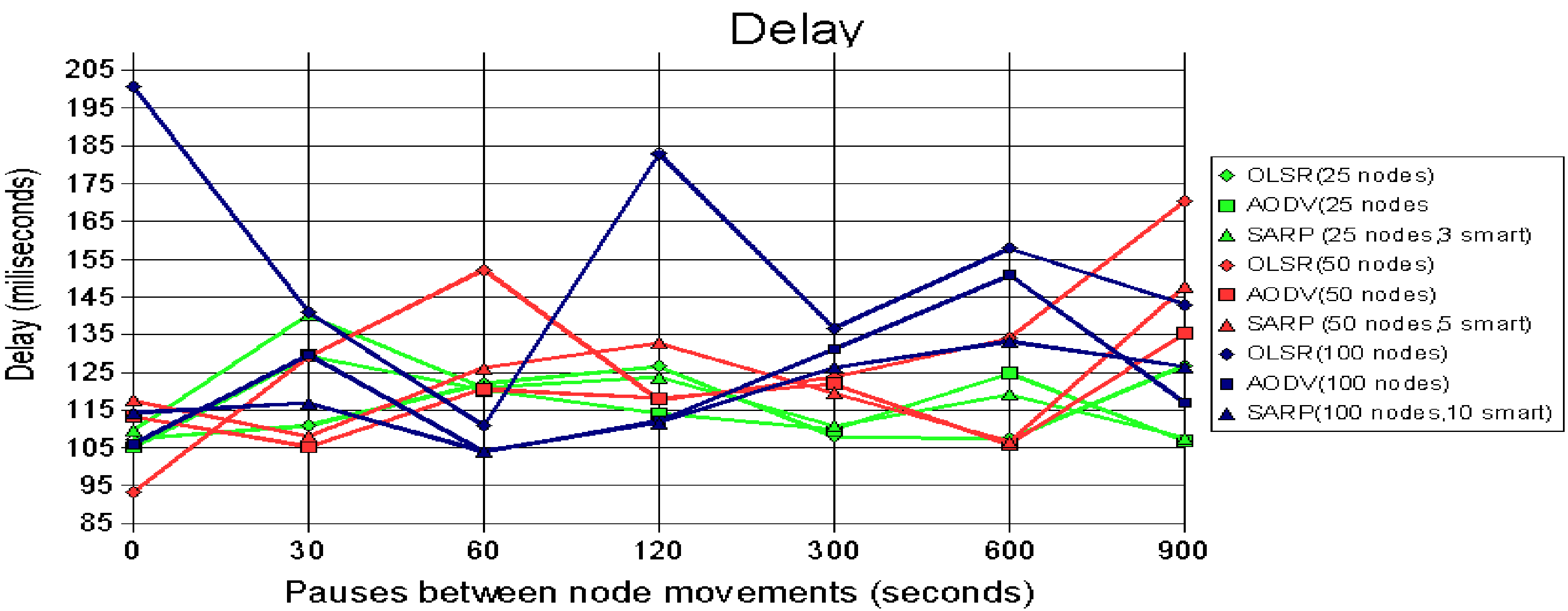

Effect of node density

Simulation parameters

- SARP, AODV, OLSR
- 25,50,100 nodes
- 10%, 30%, 60% smart nodes for SARP
- 1500 meters width, 300 meter height

- 7 different mobility levels at X-axis
- Results are at Y-axis
- 30 TCP traffic connections
  - 64 bytes TCP packets
  - Duration: 20 seconds
  - FTP is used at application layer
- Radio range: 250 meters

