MASTER THESIS

SCALABLE ROUTING MECHANISM IN AD HOC NETWORKS

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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 another 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 each other'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
SARP Simulation Analysis - I

Routing Data Size

Throughput

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
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
SARP Simulation Analysis - II

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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SARP Simulation Analysis - II

Effect of node density

Simulation parameters
- SARP, AODV, OLSR
- 25, 50, 100 nodes
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- 7 different mobility levels at X-axis
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- 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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SARP Simulation Analysis - III

Simulation parameters

- SARP, AODV, OLSR
- 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
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SARP Simulation Analysis - III

Simulation parameters

- SARP, AODV, OLSR
- 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

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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

Start OLSR

initialize timer

Bind timer to OLSR

Read OLSR/AODV routing table/cache

Is read route in AODV/OLSR routing cache/table?

Insert read route as a new route into AODV cache/OLSR routing table

Wait until timer expires

Is timer expired?

NO
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