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Application of Wireless Sensor Networks in Robotics (Swarm Intelligence)

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Abstract

This work is an overview of protocols in wireless sensor networks applied in the field of swarm robotics. The modeling of swarm intelligence resembles the social behavior of animals and the optimization is done according to the application. This is widely used due to its robustness, flexibility, self-organized and decentralized behavior. In this paper, the topic is on the swarm intelligence and its applications to routing are discussed. I conclude the paper with number of issues related to the use of scientific methodology and procedures evaluated and to identify the future prospects.

Keywords

Wireless Sensor Networks, Robotics, Swarm Intelligence, Review.

Introduction

In swarm robotics, the Wireless Sensor Networks (WSN) are deployed with autonomous nodes at large number with sensing capabilities, interfaces for communication which are mobile and this helps to interact with the environment. WSNs are widely employed in surveillance, healthcare, building control, object tracking, etc., In general, WSNs, aggregate the sensed data and it is used for statistical inference utilized in different way, resulting in different network architectures based on the application implemented [15-19].

The most commonly studied architectures are:

1. A global monitoring node (Sink-data aggregation and interference)
2. Intermediate sink nodes (Locally trigger the actions appropriately before sending it to the global sink)
3. A global sink (Partial data aggregation is done with multi-hop sensor node environment).

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Swarm intelligence (SI) is a relatively novel field that was originally defined as ‘‘Any attempt to design algorithmsor distributed problem-solving devices inspired by the collective behavior of social insects and other animal societies”. The multi component systems are generally decentralized and self-organized which provides the flexibility in networking in multi hop environment. The popular algorithms used commonly for the Swarm Intelligence are Particle swarm optimization (flock of birds) and Ant colony Optimization (ACO- Insect societies). The mechanism of this living organisms are restructured accordingly and adapted properly to the WSNs applied to the SI- based routing algorithms. The biological organisms need to search for and establish a path to back and forth from the source of the food and the storage area. These behaviors of the organisms are adaptive to the changes in environment, robust to the changing numbers in the environment which are fully distributed and scalable.

Swarm Intelligence Based Routing Protocols

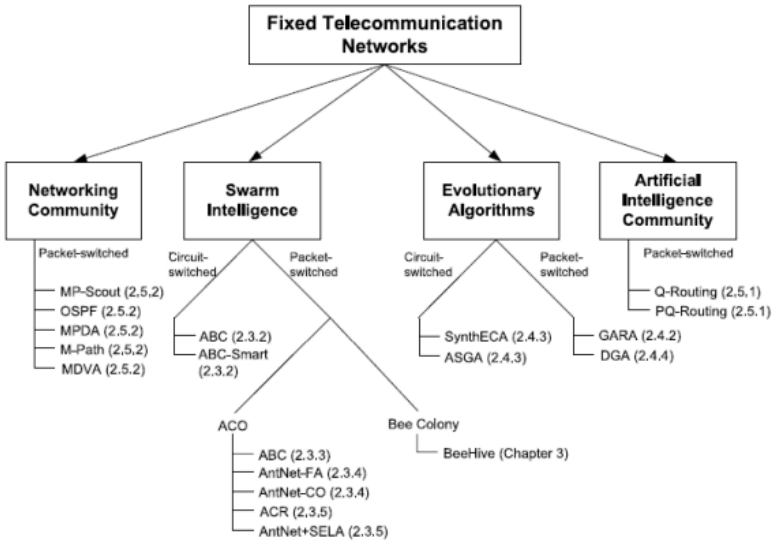

Figure 1: Routing protocols for telecom networks

The first implementation of the SI is on the wired telecommunication networks for switching circuits developed based on the Ant Colony Optimization which helps the derivation of shortest path algorithm observed from ant colonies. This helped in supporting maximum calls during high peak hours and this method is known as ant based control (ABC).

Later, telecommunication got advanced which resulted in implementation of packet switching. Ant-net is one such algorithm for packet switching which involves the probabilistic load balancing technique for transferring data packets in different paths.

This led to the development of the ant colony routing (ACR) introduces the concept of node managers and mobile agents. Node managers manage the node activities by self learning and also stochastically based on the pheromone values given locally. These mobile agents will be acting as a preceptor role actively on behalf of node managers.

