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RAHTAP Algorithm for Congestion Control in Wireless Sensor Network

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Abstract: Wireless sensor network (WSNs) can be constructed as an intelligent, large autonomous instrument for scientific observation at fine temporal and spatial granularities and over large areas such as environmental monitoring. WSNs typically operate under light load and suddenly become activate in response to a detected or monitored events. Depending on the application this can result in the generation of a large, sudden, and correlated impulse of data that must be delivered to a small no of sinks without disrupting the performance of the sensing application. This generation of data packets is usually uncontrolled and often leads to congestion. There are two techniques by which congestion can be reduced which are: either by reducing the data sending rate of source or by providing extra resources. Congestion in WSNs is high if load in the network is high. So network load is reduced upon elimination of redundant number of packets in WSNs. In this paper we implement Redundancy Aware Hierarchical Tree Alternative Path (RAHTAP) algorithm which eliminates the duplicate packets from the network and achieve reduction in network load as per packets basis which create dynamic alternative path from source to sink when congestion on a particular node. This algorithm works over the thought of existing congestion control algorithm HTAP. We use here QualNet Simulator to mimic the consequence which demonstrates RAHTAP is a proficient calculation and straightforward solution for confronting over-burden circumstance in WSN in examination with HTAP.

Keywords: Wireless Sensor network, Congestion control, Alternative path routing, Energy efficiency.

I. INTRODUCTION

THE Wireless sensor network (WSN) is a wireless network consisting of spatially distributed autonomous devices using sensors to cooperatively monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, motion or pollutants, at different locations[1][2].Wireless Sensor Networks represent a new generation of real time embedded systems with significantly different communication constraints. As these devices are deployed in large numbers, they will need the ability to assist each other to communicate data back to a centralized collection point. The tiny devices which are composed of a sensing unit, a radio, a processor integration of the sensor, coupled with unceasing electronic miniaturization, will make it possible to produce extremely inexpensive sensing device. Sensor nodes are and a limited battery power. These devices will be able to monitor a wide variety of ambient condition: temperature, pressure, humidity, soil makeup, vehicular movement, noise levels, lighting conditions [2][3][8]. In wireless sensor network, there are so many challenges. The main challenges [4] are how to provide maximum lifetime to network and how to provide a network totally rely on battery power. The main aim for maximizing lifetime energy efficient, load balancing packet transfer from source to sink to network as sensor of network is to conserve battery power or energy with the help of reducing of the duplicate data packets in to the networks.

In sensor network, the energy is mainly consumed for three purposes: data transmission [5], signal processing, and hardware operation. It is said that 70 percent of energy consumption is due to data transmission. So for maximizing the network lifetime, the process of data transmission should be optimized. The data transmission can be optimized by using efficient redundancy aware routing protocols at each node in WSNs for the removal of duplicate data packets.

In this paper we propose an algorithm to establish energy efficient data routing from source to sink. So that data can be transmit and consuming lesser energy with the avoidance of redundancy [13] at each node. This concept will provide energy efficient communication at each node and increases the lifetime of the sensor network as a whole. This algorithm aims at eliminating redundant data transmission and thus improves the lifetime of energy constrained wireless sensor network. In wireless sensor network, data transmission took place in multi hop fashion where each node forwards its data to the neighbour node which is nearer to sink. That neighbour node checks the redundant no of packets in a regular interval manner and discarded the redundant no of packets and again forwards it.

On performing data forwarding and redundancy check in this fashion from various sources to sink [9] as a result of which network load decreases, significantly energy consumption at each node also decreases in the network is involved in operation. So this approach can be considered as energy efficient. Here in this proposed calculation an redundancy check (RC) methodology is situated at every node in the long ago characterized blockage control calculation of HTAP (Hierarchical Tree Alternative Path) [6][7] encounters data redundancy issue.

The proposed algorithm will check the redundant no of packets at each node during the packet transmission from source to sink. Consequently decreasing the communication overhead and likewise diminish the load of the WSNs to provide energy efficiency for maximizing network lifetime.

