Impact of varying packet size on multihop routing protocol in Wireless Sensor Network

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***Abstract*: The sensor networks basically infrastructure less, self configured wireless networks used to monitor environmental conditions such as temperature, sounds etc. which and communicate with each other using radio signals. The sensor nodes have non chargeable batteries and they soon get drained out of energy after only few rounds of data transmission. Wireless Sensor Networks are composed of small sensor nodes in the network which may be hundreds or thousands in number .Each individual node has its own sensing and computing devices along with the radio transceivers and power components. In this paper, impact of changing the packet size on the proposed multihop routing protocol is analyzed so that its exact effect could be understood and interpreted in terms of performance parameters like throughput etc so that reasons for packet drops, routing overheads could be understood in relation to routing of data packets over the network. The simulation results show that with the increase in packet size , the throughput attains a peak value at a certain point , then further it decrease very gradually.**

KEYWORDS:- Packet size, Proposed multihop routing protocol, throughput,Assisted LEACH,residual energy.

I. INTRODUCTION

The main features of WSNs are scalability with respect to the number of nodes in the network, self-organization, self-healing, energy efficiency, a sufficient degree of connectivity among nodes, low-complexity, low cost and size of nodes WSN can contain hundreds or thousands of sensing nodes deployed randomly. As the batteries of the sensor nodes are not chargeable, the need is to make the methods of data transmission so effective that the data should be able to be routed to the intended base station as quickly as possible thus minimizing delays and negating all kinds of the packet drops, routing overheads etc along with make the design of the routing protocol energy efficient. Packet size optimization is an important issue in energy constrained wireless sensor networks.

As larger size of packets may cause data bit corruption, wireless sensor networks will suffer from higher frequency of re-transmission. As compared to a larger packet size, small size packets are more efficient but creating too short packet size might cause problems, like higher overhead, due to per packet creation overhead and startup energy consumption for each packet[12]. In addition to it, WSNs face few other challenges as well. A fundamental challenge to these small networks is that wireless sensor networks are power constrained networks i.e. the wireless sensor node can only be set with a limited power supply usually less than 1.2 V.

In some situations, recharge/refill of power resources (battery) might be impossible. So we can say that lifetime of a sensor node is totally dependant on battery lifetime. In a multihop adhoc sensor network, each node plays the double role of data originator and data router. The improper working of a few nodes can cause considerable topological changes and might require rerouting of packets and reorganization of the network. The main task of a sensor node in a sensor field is to detect events, perform quick local data processing, and then transmit the data [12]

The variety of possible applications of WSNs to the real world is practically unlimited, from environmental monitoring, health care, positioning and tracking, to logistic, localization, and so on but everywhere the longevity of such networks has been a source of concern as parameters such as QoS, maximum data transmission for any ideal network or a specific application cannot be compromised.

Once data has been made available to the CHs , the next task is to route that data either using single hop manner or in multihop manner so that it could reach Base station. The results for homogeneous networks are better than heterogeneous networks but this fact is also true that the inclusion of certain heterogeneous nodes in the homogeneous environments can further improve the lifetime of the Wireless sensor network. This would help to analyze how the performance is affected by the packet size variation.

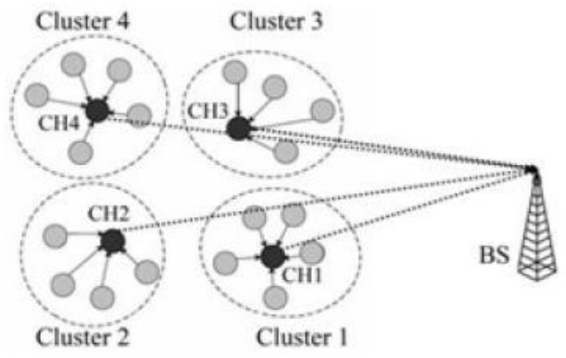

Fig 1: Structure of WSN in LEACH Protocol [1]

There are various kinds of routing in wireless sensor networks viz flat, hierarchical and location based. Various hierarchical protocols which deal with increasing the energy efficiency of WSN use the hierarchical routing in which lower level nodes sense the proximity of the target whereas the higher level nodes perform the task of sending information sent by the lower level nodes to the base station. To tackle the problem of energy efficiency of the wireless sensor networks many protocols have been developed over the years starting with LEACH(Low Energy Adaptive Clustering Hierarchy) Protocol [1] followed by HEED[2], A-LEACH[4],C-LEACH[5],M-LEACH[6] etc. The protocols like HEED, multihop LEACH, C LEACH. The second section discusses the related work, third section discussed the proposed technique, fourth section tells the result analysis and discussion finally the fifth and sixth sections describe the conclusion and future scope of the proposed technique.

