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Mathematical Modeling and Designing of a Novel Improvised Cooperative BalancingRouting (CBR) Protocol to Enhance the Lifetime of WSNS using Load Balancing Concepts

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Abstract:

In this paper, the design & development of a novel cooperative balancing routing (CBR) protocol to enhance the lifetime of WSNs using load balancing concepts by decreasing the energy consumption during the data exchanges is presented in the respective section. The main objective of the research work presented in this paper is to present an improvised version of the CBR that computes the routing path by using cooperative mechanisms using the concept of load balancing. This paper also demonstrates the various results obtained for all the test cases along with the necessary observations and explanations in the form of discussions and diagrammatic representations. The paper finally concludes with the overall conclusions of the CBR work.

Keywords: WSN, Static, Dynamic, Packets, Authentication, Sensor, Node, Distribution, Network, Key, Message Authentication Code Protocol, Security, Routing, Management, Sink, Cryptography, Source, Energy, Router, Attacker, Base Station, Machine condition monitoring, Industrial wireless sensor networks, Cooperative communication, Medium access control, Indoor industrial monitoring, Energy efficiency, Space time block, Stability.

1. Introduction

A brief review about the background work that was done till date by the various researchers in the chosen research field is presented.

What is Cooperative Balancing Routing Protocol - CBR protocol?

In a nutshell, it can be defined as a cooperative- distributed routing protocol that is designed especially for WSNs. It is based on a multi hoptechnique to deliver data to the sink node. Here, the sensor nodes act as routers to receive/send data packets from/to other nodes in their transmission domain. The CBR looks forward across the elected paths, then chooses the path that minimizes the consumed energy taking into account the residual energy of the nodes. Accordingly, nodes have the ability to take accurate decisions to balance energy consumption during the routing process, which in turn prolongs the network lifetime and minimizes network partitioning [17] [24] [31].

A routing protocol specifies how routers communicate with each other, distributing information that enables them to select routes between any two nodes on a computer network. A routing protocol shares this information first among immediate neighbours, and then throughout the network. There are different ways to classify routing protocols based on network organization, route discovery and protocol operation. According to route discovery, routing protocols in WSNs are classified to proactive, reactive or hybrid depending on how the route is determined. In proactive routing, the routes are determined before they are needed and the routes are updated when the network topology changes.

However, the network topology of ad hoc network changes constantly, because of that, proactive routing protocols are not appropriate for dynamic networks. On the other hand, reactive routing protocols only do a route discovery procedure on demand. So, the reactive protocols are appropriate for dynamic networks. But, the time taken for determining a route may lead to increase latency for data delivery where the time in some applications is significant. Hybrid protocols are combination of the reactive and proactive routing protocols. Based on network organization, WSNs have three sub-categories, viz., Flat, Hierarchical, and Location-based routing protocols.

Flat network mean that all the sensor nodes have the same level of functionality and responsibilities. But, sensor nodes in a hierarchical network have various roles to play, and they are logically located at different levels. Many hierarchical networks are divided into different clusters and each cluster designates a cluster head to aggregate and relay inter- cluster traffic. The location-based routing protocols depend on the physical location of the sensor nodes. In protocol operation, there are five sub-categories: Query-based, Negotiation-based, Multipath-based, Quality of Service (QoS)-based, and Coherent-based routing [9], [10].

Optimizing the network lifetime can be achieved by preserving energy and reducing the power consumption in WSNs through routing protocols. There are several routing proto- cols already proposed to reduce the energy consumption and enhance WSNs lifetime. However, most of these solutions try to find an energy efficient path and don't account for energy consumption balancing in sensor network. This usually leads to network partitioning. In the following an overview of literature related of these protocols. Shah and Rabaey [11] proposed a flat based algorithm for sensor networks, called Energy Aware Routing protocol (EAR) [11], is a reactive protocol improvement of Directed Diffusion (DD) [12], the authors of [11] used a multiple path with minimal cost between source and destination and assign for each path a probability.

Every time data is sent to destination on the path that has a high probability among all paths. There are more than one improvement to EAR protocol. These improvements are Fair Energy Aware Routing protocol (FEAR) [13], Balanced Energy Efficient Routing (BEER) [14] and Cross-Layer Balancing Routing (CLB-routing) [15]. Yassed *et.al.* in FEAR, add a parameter to the probability equation in [11] to achieve some kind of fairness between nodes to improve the network lifetime by reducing the probability of selecting the nodes that belong to several routes. They used two control packets, Forwarding Table Message (FTM) and Number Forwarding Table Message (NFTM) to calculate the number of data packets that are forward by each node.

Each node sends FTM message to its neighbours in forwarding table containing the identifier of these neighbours. Each node receives FTM message counts the number of FTM messages containing its identifier, and insert this number in NFTM message which sends as a response to FTM message.

In BEER, authors use the same control packets that proposed in FEAR to add new parameter to a probability equation to reduce the probability used of node belonging to a unique route of source node. Authors in Cross-Layer Balancing Routing (CLB-routing) use the Request to Send (RTS) and Clear to Send (CTS) control packets in MAC layer rather than FTM and NFTM packets in [13], [14]. They used CTS to know how much of data packets are sent by each forwarding node to achieve balancing between nodes.

