Implementation and Comparison using NS2 of Flat and Hierarchical Wireless Sensor Networks by using Multihop and Gossiping Protocols

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ABSTRACT
In this research paper, we have implement wireless sensor networks using NS2. The networks implemented are named flat and hierarchical network. We have presented an evaluation and comparison of two routing protocols flooding and gossiping. These protocols suffer from issues related to reliability and delay information. The flooding protocol has a problem of implosion and overlap while the gossip protocol comes into existence to overcome these problems. We have also implemented the clusters in the flat and hierarchical networks. The clusters are used to improve the performance of the networks. While working for this research work, the main consideration is on the performance of two networks having different structures.

Keywords
Flat WSN, Hierarchical WSN, Multihop protocol, Gossiping protocol, Distance clustring, Pattern clustring, Packet loss, Packet delay, Throughput

1. INTRODUCTION
Sensor networks are spatially scattered autonomous sensors to monitor the environ-mental and physical conditions to move cooperatively. In today's world, wireless sensor networks play a major role in connecting the different types of devices to a single mutual network.

This paper first describes the implementation of two wireless sensor networks using two different architectures. In this paper, Flat and Hierarchical architectures are used, and their performances are measured with all possible aspects. The performance of each cluster is measured one by one using three clusters namely Multi-hop cluster, Distance cluster, and Pattern cluster. Each cluster has its own method to send and receive the data on the sensor network. The performance of these networks is also measured by using two protocols that are Flooding and Gossiping. Using all these protocols, the two architectures are tested from all aspects related to their performance.In flat architecture, all the nodes in the network are connected to each other for fast transfer of messages. The flat structure is a basic network. Whereas in the hierarchical network, the nodes are connected in a tree order. The hierarchical networks remove the problems of flat archiectures like overlap and implosion. In this paper, these two networks are campared with three different clusters (Multihop, pattern and distance clusters) and two different protocols (Flooding and gossiping protocols).

2. LITERATURE
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[3] Dr. Pradeep Mittal, Swati Sharma, "Wireless Sensor Networks: Architecture, Protocols" (January 2013) "In this research paper, the author describes that the wireless sensor networks are an interconnection of a large number of nodes deployed to monitor the system by means of measuring parameters."

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3. DESIGN
The wireless networks are designed in NS2. The design of NS2 wireless network had been used as a basis for security evaluation and defines the proposed system model and the complete description of the simulations and software necessary for the implementation of theprogram. NS2 is a Network tool widely used for simulating networks. Network simulator is a part of the software that predicates the network performance is a real network without there. It is compatible a series of routing algorithms and queuing.

NS2 is very useful as it is very costly to verify the viability of new algorithms; architectures test topologies verification, check data transmission simulators,etc. They are named for the network series network simulators discrete event and are widely used in the back of ad-hoc networks. Moreover, provide popular support network protocols, which provide

simulation results for wireless networks. In NS2, I used Tcl scripts to create the nodes. The networks are designed using the code of Tcl scripts.

In a flat routing infrastructure, each network identifier is represented individually in the routing table. Network IDs do not have network / subnet structure and cannot be précised. Routing IP-based IPX internetworks commonly use flat addressing mode and the networks and have a flat structure in routing.

Hierarchical routing infrastructure, the interconnection of networks can be divided into the routing domains. The routing domain is the collection of the ongoing networks connected by routers that share the required data for paths or routes within the domain. The common routing domain called the spine connects the routing domains.