II RELATED WORK

LEACH [1] is a self-organizing, adaptive clustering protocol that uses randomization to distribute the energy load evenly among the sensors in the network. In LEACH, the nodes organize themselves into local clusters, with one node acting as the local base station or *cluster-head*. If the cluster heads were chosen a priori and fixed throughout the system lifetime, as in conventional clustering algorithms, it is easy to see that the unlucky sensors chosen to be cluster-heads would die quickly, ending the useful lifetime of all nodes belonging to those clusters.

Thus LEACH includes randomized rotation of the high-energy cluster-head position such that it rotates among the various sensors in order to not drain the battery of a single sensor. In addition, LEACH performs local data fusion to “compress” the amount of data being sent from the clusters to the base station, further reducing energy dissipation and enhancing system lifetime. Sensors elect themselves to be local cluster-heads at any given time with a certain probability. These cluster head nodes broadcast their status to the other sensors in the network. Each sensor node determines to which cluster it wants to belong by choosing the cluster-head that requires the minimum communication energy. Once all the nodes are organized into clusters, each cluster-head creates a schedule for the nodes in its cluster. This allows the radio components of each non-cluster-head node to be turned off at all times except during its transmit time, thus minimizing the energy dissipated in the individual sensors. Once the cluster-head has all the data from the nodes in its cluster, the cluster-head node aggregates the data and then transmits the compressed data to the base station

$$T(n) = \begin{cases} \frac{p}{1-p*(r \bmod \frac{1}{p})} & \text{if } n \,\mathcal{E}\, G \\ 0 & \text{otherwise} \end{cases} \quad (1) \quad [1]$$

Where p is the desired percentage of cluster heads, r is = the current round, and G is the set of nodes that have not been cluster heads in the last 1/p rounds. Since the base station is far away in the scenario we are examining, this is a high energy transmission. However, since there are only a few cluster-heads, this only affects a small number of nodes.one section of the environment that is not being “sensed” as nodes die, as occurs in the other protocols. With the passage of time the need of multihop routing was felt which was supposed to increase the network lifetime as compared to the single hop routing protocols. The basic idea was that more would be the number of hops on which the data would be carried over before it reaches the base station, the more would be the extension of the time for which the networks would be active and functional[6].

Further, the caution is also to be kept while selecting the number of cluster heads nodes in the network as compared to the other sensor nodes in the cluster. The ideal value is 5 % for every 100 nodes in a network at a given time[4]. The other important point to be considered that the functions of data aggregation and calculation of the minimum distances from cluster heads to the base station should be divided between the various nodes other than the cluster heads in the higher levels of the protocol in the network like the helper nodes or gateway nodes so that cluster head nodes consume less energy as compared to the normal conditions for data transmission and thus are able to survive the network for longer duration of time especially in multihop routing so that the intended purpose is achieved.[5]

The concept of the multihop routing was discussed and implemented in multihop LEACH protocol[7] .Then another multihop routing protocol was proposed which gave the concept of introduction of gateway nodes in the network at the next level to the cluster head nodes[8] .The total number of the gateway nodes was about 10% of the total number of sensor nodes in the network These would act as intermediaries for the transmission of data from the cluster heads to the base station.

They followed a constraint that no two gateway nodes would transfer data to the gateway at the same time, rather the gateway nodes would provide them certain set time slots during which they would transmit data to them. At the given instant of time in the network if one gateway node is not free for transmission of data to the cluster head node, it would not waste time waiting for it turn, rather it would check the availability of other gateway nodes, which so ever is free, it would select it and transfer the data to it for transmission to the base station. Thus with increase of one more hop in the network, there is considerable extension in the network lifetime as compared to the single hop routing protocol.[9]

Yet another protocol named Assisted LEACH[4] focuses on network lifetime goes down when both data aggregation and routing are carried out by Cluster Heads alone which can be eradicated by usage of Helper Nodes for Routing and Cluster Heads for Data Aggregation. It reduced the overhead for route formulation to base station by electing next hop at each Helper Node using the Received Signal Strength values of beckon signal from base station already available at helper nodes during Helper Node Selection phase. The concept of Helper Nodes in Assisted LEACH (A-LEACH) protocol has improved the lifetime of the network by distributing the minimized energy dissipation throughout the nodes.

