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Performance Analysis of Routing Protocols over WSN under the constraints of Natural Hazards using Data Logger

Jaspreet Kaur, Amit Kumar Bindal

Abstract- For disasters management, utilization of Wireless Sensor Networks (WSNs) has got much consideration by specialists over the most recent years. Real-time data collection and data sharing can play a major role during emergency and rescue operations as well as use of data loggers can enhance the accuracy of the prediction regarding natural disasters. In this paper, a logger is introduced.

Keywords-WSN, Natural Disasters, Data Logger, Resource Consumption, Accuracy, Data Aggregation

I. INTRODUCTION

Uncertain climate conditions trigger natural disasters; thus, results in loss of wild life/forest/man-made infrastructure/economic/human lives, etc. Monitoring and analysis of real-time environmental changes can reduce the overall impact of disasters [1]. But developing nations cannot afford the cutting edge technologies due to the economic conditions. So, researchers are focusing on the cost-effective remote sensing techniques which can be used to analyze various environmental factors i.e. temperature, humidity, water level, forest fire, gases, vibration of earthquakes, etc. But, it is quite complex to collect the statistics due to following issues:

a. Sensors are deployed over a large scale area. It is very challenging to maintain the accuracy of data.
b. Large scale data aggregation consumes lots of resources.
c. Multiple sensors may monitor the common field. They can produce the redundant data as well as due to any fault; some of them may transmit error prone data. So, it is hard to find out the faulty nodes in a dense network.
d. Real-time data collection under the constraints of natural hazards is a major challenge.
e. Prediction and estimation of the disasters depends upon the experience of technical team [2] [3].

Characteristics of disaster management system [4] (DMS):
a. Quick response to the events
b. Reliable data transmission with acceptable delay
c. Capability to operate over heterogeneous / unpredictable environments
d. Fault tolerance capabilities

Following are the different operations supported by DMS:
Real-time monitoring is used by DMS for data collection. It can gather the statics by analyzing any area or structure which can be further used to detect the changes in data patterns. Data comparison is used for prediction and forecast and alerts can be issued in advance. In critical situations, emergency rescue operations can be executed (as shown in Figure(s) 1-5).

Figure1: Basic operations supported by DMS

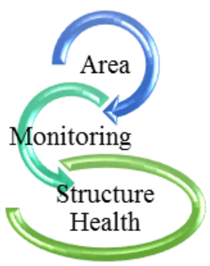

Figure2: Real-time Monitoring

Figure3: Detection of events for early warning system

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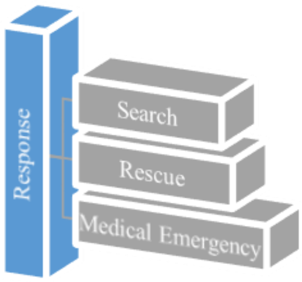

Figure4: Response for the detected events

Figure5: Forecast using data logging

II. II. DATA LOGGING OVER WSN

Data collection under the constraints of natural calamities is very important and researchers developed the following solutions in relevant domain:

T. Nakano et al. [1] developed a solution to detect the landslides. During the landslide event, nodes calculate the angle/acceleration/direction and finally, all these parameters are used to draw the patterns of landslide area. Dynamic topology is configured to adaptive the uncertain changes in routing data. Experiments show that statistics can be further utilized to estimate the frequency of the landslides.

F. Hadiatna et al. [5] developed a data logger which uses lossless compression to optimize the storage space. Experiments shows that it can compress the data up to 50% but data processing duration suffers from the sampling interval, data length and computation power of the device.

J. H. Yousif et al. [6] focused on the weather conditions and its impact over the various factors like temperature/humidity/wind velocity/rain etc. and developed a hypothesis based perdition model that is used for weather forecasting. Analysis indicates that there is no significant difference in above mentioned parameters and this study can be further utilized to predict the future weather conditions.

H. Salehi et al. [7] focused on the data collection under energy constrained environment and developed an energy aware delay tolerant data collection scheme which uses binary data format instead of data streaming for pattern detection. Data logging is done for a long interval and then data is finalized for transmission. Results shows that it consumes less energy and can perform under the constraints noise, accuracy level etc. However, its performance will be further analyzed under the constraints of variable load conditions to predict the variations in patterns.

D. Li et al. [8] did a survey of the various water resources (river/underground water/Wells/flood water/ sea etc.) and the analyzed the various properties i.e. chemical, mineral, pollution level/temperature etc. Authors also explored the different sensor based solution to measure all these attributes. Study shows that sensor deployment cost varies according to the technology standard and the region of interest to be covered.

