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Performance Analysis of TORA, LEACH and INSENS Routing Protocols for Wireless Sensor Network

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Abstract: *Wireless Sensor Networks is a rising innovation for interest of analyst with its examination challenges and different application areas. It compreises of modest nodes with detecting, calculation and remote correspondences abilities. The constrained vitality asset is one of the fundamental difficulties confronting security in such systems. Routing is a huge issue and challenge in wireless sensor networks. Many routing methods have been designed and tested so far to improve the performance and quality of wireless sensor networks. The primary goal of this paper is to analyze the performance of TORA, LEACH and INSENS routing protocols for wireless sensor networks based on three parameters packet delivery ratio, routing overload and average end to end delay. Network Simulator 2 is used to doing these simulations. The outcome of this paper demonstrates the necessities of routing protocols in wireless sensor networks. By utilizing Network Simulator 2, we set up and assess the execution of TORA, LEACH and INSENS routing protocols concerning the previously mentioned parameters.*

Keywords: *INSENS, LEACH, PDR, TORA, WSN.*

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I. Introduction

Wireless Sensor Network (WSN) is a drift of the most recent years because of the advances made in remote correspondence, data innovations and electronics field. The advancement of ease, low-control, and a multifunctional sensor has gotten expanding consideration from different businesses [1]. The wireless network made out of self-governing and compress devices called sensor nodes. A sensor network is worked in such a way that it detects, collect and process data and after processing it transmits the sensed data to the correct destination. Sensor node uses radio frequency channel (RF) to make contact with other nodes in the network [2]. Different type of physical events like temperature, humidity, vibrations and seismic events are monitored through wireless sensor networks [3].

There are two types of sensors in wireless sensor networks. One is the common sensor that is used for sensing the physical events and other is the gateway sensor that is used to make interconnection with the outside world. Based on the application of the users there are several types of sensors like heat, magnetometer, accelerometer and light sensor. The Wireless sensor network is used in the modern world for many purposes because the daily need of the users is increasing rapidly. Conventionally, the sensor network covers the area such as nuclear-threat and radiation detection system, ammunition sensors for a vessel, biomedical applications, habitat sensing, and seismic monitoring. Now a day's Wireless sensor network move their attention to national security issues and IoT applications [4]. Wireless sensor network nodes are so superficial, such that the sensor network is decentralized. Instinctively, a large number of sensors is able to sense a huge area [5][6].

This paper provides a methodical analysis of three routing protocols namely TORA, LEACH and INSENS [6]. The objective of this paper is to analyze the performance of TORA, LEACH and INSENS routing protocols by a varying number of nodes based on several parameters namely packet delivery ratio, routing load and end-to-end delay.

The rest of this paper is organized as follows. WSN Routing Protocols are described in section II. Simulation and Performance analysis is described in section III. Finally, conclusions are given in Section IV.

II. WSN Routing Protocols

In this section, we shortly describe the basic idea of TORA, LEACH and INSENS routing protocol for wireless sensor network.

A. TORA (Temporally Ordered Routing Algorithm)

The Temporally-Ordered Routing Algorithm (TORA) uses a non-hierarchical routing algorithm for reaching the high degree of acceptability. TORA is an on-demand protocol because the nodes are initiated only when they need to send data to the destination. TORA performs three basic tasks namely route creation, route maintenance and route erasure. For this reason, TORA is called a flat routed protocol. For packet routing, TORA uses a distributed protocol for multi-hop networks. In multipath routing, TORA uses a temporal-order sequence number to send the packet from source to destination [7]. The main idea behind Ad-hoc networking is that it should not be centralized. TORA is a hybrid protocol because it uses a composed version of a proactive and reactive Ad-hoc routing protocol. TORA is designed for reducing the routing overhead problem for the different topological network [8][9]. Figure 1 represents the route creation and route maintenance process.