Data Gathering algorithm Based Load Balance (DGLB) [5, 6], is divided the sensor node into several layers according to the hop count between the sink and sense node to achieve better load balance in the inter-cluster. Also, the cluster head would not be switched frequently and this can save the energy consumption on cluster head selection. Rajeh *et.al.* [16] proposed Evaluation and Enhancement of Data Gathering Algorithm based Load Balance (E2DGLB) to improve the WSNs lifetime. E2DGLB is enhancement of DGLB protocol. To achieve a fair energy consumption from nodes during the routing process.

Authors of [16] they added the residual energy of the receiver node into the probability equation. Therefore, achieved more balancing in energy consumption during the routing process. Hanckem *et.al.* proposed Simple Energy Efficient Routing Protocol (SEER) [17], is a multi-hop routing, which tries to save energy by selecting routing path that has highest residual energy. Selecting forwarding nodes depends on two metrics, the hop count and residual energy. Where the sender node chooses a forwarding node that has less hop count or hop count equal to the sender hop count and has a highest residual energy of the all neighbor.

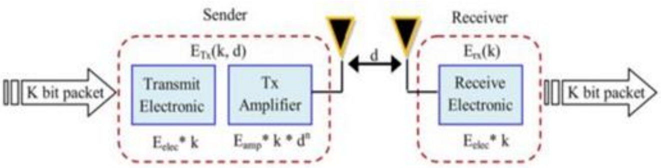

Fig.1: Energy dissipation model

However, from the stand point of energy management and balancing energy the SEER protocol is poor. Ehsan et.al. proposed Balanced Energy- Aware Routing protocol (BEAR) [18], is extended version of SEER protocol. In the network setup, authors add a new process to make a balancing in the network by calculating a probability for each neighbor node and use the probability to select the forwarding node rather than residual energy in SEER. Also they used a learning automate to update the energy level for each node, where the energy level of the sender node is attached to the data packet header. So there is no need to energy message like SEER protocol.

The sensor network model shown in the Fig. 1 has the following assumptions and properties:

- K sensor nodes are randomly deployed in a sense zone in flat structure, all sensor node splay the same role in the network.
- There are $S = K – 1$ source nodes send the sensed data to the sink.
- This K sensor node are static (the nodes and sink are not mobile).
- The energy of sensor node can't be recharged.

- Each node has a unique identifier (ID).
- All nodes are homogeneous and have the same capabilities.
- There is one sink in the network, which is deployed at a fixed place outside or inside sense zone.
- Sensor nodes can't get the location information; they are location-unaware.
- The network application is event driven.
- The radio power is controllable; the transmission power depends on the distance to the receiver, which is controlled by the nodes.
- The radio channel is symmetric, this means; the energy required to transmit a message from node *A* to node *B* is the same energy required to transmit a message from node B to node *A*.

2. Design of Enhance CooperativeBalancing Routing CBR Protocol

In this section, a new routing protocol for WSN is introduced, which is called as the Cooperative Balancing Routing (CBR) protocol. CBR is a cooperative-distributed routing protocol that is designed especially for WSNs. It is based on a multi hop technique to deliver data to the sink node. Hence, the nodes (e.g., sensors) act as routers to receive/send data packets from/ to other nodes in their transmission domain. However, the routing process may increase the load on some nodes, this leads to the network partitioning as these overloaded nodes are quickly strained. The aims of CBR is to increase the network lifetime and stability, as well as preventing network partition.

This can be accomplished by balancing energy consumption among nodes during the routing process. CBR does not need the whole information about the network like location of each node, instead, it only needs the residual energy of its neighbours and the distance to them. Thus, each node can take the appropriate decision for selecting its next hop locally during data routing. CBR categories nodes starting from the node that wishes to send data into three categories depending on their situations during the data transmission as shown in Fig. 1, which are - creator nodes (CN), also called sender nodes, Broker Nodes (BN), and proposed nodes (PN) or the levels / zonal areas.

Definition 1: Creator Node (CN) is the node that

generate a new data packet by event sense.

Definition 2: Broker Node (BN) is the node in the

transmission range of the creator node and has a hop count less than or equal to the creator's hop count.

Definition 3: Proposed Node (PN) is the node in the

transmission range of the broker node and has a hop count less than of the broker's hop count.

Before sending data to the sink, CN sends a Request Packet (REQ) to the BNs asking for some information about its proposed node that has a highest probability to select as a forwarding node. This information includes ID and the residual- energy. According to this information the node can elect appropriate forwarding node in order to keep the stability and the lifetime of the network as more as possible. When BNs receives a REQ packet, they responded by sending a Reply Packet

(REP) containing their PN information.

A sensor node contains 3 agents, namely, Routing Information Estimator Agent (RIEA), Neighbour Information Monitoring Agent (NIMA), and Forwarding Data Agent (FDA) as shown in Fig.2. RIEA is responsible for the establishment of Neighbouring Table (NT). After broadcast a preparation packet by the sink, RIEA in each node calculates the hop count between sensor nodes and the sink to build the NT and stores it in Routing Information Database (RID). RID has two tables; NT, which contains the relevant information about the node's neighbour such as ID, hop-count, residual energy, cost and distance between them etc.

