Comparative analysis of routing protocols in Wireless sensor Network

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ABSTRACT

In the last few decades many research work have been conducted by the researchers in the field of routing protocols in wireless sensor networks. Nowadays their main area of concern is based on routing protocols utilizing the concept of SWARM INTELLIGENCE. In this paper we are going to study different swarm intelligence based routing protocols and after that their comparison is made based on a number of aspects like energy efficiency, lifetime, fault tolerance, scalability, success rate, data gathering, type of routing and other ones.

Keywords: ACO Based protocols SC, FF, FP, EEABR, E and D Ants, T ants, BEE Colony Based protocol BEE Sensor.

I. INTRODUCTION

Wireless sensor networks (WSNs) consist of a large number of autonomous nodes equipped with sensing capabilities, wireless communication interfaces, and limited processing and energy resources. WSNs are used for distributed and cooperative sensing of physical phenomena and events of interests. Usually, the nodes are statically deployed over vast areas. However, they can also be mobile and capable of interacting with the environment. In these cases, the network is more appropriately referred to as a robotic network and/or as a sensor-actor network. WSNs can be employed in a wide spectrum of applications in both civilian and military scenarios, including environmental monitoring, surveillance for safety and security, automated health care, intelligent building control, traffic control, object tracking, etc.

Primary routing goals of WSN systems are to extend network life and prevent connection errors that emerged from the use of intensive energy management techniques. Therefore, there is no way to use classical routing approaches in WSNs and there is need for new routing approaches. As such, these routing approaches emerged as swarm intelligence based schemes.

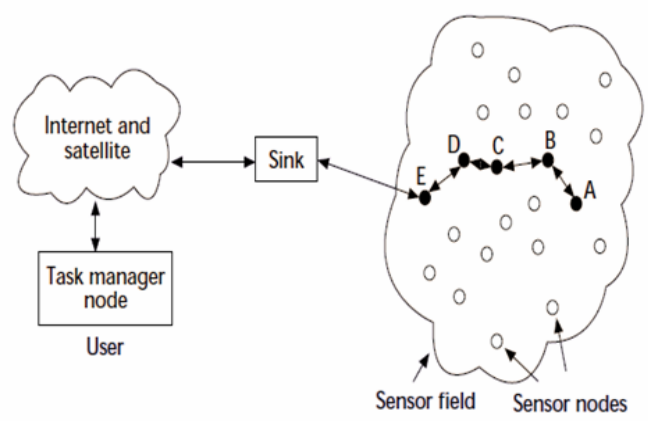

Figure 1 . The components of a sensor node

II. SWARM INTELLIGENCE

Swarm intelligence (SI) is a relatively novel field that was originally defined as ‘‘Any attempt to design algorithms or distributed problem-solving devices inspired by the collective behavior of social insects and other animal societies”. However, nowadays SI refers more generally to the study of the collective behavior of multi-component systems that coordinate using decentralized controls and self-organization[1]. From an engineering point of view, SI emphasizes the bottom-up design of autonomous distributed systems that can show adaptive, robust, and scalable behaviors[2]. The SI framework encompasses other popular frameworks such as Ant Colony Optimization (ACO).

In this work, several swarm intelligence based routing protocols were investigated and compared. Comparisons are performed in terms of some criteria such as energy consumption, scalability and so on.

III. SWARM INTELLIGENCE BASED ROUTING PROTOCOLS FOR WIRELESS SENSOR NETWORKS

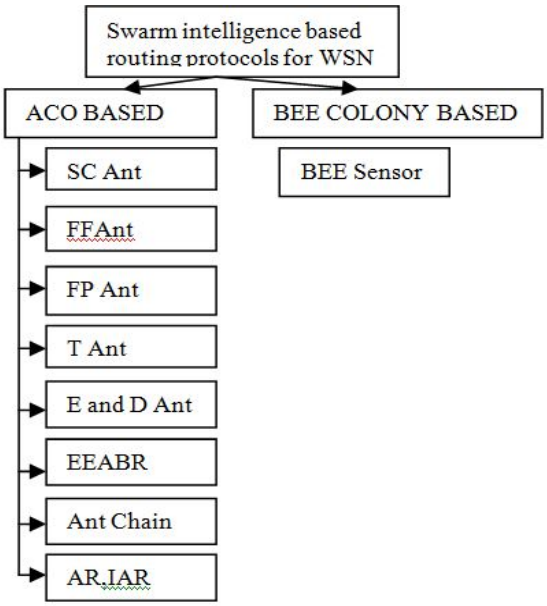

FIGURE 2 . Classification of SWARM INTELLIGENCE based routing protocols

Here, a brief literature for swarm based routing protocols is given to WSNs. Swarm based routing protocols are classified into three categories: Ant based , bee based and slim based ,but in our paper we mainly focus on ACO and BEE Colony based routing[3].