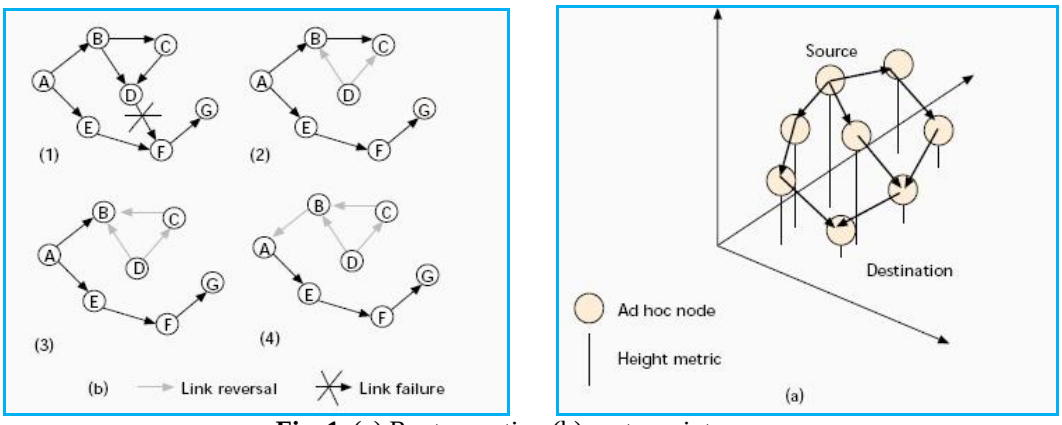

Fig. 1. (a) Route creation (b) route maintenance

B. LEACH (Low Energy Adaptive Clustering Hierarchy)

LEACH stands for Low Energy Adaptive Hierarchy routing protocol for wireless sensor network. LEACH is an energy efficient cluster-based protocol for wireless sensor networks. The concept of LEACH protocol is that it uses an energy consumption method that is uniformly distributed to every sensor node by recurrently picking separate sensor node as cluster-head. Thus the persisting time of sensor nodes becomes equal to the lifetime of the network [10][11]. In this way, energy consumption can be reduced and the lifetime of the sensor network enlarged. The purpose of LEACH protocol having two phases, one is the set-up phase and other is the steady phase. Cluster with non-cluster sensor nodes is formed using several multiple access techniques in LEACH routing protocol. This protocol is structured in such a way that it saves energy by permit the node to enter into the sleep state. LEACH rerouting the position of the cluster head with all the other nodes in the network because all the nodes are energy limited [11][12][13]. Cluster in the LEACH network are represent in fig-1.

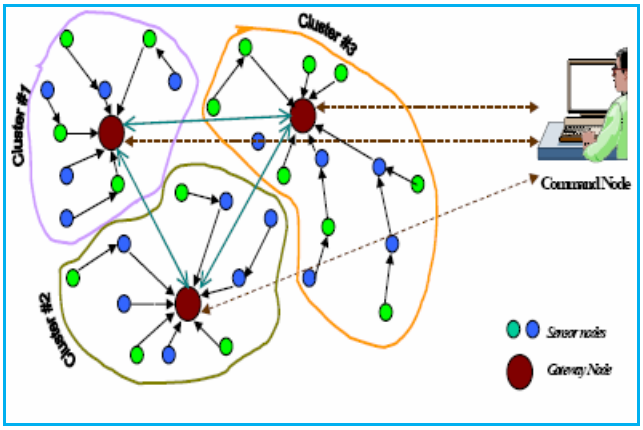

Fig. 2. Clusters in the LEACH network

C. INSENS (Intrusion-tolerant routing protocol for wireless Sensor Networks)

An intrusion-tolerant routing protocol is designed, develops and implemented by Deng, Han, and Misra [14] in 2002 for wireless sensor networks. Each node uses a forwarding table to make communication between a user and sensor nodes. The calculation, transmission, storage, and bandwidth requirements are reduced at sensor station whereas calculation, transmission, storage, and bandwidth requirements are increases at the base station. INSENS does not depend on identifying intrusions, yet rather endures intrusions by bypassing the noxious nodes. A significant property of INSENS is that while a noxious node might most likely trade-off a few nodes in its region, it cannot cause large damage in the system. Intrusion tolerance improves by bypassing malicious nodes [15].

