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Energy Utilization Based Data Collection in Decentralized Geographic Routing In WSN

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***Abstract*— Wireless sensor network is a self-governing wireless network for mobile devices. It does not require any fixed infrastructure to be configured which makes it more appropriate to be used in environments that require on-the-fly setup. The network requires no centralized management, the structure of topology is changed arbitrarily and the communication between the devices will take place via radio waves at anywhere and anytime. Nodes of ad hoc network can act as end system as well as routers. The challenges of Wireless sensor network are scalability, resource availability, security threads, no predefined boundary and limited power supply. Routing in Wireless sensor network determines the best path to reach the destination in the network and it plays a vital role in deciding the quality of service. The quality of service for wireless routing is more challenging than wired network due to node mobility and resource constraints. The goal of quality of service provides a better service to the selected network traffic. The quality of service parameter includes end-to-end delay, routing overhead, packet delivery ratio, throughput, control overhead, energy, and jitter. Optimization can be used to find out the best and optimal solution from the possible path. Different optimization techniques are available to provide improved quality of service in Wireless sensor network routing. Artificial Bee Colony algorithm is one of the swarm intelligence-based optimization techniques. Artificial Bee Colony finds out an optimal path from source to destination. This algorithm is based on the intelligent foraging behavior of a honeybee swarm.**

***Index Terms*— Wireless sensor network, Quality of Service, Swarm intelligence, honeybee behavior, scouting, foraging, path selection.**

I. Introduction

A. .WSN

Wireless sensor network (WSN) [1] is a collection of mobile devices which forms an autonomous network. The mobile nodes are not having fixed infrastructure for communication. In WSN, all the nodes can move freely at any time and it can connect to other nodes. Every node is independent in the network without having any centralized management. Each node can act as a router as well as host devices.

1) Characteristics of WSN

Dynamic Topology: The topology of the network is changed dynamically with respect to time. Decentralized Control: WSN does not require any centralized management. The mobile node in WSN is self-configuring, autonomous system and infrastructure less network.Multi-hop Routing: For nonlinear networks, multi-hop communication is performed rather than single hop.Autonomous Terminal: Each mobile node is independent node's which function both as a host and a router.Distributed Operation: The node control over the network is distributed. The nodes should cooperate with each other and communicate among themselves

2) Issues in WSN

The unpredictability of Environment: Ad hoc networks may be deployed in unknown terrains, hazardous conditions, and even hostile environments where interfering or the destruction of an actual node may be difficult.Power Constrained Operation: Some or all of the nodes in a WSN may depend on batteries or other exhaustible means for their energy. So, the communication-related functions should be developed for lean power consumption. Resource-Constrained Nodes: Mobile nodes trust on battery power, which is a rare resource. Also, storage capacity and power are severely limited. Limited Physical Security: Mobility indicates higher security risks such as peer-to-peer network architecture or a shared wireless medium accessible to both legitimate network users and malicious attackers. Eavesdropping, spoofing, and denial-of-service attacks should be considered.

Scalability: It is defined as whether the network is capable of providing an acceptable level of service even in the presence of a large number of nodes. Boundary Limitation: In WSN, physical boundary of the network cannot be defined.

3) Applications of WSN

Education: Used in virtual classrooms, ad hoc communications during meetings or lectures, universities and campus settings. Entertainment: WSN is applied to support multiuser games, wireless peer to peer networking and outdoor access of internet. Context Aware Services: It provides services like call-forwarding, mobile workspace, location specific services, and time dependent services. Sensor Networks: WSN provide services like data tracking of environmental conditions, animal movements, chemical/biological detection, body area networks.

Tactical Networks: used in military communication operation and automated battlefields. Commercial Environments: WSN is used in electronic payments at anytime and anywhere, dynamic database access and mobile offices. Emergency Services: WSN is used in Search and rescue operations, Disaster recovery and Replacement of fixed infrastructure in case of environmental disasters.