The proposed Redundancy Aware Hierarchical Tree Alternative Path (RAHTAP) algorithm will provide an energy efficient and obstructing free data routing environment in the network.

II. NETWORK MODEL AND PROBLEM DESCRIPTION USING RAHTAP ALGORITHM

The proposed algorithm called A Redundancy Aware Hierarchical Tree Alternative Path Routing (RAHTAP) in Wireless Sensor Network which includes five standard parts that could be utilized to orchestrate significance valuable are versatile to the earth: Topology Control, Hierarchical Tree Creation (HTC), The Redundancy Aware Alternative Path Creation (RAAPC), Handling of Powerless nodes and Redundancy Check Algorithm (RC)[6][7] at each node in the sensor networks. Each of these components can achieve certain level of energy efficient routing in the wireless sensor networks. RAHTAP takes into consideration the communication and computation limitations of sensor networks. While there is dependably an exchange of between repetition and execution, trial outcomes demonstrate that the proposed calculation can achieve energy efficient routing and remove over load situation at each sensor nodes.

A. Redundancy

Redundancy is the provision of additional or duplicate resources, which can produce similar results. There are three types of redundancy in WSNs. They are Spatial redundancy, Temporal Redundancy, Information Redundancy.

1. *Spatial Redundancy*

Spatial redundancy means the possibility to obtain information for a specific location from different source. Spatial redundancy is based on the in-field of geographic placement of the sensor nodes and involves the replication of resources in the network's coverage area. It is an established fact that in WSN there is tremendous spatial redundancy, i.e. information for a specific location may be available from multiple sensors. Spatial redundancy is almost inherent and very practical in wireless sensor networks because they are typically deployed densely, thus providing a large amount of redundancy in network coverage and connectivity. Spatial redundancy is of the following two types are given below.

a) *Physical Redundancy*

Physical redundancy is an attribute of a WSN that can measure a variable in a specific location using more than one sensor. Physical redundancy implies the use of supplementary sensors and selection of data that appears similarly on the majority of sensors in an aggregation process. In this paper we present spatial redundancy and how to eliminate this type of redundancy in the wireless sensor networks to avoiding congestion.

b) *Analytical Redundancy*

Analytical redundancy is an attribute of a WSN that can estimate a variable in a specific location using mathematical models based on real sensing data provided by neighbouring sensors.

2. *Temporal Redundancy*

Temporal redundancy is much related with both sensing and communication.

3. *Information Redundancy*

Information redundancy is related with duplications in the structure of messages exchanged in the network and with duplications in the measurement storage at the level of base stations.

B. Topology Control

An effective topology control algorithm should be able to preserve connectivity with the use of minimal power, while maintaining an optimum number of nodes as neighbours to each node. Topology Control can be achieved by use of the local minimum spanning tree as the initial topology control algorithm runs on the networks.

1. Local Minimum Spanning Tree (LMST)

LMST [15] is an algorithm capable of preserving the network connectivity using minimal power, while the degree of any node in the resulting topology is restricted to six nodes. Because a small node degree reduces the MAC-level contention and interference. In LMST each node builds its local minimum spanning tree independently, using Prims algorithm [16] and keeps on the tree only those neighbouring nodes which are one hop away. The resulting topology is possible to use only bi-directional links.

This LMST consists of followings phases:

- Information Collection
- Topology Construction
- Determination of Transmission Power
- An optional optimization which is used in construction of topology with bidirectional links

a) *Information Collection*

Each node broadcasts periodically a ''Hello'' message using its maximum transmission power. In this ''Hello'' message each node piggybacks its ID and its location information . Each node discovered its visible neighbour node by utilizing its maximum transmission range.

b) *Topology Construction*

In this phase each node, after obtaining the information concerning its visible neighbourhood, apply prims algorithm[16] at every node independently in order to build a power efficient minimum spanning tree. Here nodes use their Euclidean distance for the construction of the shortest path from each node to sink. In this case each node has a maximum degree restricted to six.

c) *Determination of Transmission power*

Here every node can focus the particular power levels it needs to achieve each of its neighbours. This property is utilized within case that a node needs to telecast a message when it is congested. At that point, it alters its

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transmission power to a power level that can achieve the most remote neighbour.

d) *Construction of Topology Bidirectional links*

In the data accumulation stage if this improvement applies, then the system comprises just by bidirectional connections. This is accomplished either by upholding all the unidirectional connections to get bidirectional or to erase all the unidirectional connections. Due to the thick position and the way that a plenty of bidirectional connections exists, we decide to erase all the unidirectional connections.