A. EFFECT OF PACKET SIZE ON PERFORMANCE OF NETWORK

In a wireless sensor network packet size has the direct effect on reliability and performance of communication between wireless nodes, so there is need to have an optimal packet size for wireless sensor networks. For instance having long packet size in a WSN network can cause data bits corruption and in turn increases the data packets retransmission. As we know that most of the power in a wireless sensor network is consumed in data transmission towards sink node; so having longer packet size in WSN will ultimately cause the data bits corruption and increase re transmission rate and that will affect the overall efficiency of WSN.

On the other hand, short packet sizes may increase data transmission reliability since the chances of bit errors over the link are less, but too short a packet size may not be efficient in the context of data payload carrying capacity because of the standardized data packet overhead. Also packet management at each node will become difficult. So they have chosen fixed sized data packets for energy efficient wireless sensor networks.

There are basically three fields in a data packet:
1. Packet Header
2. Payload/Data Segment
3. Packet Trailer

Hence increased retransmission will affect the network performance like it reduces the overall throughput of a link, so we can say that packet size also affects the overall network performance parameters as well in WSN cannot be captured[12]. It is well-known that the packet size directly affects the reliability of the communication since longer packet sizes are susceptible to wireless channel errors given a certain level of link quality. However, in multi-hop WSN, the quality of the communication links depend on the routes established in the network. Moreover, the existence of neighbor nodes that contend for the shared wireless medium affect the communication performance significantly leading to degradation in communication success be achieved.

However, variable packet sizes are not preferred in WSN due to strict hardware and computation constraints of wireless sensor nodes. As a result, we advocate to use fixed packet sizes. network. Usually small packet sizes lead to increased reliability due the decreased chance of bit errors over the wireless channel. On the other hand, small packet sizes lead to inefficient transmission due to the overhead caused by network protocols and error correcting codes, if applicable. This tradeoff can be influenced in favor of longer packet sizes through forward error correction (FEC) codes, which provide error resiliency in wireless communication [13].

Particularly for energy-constrained networks, packet delivery performance is important, since that translates to net-work lifetime. Sensor networks are predicated using low- power RF transceivers in a multi-hop fashion. Multiple short hops can be more energy efficient than one single hop over a long range link. Poor cumulative packet delivery performance across multiple hops may degrade performance of data transport and expend significant energy. Depending on the kind of application, it might significantly undermine application-level performance or large sized packets for data collection and aggregation[14]. On the contrary, it has been shown in the previous research works that due to the limitations and resource constraints of a WSN, its optimal packet size should be small and should have fixed length. These packet sizes can be constrained by homogenizing cluster sizes in a WSN[15].

III PROPOSED SCHEME

The proposed scheme[3] consists of assumptions, radio propagation model, algorithm which are discussed as:

A. Assumptions of proposed algorithm

1) These nodes are Mobile and homogeneous in nature.
2) Base station is far away from the network and is fixed.
3) Every sensor node is capable of communicating with every other sensor node scattered randomly in the network and to the Base Station if needed.

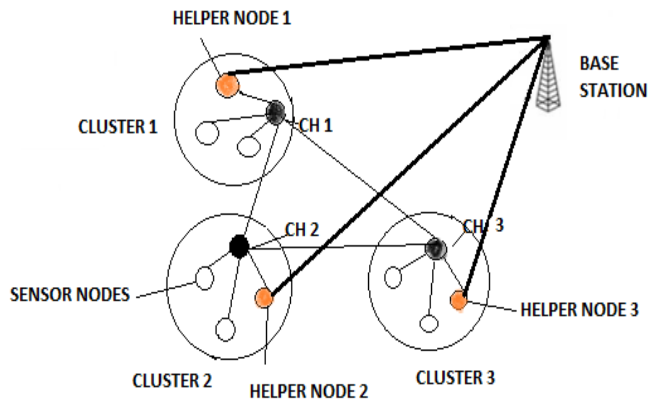

Fig 2 : Diagram of the Proposed Scheme [3]

