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GPS Based Distributed Communication Protocol for Static Sensor Network (GDCP)

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Abstract

Overall energy of network is a major issue in current sensor network. This paper proposes (GDCP) GPS (Global Positioning System) based reactive communication protocol for Static WSN (Wireless Sensor Network) to extend the life time of entire network. In GDCP, energy efficient routing is achieved using local communication among sensor nodes. While routing, packets are routed via reliable shortest path from source node to sink node. The shortest path is determined with the help of a Neighbouring Table (NT) of a node. This table stores information such as location, distance to neighbour node and distance to a sink node. If the neighbouring node has sufficient energy and its distance to a sink node is less than other neighbours then it becomes the receiver and packet forwards to neighbour node. After receiving the packet, receiver becomes sender node and it checks its neighbouring table for minimum sink node's distance and sufficient energy. This process continues till the packet reaches the sink node. Sink node is assumed to move from one location to another as its neighbour node's energy becomes less than threshold energy. Energy consumption is analysed on 100 static sensor nodes and one sink node. A simulated result shows that overall energy of network is improved.

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Keywords: Local Communication, Static WSN, GPS, Multi-hop Communication

1. Introduction

Wireless sensor networks (WSNs) use a large quantity of sensors in a target area for performing surveillance tasks such as environmental monitoring, military surveillance, animal tracking, and home applications. Each sensor collects information by sensing its surrounding region and transfers the information to a sink (also called a data centre) via wireless transmission. There are some limitations of Sensors like: limited power, limited processing capability, sensing range, connection ability and memory etc.[1]. Every node in the network is responsible to gather

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specific information, monitor its surrounding area and transmit the collected data to a sink node. Most of the energy is utilized to find the shortest path form source node to sink node and transmit data to sink node [2].

This paper explores a distributed communication protocol using GPS for static WSN. Paper is organized as follows: Section 2: explores related work of secure communication protocol for WSN. Section 3: focuses on motivation of work. Section4: explains proposed distributed communication and routing protocol. Finally, in Section 5: comparative results of proposed technique with existing techniques are shown.

2. Related work

Energy focussed literatures are studied and compared with GDCP. They are as follows:

2.1 Low Energy Adaptive Clustering Hierarchy (LEACH)

LEACH is the first protocol proposed for energy consumption in sensor network [3]. Random cluster heads are selected dynamically to gather data from the nodes and to send it to the sink node in every round. Any node can become the cluster head (CH) to save energy and send data to the sink node directly. This algorithm uses data aggression and data fusion technique. It combines all the data of the cluster node, aggregates it into smaller size and transfers only the required information.

Advantages of LEACH are:

LEACH reduces the energy by 8 times than direct communication. It is a distributed protocol having only local knowledge of nodes. But it has some limitations-

- For electing CH it requires lot of energy.
- It is not suitable for large network in which the sink node is located too far.
- It is also not suitable for multi-hop communication.

2.2 Geographic Adaptive Fidelity (GAF)

GAF disables nodes which are not part of routing [4]. Only nodes which are on the path of sending packet are made active. So, the networks energy consumption is reduced. GAF creates a virtual grid, so GPS enabled sensors form a cluster, based on their geographic locations. In every grid leading node forwards data to another node.

2.3 Power-efficient gathering in sensor information system (PEGASIS)

PEGASIS does not form a cluster like LEACH [5]. At a time only one node communicates with the sink. Aggregated and combined data transfers to sink node, by node to node by adding delay. The nodes which are in the path drain more energy but, in improved Hierarchical-PEGASIS, it is recovered.

2.4 A Stateless Protocol for real-time communication in sensor network (SPEED)

SEED stores and maintains neighbour's information in the respective node [6]. Geographic Forwarding technique is used to forward the packets. It also uses feedback control to provide end to end real-time communication. It is more scalable and energy efficient protocol than DSR and AODV.

2.5 Secure Real-Time Routing Protocol with Load Distribution (SRTLD)

Recently SRTLD protocol is introduced which is compared with LQER, RTPC & RPAR [7]. It is experimentally tested on real WSN environment. It takes decision on every hop to find optimal path. It is a routing protocol which uses Geo-directional technique. SRTLD broadcasts message to get route from hop to hop. It has some limitations-

- It consumes more energy to broadcast message at every hop.
- Ultimately overall network energy consumption is more.