The second table is a Routing Table (RT), which contains the routing information such as source node, previous node, next node, time to live (TTL) and destination node etc. On the other hand, NIMA is responsible of updating the NT in each node. Finally, FDA is responsible of calculating the cost and the probability for each node in the NT as well as selecting the most reliable path among nodes. Thus, each node can take accurate decisions for electing the next node locally based on the interaction with its neighbors.

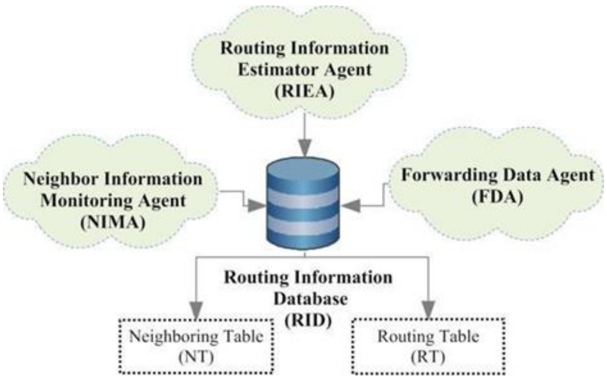

Fig. 2: The 3 sensor node modules, viz., NIMA, RIEA & the FDA

Generally, CBR consists of three phases, neighbouring table establishment phase, data transmission phase and neighbouring table update phase. Firstly, sink broadcasts a preparation packet to establish the neighbouring table of each node by calculating the hop counts between sensor nodes and the sink. Secondly, a node sends a REQ packet to its neighbours when it needs to forwarding data to the sink. Finally, update the neighbouring table in nodes.

3. Overview of CBR Routing Protocol Development

In this work, we are going to enhance the network life time, for this we are going to consider the network as a layer by layer and in the network deployed in our case, we have used 4 layers / zones. In a particular network, some event can be sensed in it. Event can be anything, say a data packet. So, this event information has to be sensed to the sink node from a particular node in a particular zone. To achieve this, we have to use the cooperative balance routing protocol to enhance the life time of the networks and increase the reliability of the same. CBR technique allows or looks forward across the elected paths, then chooses the path that minimizes the consumed energy taking into account the residual energy of the nodes, in the sense the shortest path which consumes the minimum residual energy of the nodes.

To start with the algorithm is developed in the ns2 platform by deploying the nodes in the different zones (here, taken 4 zones & in each zone 6 nodes being considered, so overall 24 nodes, 0 to 23 with last node 24 being considered as the sink). Each layer could be called as a particular zone. In the particular zone, event can occur at any node. Whenever event is generated, this CBR algorithm is going to choose the shortest path & which consumes the less energy so that the network life time is increased. Once the nodes are being deployed, all the nodes will be in the sleep mode. Now, we are going to send some kind of packets so that they will come to the active state. Once the nodes comes to the active state, the CBR algorithm gets activated.

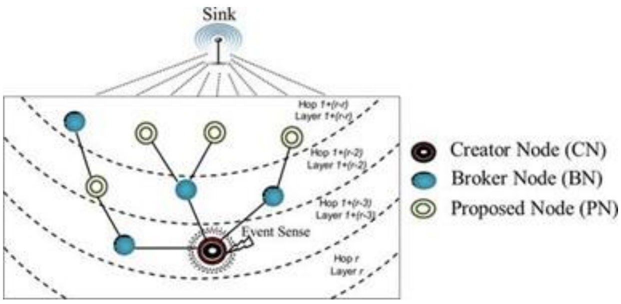

Fig. 3: Category of the nodes deployed at different levels or zones

The algorithm main job is when the event triggers in the network, there will be 2 types of packets, one is the real time packets & the other one is the normal packets, the real time packet will be having the high priority and the non-real time or the normal packets will be having the less priority. The priority will be given based on the particular option, whether it is high priority or low priority. If it is high priority, the event will be sent through the nodes which consumes the less energy. The nodes will start transmitting the packets to the neighbouring nodes. In this process, it will keep checking with the neighbours whether the neighbouring nodes has sufficient energy or not.

Cooperative Balancing Routing (CBR) Protocol

Step 1: Initialization

- Initialize network parameters, including node positions, energy levels, and routing table.

$$P\_i = (x\_i, y\_i), E\_i = E\_initial, \forall i \in \{1, 2, ..., N\}$$

Where P_i represents the position of node i, and E_i is the initial energy level of node i.

Step 2: Neighbor Discovery

- Each node discovers its neighbors within a communication range R.

$$N\_i = \{ j \mid ||P\_i - P\_j|| \leq R \}$$

Where N_i is the set of neighbors for node i.

Step 3: Route Request (RREQ) Broadcast

- Source node broadcasts a Route Request (RREQ) message to discover a route to the destination.

$$RREQ = (S, D, ID, H)$$

Where S is the source node, D is the destination node, ID is the unique request identifier, and H is the hop count.

Step 4: Route Reply (RREP) Transmission

- Intermediate nodes forward the RREQ, and the destination node sends back a Route Reply (RREP) message along the reverse path.

$$RREP = (D, S, ID, H)$$

Step 5: Path Selection and Energy Balancing

- Select the optimal path based on energy levels and hop count, ensuring balanced energy consumption.

$$Path\ Cost = \sum \left(\frac{1}{E_k}\right) for\ k = 1\ to\ H$$

Where E_k is the remaining energy of node k on the path.