B. Radio Energy Dissipation Model

For the proposed protocol, the first order radio model is used for energy dissipation in communication [10], where radio dissipates Eelec = 50 nano Joule / bit to drive the transmitter and the transmit- amplifier dissipates ε_{elec} =100 pico Joule/ bit/m2. To save energy, when required the radio can be turned on or off. Also the radio spends the minimum energy required to reach the destination. The energy consumed for data transmission of k bits packet is calculated from the Eq. (1).

$$E_{TX}(k,d) = E_{elec} * k + \varepsilon_{elec} * k*d^2 \qquad (2) \qquad [10]$$

and to receive this message, the radio expends energy is shown in Eq. (2):

$$E_{Rx}(k) = E_{RX\text{-}elec}(k) \qquad (3) \qquad [10]$$

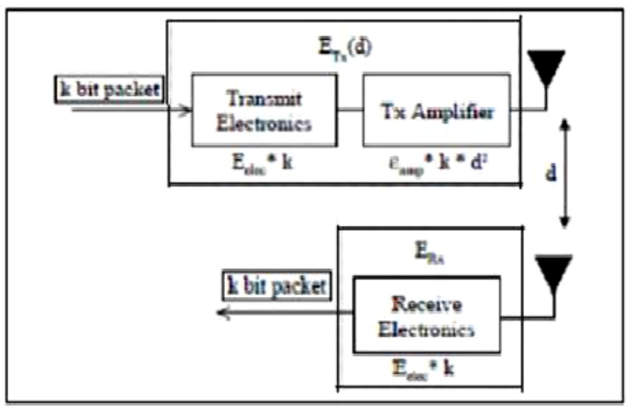

Fig 3 : Radio Dissipation Model [10]

C. Algorithm

The main goal of the approach is to extend network lifetime of the network[3]. For this reason, cluster head selection is mainly based on the residual energy of each node .The highest energy node that is if the remaining battery power is high then that node will become CH and the least mobility node will become a CH. Distance of a node from the cluster centroid. The BS calculates the distance of each node to its cluster centroid. The lesser distance node from the BS to itself will have the higher probability to become a CH. The network initialization phase starts after the sensor nodes are randomly distributed in the application area. The base station broadcasts a “HELLO” message to all the nodes in the network to ensure that the network is alive.

The algorithm starts with randomly selects a starting node that has not been visited and it retrieves all neighbor nodes which is density reachable from starting node with respect to Eps and MinPts. Here Eps is a radius of the cluster and MinPts is a minimum nodes required inside the cluster. If the number of neighbors is greater than or equal to MinPts then the cluster is formed as . Let the distance between two sets of nodes S1 and S2 be defined as dist (S1, S2) = min {dist (p,q) | P Ɛ S1, q Ɛ S2} and further the nodes with the highest energy are selected as cluster heads by the sensor nodes to which “ADVERTISEMENT” message is broadcasted by the CH and all the sensor nodes which join the cluster reply back with “ACK” message. The next phase deals with the selection of the cluster heads for each cluster. After the clusters are formed, the Base station should decide whether or not the node becomes a cluster head for the current round. To find that the value of energy are computed for all the nodes in the network for each round, the node which has highest residual energy is elected the cluster head for the specific round.

Once the clusters are created and the CH issues a TDMA schedule to all the other sensor nodes in the clusters during which they need to transmit data to their Cluster heads. Base Station constantly observes the residual energy and Mobility of the existing CH. If it is below the threshold value then it select another CH based on same conditions, described earlier. Finally the CH should be checked out the routing path. If the routing path residual energy goes below the threshold or any node fails, BS selects another path and sends the routing path to the respective CH. So, the base station calculated the distance of all nodes in the network to itself using RSSI value[18] which is calculated with the help of two ray ground model

$$P_r(d) = \frac{P_t * G_t * G_r * h_t^2 * h_r^2}{d^4 L} \qquad (4) \quad [11]$$

where

P_r: Power received at distance d
P_t: Transmitted signal power
G_t: Transmitter gain (1.0 for all antennas)
G_r: Receiver gain (1.0 for all antennas)
d: Distance from the transmitter
L: Path loss (1.0 for all antennas)
h_t: Transmitter antenna height (1.5 m for all antennas)
h_r: Receiver antenna height (1.5 m for all antennas)

