Maximum Amount Shortest Path (MASP) routing protocol implementation in ns-3

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ABSTRACT

In this work, we present an implementation of the Maximum Amount Shortest Path (MASP) routing protocol in ns-3. The main contribution of this work is to give the detailed and precise implementation of MASP. Additionally, performance evaluation from the view point of spatially unbalanced energy consumption is discussed.

Keywords

Routing protocols, WSNs, energy efficiency, constrained mobility, AODV, DSDV

1. MASP ROUTING PROTOCOL

Spatially unbalanced energy consumption among sensors is the most important issue in Wireless Sensor Networks (WSNs). This uneven energy consumption can significantly reduce network lifetime. The use of sink mobility with constrained paths and decreasing the message flood by limiting the flood area can help to improve the energy efficiency in WSNs. Maximum amount shortest path routing protocol (MASP) is an efficient protocol using this idea. MASP [3] is proactive (table-driven) in nature and tries to collect the largest amount of data using as least energy as possible. In a typical MASP topology there is one or more mobile sinks. The mobile sinks move along constrained paths in a field of randomly distributed static nodes. The static nodes that have direct communication with a mobile sink are known as *subsinks*. The rest of static nodes that do not have a direct communication with any mobile sink are known as *member nodes*. Only subsinks can communicate directly with mobile sinks. Member nodes must send their data to a subsink first to deliver their data to the mobile sink. The data sent to a subsink is queued there until a mobile sink in range collects the data. Additionally to this subsink mechanism, MASP divides the total area into independent routing zones to limit the messages flood. Zone division and data collection are achieved during multiple *rounds*. When a mobile sink goes back an forth to the beginning of its trajectory, we say that it has completed one loop (one round). The first two rounds divides the deployed nodes into independent zones to construct the nodes routing tables. Data collection takes place in the 3rd round.

2. MASP MODULE FOR NS-3

The relationship between all the classes implemented for MASP can be observed in the Figure 1. As a general rule, any protocol implemented in ns-3 must have one main class that extends from **ns3::Ipv4RoutingProtocol** class. In our implementation that class is **ns3::masp:: MaspRoutingProtocol**. Multiple classes extend from the **ns3::Header** class to create all the control packets in the protocol. Routing tables are managed in every node by an instance of the class **ns3::masp::RoutingTable** where multiple instances of the class **ns3::masp::RoutingTableEntry** are stored. The class **ns3::masp::RangesTable** controls and saves all the information related to times when subsinks are in range of a mobile sink and other calculations. The entries in the range table are made using the **ns3::masp::RangesTable Entry** class. Finally, subsinks packet queues and their entries are handle by the classes **ns3::masp::PacketQueue** and **ns3:: masp::QueueEntry** respectively. The queues implementation is similar to the one described in [4].

3. SIMULATION SETUP AND ANALYSIS

We conducted experiments using the latest available version of ns-3 (3.24.1). We used a single mobile sink moving at the bottom of a $400m$ x $200m$ rectangular area with constant speed of 5 m/s. Our *seed* value is set to 15 with a *run* value of 7 (random variables control). All the deployed nodes are using the wifi 802.11b standard with a max range set to $52m$ in the propagation loss model. Data packets size are equal to 1029 bytes. We used a shortest path method (AODV) as a target of comparison. The default parameters described in [1] are used for the experiment of AODV. Our MASP implementation uses the following essential parameters: number of zones = 3, half round time = 80 seconds. While the application data generation rate in the nodes can be configured with different settings in our experiments, the subsinks always transmit the buffered packets in the queues with the data rate of 5 *mbps*. Additionally, application data