C. *Hierarchical Tree Creation (HTC)*

1. *Root Creation*

In this step a various leveled tree is made starting at the source node. Every node is alloted a level as stated by the various leveled tree. The source node is appointed a level 0 and shows a level revelation parcel. Sensors that get this parcel are given as kids to the transmitter and are situated as level 1. Each of these nodes telecasts a level revelation bundle and the example proceeds with the level 2 nodes. The source when it accepts the level revelation parcel overhauls its neighbour table. This technique repeats until all nodes are alloted a level and stops when the level_discovery bundles achieve the sink.

2. *Flow Creation*

Association is created between every transmitter and collector utilizing a 2-way handshake. Bundles are traded between every transmitter and recipient in the system, so as to get joined. Through this parcel trade, the blockage state of every collector is imparted to the transmitter. This association is performed utilizing a 2-way handshake. Having a source hub A and a recipient B, hub A sends a first parcel to B. At the point when hub B gets this bundle, it sends an ack parcel once again to A. In this ack parcel the hub B piggybacks the clogging state at the minute. Along these lines, the source hub is mindful of the clogging state of all the youngsters and is additionally fit to send them information bundles. At the point when the clogging state of youngsters progressions to a pre-specified utmost this hub upgrades its blockage state by sending a bundle to the source hub.

On the off chance that a hub accepts a parcel from more than one hubs it holds the data of just the hub that places it at an easier level. In the event that a bundle is accepted by two hubs assume one is set with the same level and different is set at the easier level then it gained the parcel at the easier level. On the off chance that we are think about in the figure no 1 hub 7 is associated with hubs 6 and 4. Throughout the level situation methodology it will accept a parcel from hub 6 setting it at level 3, and a bundle from hub 4 making it a level 2 hub. Hub 7 will pick hub 4 as its upstream parent, turns into a level 2 hub, and will ask from its neighbour hubs to get level 3 hubs.

3. *Flow Establishment*

An association is created between every transmitter and recipient pair utilizing a two-way handshake. Through this parcel trade, the clogging state of every collector is conveyed to the transmitter. In the event that we think about again Fig. 1, where hub 1 is the source and hubs 2, 3, and 4 are collectors. Firstly, hub 1 sends a parcel to hub 2.When hub 2 accepts this bundle, it sends an ack bundle once again to 1.In this ack bundle hub 2 piggybacks its current blockage state. This trade makes the source hub mindful of the blockage state of all its next jump neighbours that can catch. When the clogging state of a kid (downstream neighbour) achieves a prespecified farthest point, the hub upgrades its upstream hubs of the blockage state utilizing a devoted control bundle.

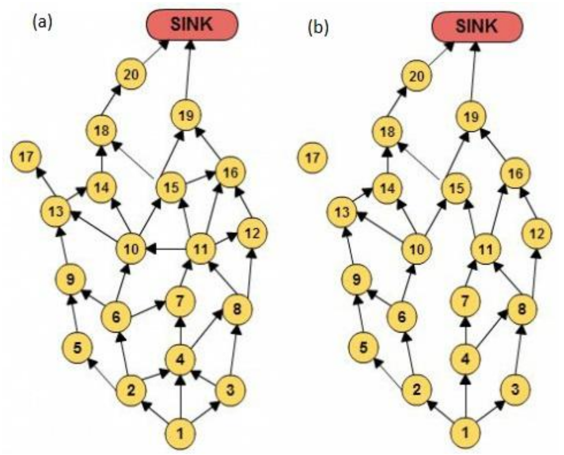

Fig.1.(a) network connectivity after topology control, (b) level placement procedure

D. *Redundancy Aware Alternative Path Creation(RAAPC)*

The RAAPC consists of two algorithms. Every hub in the system is customized with the accompanying two calculations.