All surveyed techniques are for reducing energy consumption but, still there are some limitations in every technique. GDCP proves that it requires less energy to find the shortest path due to local communication in distributed nature. So ultimately the network life time is enhanced.

3. Motivation for current work

Many researchers proposed many techniques for communication among sensor and routing data packet. But most of the techniques do not focus on energy consumption of a node. More energy is required for receiving, sending and processing the data. If the possible shortest path with minimum processing is opted to send packet to sink node then it helps to enhance the overall life time of the network.

Shortest path selection and energy consumption are the key points in multi-hop sensor network. Thus the aim of GDCP is to propose a distributed solution to find the shortest path from source to sink node with minimal local communication and to help to extend life time of the network.

4. Characteristics of Algorithm

The Energy module and GDCP algorithm is as follows:

4.1 Energy Module:

First order Radio Model is used as stated in LEACH. Radio dissipates 50 nJ/bit for transmitting and receiving and for an amplifier 100 pJ/bit/m^2, the energy loss due to channel transmission so, for '*k*' bit message and '*d*' distance transmitting and receiving energy can be calculated as-

Transmitting Energy

$$E_{TX}(k,d) = E_{TX-elec}(k) + E_{TX-amp}(k,d)$$

$$E_{TX}(k,d) = E_{elec} * k + \varepsilon_{amp} * k * d^2 \quad (1)$$

Receiving Energy

$$E_{RX}(k) = E_{RX-elec}(k)$$

$$E_{RX}(k) = E_{elec}(k) \quad (2)$$

4.2 Distance Calculation:

Using Longitude and Latitude we can calculate distance between two nodes. It is similar to calculation of two points in 2D plane.

$$LongDist_{AB} = Long_B - Long_A \quad \text{and} \quad LatDist_{AB} = Lat_B - Lat_A$$

$$Dist_{AB} = \sqrt{(LongDist_{AB})^2 + (LatDist_{AB})^2} \quad (3)$$

4.3 GDCP Algorithm:

For algorithm few assumptions are made, they are as follows:

Each node is –

- Having full initial energy
- GPS enabled
- Capable to calculate distance from itself to sink node
- Having Neighbour Table (NT)
- Having maximum 1.5m range for effective communication.

For Simulation and communication range 100 nodes are placed equidistant from each other. Horizontally & vertically all the nodes are at a distance of 1m and diagonally 1.43m .Localization of Static sensor node is shown in Fig. 1. (a) & (b) initially sink node is located at centre of simulated area.

The GDCP works in two stages-

- Initialization
- Routing

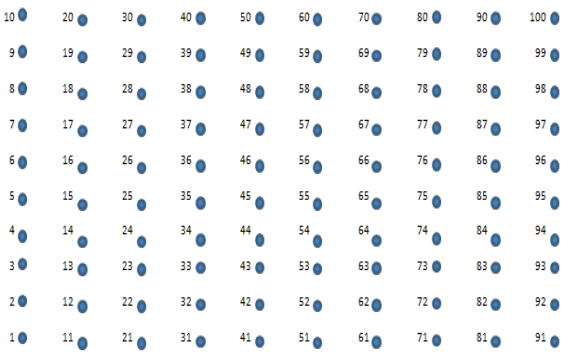
4.3.1 Initialization:

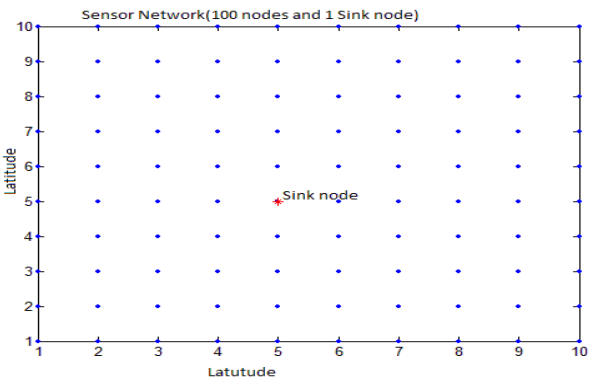
Initialization process works as follow:

1. Locate all the nodes at equal distances from each other as per their communication range.
2. Locate Sink Node at centre of network. (initially)
3. Sink node broadcasts its location to its nearest neighbour
4. After receiving message from neighbour it calculates its distance from neighbour and distance from sink node.
5. Store the message and respective distances.
6. It broadcast own location to its neighbour
7. Repeat step 4 till last node

In Step 3, sink node broadcasts its location to its neighbour nodes i.e. to node 34, 35, 36, 46, 56, 55, 54, 44 and 45. In step 4 receivers (i.e. 34, 35, 36, 46, 56, 55, 54, 44 and 45) calculate their distance from sender and sink node. Step 5, stores message and calculated respective distances in neighbour table. Now in step 6 receiver node will become the sender and broadcast the location of the sink nodes and itself to its neighbour. This process will be repeated till last node's NT is updated.

Fig1. (a) Localization of static sensor nodes (b) Simulation Setup





4.3.2 Routing

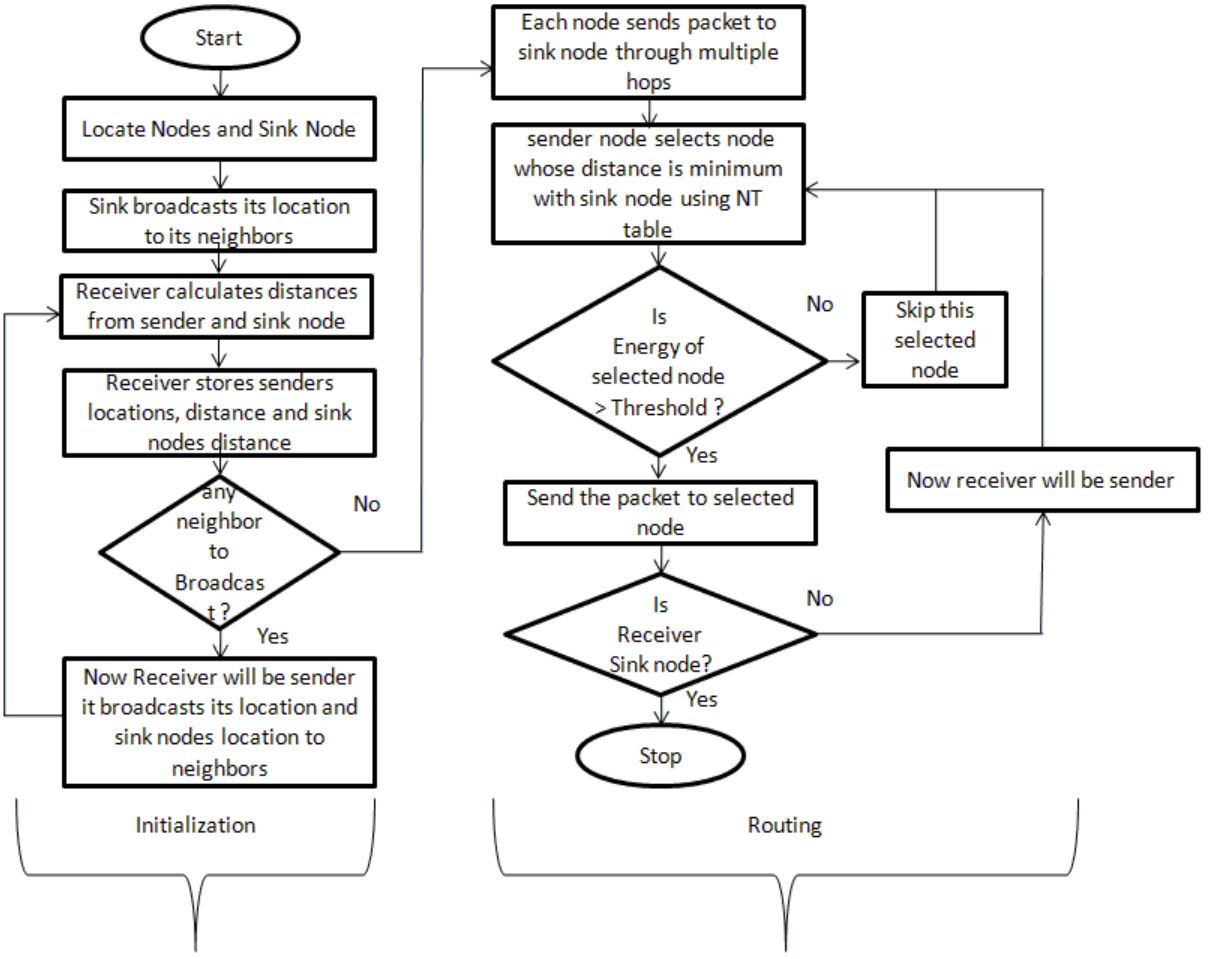
Each node sends a packet one at a time to the sink node as per the given sequence. It works in a distributed manner and only one hop path is decided at one time.