Step 6: Data Transmission

- Transmit data packets along the selected path while monitoring energy levels.

$$E\_i(t+1) = E\_i(t) - E\_tx$$

Where E_tx is the energy consumed for transmission, and E_i(t) is the energy level of node i at time t.

Step 7: Route Maintenance

- Continuously monitor and maintain the route, initiating new RREQs if necessary due to node failures or energy depletion.

$$\Delta E\_i = E\_threshold, if\ E\_i < E\_threshold$$

Where E_threshold is the minimum energy level threshold for initiating a new route discovery process.

This concept is being used layer by layer or zone by zone checking which nodes have got less residual energy so that those can be used for data transfer of packets, that too, it considers layer by layer or zone by zone. Once, the level-1 is over, level-2 starts & so on and so forth till the event information reaches the sink. In any layer the event can occur. The event is nothing but a fire accident or a data transfer or can be any kind of urgent information. If it is emergency it is called as a real time packet & if it is a non-emergency it is called as a normal packet so that the data can be sent using then nodes which are having little more energy (not that much prioritized).

The proposed algorithm is going to detect whether the process is having a high priority or a low priority. If it is having a high priority, first it chooses the node which are having less energy and forward the packets to the sink node. If it having less priority, it will choose some other path and forward the data packets to the sink node (it will not be the minimum energy path node), which is also called as the path selections. Accordingly, the nodes have the ability to take accurate decisions to balance energy consumption during the routing process, which in turn prolongs the network lifetime and minimizes network partitioning.

Considering the Fig. 3, say an event has occurred in the zone-1 (say fire), this information has to be sent to the sink node. In this process, we mainly concentrate on the delay time, i.e., the time taken from the event to the sink. Sink is deployed at the top most zone, whereas the events that occur are considered at different levels (zone-1, zone-2, zone-3, zone-4). Our main aim is to reduce the end to end delay time that means the waiting time, i.e., the high priority packets should never wait (what is the time taken from the event to the sink). The event occurs in any layer say, how much time it takes to reach the sink, this is what is called as the delay or the wait time. The scheduling has to be initiated from the event point until the event reaches the sink node.

Say, some event has occurred at the "NODE-0", some incident has occurred, this has to be transmitted to the base station or the sink node. An event has been generated at some level. Now, it has to take its own decision where it has to go. Next, it has to be decided whether it is a real time event or a normal event, i.e., prioritized event or a non-prioritized event. Based on this event, the CBR algorithm will decide in which path it has to go, whether in the path having least energy or average energy or more energy. The path is going to be generated based on the minimum energy consumption. In the annotation box or window, all the process will be displayed as to which node is sending data to which node.

Node 0 (event) – Node 11 – Node 19 – Node 24 (sink) …. Path selected as it has the less energy to send the information to the sink.

Like this '*n*' number of events can occur in the network. First priority is given to the real time packets, then the priority is given to the non-real time packets. In the work considered, we have taken the occurrence of multiple events at different levels. The speed of the simulation may also be increased in order to speed up the event transfer process by using the tab provided at the upper right hand corner of the NAM window.

Say, event occurred at Node 3, 9, 16 & 22.

Node 3 (event) – Node 9 – Node 16 – Node 22 – Node 24 (sink) …. Path selected as it has the less energy to send the information to the sink.

The algorithm developed uses this path to transmit the event information to the sink. As event can be anything, the path scheduling is done using the CBR algorithm. Hence, the algorithm is more efficient, there is no waiting for the data to be transferred to the sink in any path as it uses the multiple paths.

4. Simulation Results & Discussions with The Execution Steps

In this section, the NS2 simulation results are presented along with the discussions. Once the *main.tcl* script file is run from the command prompt, the NAM window occurs & the simulation is started and run for a specific amount of time after which the results are observed. From the simulation results, it can be observed that the methodology what has been proposed is implemented using the software tool (network simulator) successfully & these results shows the efficacy of the methodology developed by comparing with the work done by others.

Further, we *evaluate the CBR performances* using simulations done in the NS-2 platform. CBR performances are compared to those of the existing FCFS & DMP algorithm with a classical MAC layer. The simulations are run with each of these protocols using different network configurations & its parameters.

All the configurations contain a source, a destination and a number of intermediate nodes. We start by a network containing 1 node and we increase the network size gradually at each step until reaching to 25 nodes, which can be seen from the node deployment in the NAM window. The nodes are uniformly distributed in a random deployment with a side length of 200 m. The CSI of the channels is represented by the Signal-To-Noise-Ratio (SNR). The channels are Rayleigh faded with quasi-static fading - each packet is faded randomly and independently. Furthermore, we consider that the channels of the network are fully symmetric. The power consumption of the node is 15 mA for transmission, 20 mA for reception and 10^{-3} mA in Idle / static mode. It has to be noted in this stage that when the node is static or idle, it will not consume any power or energy.

The coding (script writing) for the efficient data transfer using the CBR mechanisms & is developed in the NS2 tool by writing .tcl scripts and once it is completed, it is tested for its effectiveness as per the algo steps given below from s1 to s14.