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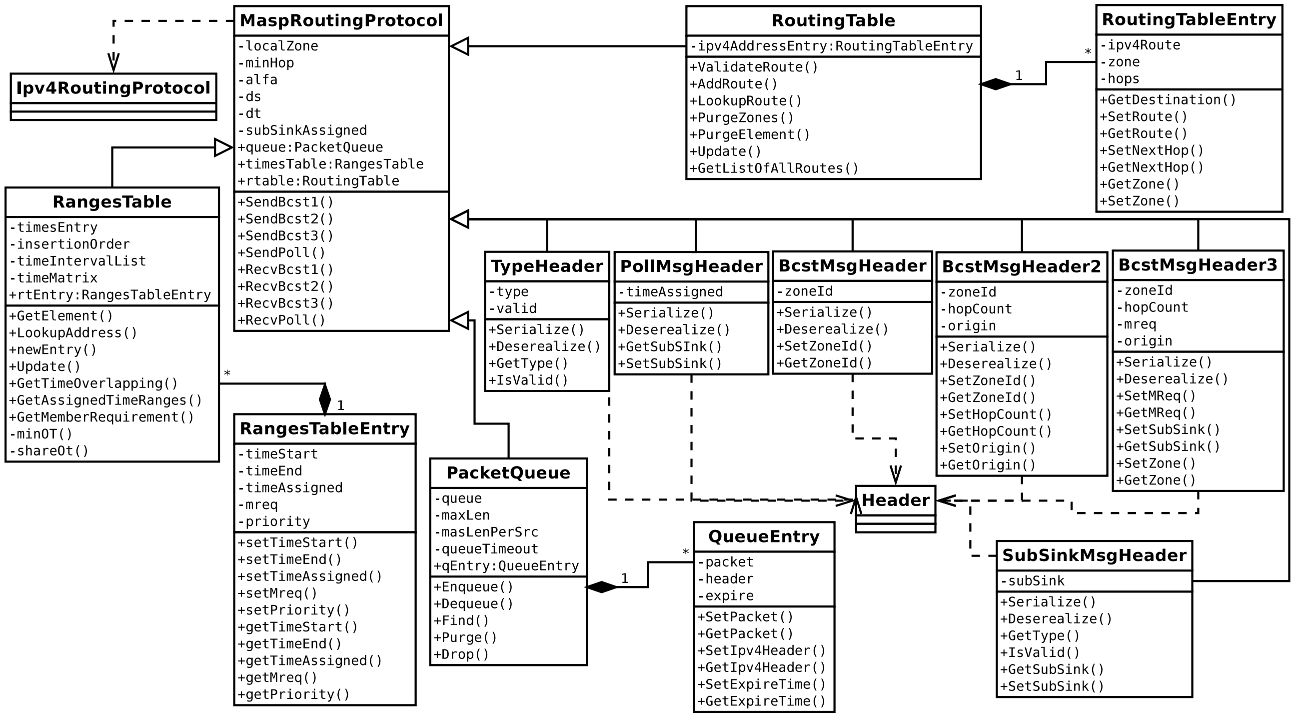

Figure 1: MASP class diagram

is only generated during one second in *round* 3. Each application have a start time with the deviation of 0.002 seconds between nodes to avoid ARP collisions in the data collection phase. We considered a data collection phase of only half round. Figure 2 shows the average energy consumed by MASP and AODV with an increasing number of nodes and their maximum and minimum energy values. We set the nodes with the data generation rate of 20000 *bps*.

Nodes have the initial energy of 3000 J with radio current set to 0.0174 *Amp* for packets transmission (Only packets transmissions consume energy). In our experiments, more energy is consumed by AODV. Nodes using AODV spend most of their energy to flood *hello* messages used to keep routes updated. Data packets are forced to pursue the constantly moving sink destination. On the other hand, MASP is aware of the route to the mobile sink beforehand. Therefore, packets do not need to pursue the mobile sink and wait in the subsinks until the mobile sink collects them instead. In AODV, as the number of nodes increases, packets stop being forced to use a single route and have more options to reach the mobile sink. In other words, the same routes are used less frequently and packet transmissions are distributed more evenly among nodes. However, collisions are still frequent because all the nodes within the range of the mobile sink send data to it. In MASP, collisions are existent but less frequent because the area is divided into multiple zones and subsinks in each zone send data to the mobile sink during the predefined time period. As seen in the Figure 2, it is clear that MASP have larger range between its min / max energy consumed than AODV. This is mostly because subsinks consume significantly more energy than non subsink nodes. Further experiments are possible using our code available at [2].