Quality of natural resources has been degraded due to excessive pollution. Traditional pollution monitoring devices suffer from the accuracy and operational cost etc. D. Patil et al. [9] analyzed this issue and designed a solution to collect sensor data using a universal interface. It uses cloud as storage and real-time data is available for end users. Analysis shows its performance in terms of cost, resource consumption and hardware compatibility with external system.

P. K. Mishra et al. [10] analyzed the behavior of sensors under coal mines which are prone to uncertain hazard condition and developed a scheme for real-time site monitoring. It can collect different types of data i.e. vibrations, temperature, surface movement etc. It can be further used for other infrastructure i.e. metal mines/tunnels.

S. K. Priya et al. [11] investigated the issues related to the water purification and the disease caused by consuming polluted water and developed a real-time sensor based solution which can predict the water quality by fuzzy logic and send the data to end user using multipath routing. It can verify the physical/chemical properties of the water and can predict its quality. Experimental results show its performance in terms of optimal energy consumption/network lifetime and prediction accuracy etc. It can be further extended for real-time data logger over distributed pipelines.

S. Renu et al. [12] developed a data logger which selects the path on the basis of attributes of intermediate nodes i.e. weight, link quality and residual energy etc. It regulates the channel interference using received signal strength and executes the scheduler for data logging. Collected data is forwarding using virtual relays Results illustrate its performance in terms of optimal resource consumption under the constraints of node failures and void regions.

M. Pule et al. [13] investigated the issues and solutions related to the sensor based data collection activities and the various constraints like limited resources, operations in hostile environment, computational cost and secure communication etc. This study can be further reused to develop the advance solutions for sensor networks.

W.H. Nam et al. [14] developed a real-time field monitoring scheme which collects the data using radio callers and QR codes. It supports the applications related to agriculture and water resource management etc. Experiments show its performance in terms of accuracy of real-time data collection which can be further utilized by decision makers. Its capabilities can be further extended by online services integration.

I. Khemapech et al. [15] developed a real-time logger to monitor the attributes of a given structure as the hostile environment can degrade the physical properties of the structure thus may result in the human casualties. It uses sensors and loggers to analyze these attributes and early warning can be produced for safety purpose. Experiments indicate that distance between logger and base station can increase the resource consumption as well as may degrade the overall network performance.

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This is still an open issue and authors may refine the proposed approach.

J. Jiang et al. [16] developed an integrated sensor based solution to handle the natural calamities as well as the transportation issues. It forms a neural network which uses weights for perdition purpose. It computes the collected data and discards the intermediate data to reduce the gaps between multiple outputs. Finally, a training set is prepared for monitoring and flash flood warnings. It can be refined for optimal resource consumption.

M. Mousa et al. [17] investigated the issues and impact of the flash floods over cities and developed a remote sensing based sensor network which utilizes machine learning algorithms to monitor the changes in water level as well as the temperature variations for real-time flash flood estimation. Experiments show its performance in terms of accuracy and optimal energy consumption.

T. H. Illangasekare et al. [18] investigated the issues related to data collection form surface/subsurface areas. Study found that data aggregation and resource optimization both are still open challenges. However, huge volume of collected data can be further utilized to build the prediction models.

H. Gong et al. [19] investigated the issues related to the performance of traditional sensor networks i.e. data aggregation delay/accuracy/electromagnetic interference and wireless channel limitation etc. Authors found that fiber optics based sensor networks are more reliable and can transmit the real-time data with high accuracy. These types of sensors can detect the minor changes in the physical and chemical attributes of a given area. Study can be further utilized to deploy the fiber based networks over a large scale distributed surface.

A. Salam et al. [20] designed a sensor based network to analyze the changes in a structure. Sensors can process the different types of data related to vibration, humidity, and temperature etc. It can change the data processing method as per requirements. Collected data is further validated using a data logger and proposed solution can be further extended to support the industrial usage.