1. The coding is done in the .tcl scripting incorporating the developed protocol.
2. The developed code is saved in a particular folder in the Ubuntu environment.
3. Ubuntu is started.
4. At the terminal, commands like sudo –s is being used to enter the kernel.
5. Password is being set.
6. The source code in which the directory / folder is present is changed using cd command and entered (Fig. 5)
7. The code is run using ns filename.tcl
8. The command window of the NS-2 simulator appears with the simulator start button along with the network animator (Fig. 6).
9. Once the simulation is started, the sensor node deployment within the '*n*' number of cluster heads along with the base station, sink, source, etc…. & the '*m*' attacker nodes appear on the NS-2 animator screen.
10. Data transfer starts from the source (normally 0), nodes starts sending & receiving the data packets as per the algorithm developed …. seen in the form of concentric circles.
11. Simulation takes couple of minutes, passes different stages of data packets sending, verification, encryption, decryption from the source to the sink, simulation speed can be increased by increasing the steps provided at the right-hand upper corner of the NAM window.
12. Once the data transfer is fully successful, all the nodes turns red indicating the 100 % success rate
13. Results are observed at the command prompt (terminal) by using the results visualizations chmod 777 results.sh & ./results.sh or sometimes the result observation command can be directly embedded into the code at the end of the program
14. Output graphs showing all the parameters such as Average energy, Jitter, Throughput, End to End Delay (EED)…. are observed with a simulation step size of 5 ms, thus showing the effectivity of the proposed methodology.

5. Developed Algorithm

The proposed algorithm development using the concepts of CBR for the efficient transfer of the event that has occurred to the sink is best shown in the form of an algorithm as shown in 24 points.

1. Start
2. display all the nodal parameters (declaration) as per the requirement.
3. 100 Joules declared.
4. creating simulator object next.
5. NAM window to be created at the next level.

6. trace file created.
7. topology to be created.
8. creating GOD object (General Operational Director).
9. node deployment of the at different zones /levels.
10. Real time data transmission (priority event consideration)
11. transmission.awk file to be called for real time data event.
12. priority scheduling considered decides which event to be considered.
13. scheduling.awk file to be called.
14. use the optimization process.
15. hop distance computation from the base station.
16. CBR checks the min hop distance to reduce the delay.
17. hopdistacne.awk file to be called.
18. event occurrence considered next.
19. event can be generated at any level.
20. event.awk file to be called.
21. check the priory levels (high or low).
22. priory-query.awk file to be called.
23. event info transferred to sink.
24. display performance characteristics
25. End

6. Chronology of The Simulated Results Observed in NS2 Platform & Discussion on The Simulation Results

Algorithm is developed in NS2 platform as .tcl file incorporating all the .awk files. The simulation is run for a specific amount of time & the results are observed as shown in the Figs. 5 to 23 respectively. Output graphs showing all the parameters such as end to end delay, wait times, etc……. are being observed & from the simulation results, conclusive remarks are drawn. The flow chart / data flow diagram shown in the Fig. is followed for the observation of the simulation results.

The flow chart or the DFD gives an idea of how to define the nodal configuration parameters, to set the type of wireless channel & the radio propagation model along with interface type and the addresses. The link layer, type of antenna model and the number of nodes with the positions is also set in the simulation process along with the energy levels. First the NAM window is created along with the creation of GOD Object. Next, the nodes are created using the Euclidean concepts & using the proposed CBR routing protocol, the real time of the data packet transmission starts using priority scheduling and calculating the hop distance from the base station answering all the priority events and queries. Finally, the relevant results are observed.

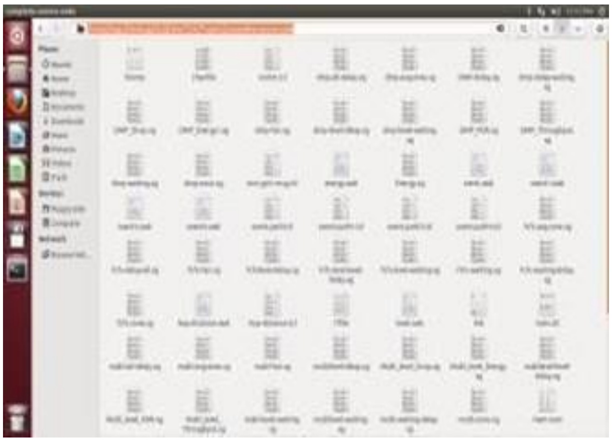

Fig. 5 : The path showing where the code has been developed with all the subsidiary files of .tcl, awk, .tr files

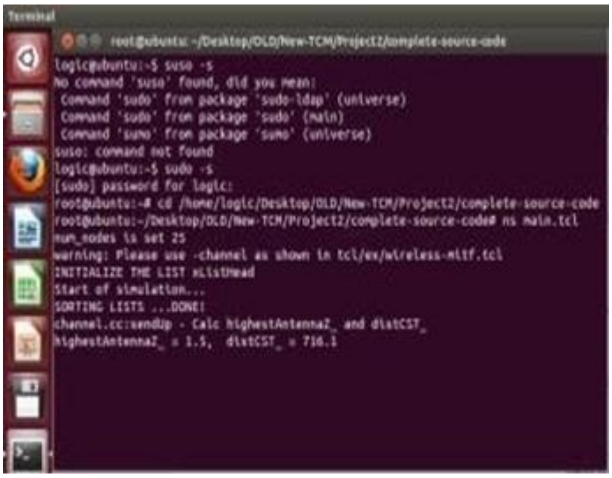

Fig. 6 : The root terminal showing how to run the main program developed by changing the directory to the location here the main file is located & the root terminal showing thatthe main program is being run