The data aggregated by all the cluster heads are sent to the helper nodes. The helper nodes are those which have second highest energy left in them at the end of each round. Sometimes there might be a situation when there is no such helper node left inside the cluster as it too has been drained out of its energy so in that case the cluster head would search for some other available nearby helper node in some other cluster to which data can be transmitted. The cluster heads enter into sleep mode once they transmit data to the helper nodes so that their energies are saved. At a given time, all the cluster head nodes send data to the helper nodes using multihop routing. Further the helper nodes are informed of the shortest path calculated by the base station along which the data is transmitted again by multihop routing[3].Thus this protocol would enhance the performance as well as improve the lifetime of wireless sensor network.

IV RESULT ANALYSIS AND DISCUSSION

The simulation scenario consists of 50 sensor nodes deployed in the network field of size 1300m*1000 m in the wireless sensor network. All the simulations have been performed using NS2.The results have been obtained at the end of seven rounds of the network at simulation time = 30 sec for both the protocols. The graphs show two lines one in blue color and other in pink color .The blue line shows the results of the Assisted LEACH protocol and the pink line shows results of the proposed multihop LEACH protocol. The main objective of simulation is to analyze the effect on performance on the two multihop routing protocols by varying packet size.

TABLE 1
SIMULATION PARAMETERS

Simulator :	Ns-2.35
Simulation time :	30 sec
Channel Type:	Wireless
No of nodes:	50
Topology:	1300m *1000m
Radio Propagation model:	Two way ground
Communication Model :	Bi direction
Transmission Range:	250m
Interface Queue Type:	Queue/Drop Tail/Pri Queue
Initial energy:	100 Joules
Antenna Type:	Omni Antenna
Traffic Type:	CBR
Packet Size:	512 bytes

A. Performance Metrics

The performance analysis of the proposed protocol is done by comparing its results of Assisted LEACH Protocol which has been considered as the base protocol for the development of the proposed scheme by using some of the performance metrics such as:

1)Throughput [3]: It is the measure of the number of bits of data packets that are transmitted from source to destination in given time. It is always less than 1. The formula of measuring throughput is

$$\frac{Number\ of\ bytes\ received}{Time\ in\ milliseconds} \qquad (5) \quad [3]$$

Generally it is measured in Kb/sec or Bytes/sec. For the protocol aiming to enhance the throughput of the network , it is must that the packet drop rate, jitters , routing overheads and congestion or packet loss should be as less as possible otherwise lower value of throughput would decrease the data packets delivery from the source to the destination.

2) Average Energy Consumption (Ea) [3]

The average energy consumption is calculated across the entire topology. It measures the average difference between the initial level of energy and the final level of energy that is left in each node.

Let E_i = the initial energy level of a node, E_f = the final energy level of a node and N = number of nodes in the simulation. Then

$$E_a = \sum_{k=1}^{n} (E_{ik} - E_{fk}) / N \qquad (6) \quad [3]$$

This metric is an important because the energy level of the network uses is proportional to the network's lifetime.

The lower the energy consumption the longer is the network's lifespan. Thus the ideal value for average energy consumed by the protocol should be as less as possible otherwise if the protocol would consume more energy after every round then it would become difficult to increase the lifetime of the network . The exact formula for calculation of average energy is inbuilt in NS2.

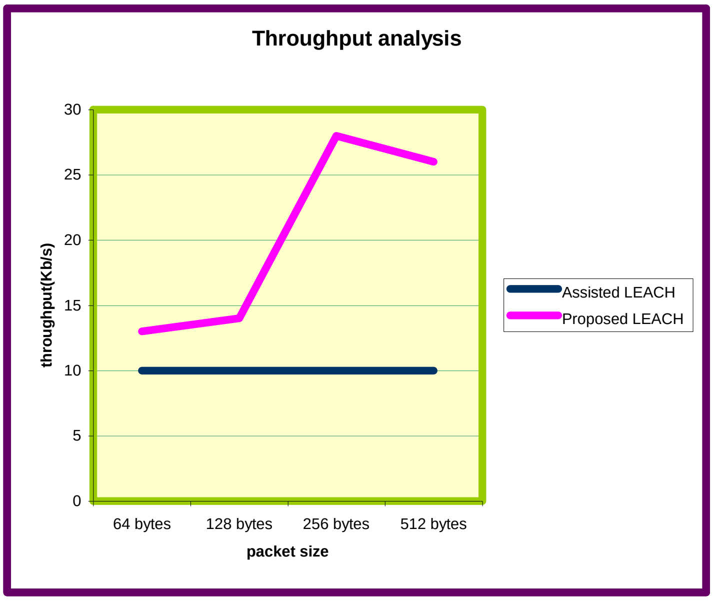

Fig 3 : Graph showing comparison of two protocols based on throughput.