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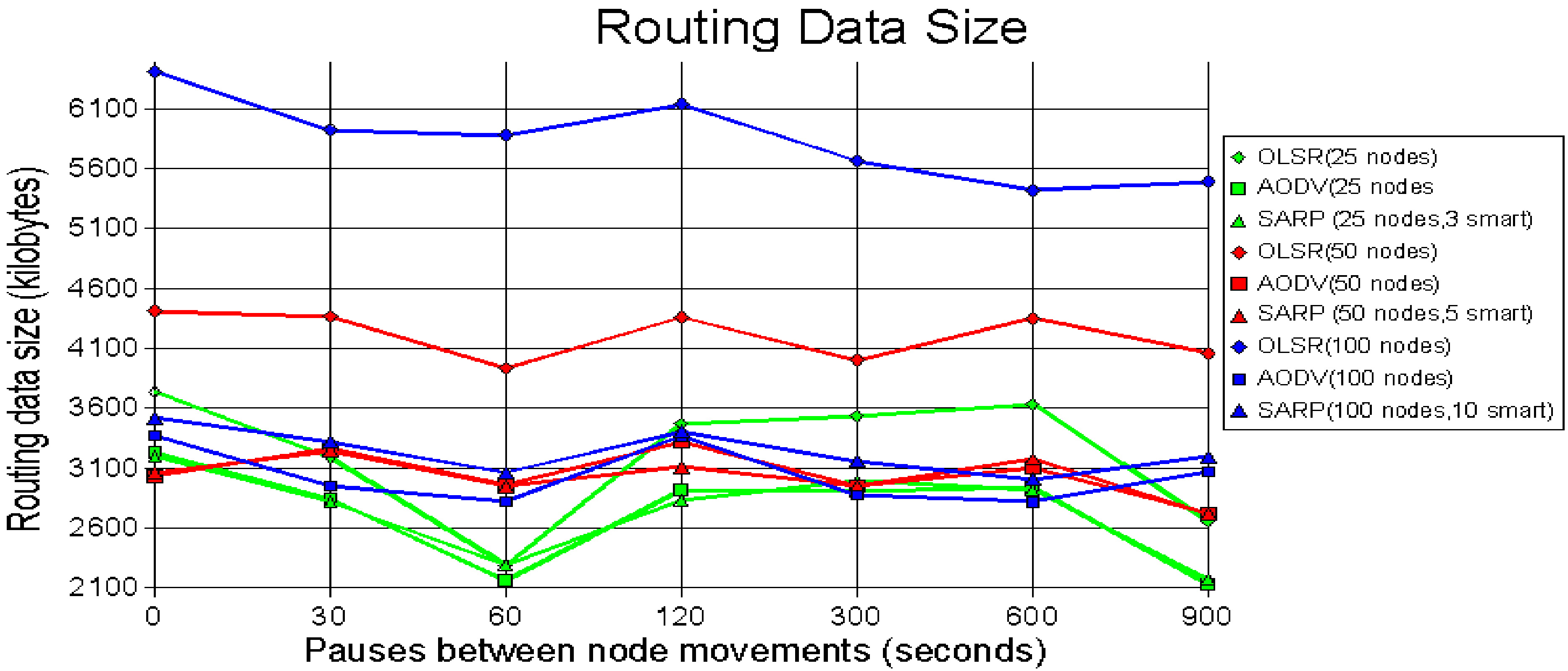

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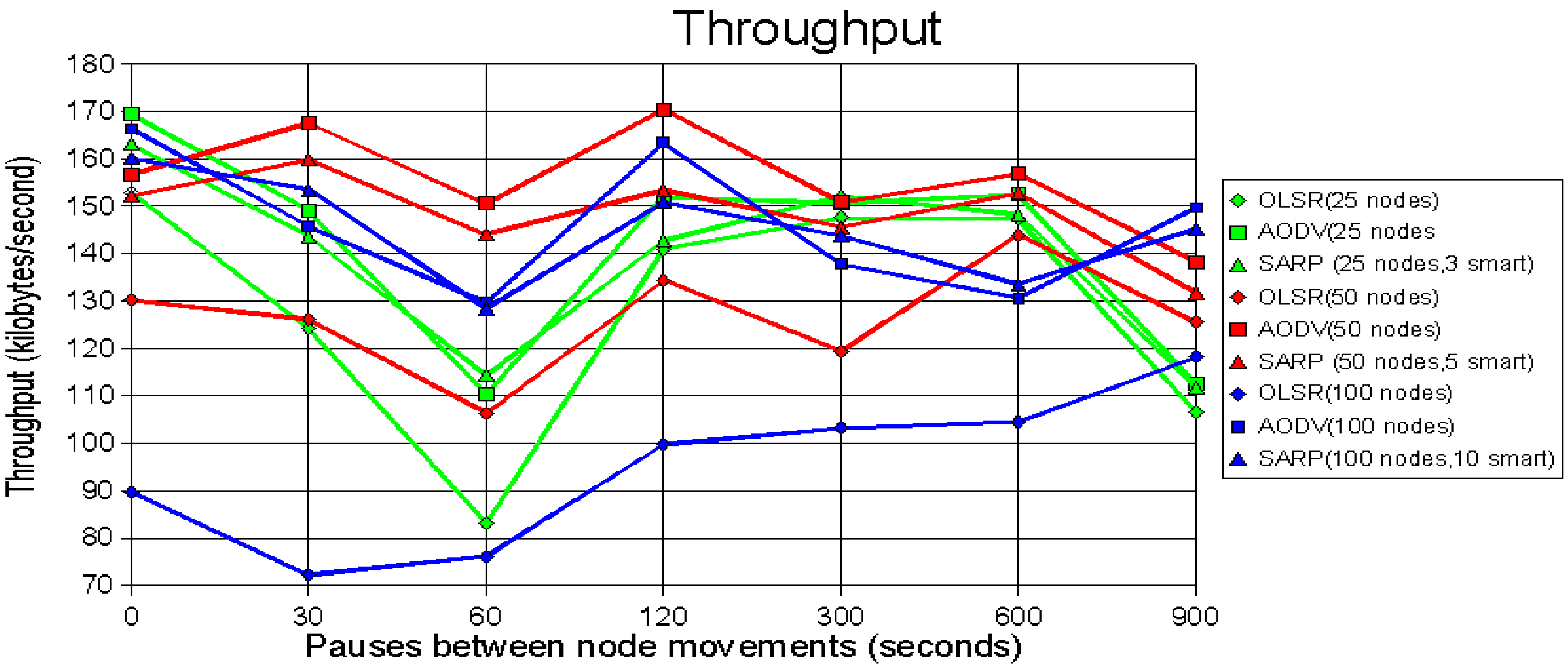