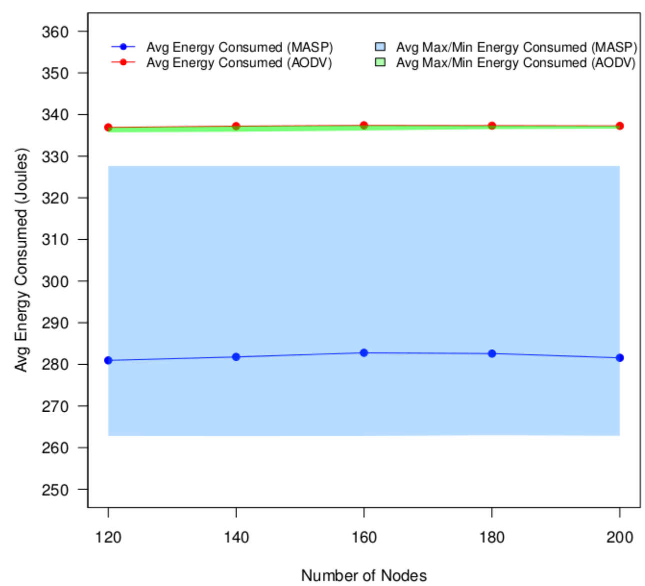

Figure 2: Average Energy Consumed with Maximum and Minimum Energy consumed

4. CONCLUSIONS

In this abstract we briefly described the implementation of MASP in ns-3. We presented a single experiment evaluating the energy consumption performance against AODV. Further experiments are possible using the current implementation. We are currently working on adding more variables to the experiments and comparison with further protocols.