III. DATA LOGGER FOR WSN

WSN Wireless Sensor Network
NN Sensor Nodes
RP Routing Protocol
Deploy WSN
Initialize NN, RP
Define Dt->Type=TEMPRARTURE or Dt->Type=VIBRATION
Switch (Dt->Type)
Case: TEMPRARTURE
Call Temp_Data_generation (TEMPRARTURE, Interval, 50^{o}c, 1000^{o}c)
Case: VIBRATION

Call Vib_Data_generation (VIBRATION, Interval, 1.0, 1.0, 10)

End

If (Temp_Data_generation==TRUE)

Logger (NNi-ID, Time, Temp_Data, Interval)

End if

If (Vib_Data_generation==TRUE)

Logger (NNi-ID, Time, Vibration_Data, 1.0)
End if

IV. SIMULATION PARAMETERS

Table1: Simulation Parameters

Simulation Parameters	Parameter Values
Routing Protocol	AODV, DSDV, LEACH
Terrain	1200x1200
MAC Protocol	802.11
Node Density	100
Propagation Models	Two-Ray Ground
Data Type	Temperature, Vibration
Sampling Interval	1.0 ms
Simulation Time	10 seconds
Network Simulator	NS-2.34
Initial Energy	10.0j
Rx Power	0.5
Tx Power	0.5
IFQ	200 Packets
Antena Type	Omni
Simulation Scenario(s)	a. **Simulation using Temperature Data** b. **Simulation using Vibration Data**

V. LOGGER FOR TEMPERATURE DATA

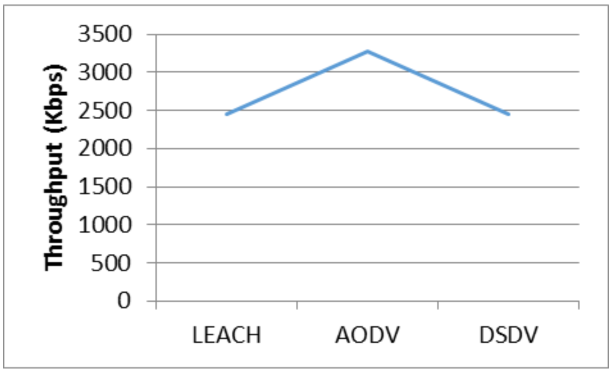

Figure6: Throughput-Temperature-Data

Figure6 shows the variations in throughput of different protocols. It can be observed that AODV delivers higher throughput as compared to LEACH/DSDV.

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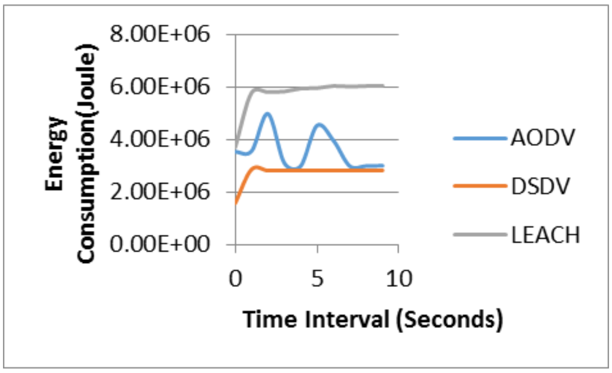

Figure7: Energy Consumption over Time Interval

Figure7 displays the variations in energy consumed by different protocols during a specific time period. It can be analyzed that LEACH consumed the highest energy followed by AODV and DSDV.

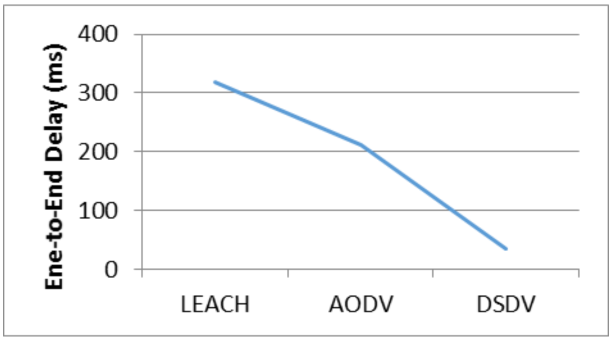

Figure8: End-to-End Delay

Figure8 illustrates that DSDV has the least End-to-End Delay followed by AODV and LEACH that suffers from the highest End-to-End Delay.