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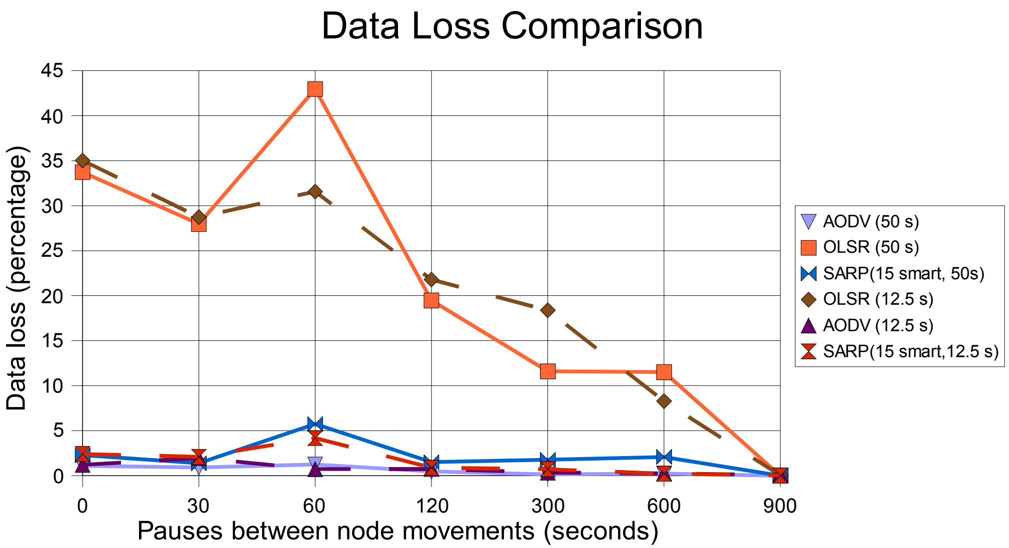