B. Quality of Service

In WSN providing QoS is more challenging than a wired network. The objective of QoS routing is to identify paths that have adequate resources to satisfy a set of constraints and at the same time attain global efficiency in resource utilization. QoS is stated in terms of end-to-end performance over the network which includes various parameters such as end-to-end delay, bandwidth, energy, throughput, packet delivery ratio, and jitter. Energy in WSN is defined as battery power in the nodes. The parameter end-to-end delay refers to the time taken for a packet to be transmitted over a network from source to destination. It comprises of processing delay, queuing delay, transmission delay and propagation delay. Bandwidth is the maximum data transfer rate of the network. Throughput has defined the rate of successful message delivery across a communication channel. Providing multiple metrics solution is not an easy task in WSN. It can be solved by using an optimization method.

C. Swarm Intelligence

Swarm intelligence [2] deals with collective behaviors that result from the local interactions of individual components like ants, termites and bees with each other and with their environment. Two of the most popular and successful examples of the SI approach are Ant Colony Optimization, Artificial Bee Colony Optimization and Particle Swarm Optimization. Once the problem is specified, the forward pass starts by artificial bees search for a partial solution to the problem. After discovering the enough information, they return to the hive where the partial solutions they have gained are shared between the searchers. Each artificial bee has to make a decision based on a certain possibility, whether it will continue searching succeeding its own path, or change to a fellow searcher's solution. The last step is to decide which solution is the best, based on certain criteria.

II. RELATED WORKS

This section discusses the algorithms that have been proposed by various authors providing on routing in WSN. Swarm intelligence techniques [3] for food foraging behavior applicable for WSN. It deals with ant based routing tofind the shortest path to reach destination. Learning strategy is based on pheromone level of ants which helps to make appropriate routing decisions and it uses the forward ant which is sent by the sender, whereas backwardant are used by the destination node. A QoS based routing protocol[4] adds quality of service to the routing in WSN. Swarm Intelligence [5] inspired the Self-Organized Networking (SON). The main idea is to provide principle and optimization approaches of various bio-inspired algorithms, measuring and comparing critical SON issues from the perception of physical layer, Media Access Control layer and network layer operations. Efficient multipath [6] routing for Wireless sensor networks constructs multiple paths using RREQs. Energy is not required for choosing the paths. Here the proposed protocol not only considers residual energy but also transmission power of nodes in paths selection to exploit the lifetime of networks. The system comprises of three stages which are 1) Control transmission power, 2) Calculate residual energy and 3) System operation. A hybrid ant routing algorithm [7] for reliable throughput using WSN is proposed. Here, ant-like mobile agents are used which sample the node between source and destination. In WSN, each node forwards the packet between two or more node. By varying the time cycle, throughput and packet performance can be increased. When throughput is increased, efficiency is also high and improves the quality of services. An improved [8] ant colony based multi-constrained QoS energy-saving routing (IAMQER) and throughput optimization in wireless Ad-hoc networks. It is constructed on the analysis of local node information such as node queue length, node forwarding number of data packets and node residual energy, balances the relationship between the network throughput and the energy consumption, thus improving the performance of network in multi-constrained QoS routing.

Ant colony [9] algorithm finds the optimal path to reach destination. Ants exchange the information with each other by pheromone factor. Algorithm uses the request and reply ants for effective route discovery. Here, congestion metrics are measured using buffer occupancy, load of the channel and packet drop rate. Connectivity level of the route is measured by received signal strength of the link.