- Congestion Detection (CD) algorithm
- Redundancy Detection (RD) algorithm

1. *Congestion Detection (CD) algorithm*

At the point when the cradle of a hub begins filling every hub is customized to run generally light weight clogging identification (CD) calculation [10][11]. At the point when the cradle achieves a support level edge esteem, the CD calculation begins tallying the rate with which parcels are arriving at the hub. Since every bundle is distinguished in its bundles header by the Node ID, the CD calculation is mindful of every last one of hubs that transmit parcels through this hub, and their information rate.

The CD [12] calculation ascertains the aggregate accepting rate and contrasts it and its Maximum transmission rate (Txmax). At the point when this proportion is expansive or more a certain rate the hub sends a backpressure message to the hubs that transmit bundles through it to scan for an elective path. Then it updates to the downstream hub that this hub will be congested soon and not to send any more parcels to this node. When the downstream discovers the message it quickly quits transmitting bundles and scans an alternate way for steering bundles. The transmitter hub seeks in its neighbour table and finds the most proper hub, towards which it starts the transmission of information.

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This might be carried out, it first quests the neighbour hubs which have minimum clogging degree and after that it chooses the hub and advances the parcel in that course. Simultaneously, all upstream hubs that live in a level easier than the congested hub redesign their neighbour tables with the data that this down stream hub is congested and abstain from transmitting any information through this hub. Additionally when this downstream hub gets accessible once more, it advises the upstream hubs likewise that now this hub gets to be blockage free and send information bundles through that hub.

2. *Redundancy Detection (RD) algorithm*

This calculation is enacted when bundles are transmitted from one hub to other hub. Every hub is modified a RD calculation, when bundle are hailing from a sender hub to a recipient hub. At the collector hub Redundancy Detection (RD) calculation is initiated and it first checks the copy bundles. In this calculation every hub have a queue which stores bundles for checking of doubles parcels. Case in point bundles are transmitting from Node A to the Node B, suppose at the Node B queue holds 10 parcels. When another bundle comes, the Redundancy Detection calculation initiates and contrasts the parcel Id of parcels which are put away in the queue. In the event that a matching bundle Id is discovered, then this calculation disposes of the parcel. Else it builds the queue and stores the parcel. In that ways it checks the copy of information bundles at each hub throughout the parcel transmission time in the remote sensor systems.

E. Handling of Powerless nodes

Exceptional consideration ought to be taken in the RAHTAP calculation concerning the hubs with debilitated batteries. These hubs are bringing on real Problems to the system, particularly when they are source hubs. In this way, when a hub is going to lose its energy, it ought to quickly be concentrated from the system and the tables of their neighbor hubs ought to be overhauled. This is conceivable because of the way that this can happen when the system is in an emergency state. This calculation manages two cases. The main case is the point at which the "dead" hub is the source hub and the other case is the point at which the "dead" hub is a tyke hub. In the first case, when the remaining source's hub power is reduced, the source hub telecast a choose parcel to its neighbor hubs. The neighbour hubs speak their energy levels with one another and the unified with the most remaining energy is chosen as the new hub. Power is lessened, and alternate hubs evacuate it from their neighbor tables.

III. DESCRIPTION OF THE REDUNDANCY AWARE HIERARCHICAL TREE ALTERNATIVE PATH (RAHTAP) ALGORITHM

Both RAAPC algorithm and HTC algorithm combined to create RAHTAP algorithm. When data packet is transmitting from source node to sink node during that period, the Redundancy detection algorithm is activated at each sensor node and it checks the duplication /redundant number of packets. The transmitted packets are stored in a queue before going to the buffer. Exactly when a packet is hailing from sending center point to the tolerant center point, this bundle has a noteworthy packet_ id and firstly the packet_ id is differentiated with the packet_ ids of those groups which are secured in the queue one by one. At the point when a matching packet_ id is found in the queue, this shows that the parcel is available and this algorithm removes the incoming packet from the node. In this process this algorithm checks the redundant number of data packets in the networks. After the process has been finished, packets are forward to the node buffer. Afterwords the Congestion Detection calculation actuates and checks whether a hub is going to be congested or not. On the off chance that a hub is going to be congested then RAAPC calculation will be enact and select elective way.
Consequence demonstrates that there is an expansion in the productivity and diminishing in the heap in the system. Vitality protection at every hub minimizes.