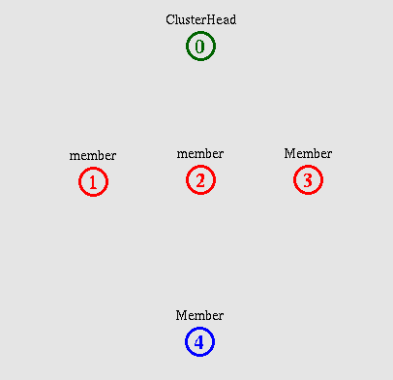

Figure 1: Design of flat architecture

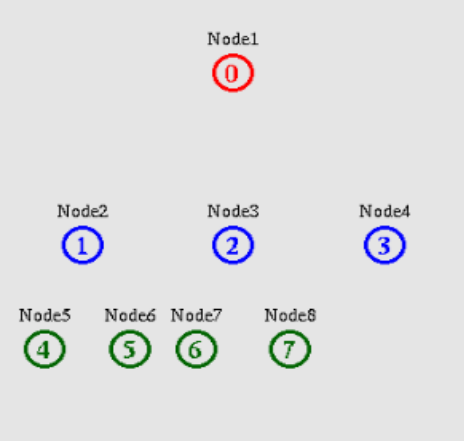

Figure 2: Design of hierarchical network

The NS2 is a good option for simulation of a wireless sensor network. In it, we can measure the various performance levels of the sensor network like its throughput, packet delay, and many others. The following line of code is used to create a new simulator object, opening and executing a nam trace file:

set ns_ [new Simulator]: ----To create a simulator object

set name trace [open Flat.nam w]: ------To open the name trace file

exec name Flat.nam &: ------To execute the name on the trace file

Before the simulation starts, we must say-ns 2 which events we want to track:

Set traced [open trace2.tr w]

Comparison of Flat and Hierarchical structures

Table 1. Difference between flat and hierarchical

Flat network	Hierarchical network
The aggregation of data is performed between different nodes.	The cluster heads perform the data aggregation.
Entire n/w breaks down if there is a failure of a sink node.	No breakdown of n/w if one node fails
High latency is involved during data transfer.	Low latency
To improve the energy efficiency, it does not utilize node heterogeneity.	Node heterogeneity can be utilized by assigning high energy nodes as the cluster heads.

4. RESULTS OF SIMULATION

Multihop Clustering: As in the multi hop cluster, all the nodes perform the tasks of sensing and sending the data. This increases the overhead of all the nodes. The multi hop cluster in flat network transfers the message to all its neighbors whenever it receives a message. While in Hierarchical, the multi hop cluster transfers the data by choosing a head of thecluster and then forward the message to its cluster members, and afurther one of the cluster members act as a cluster head to another cluster and sends the message to all the cluster members. In a flat network, there is no cluster division as in the hierarchical network.

Pattern Clustering:As in the pattern clustering, the nodes of the network are organized in a particular pattern so that they can be easily identifiable. When comparing the performance of both the networks using pattern cluster, there is more difference in flat and hierarchical networks. As we organized a Flat network in a circle network in which each node connected to no more than 2 nodes. In flat, there are some disadvantages of using circle cluster as if one of the link is broken, the half of the network goes down as there will be only one path for sending the messages.

Distance Clustering: In the Fig. 3, which is showing the performance of Distance cluster in Flat architecture, is at 0.0000 till 5 seconds, after that, when a simulation starts at 5.0, the packets starts travelling from one node to another.

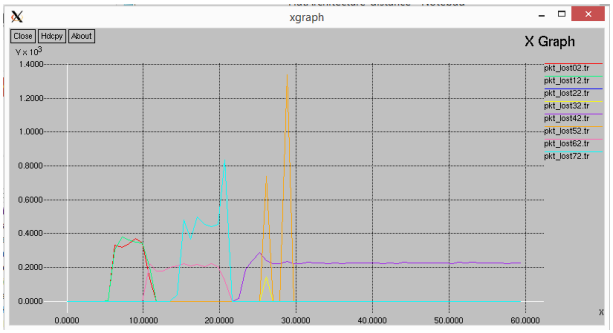

Figure 3: Packet loss of Distance clustering in Flat.

