Communication Networks
University of Bremen
Prof. Dr. rer. nat. habil. C. Görg

# OPNET Simulation of Firefighter Scenario

of

Artūras Lukošius

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Supervised by:
Prof. Dr. rer. nat. habil. C. Görg
Dr. Timm-Giel Andreas
Dipl.-Ing. Markus Becker

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# 1 Scenario description

According to the Firefighter scenario (see Figure 1), wireless sensor nodes are deployed in the building rooms by mobile firefighter (fm). Command post is placed at the floor entrance. It is the gateway (gw) to the fire station outside or connected via internet, etc. Firefighter carrying a collection of sensor nodes, moves and visits every room on the way, places there and turns on one sensor node, then this node initiates the transmission of messages. Messages are sent periodically from every static sensor node both to the gateway and to the firefighter (fm). Also messages are sent from firefighter node to the gateway. Firefighter movement path is shown as arrow directed downwards and to the left.

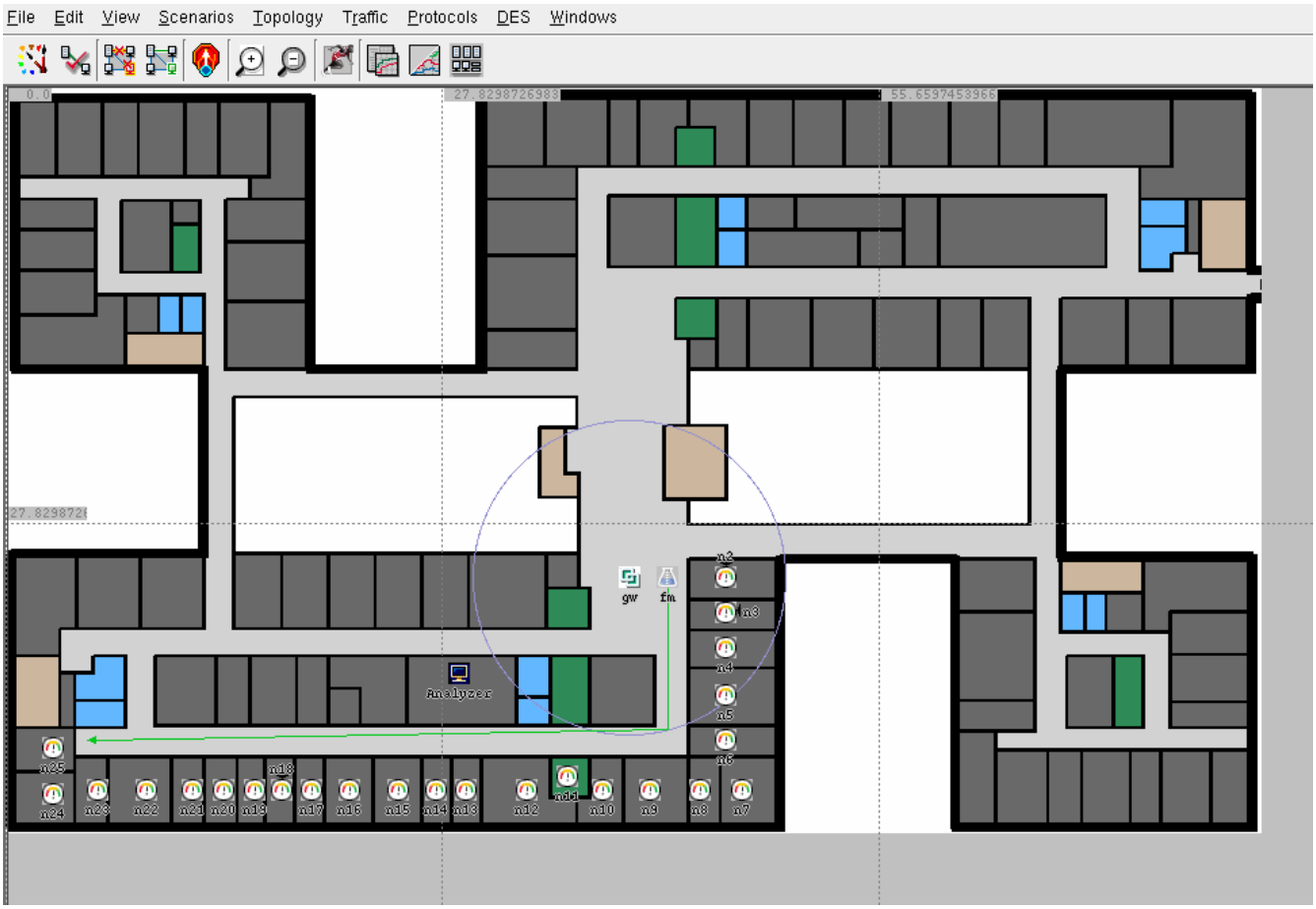


*Figure 1. Sensor deployment in OPNET simulator*

# 2 Node model

Wireless sensor node model is implemented in OPNET simulator (see Figure 2). This model has a changed structure of MANET mobile station available in OPNET. Standard model exploits IEEE 802.11 MAC. The lower MAC and PHY layers are changed to IEEE 802.15.4 MAC. This MAC works in non-beacon enabled mode and allows ad hoc communication between nodes. CSMA/CA is unslotted.

Radio model, used in this model, is 10 meter transmission radius limited model. All nodes that appear within 10 meter circle have perfect channel without path-loss. Outside this circle communication is not possible. Anyway packet collisions still appear if stations are sending packets simultaneously.

