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Design of Enhance Co-operative Balanced Route Protocol (CBRP) in WSNs

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Abstract
Wireless Sensor Networks (WSNs) are instrumental in various applications, including environmental monitoring, healthcare, and smart infrastructure. However, ensuring efficient and reliable data transmission in WSNs remains a challenge due to the dynamic nature of the network topology and limited resources of sensor nodes. This paper proposes an enhanced Cooperative Balanced Route Protocol (CBRP) for WSNs to improve routing efficiency and energy consumption. The proposed protocol introduces a cooperative approach where sensor nodes collaborate to relay data packets, balancing energy consumption and prolonging network lifetime. Simulation results demonstrate that the enhanced CBRP outperforms existing protocols in terms of network throughput, end-to-end delay, and energy efficiency, making it a promising solution for WSN applications.
Keywords : WSN, CBR, Simulation, Result, Node

Introduction
The Cooperative Balancing Routing (CBR) protocol is introduced in this section as a new routing mechanism for WSN. CBR is a cooperative-distributed routing technology built specifically for wireless sensor networks. The data is delivered to the sink node using a multi hop mechanism. As a result, nodes (such as sensors) serve as routers, receiving and transmitting data packets from and to other nodes in their transmission domain. The routing procedure, on the other hand, may raise the load on some nodes, resulting in network segmentation when these overloaded nodes become stressed quickly. CBR’s goals are to extend the network’s life and stability while also preventing network split.
This is done by balancing energy consumption across nodes during the routing process. CBR does not require all network information, such as each node's locations; instead, it simply requires the residual energy of its neighbours and their distance. As a result, during data routing, each node can make the best local option for selecting its next hop. CBR divides nodes into three groups, starting with the node that intends to send data, as illustrated in Fig. 6.1, based on their conditions during data transmission : creator nodes (CN), also known as sender nodes, Broker Nodes (BN), and suggested nodes (PN) or tiers / zones.

Rules for designing the node
Rule 1 : The Creator Node (CN) is the node that senses an event and generates a new data packet.
Rule 2 : The Broker Node (BN) is a node that is within the creator's transmission range and has a hop count that is <= the creator’s number of hops.
Rule 3 : The Proposed Node (PN) is a node in the broker's transmission range with a hop count smaller than the brokers hopping counts.

Data transmission

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Before transmitting data to the sink, CN sends a Request Packet (REQ) to the BNs, requesting information about its proposed forwarding node with the highest possibility of being chosen. ID and residual-energy are included in this data. The node can choose an appropriate forwarding node based on this information in order to maintain the network's stability and longevity as much as feasible. When BNs receive a REQ packet, they respond with a Reply Packet (REP), which includes their P-N data.

As shown in Fig. 1, a sensor node has three agents, viz., the Routing Information Estimator Agent (RIEA), the Neighbour Information Monitoring Agent (NIMA), and the Forwarding Data Agent (FDA). The establishment of the Neighboring Table is the responsibility of RIEA (NT). The RIEA in each node estimates the hop count between sensor nodes and the sink to create the NT and stores it in the Routing Information Database when the sink broadcasts a preparation packet (RID). RID has 2 tables, viz., the NT, which appears to contain key data about the node's friend, such as ID, hop-count, remaining energy, cost, and distance between them, and RID, which contains the relevant information about the node's neighbour, such as ID, hop-count, residual energy, cost, and distance between them, among other things.

Routing Table Design

The Routing Table (RT) is the 2nd table, and it contains routing information such as source node, previous node, next node, time to live (TTL), and destination node, among other things. NIMA, on the other hand, is in charge of maintaining the NT in each node. Finally, FDA is in charge of computing the cost and probability for each node in the NT, as well as choosing the most reliable routing between nodes. As a result, based on its interactions with its neighbours, each node may make precise decisions for electing the next node locally.