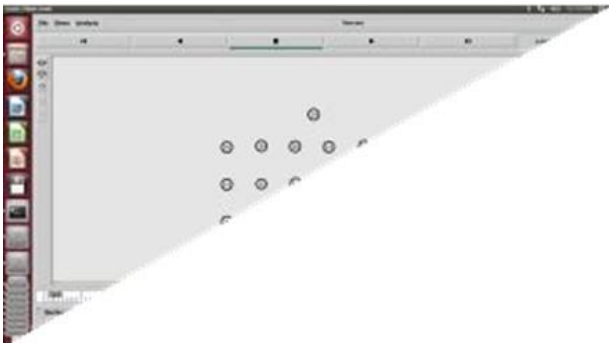

Fig. 7 : The NAM window showing the starting of the simulation process once the run command is pressed on the simulator & the NAM terminal showing the random deployment of the sensor nodes & the final nodal deployment with SN, KN tools

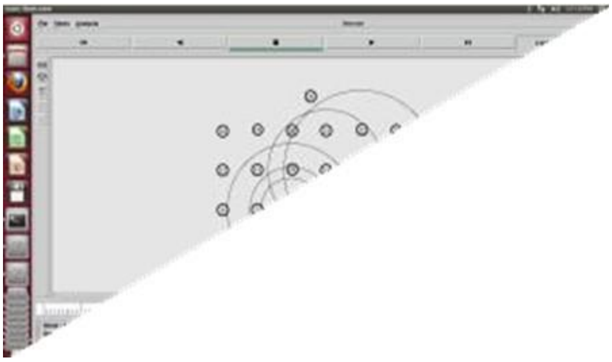

Fig.8: The NAM terminal the verification of the data with the neighboring nodes, concentric circles showing the data transfer in progress to the nearby nodes with the completionof the 1st level with node 3,4, 5 sending packets to neighboring nodes 8, 5 & 4

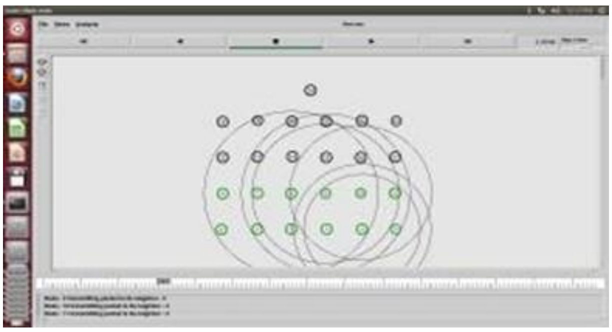

Fig. 9 : The NAM terminal the verification of the data with the neighbouring nodes, concentric circles showingthe data transfer in progress to the nearby nodes with the completion of the 2nd levelwith node 9, 10, 11 sending packets to neighbouring node 4

Fig. 10 : The NAM terminal the verification ofthe data with the neighbouring nodes, concentric circles showingthe data transfer in progress to the nearby nodes with the completionof the 3rd level with node 15, 16, 17 sending packets to neighbouring node 10

Fig. 11 : The NAM terminal the verification of the data with the neighbouring nodes, concentric circles showing the data transfer in progress to the nearby nodes with the completion of the 4th level with node 21, 22, 23 sending packets to neighbouring node 16

Fig. 12 : Sink node identification

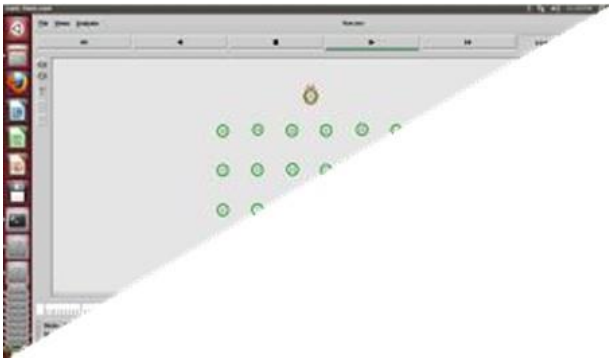

Fig. 13 : 0th node being identified as the start of the event of the data transfer

Fig.14: Intermediate events being identified (shown in yellow colour) in the context of showing that node 21 sending event messages to its neighboring node 24,similarly – 13 to 21 & 21 to 24

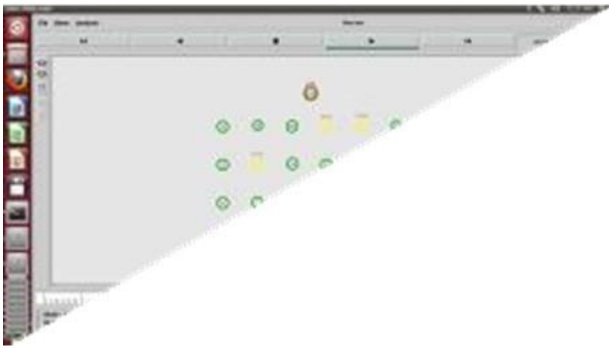

Fig.15 : Intermediate events being identified(shown in yellow colour) in the context of showing that node 16 sending event messages to its neighboring node 22, similarly – 22 to 24 & 3 to 9.