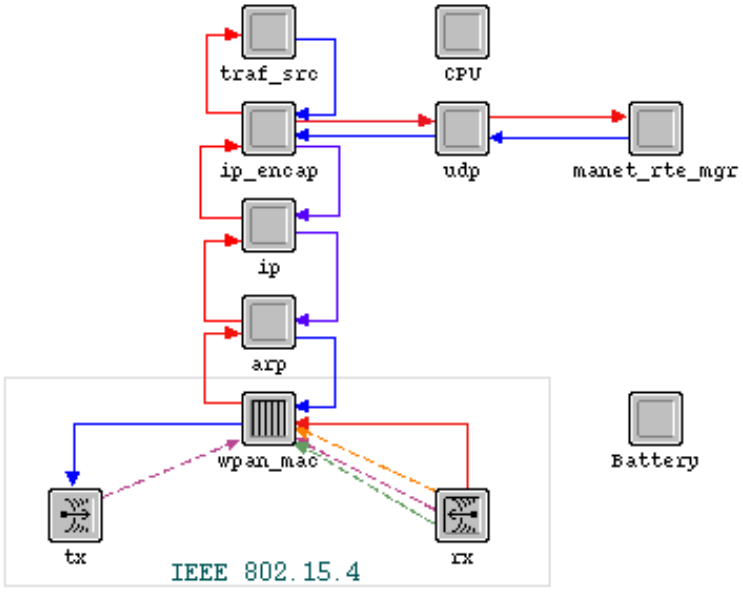


*Figure 2: Node model*

Routing protocol AODV. Periodic purge of the active route and routing tables is disabled. Hello messages are transmitted periodically. This cannot be avoided because standard AODV model in OPNET does not support broken link indication from MAC layer, when acknowledged transmission fails. Hello messages are used instead for indication of link failures. When number of lost hello messages becomes greater than the maximum allowed hello loss number, route error messages are send in order to repair the route. AODV messages are sent as UDP packets over IP protocol.

Traffic source generates random data packets according requested criteria, such as generation start/stop times, packet size, packet inter-arrival rate, destination address.

Battery model is used for calculation of total amounts of energy used for communication. Energy wasted for processing power is not accounted.

# 3 Simulation parameters

## *3.1 Scenario*

- 1 mobile firefighter (fm). IP address: 10.0.0.1.
- 1 command post or gateway (gw). IP address: 10.0.0.250.
- 24 static sensor nodes deployed in the rooms as shown in Figure 1. IP address auto assigned.
- Simulation time: 360 s.
- Mobility: all nodes except the firefighter node are static. The firefighter node moves with a speed of 0.5 km/h. Initial coordinates are (42.16, 31.34). The firefighter node moves downwards a distance of 10.3 meters and then moves to the left for 36.94 meters. At this point it stops.
- Nodes fm and gw are enabled from the beginning of simulation, n2 n25 are enabled as firefighter (fm) moves by.
- Node recovery time table is shown in Figure 3.

