Chapter 13
A Comprehensive Review of Ant Colony Optimization (ACO) Based Energy-Efficient Routing Protocols for Wireless Sensor Networks

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ABSTRACT

Wireless Sensor Networks (WSNs) have always been a hot area of researchers for finding more solutions towards making WSN network more energy efficient and reliable. Energy efficient routing is always a key challenging task to enhance the network lifetime and balance energy among the sensor nodes. Various solutions have been proposed in terms of energy efficient routing via protocol development, various techniques have also been incorporated like Genetic Algorithm, Swarm Intelligence etc. The main aim of this research paper to study all the routing protocols which are energy efficient and are based on Ant Colony Optimization (ACO). This paper also highlights the pros and cons of each of routing protocol which has been developed on lines of Energy Efficiency and has also been compared among one another to find which protocol outwits one another. Further, we conclude that Swarm Intelligence being a novel and bio-inspired field has contributed as well as contributing much in the area of improving routing issues of sensor networks.

1. INTRODUCTION

In the recent years, there has been seen an exponential growth in the field of Wireless Communications because of high end development in wireless devices and applications (Saleem, Fisal, Hafizah, Kamilah, & Rashid, 2009). As, wireless communication has a huge importance in the area of telecommunications and computer networks, so this area has emerged an important field of research and with further development, complexity is rising. By identifying various important

DOI: 10.4018/978-1-4666-8751-6.ch013

technologies of 21st Century, Wireless Sensor Networks are gaining importance communication and taking the communications to next level in information sharing revolution. The concept of Wireless Sensor Networks (WSNs) has become possible due to recent advances in micro-electro-mechanical systems (MEMS) which have led to the development of sensor technology. (Yick, Mukherjee, & Ghosal, 2008) Wireless Sensor Networks comprise of sensor nodes capable of sensing (measuring), computing and communication elements deployed over a geographical region for varied activities. Wireless sensor networks are being utilized in diverse areas these days like scientific, medical, commercial and military domains. Wireless Sensor Networks applications include healthcare, monitoring, surveillance, battlefield operations, smart homes and others. Wireless sensors are typically very small with very limited processing and computing resources. Every node of facilitated with embedded processors, sensing devices, storage and radio receivers. But on the other hand, these sensors have limitations and constraints regarding battery energy, processing abilities, communication speed and storage space (Zungeru, Seng, Ang, & Chong Chia, 2013). As the sensors have limited memory and are deployed in difficult-to-access locations, for that every sensor is equipped with a radio to transfer the data to the base station. The main source of power to sensor network is battery. In addition to this secondary power is being facilitated in sensor networks via solar panels in order to handle the energy problem but makes it bulky.

Typically a wireless sensor network has little or either no infrastructure. It can consist of few to hundreds or thousands of sensors which work together to monitor a region and capture data. (Yick, Mukherjee, & Ghosal, 2008) Wireless Sensor Network is basically of two types: Structured WSN and Unstructured WSN. In Structured WSN, all the sensor nodes are deployed in proper manner so that proper connectivity is there which cuts down the cost as well as network maintenance problems. In Unstructured WSN, there are many nodes and the deployment of sensors is done in adhoc manner which adds to the problems of network failure and connectivity problems.

Wireless Sensor Networks have various issues which are listed as follows: (Nayyar & Sharma, 2014; Al-Karaki & Kamal, 2004):

- **Connectivity:** (Nayyar & Sharma, 2014) As the sensor nodes are connected together to transfer the data. In order to maintain continuous connectivity every node requires continuous energy and leads to depletion of energy and failure of node. Sensor Networks basically operate in dynamic topology, where the sensor's positions change from time to time and affects various characteristics in terms of robustness, latency, throughput etc. Therefore, Connectivity is one of the issue concerning around the deployment of sensor nodes.
- **Coverage:** (Nayyar & Sharma, 2014) In order to ascertain the Quality of Service of sensor networks, Coverage lays the foundation. It is classified into three main categories: Area Coverage, Point Coverage and Barrier Coverage. Area coverage relates to Art Gallery Problem; Point coverage relates to Target Coverage. This issue relates to the deployment of sensor nodes in such a way which covers the entire region.
- **Sensing Range:** (Nayyar & Sharma, 2014) In order to enhance the sensing area, high range sensors are required which increase the cost of the network. Sensors should be deployed in deterministic manner as compared to random deployment so that coverage improvement can be there and nodes communicate in an efficient manner among each other. But in order to increase the cov-