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Dynamic GRID Clustered Protocol to Improvise QOS Performance of Wireless Sensor Networks

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Abstract- In wireless sensor networks data packet communication among sensor nodes is a major issue. Wireless Sensor networks can be deployed in various applications namely environmental monitoring e.g. volcano detection, distributed control system, detection of radioactive sources, agricultural and farm practices, internet, military and surveillance. These applications often include the monitoring of sensitive information such as enemy movement on the battlefield or the location of personnel in a building. Security is therefore important in WSNs. WSNs suffer from the use of insecure wireless communication channels. Due to limitation on WSNs battery make security in WSN challenging. Since the WSN nodes battery energy is limited, the primary design goal is to optimize the amount of energy used for packet communication. In this paper the dynamic grid clustered protocol (DGCP) energy efficient protocol is designed and developed to improve quality of service provided by WSN compare to present existing methods.

Keywords: *Sensor networks, Packet Communication, Applications, Routing, hierarchical, Scalability and Security.*

1. INTRODUCTION

Generally Wireless Sensor Network (WSN) consists of a base station (BS) or gateway, a number of motes and they communicate each other wirelessly via a radio link. Physiological signals is collected by the motes; then the collected data is processed, compressed, and transmitted to the gateway using proper routing techniques. The transmitted data is then presented to the destination by the gateway connection. The sensor nodes which communicate wirelessly in a wireless sensor network generally consists of one or more processor, memories, a RF transceiver with a single antenna and power sources as shown in fig.1 below. The sensor device which is commonly referred to as mote provides functionality for measuring physiological signals; the sensed data is processed, and then sent to neighboring mote or base station wirelessly. Table-I shows the function of each sensor device or mote component.

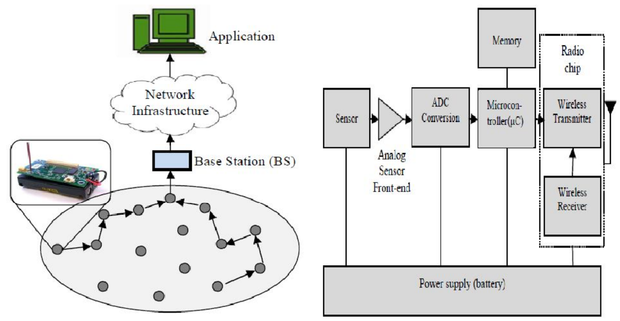


Figure 1: Wireless Sensor Networks and node functional block diagram & its Components [1]

Table I: Sensor Device Components

Component Name	Component Function
Processor	The duty of processor is to interpret mote's sensed data for computation.
Memory	RAM and ROM which are used by the processor for instruction execution and also for storing raw & processed data.
Radio Transceiver	For transmission & Reception of signals with wireless radio.
Sensor(s)	To sense physiological signals.
Power Source	It provides the energy to the required parts.
Geo-Positioning	To know about their locations.

2. NETWORK CHARACTERISTICS AND DESIGN OBJECTIVES

Sensor networks and application requirements characteristics play major roles in the network design objectives in term of network capabilities and network performance [2].

2.1 Network characteristics & constraints

Wireless sensor networks have the following network characteristics & constraints [2]:
Dense sensor node deployment, Battery-powered sensor nodes, Severe energy, Computation & Storage constraint, Self-configurable, Unreliable sensor nodes, Data redundancy, Application specific, Many-to- one traffic pattern, Frequent topology change.

2.2 Network Design Objectives

The main design objectives [2] of WSN are:
Small node size, Low node cost, Low power consumption, Scalability, Reliability, Self-configurability, Adaptability, Channel utilization, Fault tolerance, Security and QoS support.

2.3 Network Design Challenges and Routing Issues

The design challenges in sensor networks involve the following main aspects [2]:
Limited energy capacity, Sensor locations, Limited hardware resources, Massive and random node deployment, Network characteristics and unreliable environment, Data Aggregation, Diverse sensing application requirements and Scalability.

3. ROUTING IN WIRELESS SENSOR NETWORK

3.1 Wireless ad hoc Routing Protocol

Routing protocols for wireless ad hoc networks can be mainly classified into the two categories: Table-driven (or Proactive) and On-demand (or Reactive).