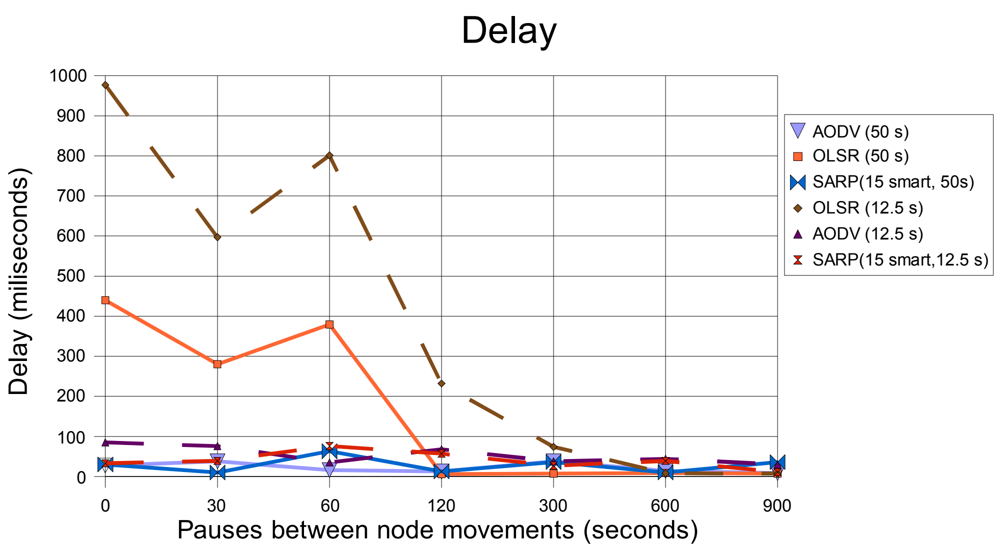

Simulation parameters

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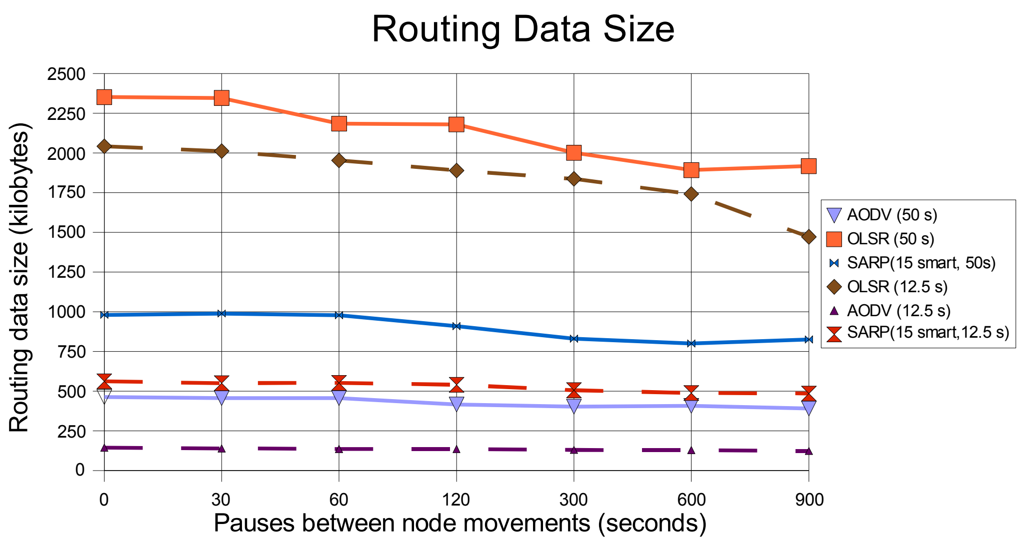
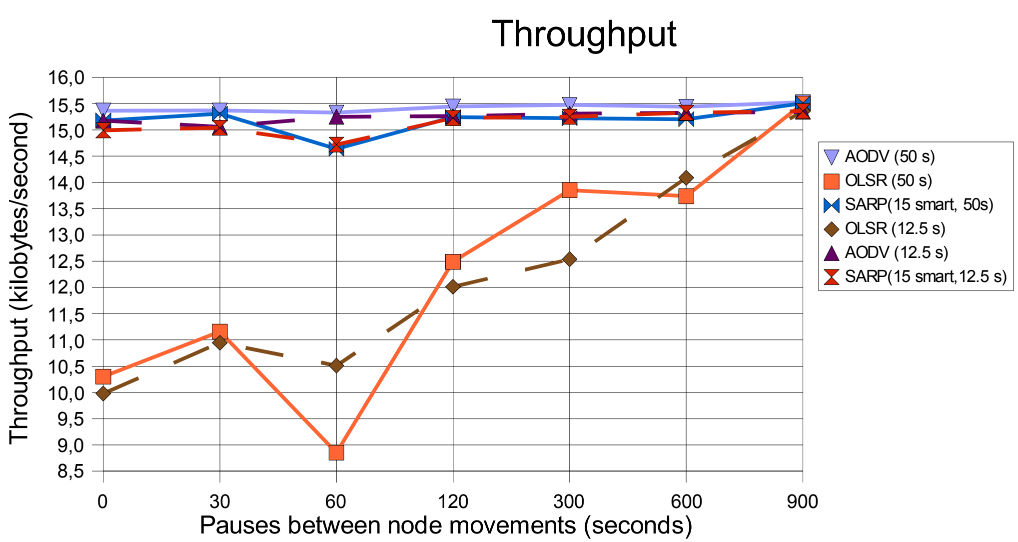
- 50 nodes
- 5, 10, 25 smart nodes for SARP
- 1500 meters width, 300 meter height
- 7 different mobility levels at X-axis
- Results are at Y-axis
- 30 CBR traffic connection
  - 65 bytes UDP packets
  - Duration: 50 seconds
  - Rate: 8 packets/second
- Radio range: 250 meters