5. REFERENCES

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Approach

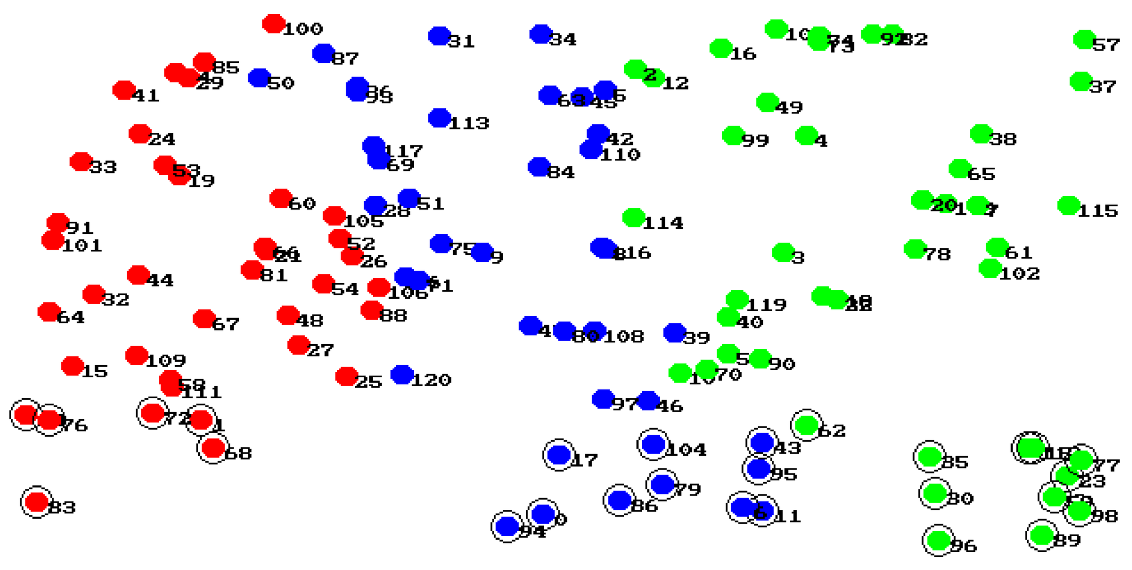

Figure 1 : MASP Zone Division

In a typical MASP topology of wireless sensor networks, there is one or more **mobile sinks**. The mobile sinks move along constrained paths in a field of randomly distributed static nodes. The static nodes that have direct communication with a mobile sink are known as "**subsinks**". The rest of static nodes that do not have a direct communication with any mobile sink are known as "**member nodes**". Only subsinks can communicate directly with "mobile sinks". Member nodes must send their data to a subsink first to deliver their data to the mobile sink. The data sent to a subsink is queued there until a mobile sink in range collects the data. Nodes select their subsink destination based on a process called **member requirement calculation**. In this process the best subsink is selected based on its transmission time with the mobile sinks (**overlapping transmission times** of other subsinks are also considered).

Additionally to this subsinks mechanism, MASP divides the total area into independent routing zones to limit the messages flood. **Zone division** and data collection are achieved during multiple "**rounds**". When a mobile sink goes back an forth to the beginning of its trajectory, we say that it has completed one loop (one round). Figure 1 shows the result of round 1. Different colors correspond to different zones. Subsinks are depicted by double-lined circles. Summarizing, in MASP the first two rounds divide the deployed nodes into independent zones to construct the nodes routing tables and the selection of the subsink destinations. Data collection takes place in the 3rd or more consecutive rounds.