| Name | Time | Status |
|---|---|---|
| Office Network.n3 | 16.12 | Recover |
| Office Network.n4 | 32.256 | Recover |
| Office Network.n5 | 53.712 | Recover |
| Office Network.n6 | 74.16 | Recover |
| Office Network.n7 | 74.16 | Recover |
| Office Network.n8 | 74.16 | Recover |
| Office Network.n9 | 82.224 | Recover |
| Office Network.n10 | 103.68 | Recover |
| Office Network.n11 | 119.808 | Recover |
| Office Network.n12 | 138.6 | Recover |
| Office Network.n13 | 166.536 | Recover |
| Office Network.n14 | 180 | Recover |
| Office Network.n15 | 194.544 | Recover |
| Office Network.n16 | 219.744 | Recover |
| Office Network.n17 | 237.456 | Recover |
| Office Network.n18 | 250.92 | Recover |
| Office Network.n19 | 263.232 | Recover |
| Office Network.n20 | 277.776 | Recover |
| Office Network.n21 | 292.248 | Recover |
| Office Network.n22 | 313.2 | Recover |
| Office Network.n23 | 335.232 | Recover |
| Office Network.n24 | 335.232 | Recover |
| Office Network.n25 | 335.232 | Recover |

*Figure 3. Node wake up time table. Time in seconds*

## 3.2 Simulator

- OPNET simulator, version 11.5.A PL3.
- Wireless 11.5A license.
- X86/Linux host system type.

## 3.3 Physical Layer parameters

- Communication range: 10 meters.
- Data rate: 250 kbps.
- Bandwidth: 2 MHz.
- Base frequency of a channel: 2.401 GHz.

## 3.4 MAC Layer Parameters

- Standard: IEEE 802.15.4 with unslotted CSMA/CA, non-beacon enable mode.
- CSMA/CA parameters:
  Minimum Backoff Exponent - 3,
  Maximum Bachoff Number - 4,
  Maximum Number of Retries - 3.
- MAC addresses assigned to each node.

## 3.5 AODV Parameters

- Route discovery parameters:
  Route Request Retries 2,
  Route Request Rate Limit (packets/s) 10,
  Route reply is sent only by destination.
- Active route expiration is disabled except the firefighter node (5s).
- Hello interval (seconds) - uniformly distributed from 2 to 3.
- Allowed hello loss - 1.
- Net diameter - 35.
- Node Traversal Time (seconds) - 0.04.
- Route Error Rate Limit (packets/s) - 10.
- Timeout Buffer: 0.
- TTL Parameters:
  TTL Start 1,
  TTL Increment 2,
  TTL Threshold 7,
  Local Add TTL 2.

- Packet queue size infinite.
- Local repair is disabled.
- Addressing mode - IPv4.

## *3.6 Packet Generator Parameters*

- Static Sensor Node:
  Generation Start Time - according time table (see Figure 3). Node n2 wakes up at 0 s.
  Packet Interarrival Rate (packets/s) 5.
  Packet size (bytes) 32.
  Destination IP address: 10.0.0.1 and 10.0.0.250
  Stop time: the end of simulation.
- Firefighter node:
  Generation Start Time beginning of simulation.
  Packet Interarrival Rate (packets/s) 5.
  Packet size (bytes) 32.
  Destination IP address: 10.0.0.250.
  Stop time: the end of simulation.