Based on the signals from the mobile agents, the control action is taken by the node managers.

From the behavior of honey bees, Beehive model is inspired which is used for the complex and large node environment. It makes uses of the state of art algorithms with less processing time and occupies lesser bandwidth.
Energy efficient ant based routing (EEABR) has the artificial ant in its network chooses the shortest path based the pheromone levels assigned in the node path. The other protocol named flooded piggy bank ant routing algorithm (FP-ANT) which flood the data in wireless network. In this method the probability of losing packets is more compared to other networks.

Challenges Faced During the Design of Routing Protocols for WSN

During the design of the WSN many challenges are faced as it has tiny nodes with lesser bandwidth, limited non rechargeable battery, little memory and with small bandwidth allocation. As a common node sink transmission connected to thousands of nodes has to transfer every bit that has huge data which has to maintain the redundant information with greater bandwidth and transmission power.

The main challenges are:

1) Automaticity and self organization
2) Minimal memory and computational components
3) Energy efficiency
4) Scalability
5) Characteristics of Traffic patterns matching the architecture
6) Support for the aggregation of network data

Routing Protocol Taxonomy

It is mainly classified in four categories:

1) Data-Centric: No requirement of ID's for each node and follows multi-hop based transmission of data.

2) Hierarchical: Divide into small clusters and cluster node will be acting as a intermediate.

3) Location based: Using the position of the node the data is retrieved thereby making network efficient.

4) QoS aware: multi constrained requests based transmission.

Further the classification can be written as:

1) Single Path and multipath routing:This is said by the node sensor uses a same or single path or it uses different path during its transmission.

2) Reactive, Proactive and hybrid routing: for reactive, search is done only when the path is required for transmission. For proactive, the path forall nodes is maintained all time. Hybrid is the combination of both the protocols.

3) Source and next hop routing: Next hop contains the information about the data and final destination of the packet whereas Source has all its path information with data and final destination.

4) Flat and hierarchical routing: In flat all nodes belong to same hierarchy whereas hierarchical has set of clusterswhich transmits through the cluster heads

5) Data-centric and address centric routing: Data centric is content based routing which doesn't require IDs for transmission whereas address centric requires unique IDs for each node.

6) Distributed and centralized routing: Sink node which maintains all data information in centralized routing. In distributed, it generates its own routing information.

7) Best-effort and QoS based routing: Best effort does not provide any quality assurance for its applications. QoS provides quality assurance for its applications.

8) Event driven or query based routing: after the detection of the event the sensor hub starts to transmit data. In query mode, the data is sent only as a response to the query from the main hub.

9) Energy aware routing: The routes are prioritized based on the energy metric is energy aware routing. These are widely used in WSN due to its energy efficient characteristics.

10) Loop free: Looping in network reduces the efficiency that's data throughput. This protocol is free from cycles.

11) Fault-Tolerance: The network should be able to be fault tolerant to the loss of packets. Multi path algorithm is used avoid fault s.

12) Load Balancing: The data is sent through multiple paths in a balanced way from source to destination.

Evaluation Methodology

For peculiar characteristics of SI algorithm in WSN experimentally the following aspects are to be taken:

1) The selection of proper simulation is required with the details of the input i.e., no of nodes, MAC, Energy depletion has to be specified.

2) The specification of the performance parameters has to be stated such as delays, packet delivery ratio,etc.,

3) The algorithms for WSN should be used instead of the wired or MANET algorithms are used.

4) The algorithm should be adaptable for dynamic members in the environment i.e., it should be scalable and robust to the losses and noises.

5) The code of different algorithms should be made available easily. So that it is comparable.
6) Demanding should be less for an algorithm when it is written in computational point.

For an algorithm, it should be clear and simple written with a pseudo code.

Conclusion

The WSN design is a challenging task as it should be efficient, robust and scalable. On the other hand the algorithms on SI are created are based on biological systems which are complex made adaptable according to the application is another big challenge. The Implementation of SI in WSN lacks in the bridge between the mathematical modeling and the real world implementation. The Swarm Intelligence will be a big field once it tackles the challenges in the real world environment.

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