IV. RAHTAP ALGORITHMS

Flooding algorithm with level discovery

```
set neighbour nodes to 0
if current_node is source node
    Set level to 0
    broadcast flood_packets with level
Else if current_node receives flood_packets and is
  accepting them
   Set current_node to level+1
   send ack_packet with current_node_id
   broadcast  flood_packet with current_node_id and level
   ignore subsequent flood_packets
 else if current_node receives ack_packet
   neighbour nodes+1
```

Hierarchical Tree Creation (HTC) algorithm

```
if current_node receives hello_message
   send ack_hello
else if current_node sends hello_message
   wait specific_time
     if current_node receives ack_hello
          update neighbour table
       else if time_expires
          resend-hello message
```

RAAPC : Redundancy Aware Alternative Path Creation Algorithm

```
Set queue to 0
Broadcast flood_packet to the queue
if current packet_ id =stored packet_id in the queue
   Ignore the floood_packet
Else
   Queue = queue +1
If current_node receives ack with congestion level full
    Update neighbour table
    Search neighbor table
    Find node_id with min (congestion-level)
    Send data packet
If current_node receives congestion_update message
   Update neighbour table
Else if current_node receives date packet and accepting
them
    Set buffer to buffer+1
    If buffer +b = full
   Send ack packet with congestion_level full
```

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RAHTAP : Redundancy Aware Hierarchical Tree Alternative Path algorithm

Set neighbour_node threshold to prespecified value
If neighbour_node < neighbour_node threshold
Apply RAAPC
Else
Apply HTC

V. PERFORMANCE ANALYSIS

To access the excution of RAHTAP we picked a simulation gadget. Here in the arrangement of trial we introduce the execution of the existing HTAP [7] calculation for examination reason. We take a gander at our RAHTAP (Redundancy Aware Hierachical Tree Alternative Path) estimation with the temporarily back defined HTAP computation.

A. Simulation Environment

To perform our simulations we have used the Qualnet simulator[14] a fast, scalable and high-fidelity network modeling software. QualNet has incomparable speed, fidelity and scalability, which makes it an easy working tool for modelers to study and analyze different networks through quick model setup and easy scenario creation according to ones visualization.

1. *QualNet Scenario*

Scenario implemented in the simulation consists of 12 nodes. Each individual node is identified as Node1 to node12. Fig.2 is the snapshot of the scenario deployed in QualNet. The sink was set in the upper right corner of the lattice. Events were created at the lowest part left corner of the framework and all hubs that sensed an occasion were getting to be sources. In this way the amount of sources in our recreations is dynamic.

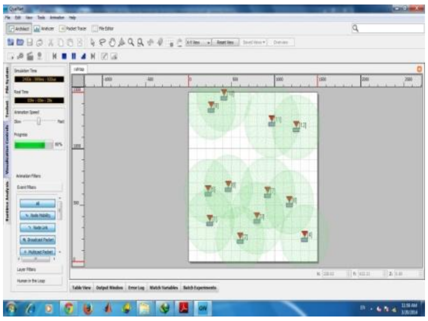

Fig. 2 WSN Scenario in QualNet

Scenario Parameters

The following table gives a brief description of various the Simulation parameters used.