The graph clearly shows that by varying the packet size from 64 bytes to 512 bytes, the Assisted LEACH protocol shows no change in throughput over seven rounds of simulation and that its value is much less than that of proposed multihop LEACH protocol and in addition to it, at no point of time the value of throughput of the proposed scheme drops below the value of the Assisted LEACH Protocol which certainly advocates better performance of the proposed scheme. The value of throughput is highest for packet size of 256 bytes.

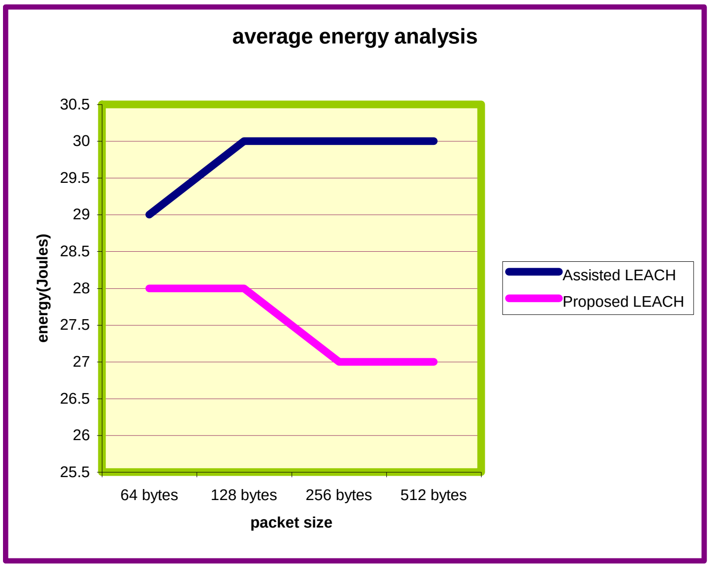

Fig 4: Graph showing comparison of two protocols based on average energy.

The graph clearly shows that by varying the packet size from 64 bytes to 512 bytes, the Assisted LEACH protocol shows an early consumption of energy for packet size 64 bytes and 128 bytes and then it becomes stable for other packet sizes whereas as it is a known fact that less the energy consumed by any protocol over the period of time, more would be its lifetime.

After seven rounds of simulation, the energy consumed by the roposed LEACH multihop routing protocol is stable for packet sizes 64 to 128 bytes then it lowers down and stabilizes for 256 bytes packet size and onwards which clearly indicates that for bigger packet sizes, the energy consumed by the protocols in data transmission over the network is reduced .

TABLE 2
SUMMARY OF RESULTS

Packet Size	Assisted LEACH		Proposed Scheme	
	Throughput	Average Energy	Throughput	Average Energy
64 bytes	10 Kb/s	29 J	13 Kb/s	28 J
128 bytes	10 Kb/s	30 J	14 Kb/s	28 J
256 bytes	10 Kb/s	30 J	28 Kb/s	27 J
512 bytes	10 Kb/s	30 J	26 Kb/s	27 J

V. CONCLUSION

The above results provide an insight to the fact that by varying the packet sizes while transmission of data over the network and analyzing its impact on the various performance metrics the inference thus drawn is that due to difference in main technique of both the multihop routing protocols the results show a marked variation as throughput is more for the proposed scheme than the Assisted LEACH protocol whereas the energy consumption is less which proves the proposed multihop routing protocol to be better in performance than the Assisted LEACH Protocol.

VI. FUTURE SCOPE

In future many other protocols based on the same concept can be developed which work in the heterogeneous environment, by doing so the network lifetime of the protocols would further be extended .Apart from it the performance analysis can be made for such routing protocols to understand the impact various parameters have on it working. This would provide an estimate as to areas of improvement of those protocols by applying suitable techniques . The adaptability of the protocols can be checked out and they even can be made more flexible to all kinds of changes made to them from time to time.

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