Wireless Sensor Networks Protocols Performance Investigation

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Introduction

Wireless Sensor Networks (WSN) being a part of an Internet of Things (IoT) technology is often used as a data sensing and data acquiring layer. In the presented performance analysis, the dynamically reconfigurable Mobile Ad-hoc Network (MANET) with parameters of a real system is simulated and investigated. The main feature of MANET leads to its selection for investigation - it does not have any centralized management mechanism, nor strict topological infrastructure, hence each node acts as a router for remaining nodes in the network. Often WSN nodes transfer data in open field, therefore adverse weather conditions drastically impact MANET performance, in certain environments different weather conditions may cause delays or even complete data loss. To overcome this issue, a variety of different transmission protocols are developed, each of them is based on different mechanisms, thus possessing distinct advantages and disadvantages.

Aims

The goal of the study – to reveal popular WSN protocols specifics and find out the best performing protocol of the analyzed protocols under quickly changing conditions.

The main objectives:

- set up and perform WSN simulation substituting four different protocols and three different disturbance models;
- perform invetigation of the gathered results revealing the most disruptive analyzed disturbance and reveal the most robust analyzed WSN protocols;
- reveal additional WSN specifics related to this investigation parameters.

Simulation

The communication protocol between the sensors and the gateway is the main object of analysis. Four different tree and mesh topology-based protocols were chosen for investigation: 1-Hop Neighbour Discovery and Clustering Protocol, On-Demand Multicast Routing Protocol, Hop Limited Multicast Routing Protocol and Dynamic Source Routing. Simulation and analysis is performed using MATLAB software package and MANET toolbox. Real RF sensors parameters were used for the simulation. Three different RF disturbance models were substituted: fog, rain, and snow. Additionally, the baseline performance of each protocol was investigated without any disturbance applied.
Disruption models used for the simulation are characterized by specific attenuation γ, measured in dBm/km and expressed by the following equations:

- *fog attenuation model* depends on the attenuation $K(f)$ coefficient, based on frequency of the signal f and liquid water density M:

$$\gamma_{\mathrm{f}} = K(f)M;$$

- *rain attenuation model* depends on the rain rate R:

$$\gamma_{\mathrm{r}} = 1.076\, R^{0.67};$$

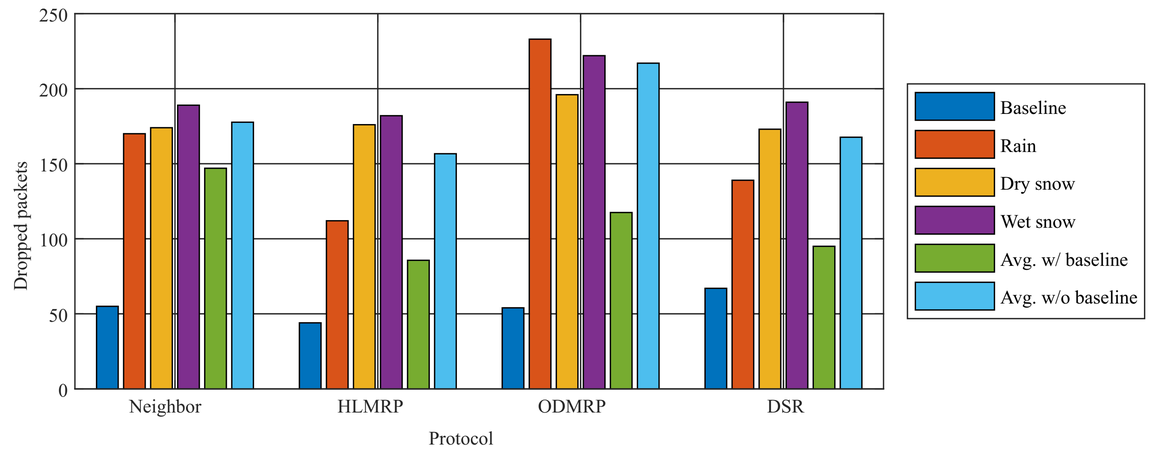
- *snow attenuation model* depends on the rain rate R and the wavelength of signal λ:

$$\gamma_{\mathrm{s}} = 0.00349\, R^{1.6}/\lambda^4 + 0.00224\, R/\lambda.$$

Additionally, a simulation *without any disruption model* is performed to figure out what is the baseline (natural) dropped packet rate for the analyzed protocols.

Results

A total of 16 different, time-limited simulations were performed and average absolute numbers of dropped data packets were analyzed. Finally, the analysis of the overall protocol performance over all disruptions as the ratio of the dropped packets to total sent packets was performed.



Average number of dropped packets for different weather-based disruptions within analysed protocols

It is evident that the baseline (reference) values for all protocols are more or less evenly distributed and are nonzero, which implies that even without disruption such network is highly loaded and some packet drops occur.

The summary of dropped packets ratio per protocol over 4 disruption models applied

Protocol	Average with baseline, %	Average without baseline, %
1-Hop Neighbour	37.89	46.01
HLMRP	27.09	27.76
ODMRP	39.51	40.36
DSR	43.37	50.24

Revealed specifics:

- ODMRP protocol shows the highest number of dropped packets – 35.84%;
- HLMRP protocol is found to be very sustainable to rain attenuation – 8.56% dropped packets;
- The rain model caused the highest variation between protocols;
- Different protocols features different techniques on collecting the knowledge about network topology and neighbor nodes;
- Snow model is found to be the most stressful within all four analysed protocols.

Conclusions

The performance analysis of four different WSN protocols simulation results confirms that:

1. In the Radio Frequency WSN for IoT case, the natural packet drops are inevitable.
2. Snow disruption model is found to be the most stressful for all four analysed protocols.
3. ODMRP data communication protocol results in the highest number of dropped packets.
4. HLMRP data communication protocol performs the best of all considered protocols.

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