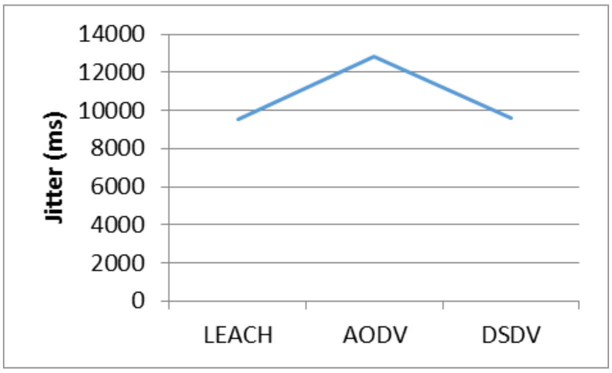

Figure9: Jitter (ms)

Figure9 indicates that AODV has the highest Jitter as compared to DSDV and LEACH.

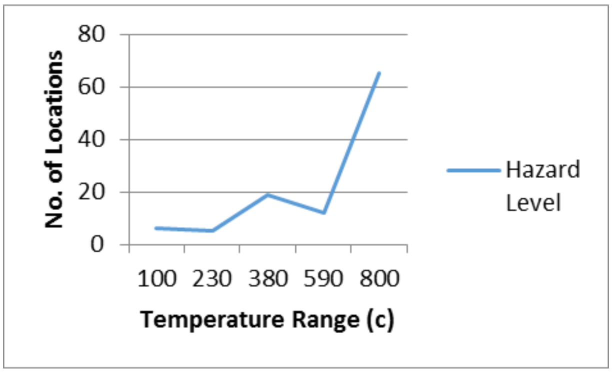

Figure10: Variations in temperature at different locations

Figure10 shows the number of variations in temperature of different locations (as per the table given below) and location data can be obtained to identify the most critical regions and fire hazard alerts can be issued.

Table2: Temperature Index for Forest Fire Hazard

Temperature	Event [21]
100 °c	vaporization
230 °c	pyrolysis of wood
380 °c	Smoulder
590 °c	Fire Ignition
800 °c	Flames

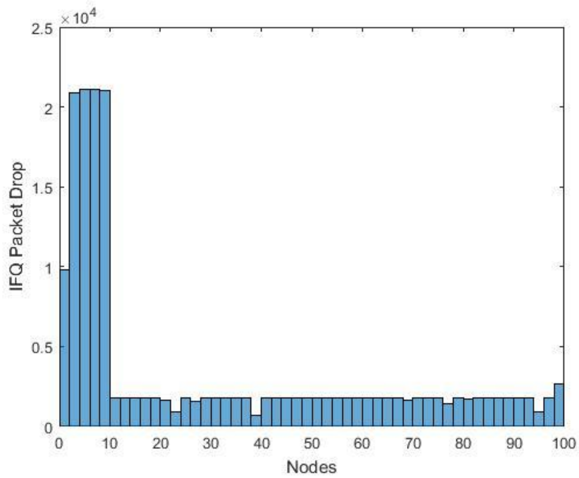

Figure11 IFQ Packet Drop-AODV

Figure11 shows the packet drop of interface queue by AODV at node level. It can be observed that the nodes 0-10 suffered from highest packet drop.

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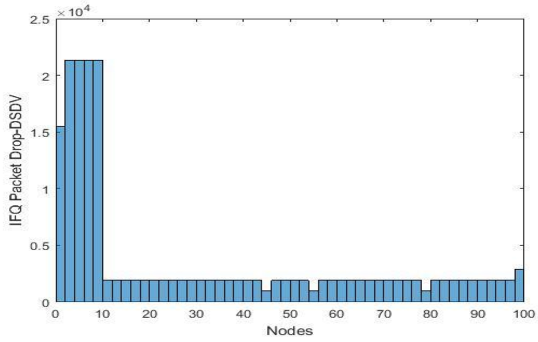

Figure12: IFQ Packet Drop-DSDV

Figure12 shows the packet drop of interface queue by DSDV at node level. It can be observed that the nodes 0-10 suffered from highest packet drop.

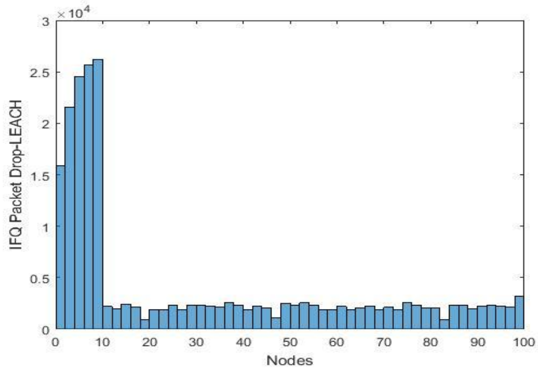

Figure13: IFQ Packet Drop-LEACH

Figure13 shows the packet drop of interface queue by LEACH at node level. It can be observed that the nodes 0-10 suffered from highest packet drop.