# 4 Simulation results

## *4.1 Global statistics*

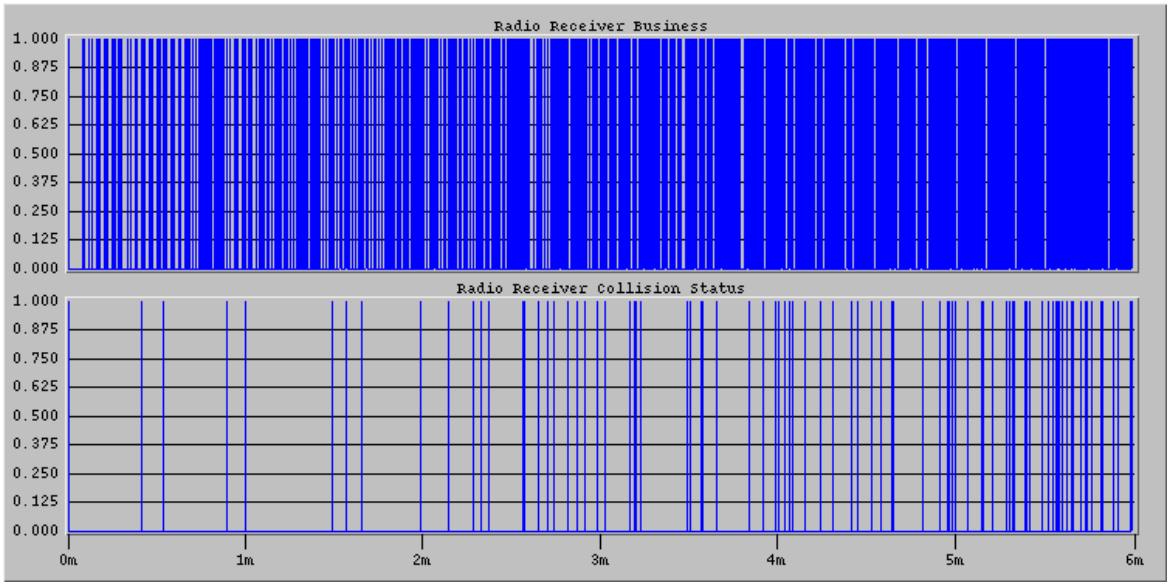


*Figure 4. Global radio receiver business and collision status*

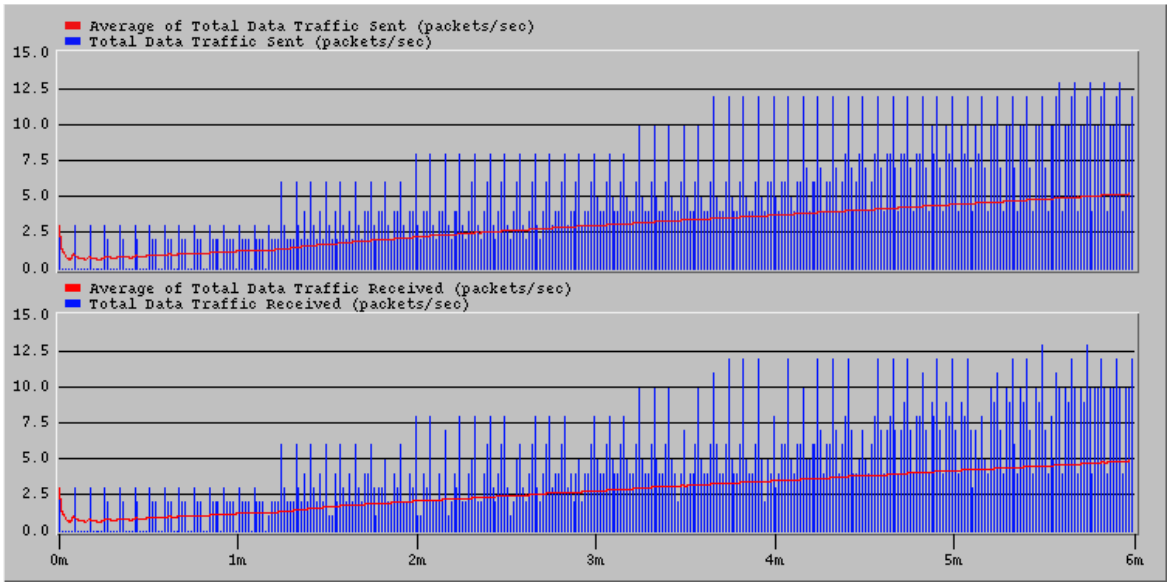


*Figure 5. Throughput of sent and received acknowledged data*

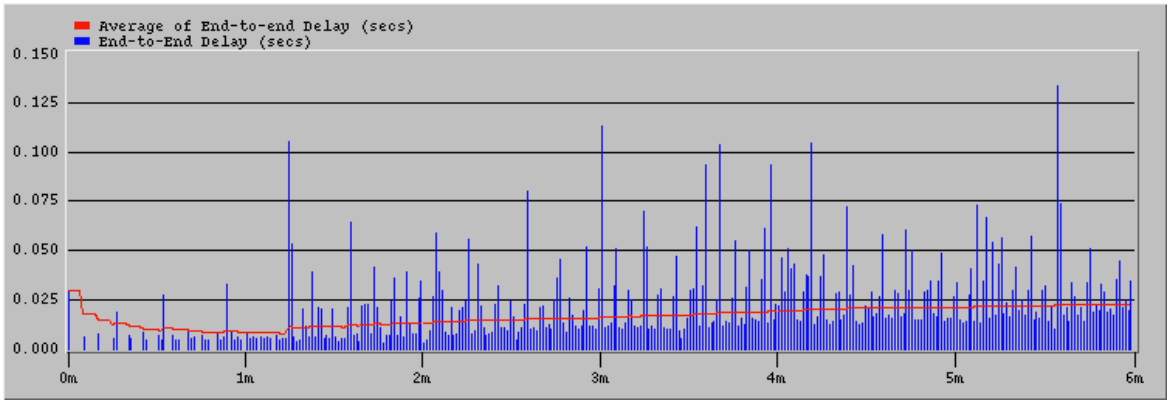


*Figure 6. Global end-to-end delay of acknowledged data packets*

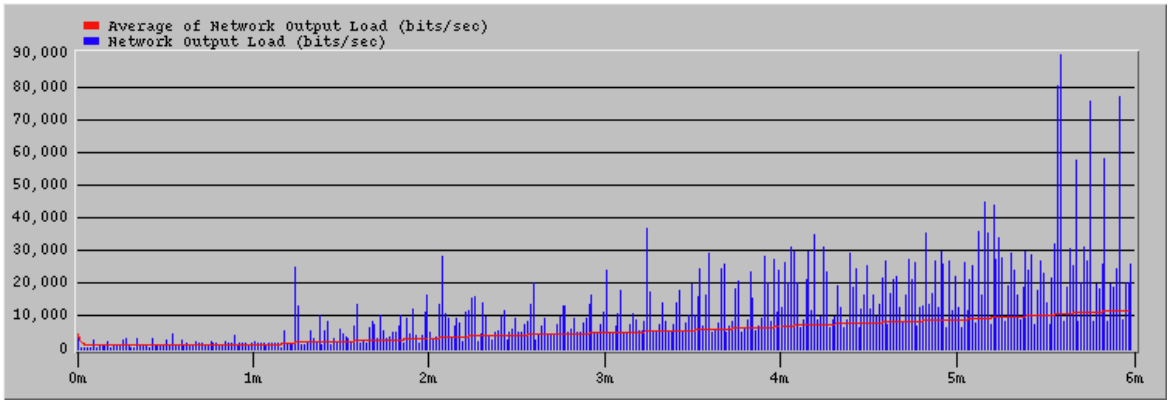


*Figure 7. Total network output load*

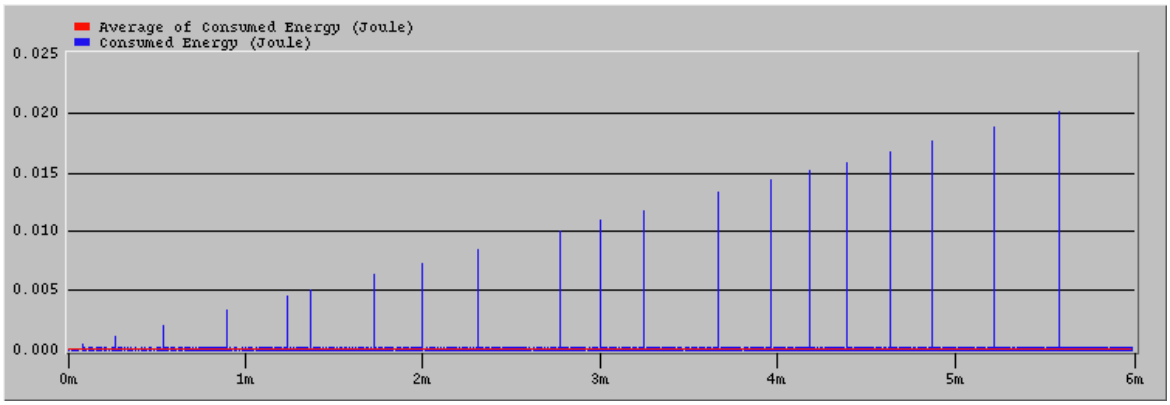