- Effect of traffic congestion
  - Continuous lines show results for third simulation analysis
  - Dashed lines show results for first simulation analysis

SARP Simulation Analysis - III





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- Effect of traffic congestion
  - Continuous lines show results for third simulation analysis
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SARP Simulation Analysis

- Conclusions
  - SARP provides lower delay and data loss than OLSR, but similar to AODV
  - SARP uses less data for routing than OLSR, but slightly more than AODV
  - When amount of smart nodes increases, it does not have positive effect in the performance
    - Best performance is observed when 10-30 percent of nodes is smart
  - SARP performance is similar to AODV
    - SARP decrease data loss slightly in some cases
    - SARP decreases delay
    - SARP increases throughput slightly in some cases
    - SARP increases routing data size

SARP Implementation

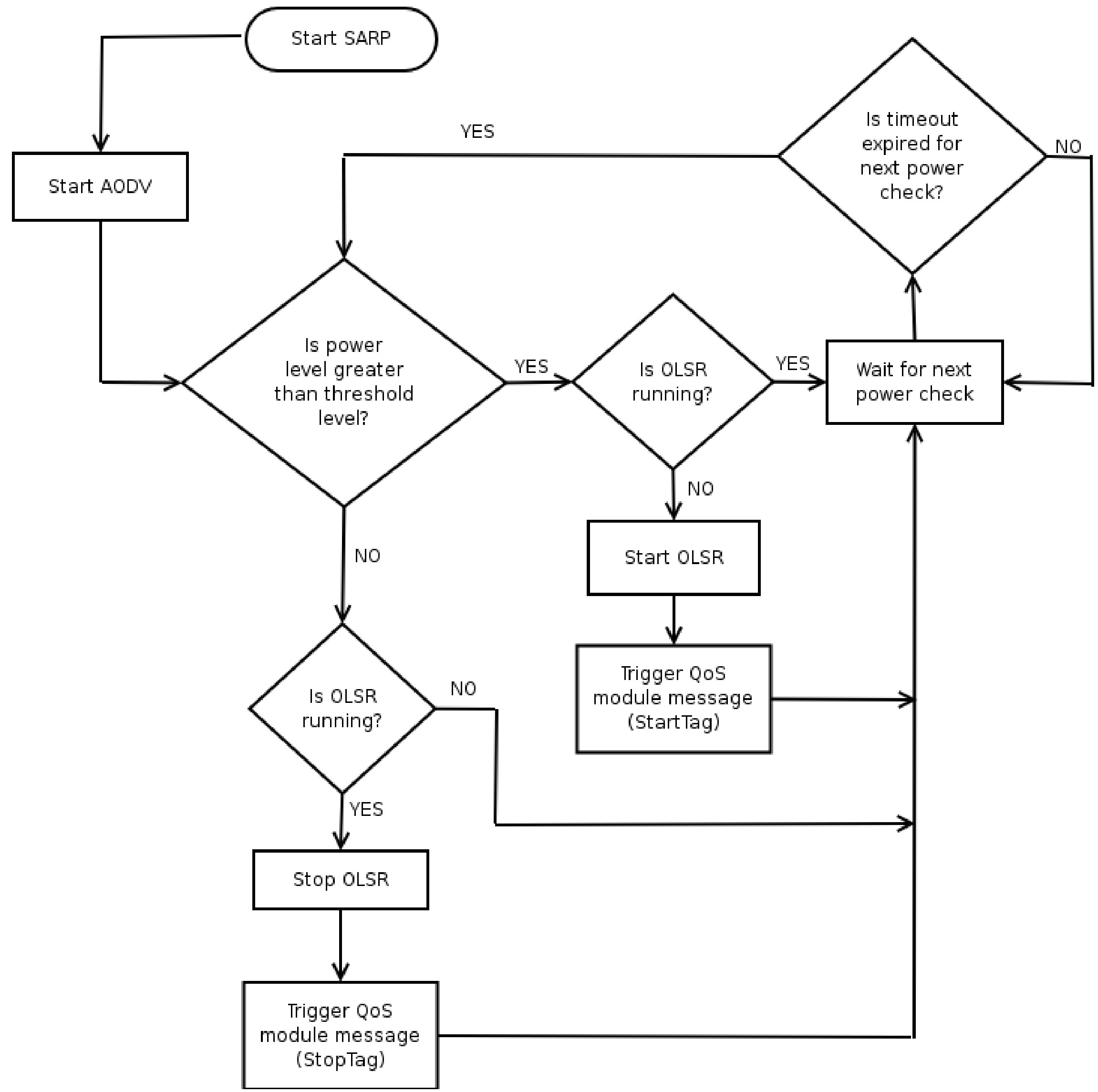
- Combination of AODV and OLSR in the same memory address space
  - AODV and OLSR existing functionality is kept unchanged
- 3 new modules added for SARP functionality
  - Node identification module added to AODV impl.
    - Decides if the node is smart or ordinary
  - QoS integration module added to AODV impl.
    - Initiated by node identification module
    - Supports integration of SARP with external QoS module (optional)
  - Routing table merging module added to OLSR impl.
    - Merges routes from AODV routing cache into OLSR routing table
    - Merges routes from OLSR routing table into AODV routing cache