Levels Zones	Average task (end-end delay)		
	Multi	DMP	FCFS
4	8	9	14
6	11	14	20
8	14	18	25
10	30	22	16

Table 1 : Quantitative results

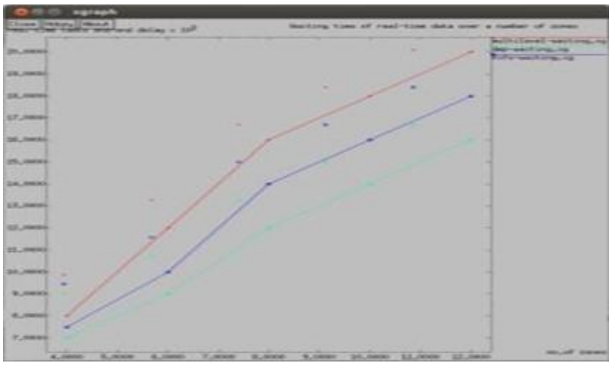

Fig. 16 : Simulation result showing the waiting time of real time data over a number of zones (in our case – 4 zones considered) & comparing with dmp & fcs algo

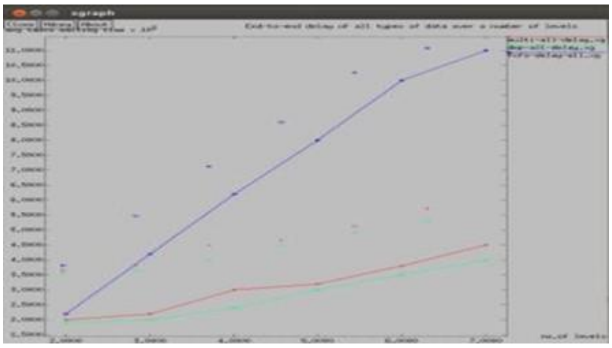

Fig. 17 : Simulation result showing the end to end delay showing all types of data over the number of levels (in our case – 4 levels considered) & comparing with dmp & fcs algo

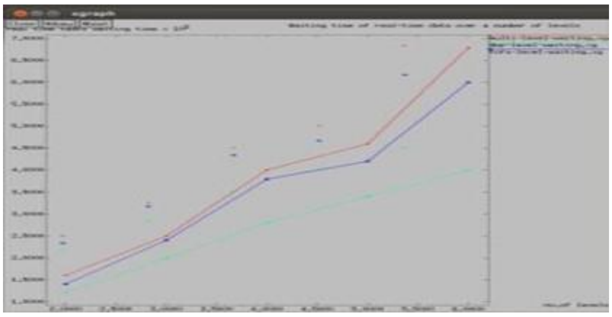

Fig. 19 : Simulation result showing the waiting time of real time data over a number of levels (in our case – 4 levels considered) & comparing with dmp & fcs algo

From the simulation results, the following observations can be made. This shows the waiting time of real time datas versus the number of levels considered. Since 4 levels or zones are there, there will be 5 nodal points in the network. Proposed system (represented by red colour) whereas the existing systems (shown in blue colour) and are waiting for long time as they don't have channels or the minimum energy paths. Our proposed system is no need to wait for a long time & keeps on sending the packets from e occurrence of the event point to the sink in less time choosing the minimum residual energy node path. Hence, the name cooperative routing balancing protocol reducing the time of event transfer.

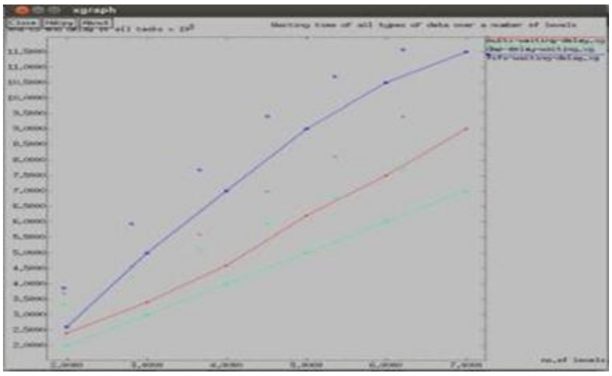

Fig. 20 : Simulation result showing the waiting time of all types of data over a number of levels (in our case – 4 levels considered) & comparing with DMP & FCS algo

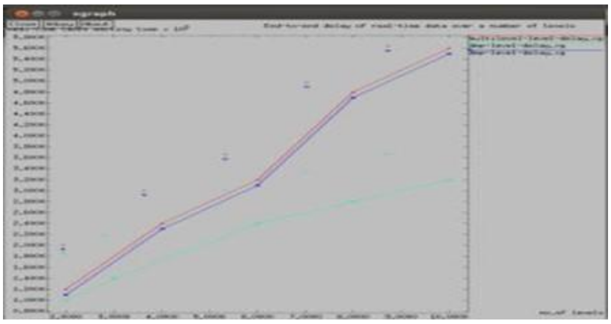

Fig. 21 : Simulation result showing the end to end delay of real time data over a number of levels (in our case – 4 levels considered) & comparing with dmp & fcs algo