Pro-active Routing (Table-driven)

Table driven ad hoc routing protocols maintain at all times routing information regarding the connectivity of every node to all other nodes that participate in the network. Also known as proactive, these protocols allow every node to have a clear and consistent view of the network topology by propagating periodic updates. Therefore, all nodes are able to make immediate decisions regarding the forwarding of a specific packet. The main disadvantages of such algorithms are –

i. Requirement for maintenance of a large amount of data at every node.
ii. Slow reaction on restructuring and failures.

The example of proactive routing protocol is Destination Sequenced Distance Vector (DSDV). DSDV algorithm uses routing table like Distance vector but each routing table entry is tagged with sequence number, generated by destination. To maintain consistency among routing tables in a dynamically varying topology, updates are transmitted periodically. Each mobile station advertizes its own routing table to its current neighbors.

Routing information is advertised by broadcasting or multicasting. Packets are transmitted periodically and incrementally as changes are detected. In a wireless medium broadcasts are limited by the physical characteristic of medium. If a node invalidates its entry to a destination due to loss of next hop node, it increments its sequence number and uses new sequence number in its next advertisement of the route. Data broadcast by each mobile computer will contain new sequence number, Destination IP address, Number of hops required to reach the destination & Sequence number of the information received regarding that destination.

Reactive Routing (On-demand)

Reactive routing protocols, which appear to be more suitable for ad hoc networks, do not maintain up-to-date information about the network topology, as is done by the proactive ones, but they create routes on demand. Among reactive routing protocols, the Ad hoc On Demand Distance Vector Routing (AODV) and the Dynamic Source Routing (DSR) are the most established and popular. This type of protocols finds a route on demand by flooding the network with Route Request packets. The reactive routing protocols are AODV & DSR.

Ad hoc On Demand Distance Vector (AODV)

This protocol performs Route Discovery using control messages Route Request (RREQ) and Route Reply (RREP). In AODV, routes are set up by flooding the network with RREQ packets which, however, do not collect the list of the traversed hops. Rather, as a RREQ traverses the network, the traversed mobile nodes store information about the source, the destination, and the mobile node from which they received the RREQ. The later information is used to set up the reverse path back to the source. When the RREQ reaches a mobile node, that knows a route to the destination or the destination itself, the mobile node responds to the source with a packet (RREP) which is routed through the reverse path set up by the RREQ. This sets the forward route from the source to the destination. To avoid overburdening the mobiles with information about routes which are no longer (if ever) used, nodes discard this information after a timeout.

When either destination or intermediate node moves, a Route Error (RERR) is sent to the affected source nodes. When source node receives the RERR, it can reinitiate route discovery if the route is still needed. Neighborhood information is obtained by periodically broadcasting Hello packets. For the maintenance of the routes, two methods can be used:
a) ACK messages in MAC level or b) HELLO messages in network layer.

Dynamic Source Routing (DSR)

In DSR, when a mobile (source) needs a route to another mobile (destination), it initiates a route discovery process which is based on flooding. The source originates a RREQ packet that is flooded over the network. The RREQ packet contains a list of hops which is collected by the route request packet as it is propagated through the network. Once the RREQ reaches either the destination or a node that knows a route to the destination, it responds with a RREP along the reverse of the route collected by the RREQ. This means that the source may receive several RREP messages corresponding, in general, to different routes to the destination. DSR selects one of these routes (for example the shortest), and it maintains the other routes in a cache. The routes in the cache can be used as substitutes to speed up the route discovery if the selected route gets disconnected. To avoid that RREQ packets travel forever in the network, nodes, that have already processed a RREQ, discard any further RREQ bearing the same identifier.

3.2 WSN Routing Protocol

There are wide varieties of algorithms for improving energy efficiency and lifespan of wireless sensor networks. Some of the widely used techniques are presented below:

LEACH (Low-Energy Adaptive Clustering Hierarchy) is one of the most popular hierarchical routing algorithms for sensor networks. LEACH randomly select sensor nodes as cluster-heads, so the high energy dissipation in communicating with the base station is spread to all sensor nodes in the sensor network. LEACH uses single-hop routing where each node can transmit directly to the cluster-head and the sink. Therefore, it is not applicable to networks deployed in large regions. Furthermore, the idea of dynamic clustering brings extra overhead, e.g. head changes, advertisements etc., which may diminish the gain in energy consumption.