Architecture

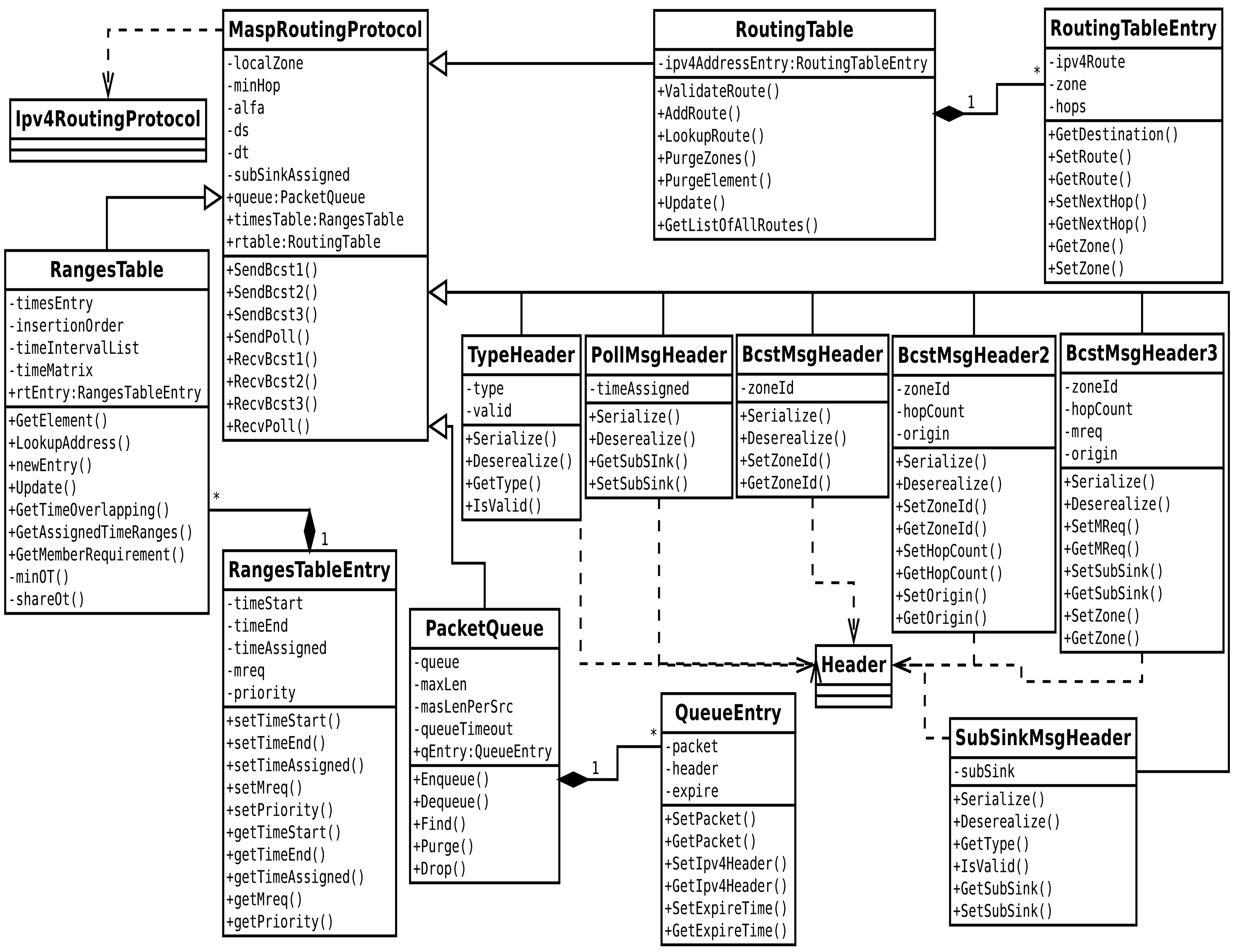

Figure 2 : Class Diagram

Conclusions

We developed a full implementation of the MASP protocol in ns-3. The first implementation of this protocol used OMNET++ and assumed the precise synchronization of the clocks in all the subsinks to send their data to the mobile sink when in range. This, however implies difficulties in a real implementation because the internal clocks in each node can easily be desynchronized by external factors. Our implementation use a poll mechanism in the round 3 to trigger the data transmission between the subsinks and the mobile sinks. MASP zone division and a subsink - queue mechanism provides an even energy variability among the nodes when compared to AODV and DSR protocols.

Experiments Setup

Table 1 : Experiments Attributes

Attributes	Values
ns-3 version	3.24.1
Field Area	400 x 200 m (1312.34 x 656.168 ft)
Mobile Sink Speed	5 m/s (16.4042 ft/s)
Wi-fi Standard	Wi-fi 802.11b
Nodes Max Range	52 m (170.604 ft)
Protocols Tested	MASP, AODV, DSR
Packet Size	1029 bytes
Initial Nodes Energy	3000 J
Tx Current	0.380 Amp
Idle Current	0.273 Amp
Number of Round	2 and half
Half Round Time	80 seconds
Data Generation Rate	20000bps - 100000bps
MASP Zones Num.	3
MASP Subsink Tx rate	50000 bps
Mobile Sinks	1