A. BEEIP

1) Basic Honeybees Behavior

One of the most noticeable behaviors in honeybee algorithm [10] visible to us is the foraging of each individual bee. The foraging process includes two main modes of behavior: recruitment of nectar source and abandonment of a source. It starts with some scout bees left the hive in order to search food source to gather nectar. After discovering the food (i.e., flowers), scout bees come back to the hive and inform their hive-mates about the richness of the flower and the distance of the flower to the hive (i.e., location) through a special movements called dance, which are round dance, waggle dance, and tremble dance depending on the distance information of the source. Typically, it dances on different areas in an try to advertise food locations (by touching her antennae) and encourage more remaining bees to gather nectar from her source. After the dancing show, more foraging bees will leave the hive to collect nectar follow one of the dancing scout bees. Upon arrival, the foraging bee stores the nectar in her honey stomach and returns to the hive. The described process continues repeatedly until the scout bees discover new areas with potential food sources.

The honeybee behavior is applied over the routing in WSN for route discovery. BeeIP is a new honeybee-inspired adaptive routing protocol based on the collaborative behaviors of honeybee foragers. BeeIP is a multipath reactive honeybee agent explores the topology only when data are required to be transmitted between nodes. They are designed to monitor and estimate the performance of the discovered paths and select the optimal one based on a selection mechanism inspired by their natural counterparts.

Three kinds of honey bee are used to search the food sources is shown in Figure 1, which includes scout bees, employed bees, and onlooker bees. Scout bees examine the food source randomly; employed bees will examine the food source and share food information to the onlooker bees. Then, onlooker bees will calculate the fitness and select the best food source. After scout bees finding the food sources and return to the hive, and it compares the quality of food source. The waggle dance is performed to share the information about the food source direction. Then, the scout bees will be sent through the best food source path to bring nectar back to the hive.

Honey bee algorithm is a population-based search algorithm. It mimics the food foraging behavior of honey bee colonies. The feature of honey bee routing in WSN is how adaptive behaviors that are met in the natural system of the hive are applied to solve a complex routing problem and to find the optimal path to reach the destination.

2) Honey bee foraging Algorithm

The elements of honeybee are scout,ack_scout, forager and ack_forager. When a route [2] is required at the source node and there is no former routing information is available, and then a scout packet is generated and broadcasted to the network. The scout packet is responsible for discovering available paths to its destination, while it introduces neighboring nodes to each other, in a hop by hop manner. The scouting process is considered successful when source node receives one or more ack_scout packet. When a forager is received by the destination node, it sends piggybacked data to the transport layer and converts to an ack_forager. Like the real honeybees which take some time on the flower to gather the pollen or the nectar, the ack_forager stays at the destination node until some data packet needs to return to the initial source. While traveling back home, it collects up-to-date information about the nodes it visited and the links between them.

B. PROPOSED SCHEMES

The proposed scheme is that a number of routing protocols proposed for WSN use shortest route in terms of hop count for data transmission. It may lead to quick reduction of resources of nodes falling on the shortest route. It may also result in network congestion resulting in poor performance. The required parameters used are defined in the following

1. Route energy: (RE) the route energy of a path is the minimum of residual energy of the nodes falling on the route. Higher the route energy lesser is the probability of the route failure due to the exhausted nodes.
2. Traffic queue: (TQ) the traffic queue of a node is number of packets queued up in the node interface. Higher the value, more number of nodes is occupied.
3. Average Traffic Queue: (ATQ) it is the mean of traffic queue of the node from the source to destination node. It indicates load on a route and helps in determining the heavy loaded route.
4. Hop Count: (HC) The Hop Count is number of hops for a feasible path.

Ad-hoc On-demand Distance Vector (AODV) is an on demand routing algorithm. When a node needs to send data to a specific destination it creates a Route Request and broadcast. When the request reaches a destination node it creates again a Reply which contains the number of hops that are require to reach the destination. All nodes forwarding this reply to the source node create a forward route to destination [1][12]. Dynamic source routing (DSR) allows nodes to maintain and discover the routes to its destination.