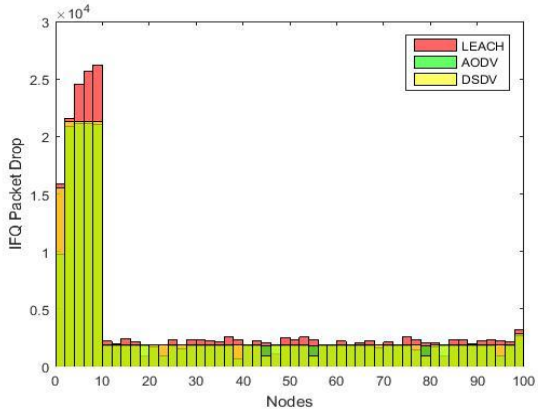

Figure14: Comparison-IFQ packet Drop

Figure14 shows the comparison of packet drop of interface queue by LEACH/AODV/DSDV at node level. It can be observed that the LEACH suffered from highest packet drop followed by AODV and DSDV.

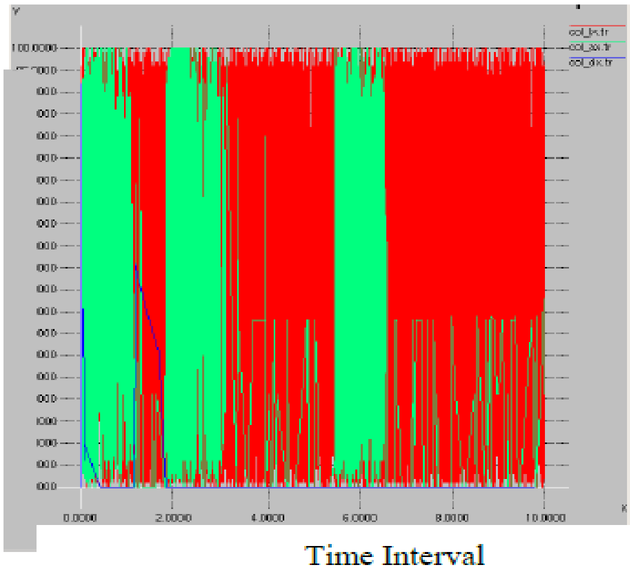

Figure15: the number of collisions at node level

Figure15 shows the number of collisions using different protocols at node level. LEACH has higher collisions as compared to AODV and DSDV which has least number of collisions.

Figure16 shows that AODV sent/received the highest RTS packets and there is minor packet drop as compared to DSDV and LEACH.

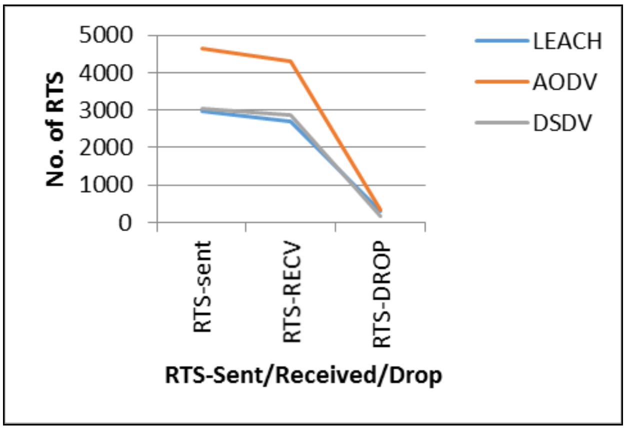

Figure16: No. of RTS sent/Received/Drop

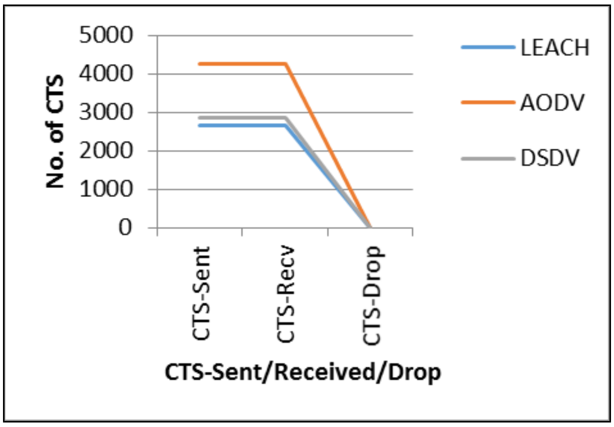

Figure17: No. of CTS sent/Received/Drop

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Figure17 shows that AODV sent/received the highest CTS packets and there is minor packet drop as compared to DSDV and LEACH.