*Figure 8. Consumed energy by all nodes*

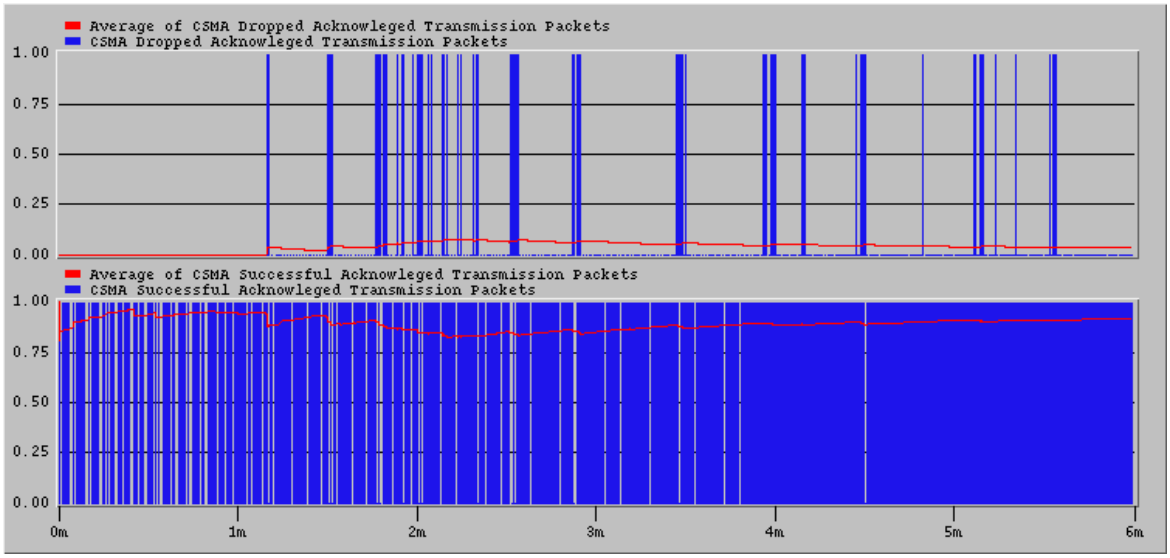


*Figure 9. Dropped and successful acknowledged transmission*

## 4.2 Firefighter node statistics

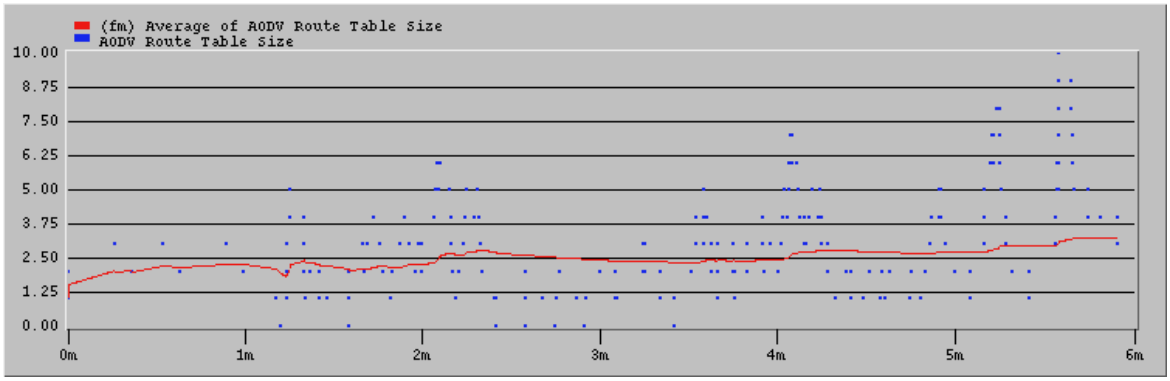


*Figure 10. AODV routing table size of firefighter node*

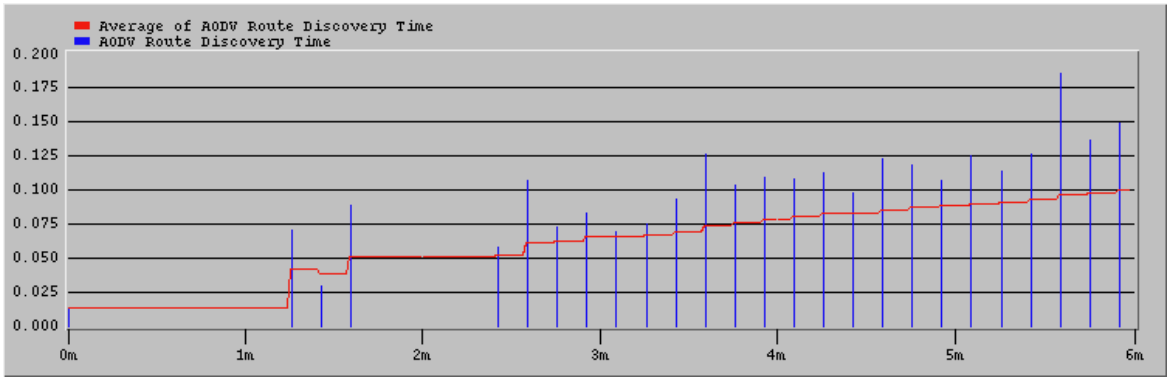


*Figure 11. AODV route discovery time of firefighter node*

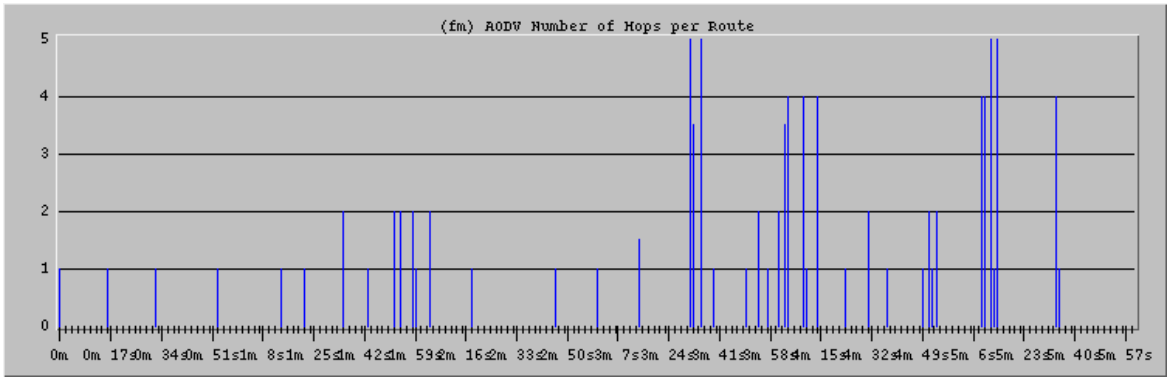


*Figure 12. Number of hops per route of firefighter node*