III. Simulation and Performance Analysis

The simulation and performance analysis outcome is demonstrated in the following section using bar graphs. These bar graphs show the difference between TORA, LEACH and INSENS routing protocols by a varying number of nodes based on packet delivery ratio, routing load and average end to end delay.

A. Simulation Parameters

In this section, Simulation Parameters are depicting in table-1.

Table 1. Simulation Parameters

Simulation Parameters	
Parameters	**Value**
Simulator	Network Simulator-2
Studied protocols	INSENS, TORA, LEACH
Simulation time	100 seconds
Simulation area	500 m x 400 m
Node movement model	mobile
Speed	8 m/s
Traffic type	UDP, cbr
No. of Nodes	75, 100, 125

B. Packet Delivery Ratio for WSN Routing Protocols

The ratio between the number of packets that are received and the number of packets sent. TORA has a lower PDF than the other two protocols, as TORA reduces communication overhead; it increases unnecessary overhead due to its route adaptation feature in response to topological changes. TORA provides fewer PDR because of larger routing overhead where the path is upgraded in a versatile manner.

Table 2. Simulated Result for PDR.

No. of Nodes	TORA	LEACH	INSENS
75	35.12	71.85	63.21
100	45.67	78.91	64.56
125	58.45	77.29	65.67

LEACH provides better performance because it reduces routing overhead using cluster heads. INSENS sends the same packets multiple times to the destination thus lowering the PDR. Table 2 represents data of Packet Delivery Ratio that we are getting from our simulation and figure 3 depicts the performance comparison of Packet Delivery Ratio for WSN Routing Protocols.

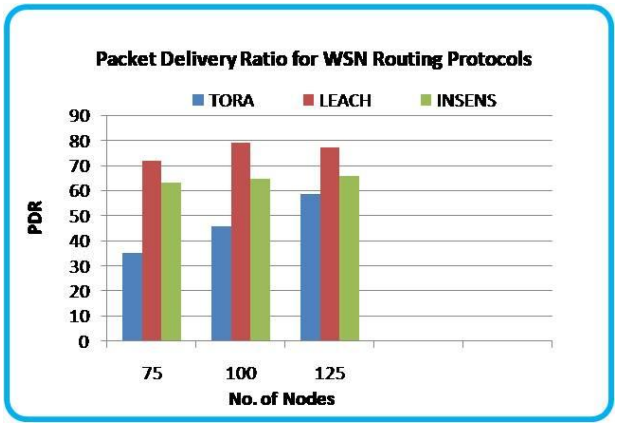

Fig. 3. Performance Comparison of PDR for WSN Routing Protocols

C. Routing Overhead for WSN Routing Protocols

The routing overhead measures by the total number of control packets sent divided by the number of data packets sent successfully. However, TORA provides a high degree of control for routing load because of its adaptive nature. TORA does not require any rerouting when a connection drops whereas LEACH and INSENS require rerouting when a connection fails. Therefore TORA becomes very suitable for larger networks yet has higher overhead for smaller networks.

Table 3. Simulated Result for Routing Overhead

No. of Nodes	TORA	LEACH	INSENS
75	4.14	1.46	2.35
100	3.23	1.42	2.13
125	2.67	1.38	1.89

INSENS sends more packets than the other protocols, and the difference increases with increasing numbers of nodes in the network. This difference is attributed to the overhead involved in dealing with security and intrusion tolerance issues. LEACH provides better performance even it has a cluster head routing load problem. There is also a co relation with the number of nodes. LEACH and INSENS provide better performance when the number of nodes is higher. Table 3 represents data of Routing Overhead that we are getting from our simulation and figure 4 depicts the performance comparison of Routing Overhead for WSN Routing Protocols.