VI. Logger for Vibration Data produced by Earthquake

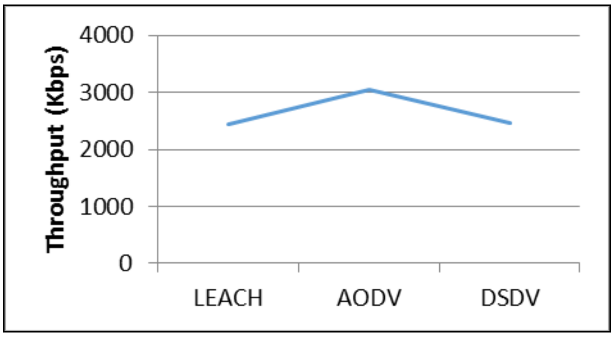

Figure18: Throughput-Vibration-Data

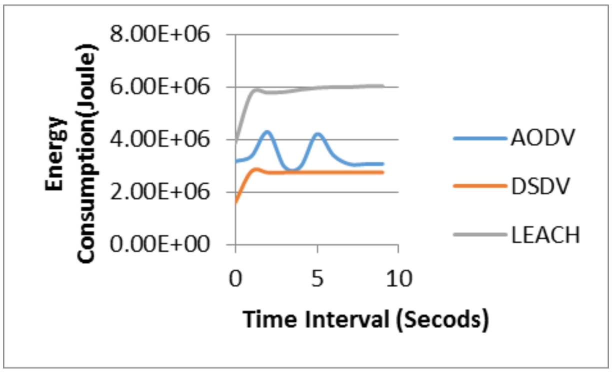

Figure19: Energy Consumption over Time Interval

Figure19 shows the energy consumption during a time period. It can be observed that LEACH consumed that highest energy as compared to AODV and DSDV.

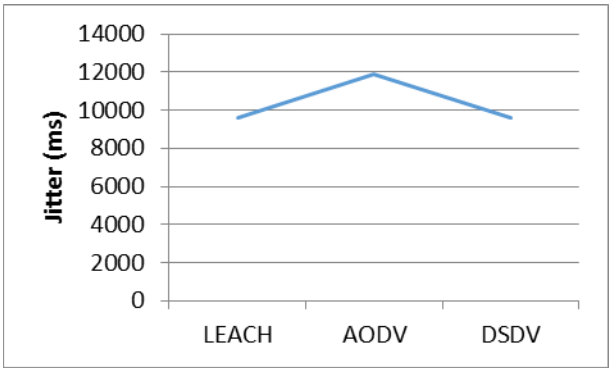

Figure20: Jitter

Figure20 indicates that AODV has the highest Jitter as compared to DSDV and LEACH.

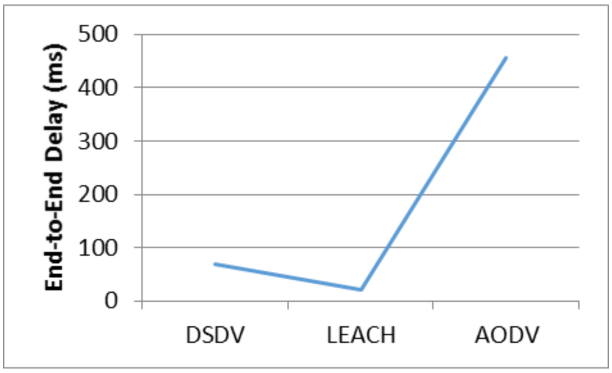

Figure21: End-to-End Delay

Figure21 illustrates that LEACH has the least End-to-End Delay followed by DSDV and AODV that suffers from the highest End-to-End Delay.

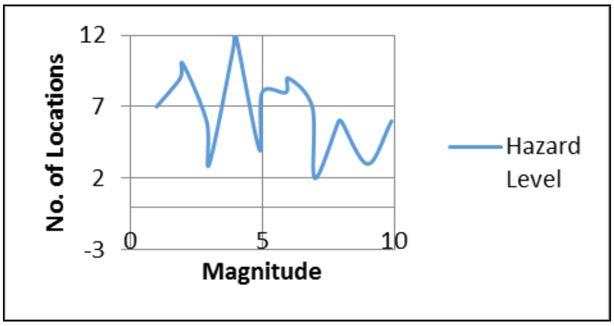

Figure22: Variations in Magnitude for different locations

Figure22 shows the variations in different locations (as per the table and location data can be obtained to identify the most sensitive areas and earthquake hazard sample data can be collected for future use.