1. Node gathers data and forms a packet to send
2. Node checks its NT and selects the next node which is located at minimum distance from sink node and energy is more than threshold.
3. Packet will be forwarded to selected node.
4. Repeat step 2 till packet reaches the sink node

Threshold energy is kept so that no node dies early. If the nodes energy is less than threshold energy then it will only send its own packet and it will not be part of path of other nodes. Flowchart of GDCP is shown in Fig. 2.

Generally if the network is too large, then the neighbouring nodes of sink node dissipate more energy because they are the part of route to reach sink node. In GDCP, sink node changes its location if one or more of its neighbour's energy is below threshold energy. Its new location is calculated randomly. Once the location of the sink node is changed the neighbour tables of all nodes is updated with the new distance

Fig.2. Flowchart for proposed technique



5. Result analysis

Simulations parameters considered:

Test Bed: 10 X 10 meters

Range of sensor node: 1.5 meter

Energy model: First order radio model

Message size: 2000 bit

Initial energy of node: 0.25 and 0.5 J

Threshold for energy : 0.02 J

Transmitting Energy: (E_{TX}) & Receiving Energy : (E_{TY}): 50 nJ/bit

Data Aggregation Energy: (EDA) : 5nJ/bit

TransmitAmplifier:(amp):0.0013pJ/bit/m^2

Sensor placement: 1 meter from other horizontally and vertically. And 1.42 meter diagonally.

Fig. 3 shows the comparison of energy consumption in the network. Three protocols are tested and compared considering a number of rounds. Number of rounds are recorded when first node and last node of network dies. Fig. 3.(a) & (b) shows the death of first node and last node for Initial Energy 0.25J. After 590 rounds and 680 rounds in Leach and PEGASIS respectively first node is dead. But in GDCP due to sink mobility and threshold energy first node is dead in 800 rounds. It shows in Fig.3. (a). The rounds required to dead whole network (last node) are 1811, 2282 and 2458 rounds in LEACH, PEGASIS and GDCP respectively which is shown in Fig3. (b).

And Fig.3. (C) & (d) shows the death of nodes for Initial Energy 0.5J. Fig.3. (c) shows that first node is dead in 1141, 1877 and 5137 rounds in LEACH, PEGASIS and GDCP respectively. And Fig.3. (d) shows that last node is dead in4087, 5017 and 5137 rounds in LEACH, PEGASIS and GDCP respectively.

Experimental result shows that GDCP protocol consumes approximately equal energy of all nodes than LEACH and PEGASIS. Hence GDCP enhances network life time.