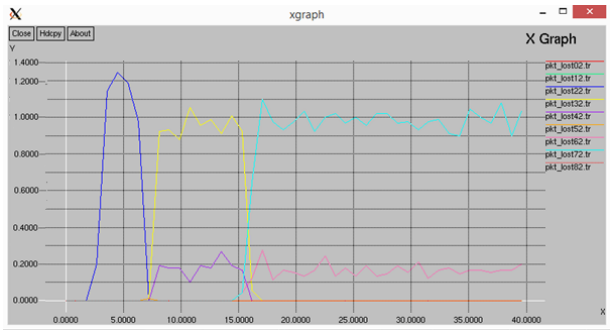

Figure 4: Packet loss of Distance clustering in Hierarchical

Due to the existence of a large number of nodes, it is not acceptable to assign a global variable to each node in a sensor network, and the line here describes the packet loss among those packets. As at time 22.00 the delay is small and at time 30.00 the delay is maximum. So it can be seen for hierarchical (Fig. 4), Maximum packet loss is at time 5.00 and minimum after 6.0000 and 20.0000.

Protocols: They define the method or rules for the transmission of the messages or data. In this research, we used two protocols flooding and gossiping. These protocols are completely different from each other. Their comparison is shown in below table:

Table 2. Difference between flooding and gossiping protocol

Flooding	**Gossiping**
Easy to implement.	Difficult to implement
Implosion problem (sensor node receives duplicate packets)	No implosion
Overlapping problem.	No overlapping problem
Information or the messages are flooded through the network.	Information or messages are sent only to selected nodes.
No Route calculation in it.	In it, the route calculation is there.
Packets are provided to all the nodes in the network.	The information packets are routed to selected nodes.

As in flooding protocol, the nodes distribute the message to all nodes, and that node further distributes the message to nodes adjacent to them. But in gossiping protocol, the nodes that want to send data will select the node randomly through which the data is to be sent. That selected node further selects one of its neighbors at the random basis and forward the message to that. This process continues until the message received by the particular receiver of the message. In this way, the load on the network will be greatly reduced as compared to flooding protocol.

5. SIMULATION SCENARIO

In the simulation scenario of Flat architecture (as shown in fig. 1), 5 nodes are organized in the grid size of 500 by 500. The basic simulation is done in a way that node 1 wants to send the data to node 5. So, node 1 distributes the data to all its neighbors i.e. to node 2, 3 and 4. Further, all the three nodes checks whether the data is for their processing or not. If not, they broadcast the data to all their neighbors. In this way, the node 5 will have 3 copies of the same data as sent by the node 1.

In Hierarchical (shown in fig. 2), 8 nodes are organized in the grid size of 500 by 500. The nodes are divided into ahierarchical structure using the clusters. It is different from flat in such a way that it broadcast the data to its clusters members only rather distribute it to all the neighbours.

Performance Measures

The performance measures are the parameters that are used to measure the overall performance of the network. In this research I user three performance parameters namely throughput, packet delay and packet loss. The throughput is the amount of successful packet transferred on the network. The packet delay is the amount of delay in the transfer of packets in one way communication. The packet loss occurs when one or more packet transferring across the computers fails to reach their destination.

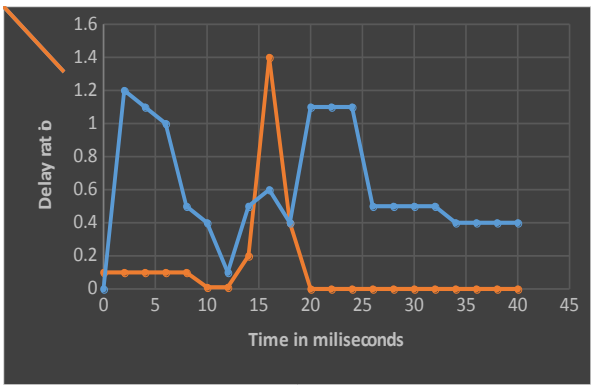

Figure 5: Packet delay in flat and hierarchical based on Multihop.

This chart shows the performance of flat and hierarchical architecture based on the delay of transmitting the packet. As shown in the chart, the flat architecture has relatively high packet delay as compared to hierarchal architecture. In flat architecture, the maximum delay is 1.2 ms whereas in hierarchical the maximum delay is 1.4 but just for some time.