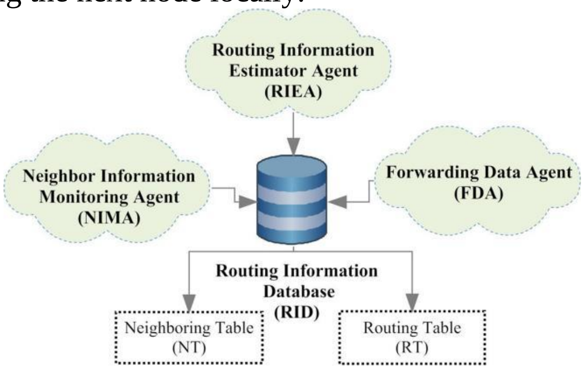

Fig. 1 : The 3 sensor node modules, viz., NIMA, RIEA and the FDA

CBR is divided into three phases, i.e., the formation of neighbouring tables, data transmission, and the update of neighbouring tables. To begin, the sink broadcasts a preparatory packet to calculate the hop counts between sensor nodes and the sink in order to establish the neighbouring table of each node. Second, when a node wants to pass data to the sink, it sends a REQ packet to its neighbours. Finally, in nodes, update the neighbouring tables.

CBR route protocols development

Here, the network life time is going to be enhanced, for this the network as a layer by layer and in the network deployed in the case is going to be considered, 4 layers / zones are used. In a particular network, some event can be sensed in it. Event can be anything, say a data packet. So, this event information will have to be sensed to the ending nodal point from a particular node in a particular zone. To achieve this, one use the cooperative balance routing protocols for enhancing the life time of the network and increase the reliability of the same. The CBR method lets or looks ahead over the chosen paths, then chooses the path that uses the least amount of energy while taking into consideration the nodes' residual energy, in the sense the shortest path which consumes the minimum node's residual energy.

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To start with, the DFD is developed in the ns2 platform by deploying the nodes in the different zones (here, taken 4 zones and 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 and which consumes the less energy as the network's life times are increased. Once the nodal points are being deployed, all the nodes will be in the sleep mode. Now, 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.

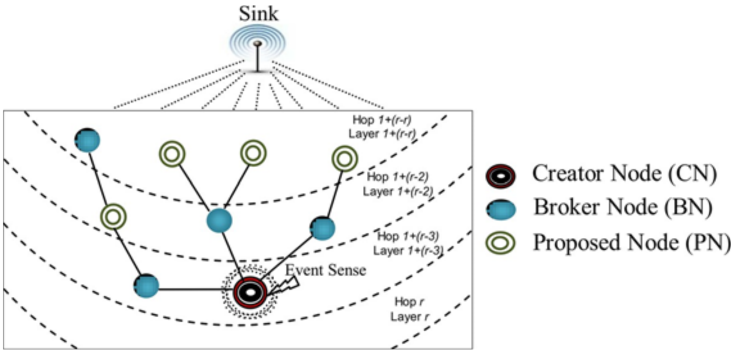

Fig. 2 : Category of the nodes deployed at different levels or zones

The algorithm's main job is when the event triggers in the network, there will be 2 types of packets, one is the real time packets and 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 as shown in the Fig. 2.

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 and 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 and 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).

Proposed algorithm

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 data packs are being forwarded to the sink's nodal points. If it having less priority, it will choose some other path and forwarding the data information to the sink node (it will not be the minimum energy path node), which is also called as the path selections. As a result, the nodes may make precise decisions to balance energy consumption during the routing process, extending the network's lifetime and reducing network fragmentation.

Considering the Fig. 2, say an event has occurred in the zone-1 (say fire), this information has to be sent to the sink node. In this process, delay time is considered, 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 (zones-1, zones-2, zones-3, zones-4). Our primary aim is the reduction of the ending to ending delay times 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 sent to the base nodal point or the BS to 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's real-time packets are given first priority, followed by non-RT packets of data. In the work considered, the occurrence of multiple events at different levels by increasing or decreasing the speed of simulation is taken into consideration.

Say, event occurred at Node 3, 9, 16 and 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.

Simulation results and discussions with the execution steps

Here, in the next paragraphs, the NS2 results of simulation are discussed along with justifications. Once the *main.tcl* script file is run from the command prompt, the NAM window occurs and the simulation is started and executed for a certain time period, after which the result is seen. Once the results are observed, it could be inferred that the methodology what has been proposed is implemented using the software tool (network simulator) successfully and these observations predict the efficiency of the developed protocol by comparing with the work done by others.