PEGASIS (Power-Efficient Gathering in Sensor Information Systems) is an improvement of the LEACH protocol. The difference from LEACH is to use multi-hop routing by forming chains and selecting only one node to transmit to the base station instead of using multiple nodes. PEGASIS introduces excessive delay for distant node on the chain. In addition the single leader can become a bottleneck.

APTEEN (**A**daptive **T**hreshold sensitive **E**nergy **E**fficient sensor **N**etwork protocol) when the base station forms the clusters, the cluster heads broadcast the attributes (e.g., temperature), the threshold values, and the transmission schedule to all nodes. Cluster heads also perform data aggregation in order to save energy. The main drawbacks of this approach is the overhead and complexity of forming clusters in multiple levels, implementing threshold-based functions and dealing with attribute-based naming of queries. Also there is possibility of collision occurrence in the cluster.

HEED (Hybrid, Energy-Efficient Distributed) Clustering extends the basic scheme of LEACH by using residual energy and node degree or density as a metric for cluster selection to achieve power balancing. However, the cluster selection deals with only a subset of parameters, which can possibly impose constraints on the system.

4. Performance Metric terms in WSN

The following terms are related to the energy efficiency of WSN which are used to evaluate the performance of the routing protocols:

Network Lifetime: Network Lifetime is the time span from the deployment to the instant when the network is considered nonfunctional.

Average Energy Dissipated: This metric is related to the network lifetime and shows the average dissipation of energy per node over time in the network as it performs various functions such as transmitting, receiving, sensing and aggregation of data.

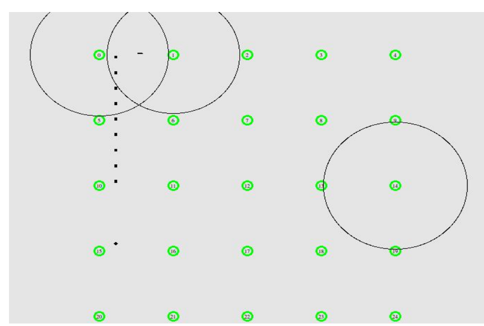
Average Packet Delay: This metric is calculated as the average one-way latency that is observed between the transmission and reception of a data packet at the sink. This metric measures the temporal accuracy of a packet.

Packet Delivery Ratio: It is calculated as the ratio of the number of distinct packets received at sinks to the number originally sent from source sensors. This metric indicates the reliability of data delivery.

Throughput: It is the measure of how fast a node can actually sent the data through a network. So throughput is the average rate of successful message delivery over a communication channel.

Distance: The size of a packet determines the time that a transmission will last. Therefore, it is effective in energy consumption. The packet size has to be reduced by combining several packets into one large packet or by compression.

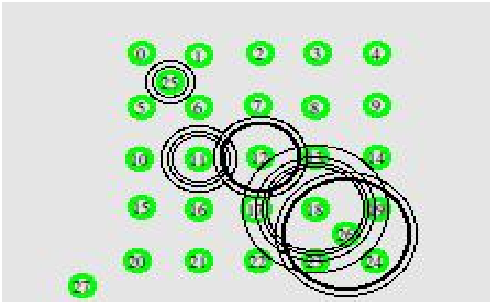
5. SPHERICAL GRID BASED PROTOCOL (SGBP)



Network Scenario-I:

- A 25 nodes Grid Topology network is created.
- Node-0 acts as a source node.
- Node-14 acts as a destination node

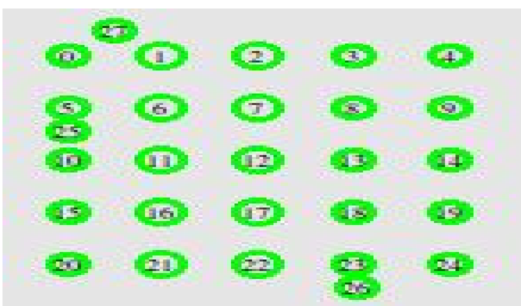
Figure 2. A general 5*5 WSN Topography



Network Scenario-II:

- 25 nodes Grid Topology network is created.
- Node-25 acts as a source node.
- Node-26 acts as a destination node.
- Node 25, 26 & 27 acts as local cluster nodes.
- Node-25 sends information through grid structure topology/networks to destination node 26 at different

Figure 3. 25 Nodes WSN with Source & Destination Node



Network Scenario-III:

- Network forms another stage of 25 nodes Grid Topology networks.
- Local cluster Node-25 or 27 acts as a source node.
- Node-26 acts as a destination node
- Node-27 or 25 sends information through grid structure topology networks to destination node 26.