Other than this the delay in hierarchical is very less as compared to flat architecture. So, the hierarchical architecture gives better performance as compared to flat architecture.

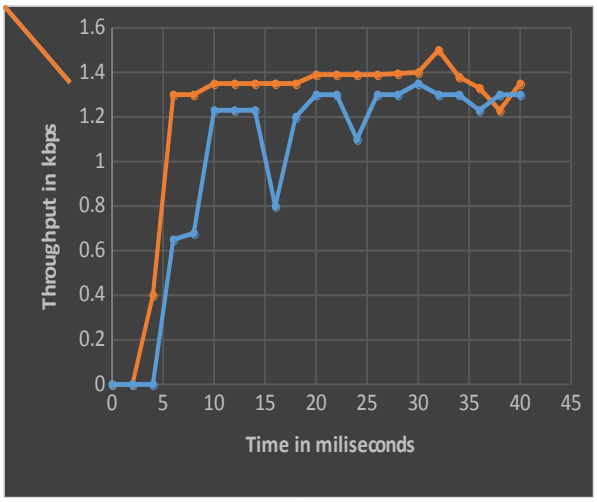

Figure 6: Throughput in flat and hierarchical based on pattern clustering.

The above chart displays the performance comparison of the flat and hierarchical networks. The graph shows the throughput of kbps of these networks. In the flat architecture, the throughput is relatively slow as compared with hierarchical networks. The maximum throughput of the hierarchical network is 1.5 kbps and in flat it is 1.39 kbps approx.

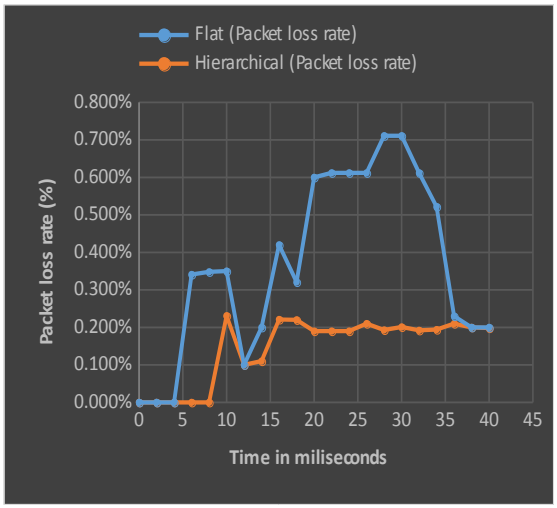

Figure 7: Packet loss rate in Flat and hierarchical based on distance clustering.

In the table 3, the packet loss rate of both the architectures is shown. As we can check from the graph that the packet loss rate in the flat network is very high because it commonly uses flooding protocol for sending the data. It distributes the packet to all its neighbours, so the packet loss is comparatively high in flat architecture. The maximum packet loss in flat if 0.70% but in hierarchical it is 0.22%. That means hierarchical gives better performance that the flat architecture.

Table 3. Performance based on flooding protocol in flat and hierarchical

Performance Comparison		
Flooding Protocol		
Time	Flat (Throughput in kbps)	Hierarchical (Throughput in kbps)
0	0	0
2	0.56	0.2
4	0.76	0.4
6	0.8	0.76
8	1.4	0.8
10	1.5	0.98
12	1.45	1.34
14	1.35	1.32
16	1.4	1.24
18	1.4	1.2
20	1.4	1.15

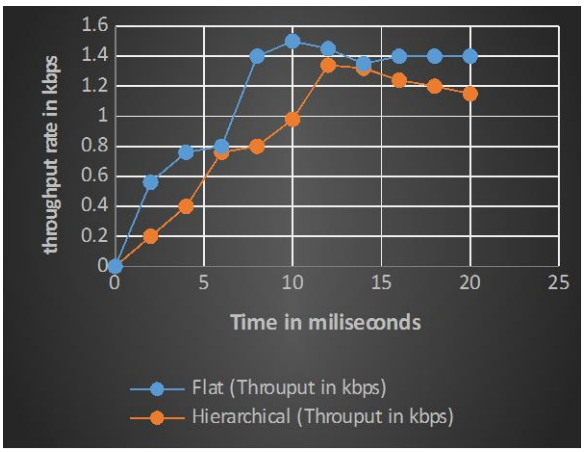

Figure 8: Throughput using flooding protocol.