Table3: Earthquake impact measurement

Magnitude	Level	Impact [22]
1.0–1.9	Micro	No Damage
2.0–2.9	Minor	
3.0–3.9		
4.0–4.9	Light	May cause marginal damage
5.0–5.9	Moderate	May cause marginal damage, threat to old infrastructure
6.0–6.9	Strong	May cause medium level damage
7.0–7.9	Major	May cause medium level damage
8.0–8.9	Excessive	It can damage the large scale area
9.0 and greater		It can change to earth surface and thus may results in destruction at very large scale

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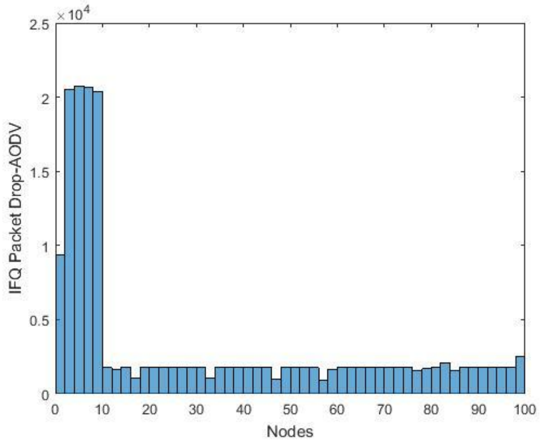

Figure23: IFQ Packet Drop-AODV

Figure23 shows the packet drop of interface queue by AODV at node level. It can be observed that the nodes 0-10 suffered from highest packet drop.

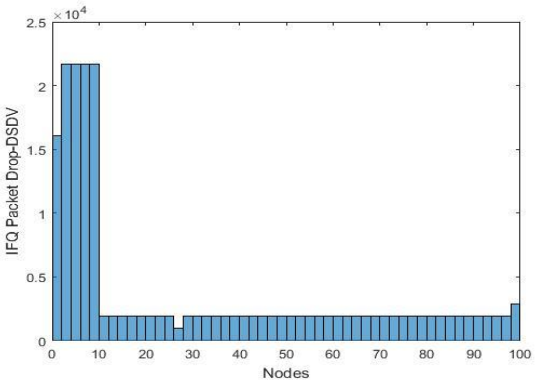

Figure24: IFQ Packet Drop-DSDV

Figure24 shows the packet drop of interface queue by DSDV at node level. It can be observed that the nodes 0-10 suffered from highest packet drop.

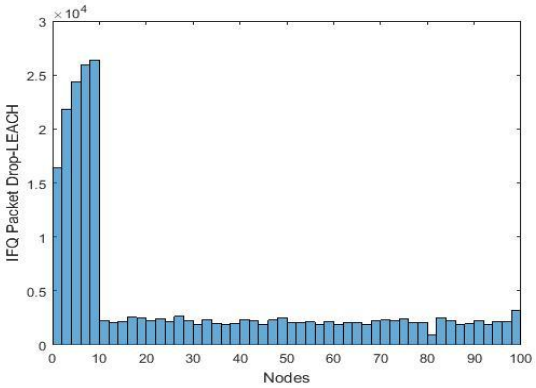

Figure25: IFQ Packet Drop-LEACH

Figure25 shows the packet drop of interface queue by LEACH at node level. It can be observed that the nodes 0-10 suffered from highest packet drop.

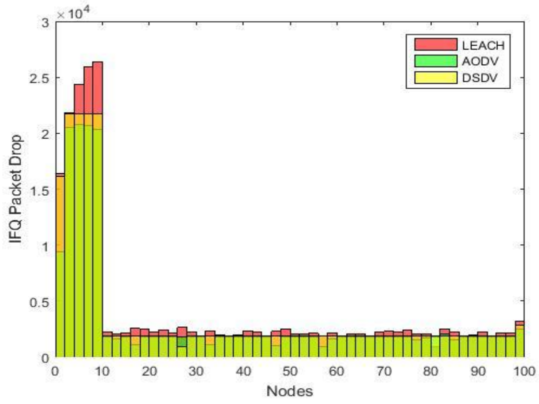

Figure26: Comparison-IFQ Packet Drop

Figure26 shows the comparison of packet drop of interface queue by LEACH/AODV/DSDV at node level. It can be observed that the LEACH suffered from peak packet drop followed by AODV and DSDV.