Figure 4. A WSN Architecture at different coordinates

6. SGBP IMPLEMENTATIONS

NS2 simulation parameter setup is shown in table II & the comparison between performance metric calculation for Transmitted packet, Received Packet, Packet Delivery Ratio, Average Throughput and Average Energy of DGCP protocol using AODV, DSR & DSDV protocol is shown in table III:

Table II. Simulation Parameters For WSN

Simulation Parameters	Value
Channel type	WirelessChannel
Radio-propagation model	Propagation/TwoRayGround
Network interface type	Phy/WirelessPhy
MAC type	Mac/802_11
Interface queue type	Queue/DropTail/PriQueue
Link layer type	LL
Antenna model	Antenna/OmniAntenna
Max packet in ifq	50
Number of mobile nodes	25
Routing protocol	AODV
X dimension of topography	200, 400, 600, 800, 1000
Y dimension of topography	200, 400, 600, 800, 1000
Time of simulation end	100.0
Initial energy in Joules	100
Network Type	Mobile
Connection Pattern	Random
Packet Size	500 bytes
Connection type	CBR/UDP
Number of Nodes	20, 30, 40, 50, 60
Pause time	0s, 20s, 80s, 110s, 140s

Table III. Performance Metrics Calculations

AODV					
CBR:1Mb, Pkt Size:1000	Tx Pkt:1126	Rx Pkt:227	PDR:20.157%	Avg. Thrput:25.23	Avg Energy:98.59
CBR:0.5Mb, Pkt Size:1000	Tx Pkt:563	Rx Pkt:227	PDR:40.32%	Avg. Thrput:25.22	Avg Energy:98.59
CBR:0.1Mb, Pkt Size:1000	Tx Pkt:113	Rx Pkt:113	PDR:100%	Avg. Thrput:12.56	Avg Energy:96.35
CBR:1Mb, Pkt Size:500	Tx Pkt:2251	Rx Pkt:380	PDR:16.88%	Avg. Thrput:42.35	Avg Energy:98.59
CBR:1Mb, Pkt Size:200	Tx Pkt:5626	Rx Pkt:644	PDR:11.45%	Avg. Thrput:71.62	Avg Energy:98.6
CBR:1Mb, Pkt Size:1500	Tx Pkt:751	Rx Pkt:160	PDR:21.30%	Avg. Thrput:17.83	Avg Energy:98.61

DSR					
CBR:1Mb, Pkt Size:1000	Tx Pkt:1164	Rx Pkt:216	PDR:18.56%	Avg. Thrput:24.55	Avg Energy:98.540
CBR:0.5Mb, Pkt Size:1000	Tx Pkt:585	Rx Pkt:209	PDR:35.72%	Avg. Thrput:23.369	Avg Energy:98.50
CBR:0.1Mb, Pkt Size:1000	Tx Pkt:133	Rx Pkt:103	PDR:77.05%	Avg. Thrput:28.66	Avg Energy:97.95
CBR:1Mb, Pkt Size:500	Tx Pkt:2320	Rx Pkt:364	PDR:15.68%	Avg. Thrput:40.512	Avg Energy:98.443
CBR:1Mb, Pkt Size:1500	Tx Pkt:1165	Rx Pkt:173	PDR:14.84%	Avg. Thrput:19.39	Avg Energy:98.539

DSDV					
CBR:1Mb, Pkt Size:1000	Tx Pkt:1111	Rx Pkt:206	PDR:18.54%	Avg. Thrput:23.75	Avg Energy:97.43
CBR:0.5Mb, Pkt Size:1000	Tx Pkt:576	Rx Pkt:204	PDR:35.41%	Avg. Thrput:24.52	Avg Energy:97.43
CBR:0.1Mb, Pkt Size:1000	Tx Pkt:205	Rx Pkt:176	PDR:85.85%	Avg. Thrput:17.56	Avg Energy:97.55
CBR:1Mb, Pkt Size:500	Tx Pkt:1987	Rx Pkt:780	PDR:39.22%	Avg. Thrput:21.25	Avg Energy:97.47
CBR:1Mb, Pkt Size:200	Tx Pkt:799	Rx Pkt:104	PDR:13.09%	Avg. Thrput:57.42	Avg Energy:97.60
CBR:1Mb, Pkt Size:1500	Tx Pkt:800	Rx Pkt:158	PDR:19.75%	Avg. Thrput:37.83	Avg Energy:97.41