The above graph shows the performance based on the flooding protocol of both the architectures. In the flooding protocol, the packets/data is distributed to all the neighbors until it reaches its destination. Now the networks simulated by me, there is the high performance of flat network using the flooding protocol. Because in flat architecture, the nodes distribute the packets to all its neighbors resulting in fast delivery of the message. Whereas, in hierarchical, the nodes are connected in some structure, so it takes the time to transmit the packet because the packets have to go through all the levels until it reaches the destination.

Table 4. Performance comparison based on gossiping protocol

Performance Comparison		
Gossiping Protocol		
Time	Flat (Throuput in kbps)	Hierarchical (Throuput in kbps)
0	0	0
2	0.61	0.4
4	1.21	1.3
6	1.35	1.3
8	1.35	1.3
10	1.35	1.35
12	1.35	1.4
14	1.35	1.41
16	1.35	1.41
18	1.35	1.41
20	1.35	1.41

The following graph shows the performance based on the gossiping protocol of both the architectures. The graph shows that both the architectures have arelatively good performance by using the gossiping protocol. The chart shows the throughput of both the architectures using this protocol. As in the gossiping protocol, the nodes selects one node among its neighbors and send the message only to that node. This reduces the overall traffic of the network as well as speed up the transfer speed.

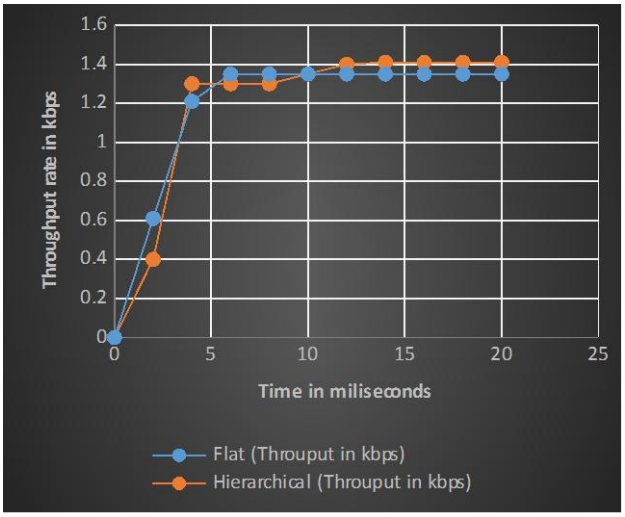

Figure 9: Throughput comparison using gossiping protocol in flat and hierarchical.

6. CONCLUSION

In this research, a detailed study of the techniques of routing wireless sensor networks that have been mentioned above are presented. They have the common goal of trying to extend the lifetime of the sensor network, without compromising data delivery. In general, the flat network which is an approach to design computer network that aims to reduce costs, maintenance, and administration is studied. The techniques of routing are classified based on the network structure in two categories on hierarchical routing protocols, and the flat routing protocols. Also, these protocols are classified based on multipath, based on consultations based negotiation, or QoS-based routing techniques, according to the protocol operation. Also, the advantages and disadvantages routing techniques and the gossiping and flooding protocols are highlighted.

Implementation of the Multi-hop, pattern, and distance clustering is done in the hierarchical and flat network, and their comparison is made. Although many of these routing techniques appear promising, there are still many challenges to be resolved sensor networks. So, the research specifies that the wireless sensor network that uses hierarchical structure are more efficient as compared to aflat structure. But in some cases the flat network also gives high performance for example when we have to distribute some message to all the nodes in the network.

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