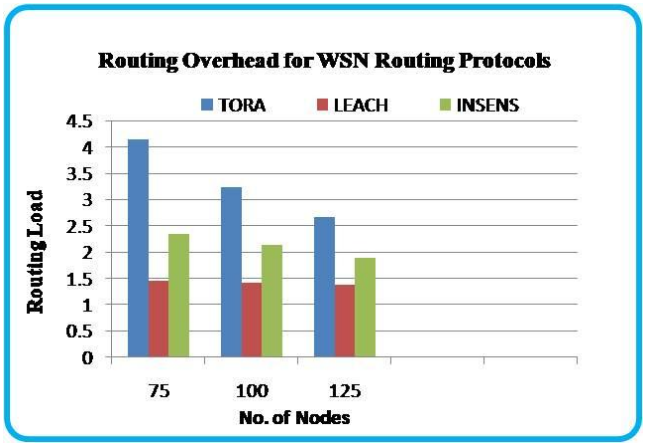

Fig. 4. Performance Comparison of Routing Overhead for WSN Routing Protocols

D. Average End to End Delay for WSN Routing Protocols

By using localization TORA reduces communication overhead. This feature of TORA helps to reduce end-to-end delay. However, LEACH provides lower end-to-end delay because it uses a single-hop clustering routing protocol method.

Table 4. Simulated Result for Average End to End Delay

No. of Nodes	TORA	LEACH	INSENS
75	11456	8564	10111
100	8765	8423	10786
125	7890	8398	11456

The Average end to end delay is higher for INSENS as in this protocol all nodes share authentication key with the base station creating more delay. Table 4 represents data of Average End to End Delay that we are getting from our simulation and figure 5 depicts the performance of Packet Delivery Ratio for WSN Routing Protocols.

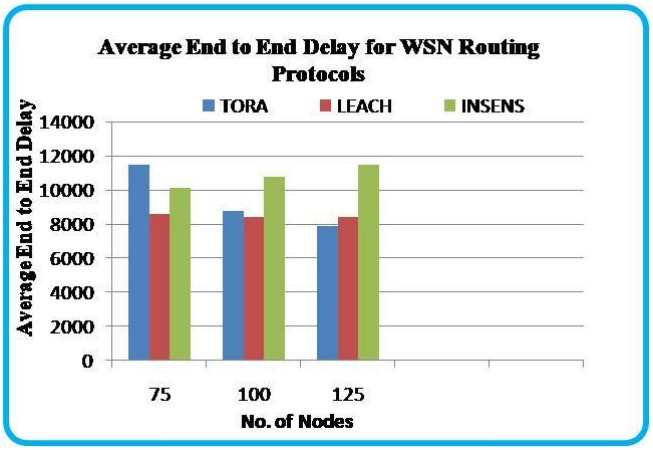

Fig. 5. Performance Comparison of Average End to End Delay for WSN Routing Protocols

IV. Conclusion

After analyzing and comparing the simulation result of all three protocols, we found that TORA provides less performance than LEACH and INSENS. TORA provides better performance when the number of node rises. TORA does not require any rerouting when a connection drops whereas LEACH and INSENS require rerouting when a connection fails. Therefore TORA becomes very suitable for larger networks yet has higher overhead for smaller networks. LEACH provides better performance than TORA and INSENS containing single-hope cluster architecture. The use of single-hop cluster architecture leads the LEACH protocol to achieve a higher packet delivery ratio. The Quality of Service is the main measuring factor for INSENS routing protocol, thus the execution of the system somewhat decreased, regardless of the way that there is apparently a close-by test between INSENS and LEACH, as a superior Quality of Service again implies a higher PDR.

Acknowledgements

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