SARP Implementation

- Implementation is done using C language
  - AODV-UU 0.9
  - Unik OLSR 0.4.4
- Built for iPAQ PDA devices running Familiar Linux
  - ARM cross compiler
  - Familiar Linux kernel source code

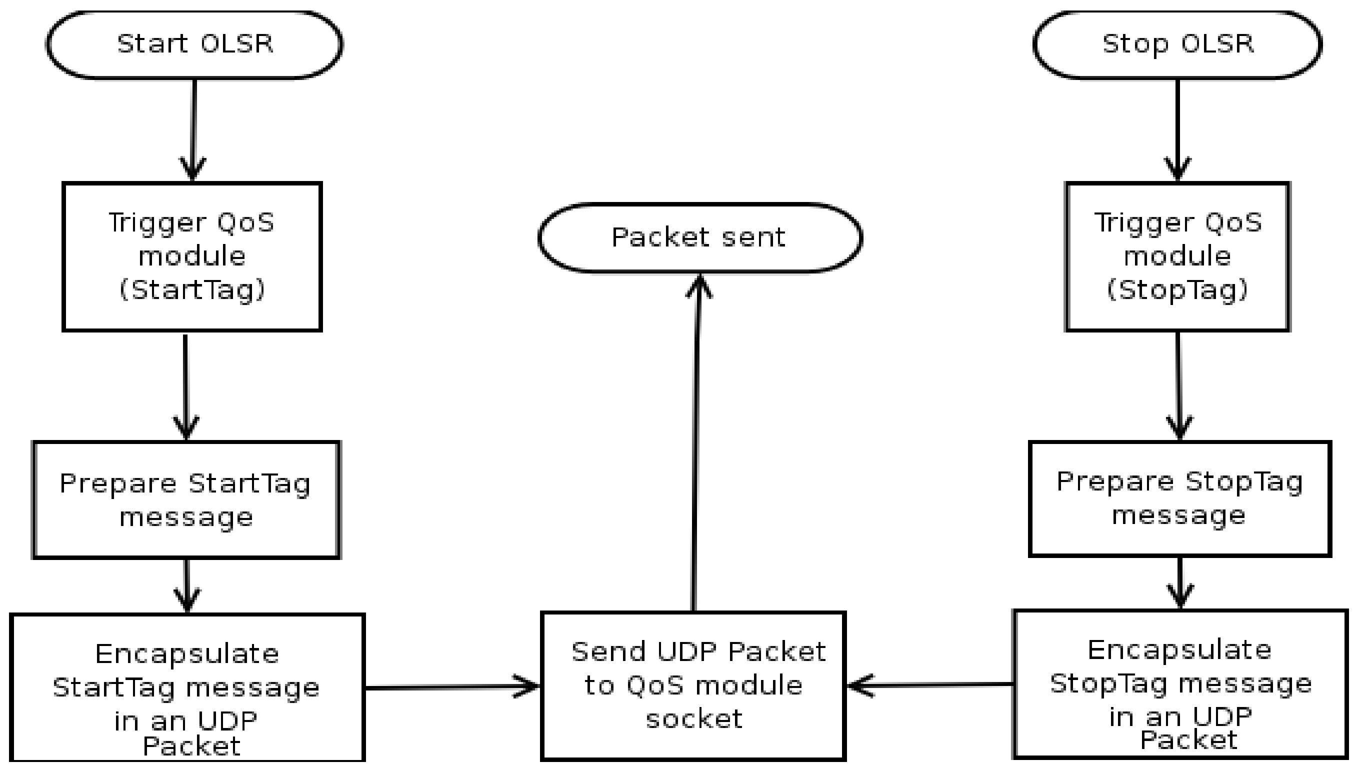
SARP Implementation

- Node identification module



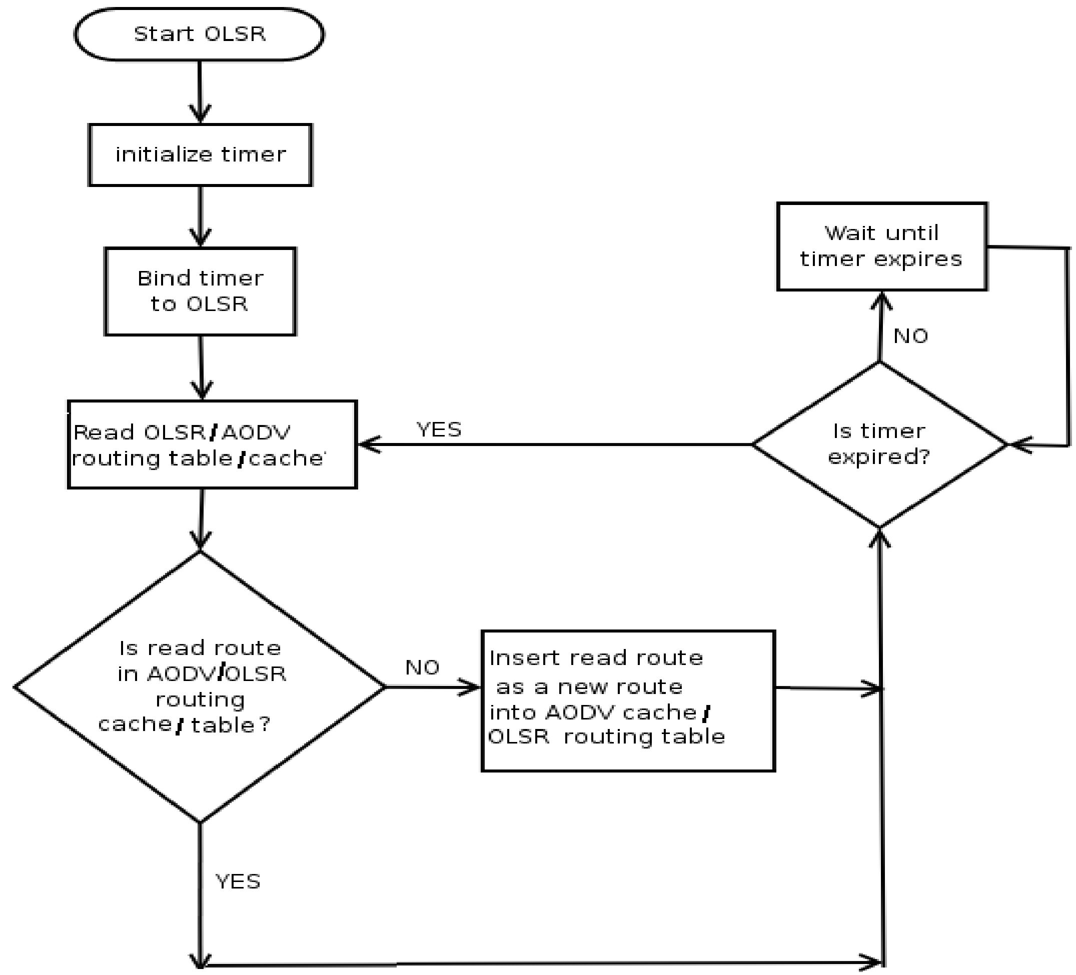
SARP Implementation

- QoS integration module



SARP Implementation

- Routing table merging module



SARP testing

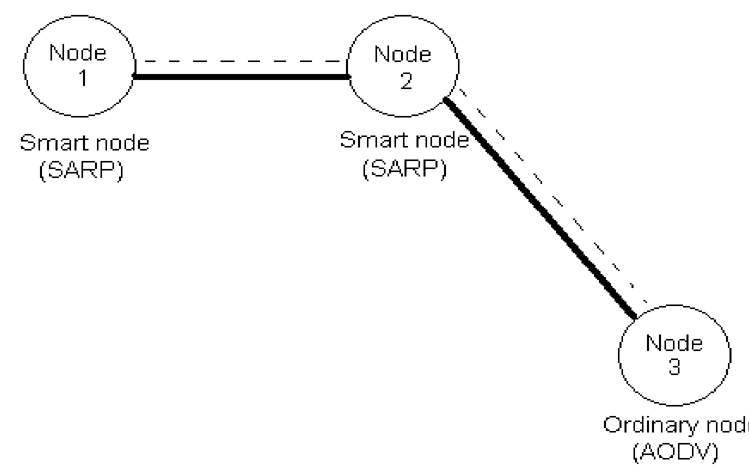
- Four different test cases
- Tested on iPAQ PDAs running Familiar Linux
- Test case I
  - Communication between smart node and ordinary node
  - Communication was totally handled by AODV
  - Initial route discovery was 2-3 seconds
    - Test number 1: 2173 ms
    - Test number 2: 1968 ms
    - Test number 3: 1725 ms
    - Test number 4: 2483 ms
    - Test number 5: 2268 ms

SARP testing