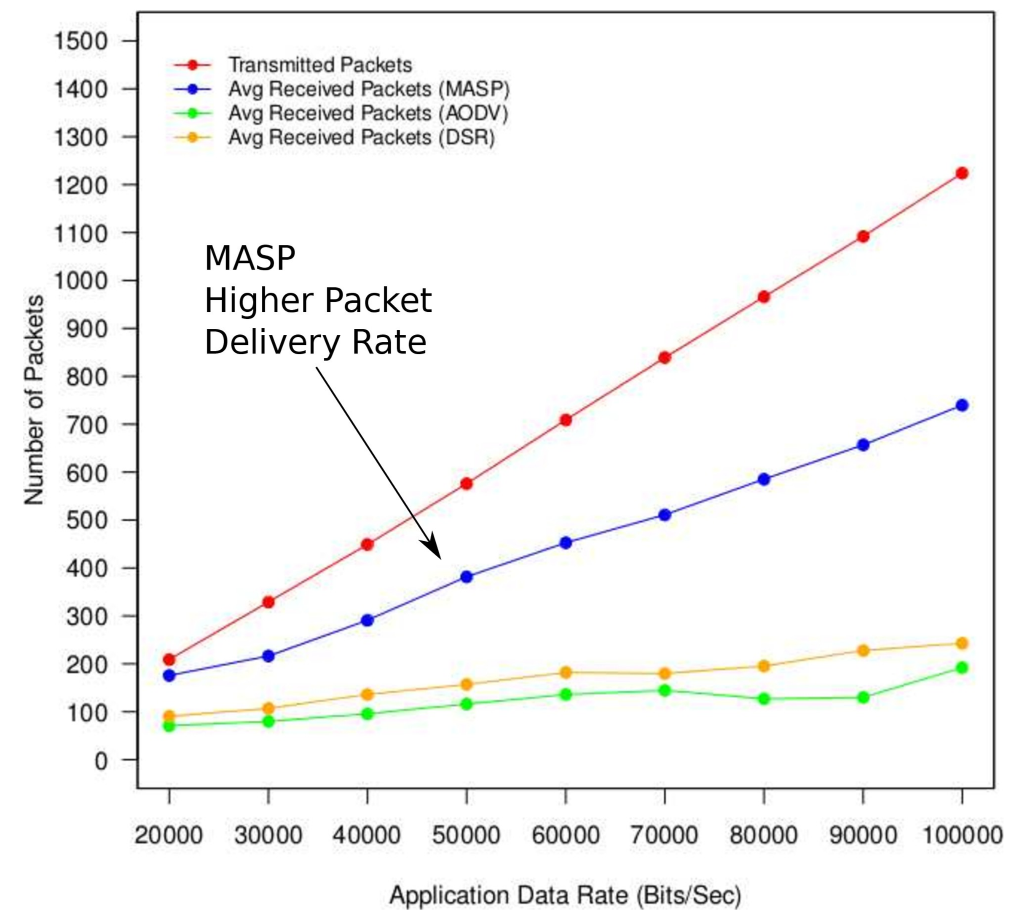

Figure 3 : Packet Delivery Number

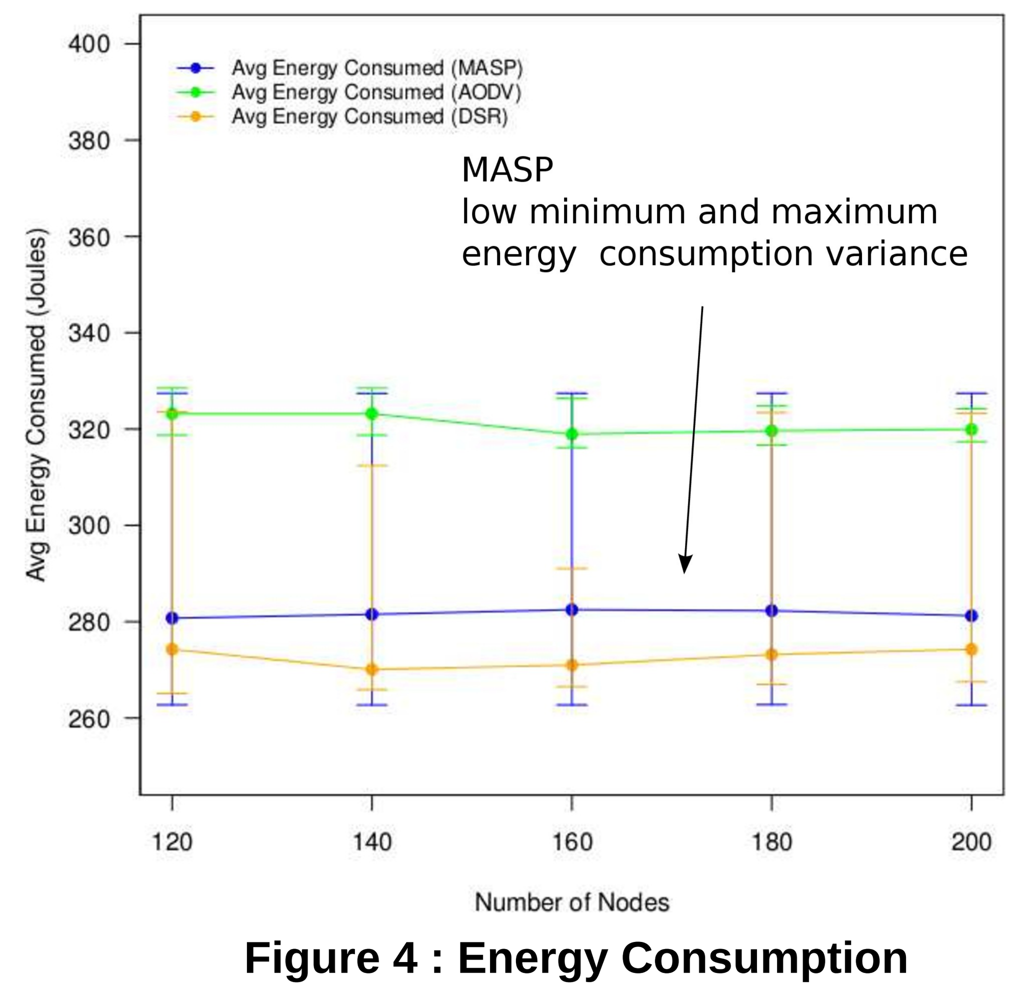