A. Ant Colony Optimization (ACO) Based Routing

Ant Colony Optimization (ACO) is general purpose optimization technique which is based on foraging behavior of ant species in real life. These real life ants walking to and from a food source, deposit a chemical substance called pheromone which establish the shortest path for other members of colony to be followed. Similarly in ACO, artificial ants are the agents which are used to solve the various optimization problems. These agents (ants) moving around in the network from one node to the other, updating routing tables (called pheromone table) of the nodes that they visit with what they have learned in their traversal so far. Afterwards agents selecting best shortest path from updated pheromone table.

Sensor-driven and cost-aware ant routing (SC)

In this approach, the performance of the forward ants is increased with sensors to sense the best direction that the ants will go initially.

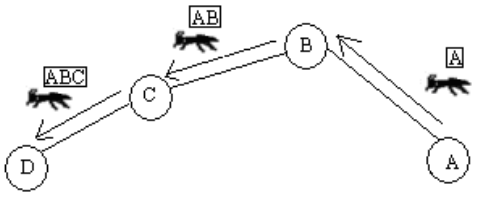

Fig.3. Ant traversing the network and providing routing information to the nodes .

In addition to storing the probability distribution, each node estimates and saves the cost to the destination from each of its neighbors.

Flooded Forward Ant Routing (FF)

In the second variant, the source nodes flood the forward ants towards the sink node. FF, like SC, assumes that the forward ants are equipped with direction/location sensors. Forward ants in FF are flooded stochastically to reduce protocol overhead.
Two methods are used to restrict the flooding process. First, an intermediate node i rebroadcasts a replica of a forward ant only if i estimates that it is closer to the destination than the node it has received the ant from. Second, node i waits for a random amount of time before forwarding the ant to the next hop[5]. If, in the meantime, it receives the broadcast of the same replica of a forward ant from one of its neighbors, the node simply drops it.

Flooded piggybacked ant routing (FP-Ant)

FP-Ant is developed by Ying Zhang in 2004. The flooding mechanism is significantly helpful in wireless networks, especially in sensor networks, where the probability of a packet loss is substantially higher compared to that of fixed networks[4]. FP-Ant is a variation of the AntNet proposed in and is based on the flooding mechanism.

Energy-efficient ant-based routing (EEABR)

EEABR is developed by T. Camilo in 2006 and a new communication protocol for WSNs called energy efficient ant-based routing algorithm (EEABR), which is based on the Ant Colony Optimization (ACO).EEABR uses a colony of artificial ants that travel through the WSN looking for paths between the sensor nodes and a destination node, that are at the same time short in length and energy-efficient, contributing in that way to maximize the lifetime of the WSN. Each ant chooses the next network node to go to with a probability that is a function of the node energy and of the amount of

pheromone trail present on the connections between the nodes. When an ant reaches the destination node, it travels backwards trough the path constructed and updates the pheromone trail by an amount that is based on the energy quality and the number of nodes of the path. After some iteration the EEABR protocol is able to build a routing tree with optimized energy branches.

Energy-Delay ant-based (E-D ANTS)

This approach is developed to minimize the time delay in transferring a fixed number of data packets for the sake of the energy constrained. In this study, a novel Energy x Delay model based on ant algorithms is proposed and called "E and D ants" for short[6]. The lifetime maximization of the network and realtime data transmission services are the main features of the developed algorithm. E and D ants algorithm is compared to other ant-based routing algorithms like 'antnet and ant-chain' about the issues of routing information, routing overhead and adaptation, and as such, simulation experiments are done in OPNET. Results show that E and D ants algorithm outperforms ant-net and ant-chain about seven times better.

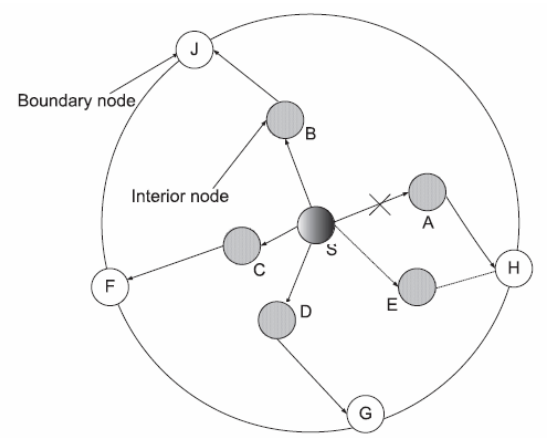

Figure 4 . JARA: nodes A, B, C, D and E are interior nodes, E, F, G and H are boundary nodes, S is the central node.