- Test case II
  - Communication between smart node and smart node
  - Communication was handled by AODV
  - OLSR module was running and updating AODV routing table
  - Initial route discovery was 2-3 seconds
    - Test number 1: 2423 ms
    - Test number 2: 2489 ms
    - Test number 3: 2654 ms
    - Test number 4: 2543 ms
    - Test number 5: 2802 ms

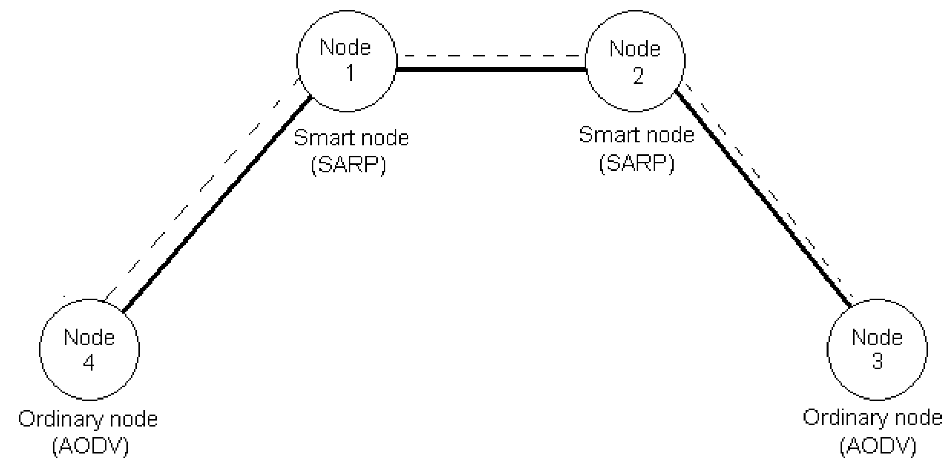
SARP testing

- Test case III
  - Communication between two smart nodes and an ordinary node
  - Communication was handled by AODV and OLSR
  - OLSR module was running and updating AODV routing table
  - Initial route discovery from Node 1 to Node 3 takes 3-4 seconds
    - Test number 1: 3372 ms
    - Test number 2: 3464 ms
    - Test number 3: 3781 ms
    - Test number 4: 3267 ms
    - Test number 5: 3466 ms



SARP testing

- Test case IV
  - Communication between two smart nodes and two ordinary nodes
  - Communication was handled by AODV
  - OLSR module was running and updating AODV routing table
  - Initial route discovery from node 4 to node 3 takes 4-5 seconds
    - Test number 1: 4835 ms
    - Test number 2: 4904 ms
    - Test number 3: 5067 ms
    - Test number 4: 5384 ms
    - Test number 5: 5130 ms



Conclusions and future work

- Good results for SARP in simulations
  - Increase in number of smart nodes do not increase the overall performance
  - Up to the simulation results, SARP performance is similar to AODV, even better in same cases
- Real-time tests show SARP implementation as stable enough
- Real-time tests show AODV and OLSR inside SARP exchanging routes
  - This decreases time spent for initial route discovery
  - Benefit of SARP may be seen better in larger size Ad Hoc networks as it is shown by simulations
    - Real-time tests in a bigger network is good to do in the future