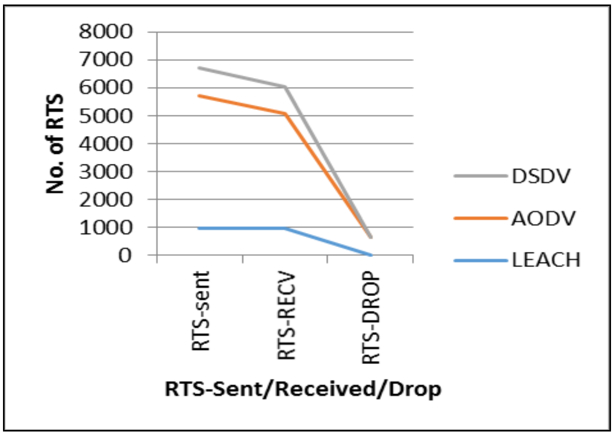

Figure27: No. of RTS sent/Received/Drop

Figure27 shows that DSDV sent/received the highest RTS packets as compared to AODV and LEACH which has the minor packet drop followed by AODV/DSDV.

Figure28 shows that DSDV sent/received the highest CTS packets as compared to AODV and LEACH which has the minor packet drop followed by AODV/DSDV.

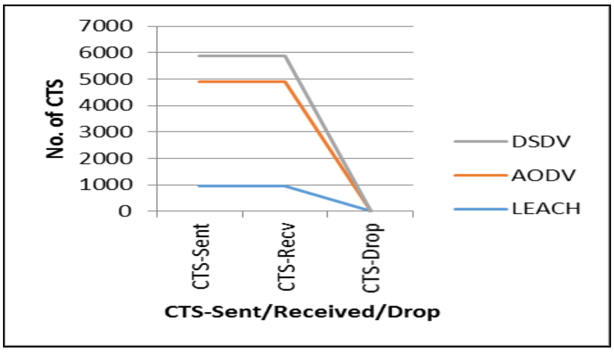

Figure28: No. of CTS sent/Received/Drop

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Figure29 shows the number of collisions at node level using different protocols. LEACH suffers from the highest collisions as compared to AODV and DSDV which has minimum number of collisions.

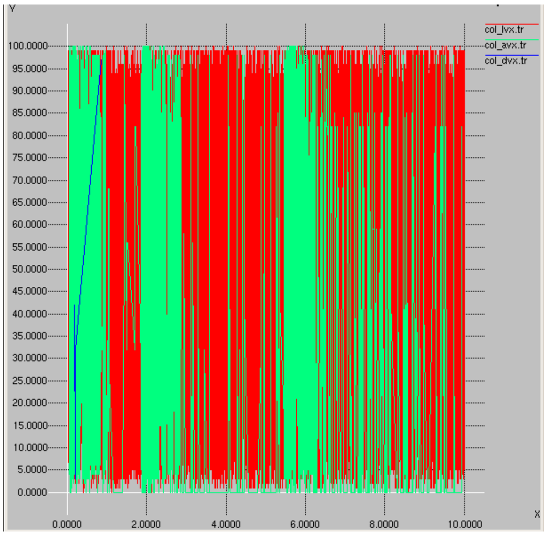

Figure29: the number of collisions at node level

VII. CONCLUSION

In this paper, a data logger is introduced which can collect the data under the constraints of natural hazards. It can handle both Temperature and Vibration data. Performance analysis is done using different routing protocols (AODV/DSDV/LEACH) under the QoS constraints i.e. Throughput/Jitter/End-to-End Delay and energy consumption, etc. Results illustrate that the performance and resource consumption of the routing protocols also vary with each data type. In case of temperature data, AODV outperformed (on the cost of Jitter and End-to-End Delay)as compared to others (DSDV/LEACH).

Performance of LEACH suffers due to high collision level followed by AODV/DSDV. It can also be observed that number of packets drop, RTS/CTS sent/received at IFQ also vary as per data type. Finally, it can be concluded that protocol must adopt the uncertain network environment as well as it must be compatible with different type of WSN applications. Its scope can be extended by introducing the machine learning approach for accurate predictions and forecasting.

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