Ant Chain

Ant Chain is a centralized algorithm which partitions the responsibilities of sensor nodes and the sink node according to their hardware resources and relative distances with the aim of optimizing energy consumption and transmission delays. Ant Chain targets the applications in which the location and the identity of the sensor nodes are known in advance (e.g., in some health care applications).The sink node exploits location information to calculate a near-optimal chain organization for the nodes, which is then used for efficient data transmission[9]. Ant Chain assumes that each sensor node can directly reach every other node in the network and can directly communicate with the sink. A node can be in one of the four states: sleeping, idle, receiving, or transmitting.

AR and IAR

AR and IAR are developed by Ghasem Aghaei et al.(2007)as a biologically-inspired swarm intelligence based routing algorithm, which is suitable for sensor networks[8]. The developed ant routing algorithm also meet the enhanced sensor network requirements, including energy consumption, success rate, and time delay. Comparisons are made with SC-Ant, FF-Ant, FP-Ant and ant-net in Java-based simulation environment.

T-ANT

T ANT which is a distributed, cluster-based data gathering protocol for WSNs. The major objective of T-ANT is to optimize network lifetime by forming evenly distributed clusters at minimal energy cost. The protocol exploit the separation and alignment principles found in biological swarms, thereby making use of a very limited number of ants to form clusters, hence incurring in limited energy overhead. T-ANT uses two methods: variance estimation and clustering methods. In clustering method, a CH election ant is deployed. In case of node initialization, sink deploys a number of ants (that is, control messages)[5]. As such, ants can trespass the network limited to its time-to-live (TTL) value. When an ant arrives at a node, the next node is randomly chosen hence routing is probabilistic.

B. Bee colony based routing protocols

These protocols are inspired from honeybees foraging behaviors. The routing in computer networks has several resemblances with honeybees Honey bees in particular have mechanisms for WSNs
such as self organization and division of labor. There are a few routing protocols for WSNs, inspired from bees.

Bee Sensor

Saleem and Farooq have proposed Bee Sensor, a bee-inspired, reactive and event-driven multipath routing protocol for WSNs. Bee Sensor aims at energy efficiency, scalability, and long network lifetime. Energy efficiency is achieved by limiting the number of control messages, as well as of data packets through in-network aggregation. Paths are prioritized on the basis of their remaining energy levels to extend the network lifetime.
In addition to forward and backward scout agents, Bee Sensor makes use of additional agents such as packers, foragers and swarms. Packers receive data packets from the upper layers of the node architecture, and hand them

over to a forager for transportation to a sink node[11]. In turn, swarms transport a group of foragers back from the sink to the source node. Foragers are the main agents that transport events from the source to a sink node. Forward scouts carry the data, and are therefore launched on reactive basis[22]. Intermediate nodes at Hl hops (or less) away from the source, deterministically broadcast them.

Table 1. Comparison between Ant Based Protocols and Honeybee Based Protocol

Feature	ROUTING PROTOCOLS						
	SC	*FF*	*FP*	*EEABR*	*T ANT*	*E D ANT*	*BEE SENSOR*
Energy efficiency	Very strong	Weak	Weak	Very Strong	Strong	Strong	Very Strong
Scalability	Weak	Weak	Weak	Weak	Strong	Weak	Weak
Data gathering	Weak	Weak	Weak	Weak	Very Strong	Weak	Weak
Network Lifetime	Weak	Weak	Weak	Strong	Strong	Weak	Strong
Fault Tolerance	Weak	Weak	Strong	Strong	Weak	Weak	Strong
Packet Delivery Latency	Weak	Very Strong	Weak	Weak	Weak	Strong	Very Strong
Success Rate	Weak	Weak	Very Strong	Weak	Weak	Weak	Weak
Loop Free	No	No	No	No	Yes	No	Yes
Flat(F) /Hierarchical (HR)	F	F	F	F	H	F	F

IV. CONCLUSION

Wireless sensor networks consist of large sets of resource-constrained nodes. The design of effective, robust, and scalable routing protocols in these networks is a challenging task. On the other hand, the relatively novel domain of swarm intelligence offers algorithmic design principles, inspired by complex adaptive biological systems, that well match the constraints and the challenges of WSNs. Therefore, a number of routing protocols for WSNs have been developed in the last years based on SI principles, and, more specifically, taking inspiration from foraging behaviors of ant and bee colonies. When the literature was investigated, it was obviously seen that routing protocols for WSNs were implementations from wired networks. The researches done have shown that swarm intelligence based routing protocols can remove at least one or several problems in the area such as battery life, scalability, maintainability, survivability, adaptability and so on. As such, ant based approaches are attracted by much researchers than other approaches.

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