Fig.3 Comparison of energy consumption

Fig.3. (a) First node dies when initial energy is 0.25J

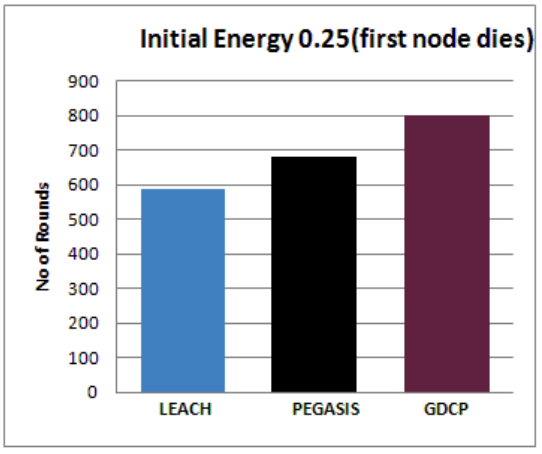


Fig.3. (b) Last node dies when initial energy is 0.25J

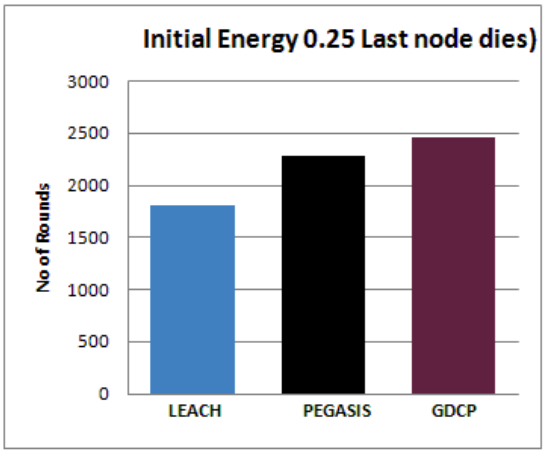


Fig.3. (c) First node dies when initial energy is 0.5J

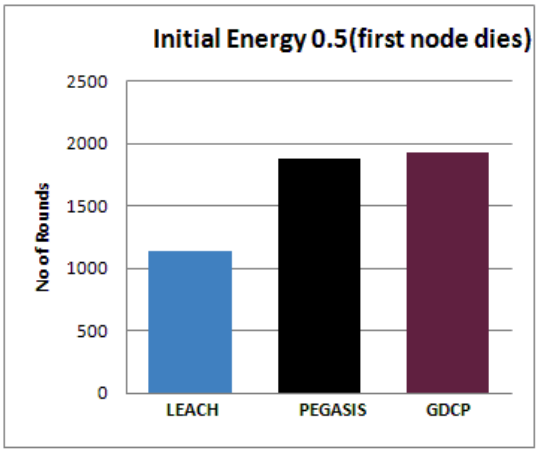
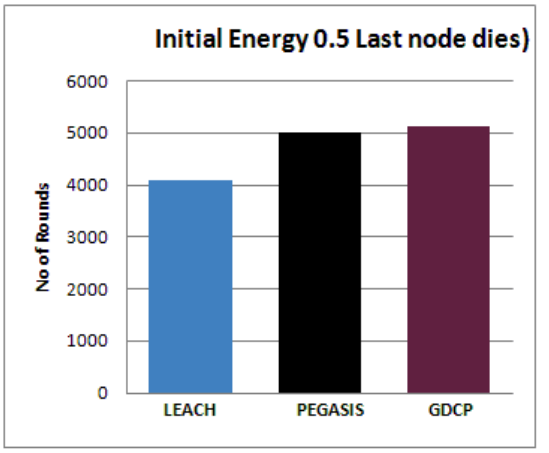


Fig.3. (d) Last node dies when initial energy is 0.5J



6. Conclusion

In WSN for communication sending a packet requires more energy. It is observed that neighbouring nodes of sink node drains more energy and die early because other node sends their packet through these nodes. First modification is, keeping sink node randomly movable if neighbour nodes energy becomes less. Due sink nodes mobility, every movement of sink node new node will be neighbours. So it helps to improve whole networks energy. Second modification is considering threshold energy. If any node's energy becomes less than threshold energy, it will not take part in sending packet of others. It only sense data and forward its own packet. So all node dissipates approximately equal energy. This helps to increase life time of sensor network. The results have proved that due to mobility of sink node and threshold energy, GDCP algorithm extends life time of sensor network.

Same technique can not be used for mobile sensor network because mobile node changes their locations periodically. Node needs to update NT very frequently. So it will be overhead on node to update its NT and it will require more energy to update it. Some new technique needs find in future.

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