TABLE.1 SIMULATION PARAMETERS

Simulation parameters	*Values*
X distance (m)	**1500**
Y distance (m)	**1500**
Transmission Power (dBm)	**-3**
Max datarate (kbps)	**250**
Transmission current(mA)	**17.4**
Frgment size(bit)	**1024**
Buffer size	**512k**
Network protocol	**IpV4**
MAC protocol	**802.11**
Energy model Specification	**MICA Z**

B. Result and Discussion

1. *Percentage of Successfully Received packets*

In this performance matric we have examined the percentage of successfully received packets as per the equation (1).

$$\text{ReceivedPacketsRatio (\%)} = \frac{\text{Successfully Received Pkts}}{\text{Total Pkts Sent}} \quad (1)$$

Examining the outcomes in figure.3 we recognize that HTAP and RAHTAP diminishing their rate of effectively accepted parcels after a particular moment that the information source rate surpasses 90 packets /s because of system over-burden. In any case in this particular recreation the proposed calculation RAHTAP performs superior to the existing HTAP calculation because of the less system over-burden.

2. *Total Energy Consumption*

In this performance matric the the energy consumption is the sum of used amount of energy consumed by MICAZ node devices for the periods of transmitting (P_{t}), receiving (P_{r}), idle (P_{i}) and sleep state (P_{s}).

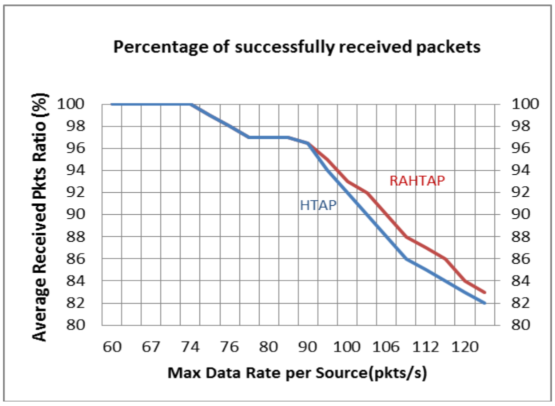

Fig.3. Percentage of successfully received packets

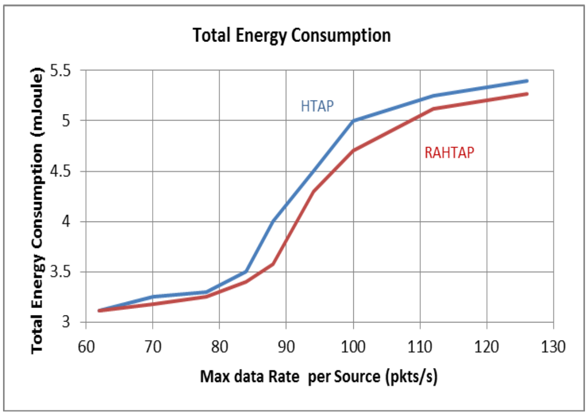

Fig.4.Total energy consumption

The total energy that a node consumes is

$$E_{node} = T_t . P_t . L + T_r . P_r + T_i . P_i + T_s . P_s$$

where Tt, Tr, Ti, Ts is the total time that a node transmits, receives or it is in idle or sleep state and L is the transmission power. We measure the power consumed in units where each unit equals to 1000 mW in 1 s (W * s). The sum of the consumed power of all nodes after the end of simulation according to the following equation.

$E_{total} = \sum_{i=1}^{n}(Enode)$ Where n is the number of nodes (2)

Examining Fig .4 given above here energy utilization is a function of load, as burden increments the utilization of energy in both HTAP and RAHTAP increments. Anyhow the utilization of energy in RAHTAP is low as contrasted with that of HTAP, on the grounds that HTAP could not evacuate the repetition and it experiences excess issue as a result of which the copy information bundles devour more energy, so burden in the network increases in case of HTAP.

VI. CONCLUSION

RAHTAP algorithm manages to control congestion in WSNs using Redundancy Detection and elimination when congestion appears in the network. The main advantage of RAHTAP is redundancy detection and elimination method it uses on sensor node to eliminates the duplicate packets in each sensor nodes, as a result of which network throughput and efficiency increases. It also reduces the overhead to already heavy loaded networks. Further this algorithm is an algorithm for energy constraints in WSNs. RAHTAP has been assessed and its execution was contrasted with an alternate existing asset control calculation HTAP. Recreation outcomes demonstrate that RAHTAP is a productive and straightforward answer for confronting over-burden circumstances in thickly conveyed WSNs in correlation with HTAP.

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