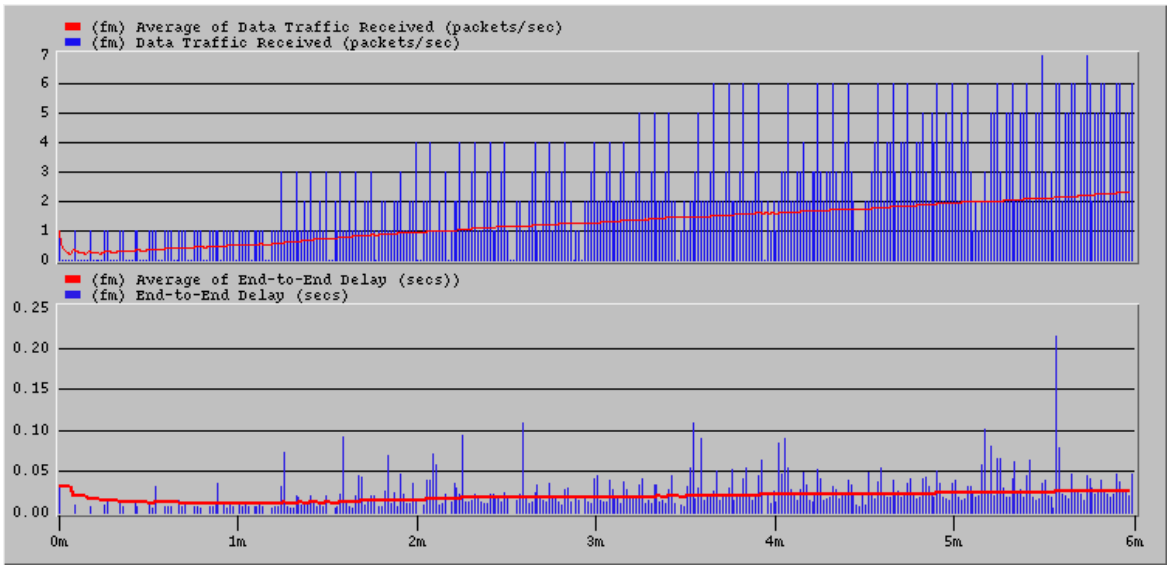


*Figure 13. Throughput and end-to-end delay of firefighter node*

## 4.3 Command post statistics

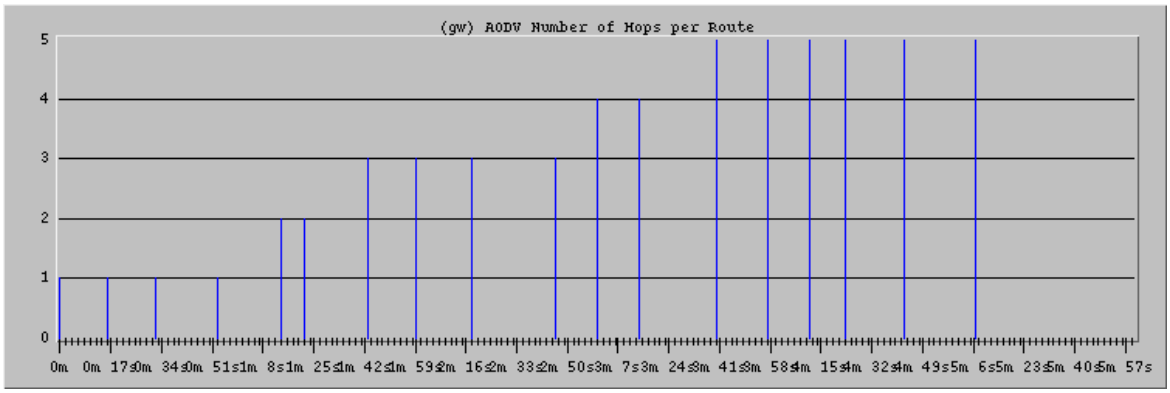


*Figure 14. AODV number of hops per route of command post node*

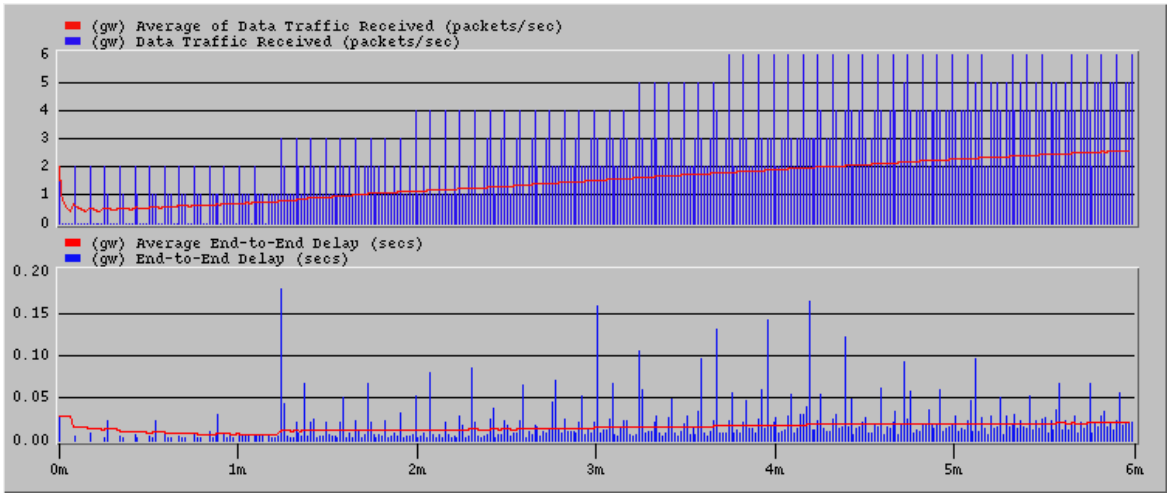


*Figure 15. Throughput and end-to-end delay of command post node*

# 5 Conclusions and future work

In this work firefighter scenario was simulated and analyzed in OPNET. Wireless sensor node model was created with a help of available MANET station model. Statistic results were obtained in order to analyze the performance of the given network scenario. Comparing total amounts of received acknowledged transmission packets, we can notice that received traffic at command post is less than that of the firefighter node. That is because not all traffic from the firefighter node reaches the command post. It is necessary to enable active route expiration timers for every node. That will increase global network load and will consume more energy. The use of expiration timers is not the efficient way of improvement, because in this scenario all routes are static except those with firefighter node.

The future work may have the scope on implementation of link failure indication from MAC layer to the upper layers, for example generation of RERR message at the same node MAC layer. The other, more complex way is to create custom AODV model from the existing standard model in OPNET and integrate control channel for link error indication.