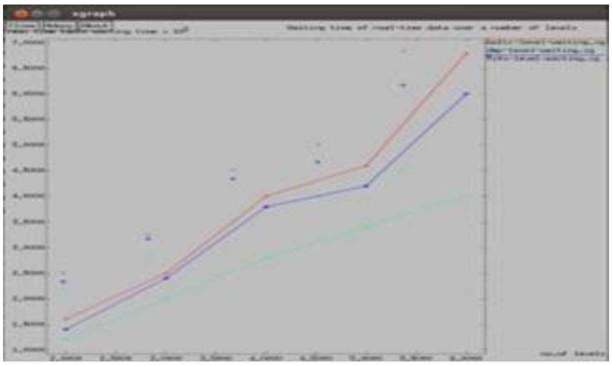

Fig. 22 : Simulation result showing the waiting time of real time data over a number of levels (in our case – 4 levels considered) & comparing with dmp & fcs algo

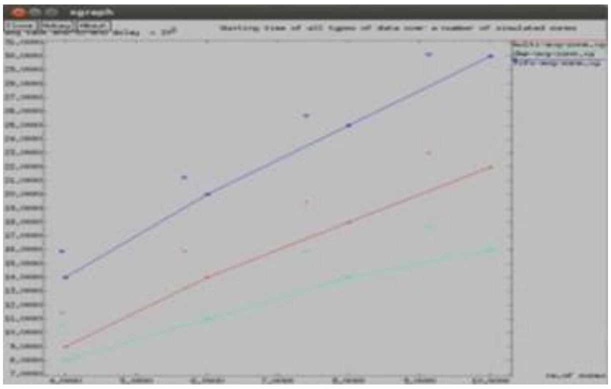

Fig. 23 : Simulation result showing the waiting time of all types of data over a number of simulated zones (in our case – 4 zones considered) & comparing with dmp & fcs algo

From the simulation results, the following observations can be made. This shows the end to end delay of all types of data over a number of levels. w.r.t. this result, it could be observed that the end-to-end-delay is less compared to the work done by others. Proposed system (represented by red colour) whereas the existing systems (shown in blue colour) and are waiting for long time as they don't have channels or the minimum energy paths. Our proposed system is no need to wait for a long time & keeps on sending the packets from the occurrence of the event point to the sink in less time choosing the minimum residual energy node path.

From the simulation results, the following observations can be made. This shows the end to end delay of all types of datas or events over a number of zones. Our proposed system is going to reduce the end to end delay because there is no need to wait at any point. Only thing is it is being checked whether it is a real time event (high priority) or a normal event (low priority). In the case of existing system, it is taking a lot of time for the event to reach to the sink. Our proposed system is taking less time to transfer the packet (event) to the sink.

The Fig. No. 19 shows the simulation result showing the waiting time of real time data over a number of levels (in our case – 4 levels considered) & comparing with dmp & fcs algo from which it could be understood that the real time data (priority data) takes very less time compared to the other existing systems, which are consuming more time.

This result shown in the Fig. 20 depicts the waiting time of all types of data over a number of levels, that means we are checking zone wise levels packet wise. Waiting time is less for the proposed system, whereas it is more for the existing system. From the simulation results, the following observations can be made. This shows the end to end delay of all real time datas or events over a number of levels, i.e., at each level how the event is being transferred. First level is good, similarly, 2nd, 3rd & 4th level is also good (shown in red colour), i.e., in each and every level, we are checking how was the delay. In the proposed system, the packets are delivered in the requisite time & are not waiting for long time.

From the simulation results, the following observations can be made. This shows the waiting time of all types of datas over a number of simulated zones. Zone by zone the data is going to be transmitted. The work (green) is compared with the other existing systems which takes more waiting time for the data to reach the sink (blue & red). Time taken for the proposed system is less & hence it is more efficient, which can also be observed from the quantitative results displayed in the table 1.

7. Conclusions

In this research work considered in this paper, the design & development of the concepts relating tothe design & development of a novel cooperative balancing routing (CBR) protocol to enhance the lifetime of WSNs using load balancing concepts by decreasing the energy consumption during the data exchanges.is presented In this paper, a new revised or improvised routing protocol named Cooperative Balancing Routing (CBR) protocol proposed to balance energy consumption among nodes during the routing process.

The aims of CBR protocol are increase the lifetime and efficiency of network and prevent the partition of network by load balance during routing data to the sink. The performance of the proposed protocol CBR is evaluated with a mathematical model and simulation, the result are compared with the other related protocols, which shows the efficiency of the method developed by us. It is based on a multi hop technique to deliver data to the sink node. Here, the sensor nodes act as routers to receive/send data packets from/to other nodes in their transmission domain.

The CBR looks forward across the elected paths, then chooses the path that minimizes the consumed energy taking into account the residual energy of the nodes. Accordingly, nodes have the ability to take accurate decisions to balance energy consumption during the routing process, which in turn prolongs the network lifetime and minimizes network partitioning. Algorithms were developed using NS2 tools in the Ubuntu environment. Simulations are observed after running the developed code, thus finally demonstrating the various results obtained for all the test cases along with the necessary observations and explanations in the form of discussions showing the effectivity of the methodology proposed in comparison with the work done by the others.

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