Figure 4 : Energy Consumption

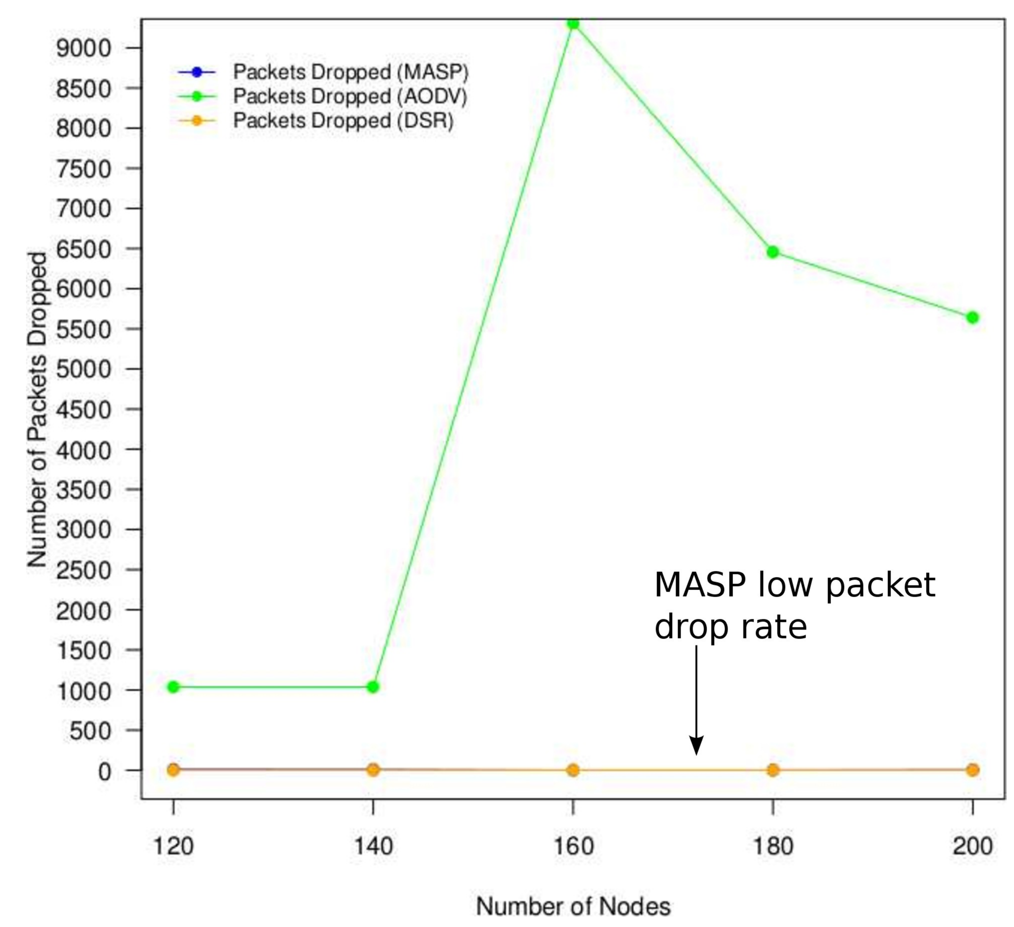

Figure 5 : Packets Dropped