7. CONCLUSION

All the optimal energy management routing protocols for resource constrained wireless sensor networks available so far in this area, has certain limitations in Energy consumption, Data aggregation, scalability, Mobility, Route metric, Periodic message type, Robustness and Quality of service of the Sensor Networks. Among varieties of routing schemes dynamic grid clustered protocol (DGCP) schemes offers better choices to researchers to achieve better energy efficiency. DGCP techniques give wider choice to researchers to understand the performance metrics of sensor networks and to find new horizon for the further improvement. Also the comparison between performance metric calculation for Transmitted packet, Received Packet, Packet Delivery Ratio, Average Throughput and Average Energy of DGCP using AODV, DSR & DSDV protocol concludes that AODV performance is better. At same time topological change services consume more energy on computation, communication, and storage overhead in WSNs and this limitation can be further improvised by the researcher.

REFERENCES

[1]. Mohsen Nasri, Abdelhamid Helali, Halim Sghaier and Hassen Maaref, Energy-Efficient Wavelet Image Compression in Wireless Sensor Network, *International Conference on Wireless and Ubiquitous Systems*, 8-10 October 2010, Sousse, TUNISIA.

[2]. Kemal Akkaya and Mohamed Younis, A Survey on Routing Protocols for Wireless Sensor Networks, *Ad hoc Networks, vol. 3,* no. 3, pp. 325-349, May 2005.

[3]. Ananthram Swami et al., “Wireless Sensor Networks: Signal Processing and Communication Perspectives”, John Wiley, 2007.

[4]. T.P. Sharma, R.C. Joshi, Manoj Misra, “GBDD: Grid Based Data Dissemination in Wireless Sensor Networks,” *In Proc. 16th International Conference on Advanced Computing and Communications (ADCOM 2008)*, Chennai, India, 2008, pp. 234-240.

[5]. Jamal N. Al-Karaki Raza Ul-Mustafa Ahmed E. Kamal, “Data Aggregation and Routing in Wireless Sensor Networks: Optimal And Heuristic Algorithms”, *Computer Networks,* Volume 53, Issue 7, Pages 945–960, 13 May 2009.

[6]. Dragoş I. Săcăleanu, Dragoş M. Ofrim, Rodica Stoian, Vasile Lăzărescu, “Increasing lifetime in grid wireless sensor networks through routing algorithm and data aggregation techniques”, *International Journal Of Communications*, Issue 4, Volume 5, 2011.

[7]. Neng-Chung Wang, Yung-Kuei Chiang, Chih-Hung Hsieh, and Young-Long Chen, “Grid-Based Data Aggregation for Wireless Sensor Networks”, *Journal of Advances in Computer Networks*, Vol. 1, No. 4, December 2013.

[8]. Yung-Kuei Chiang, Neng-Chung Wang and Chih-Hung Hsieh, “A Cycle-Based Data Aggregation Scheme for Grid-Based Wireless Sensor Networks”, Sensors 2014, 14, 8447-8464; doi:10.3390/s140508447.

[9]. I. F. Akyildiz et al., A Survey on Sensor Setworks, *IEEE Communication Mag., vol. 40,* no. 8, Aug. 2002, pp. 102–114.

[10]. W. R. Heinzelman, A. Chandrakasan, and H. Balakrishnan, Energy efficient communication protocol for wireless micro sensor networks, *in Proceedings of the 33rd Annual Hawaii International Conference on System Sciences (HICSS),* pp. 10–20, January 2000.

[11]. S. Mohapatra, P.Kanungo, Performance analysis of AODV, DSR, OLSR and DSDV Routing Protocols using NS2 Simulator, *International Conference on Communication Technology and System Design 2011*, Procedia Engineering 30 (2012) 69 – 76.