Further, *evaluate the CBR performances* using simulations done in the NS-2 platform. CBR performances are compared to those of the existing FCFS and DMP algorithm with a classical MAC layer. The simulations are run using every developed protocols that too using a number of network configurations and its parameters. A source, a destination, and a number of intermediate nodes are present in every setup.

Firstly, network containing 1 node is used for simulation and go on increasing the size of the networks gradually at each step until reaching to 25 nodal points, which can be seen from the node deployment in the NAM window. The nodes are randomly distributed with a side length of 200 *m* and are uniformly scattered. The Signal-To-Noise-Ratio represents the CSI of the channels (SNR). Rayleigh fading with quasi-static fading is used on the channels, with each packet faded randomly and independently. Furthermore, assume that the network's channels are entirely symmetric. The node uses 15 milliamps for transmission, 20 milliamps for reception, and 103 milliamps in idle / static mode. It is important to remember at this point that the node will not consume any power or energy when it is stationary or inactive.

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 25 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.

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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

Chronology of the simulated results observed in NS2 platform

Algorithm is developed in NS2 platform as *.tcl* file incorporating all the *.awk* files. The simulation is executed for a certain time period and the results of simulation are observed as shown in the Fig. 6. Output graphs showing all the parameters such as end to end delay, wait times, etc……. are being observed and from the simulation results, conclusive remarks are drawn. The flow chart / data flow diagram shown in the Fig. 6 is followed for the observation of the simulation results.

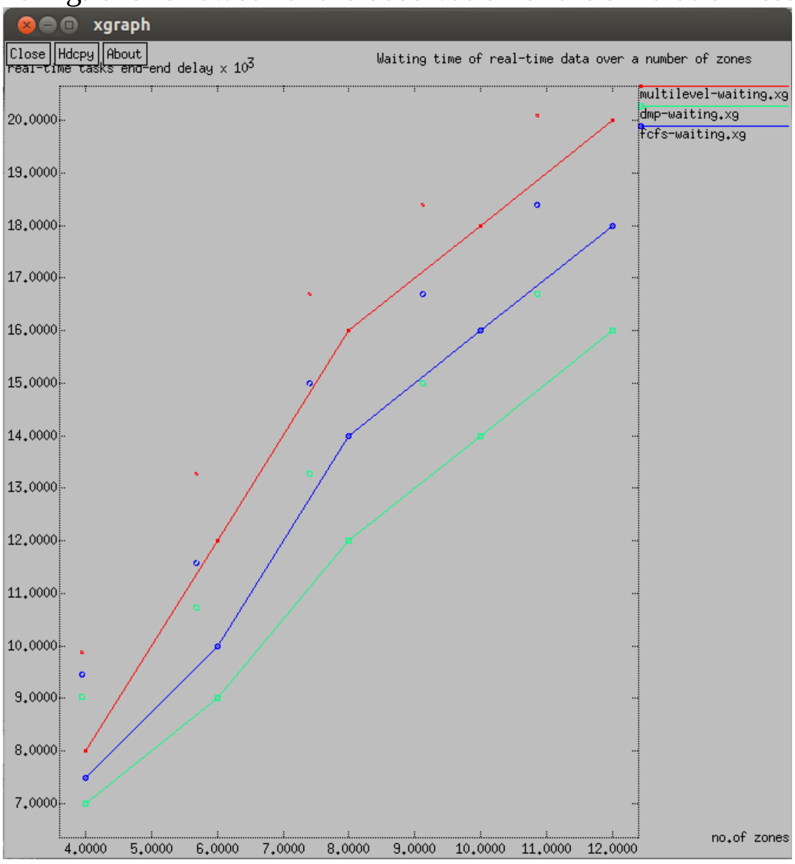

Fig. 6 : Simulation result showing the time of waiting of the RT information over a no. of zonal areas (in our case – 4 zones considered) and comparing with DMP and FCS algo

Conclusions

Research was conducted on the topic of Design of Enhance Co-operative Balanced Route Protocol (CBRP) in WSNs. The flow chart or the DFD gives an idea of how to define the nodal configuration parameters, to set the type of wireless channel and the radio propagation model along with interface type and the addresses. The link layer, type of antenna model and the no. of nodal points 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 and 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.

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