A source node initiates the route discovery process by broadcasting a route request (RREQ) packet whenever it wants to communicate with another node for which it has no routing information in its table. On receiving a RREQ packet, a node checks its routing table for a route to the destination node. If the routing table contains the latest route

to the destination node, the intermediate node sends a destination node sends a RREP packet along the reverse path back to source node also appending the weight value for the route. When a source node receives more than one RREP packet for RREQ, it compares the weight value of the route and selects the route with maximum weight [10]. However, if an intermediate node has no information of the destination node, it adds its own traffic queue value, compare and finds the minimum of residual battery capacity field of RREQ packet, increments the hop count by one and rebroadcast the route discovery packet when destination mode receives a route request packet, it waits for a certain amount of time before replying with a RREP packet in order to receive other RREQ packets. Then destination node computes ATQ and the weight value for each feasible path using equation 2 and using weight function as given in equation 1 respectively. The route with highest weight value is selected as the routing path and a RREP packet is sent back towards the source node and the selected path. The different topology based routing protocols are compared to optimize the packet delivery ratio using geographic routing.

C. PERFORMANCE EVALUATION

The proposed scheme is simulated in two scenarios as in Figure. The bandwidth of each link is 1 Mbps and the wireless channel is error free. All the sources have the same demand function $xs(t+1) = xmaxe{-}k \cdot qs(t)$. The parameter $\gamma = 0.1$. The calculated source rates of the flows are shown in Figure. The time interval represents the roundtrip- time. Initially, all the maximal cliques have price $p\Omega = 0$, so all the sources have $qs= 0$ and get the calculated price as $xmax$. Then the prices are updated at each maximal clique, and the maximum one is sent back to source nodes.

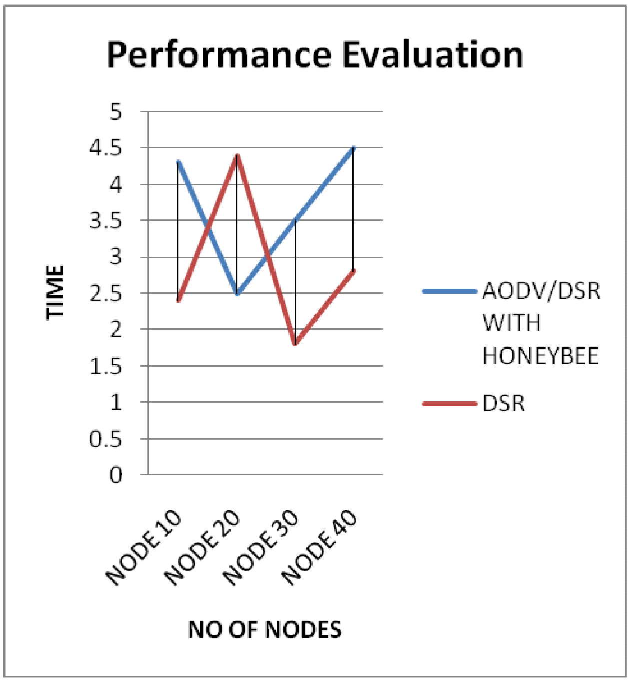

Figure 1: Performance evaluation

Every source adjusts its end-to end flow rate according to the congestion signal and finally achieves the max-min fair rate listed in fig. Note that during the transient period, the actual rates are not equal to the calculated rates In general, flows in the network change dynamically. We have also done evaluations with dynamic flows. The results demonstrate that this algorithm works well with dynamic flows. However, due to the space limitation, we omit further discussion on dynamic flows in this paper.

III. CONCLUSION

Routing in WSN determines the best path for data to reach the destination in the network. The path availability and stability of routes at an instance is an issue in WSN that affects the quality of service in the network. For different application, different QoS metrics are considered. Some of the optimization techniques considers multiple QoS metrics for stable routing in WSN. One of the optimization techniques to solve QoS issues in WSN is adaptive behavior inspired by honeybees which dynamically discovers and maintains the routing solutions and forward data packets over the wireless paths. The proposed scheme on honey bee based QOS routing reduces an end-to-end delay by monitoring the path quality of the route.

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