Agents- based Methodology for Wireless Sensor Networks

A. H. Mohamed[1]

[1] Solid State and Electronic Accelerators Dept.,
National Centre for Radiation Research and Technology (NCRRT), Atomic Energy Authority.
amirahmaz@hotmail.com

Abstract - Nowadays, agents-based systems are widely used to solve many engineering problems. The characteristics of the agents-based approach enable them to be used for the wireless sensor networks (WSNs) successfully. The proposed system introduces a novel algorithm that uses the agents-based approach for the WSNs to improve their performances. The suggested system has been applied for three WSNs having different applications. Its achieved results have proved its goodness and acceptance for the practical WSNs applications.

Keywords: Agents-based systems, wireless sensor networks.

1. Introduction

Recently, the modern technology introduces a great help in producing wireless sensor devices. These devices can observe and measure the physical parameters of their environments [1].

A wireless sensor network (WSN) consists of a great number of small, inexpensive, robust, co-operated and low power sensor nodes [2]. Each sensor node constructs from two main parts: (1) a sensing unit used to measure the environment' parameters, and (2) a processing unit that is the core element used to process the sensed raw data, memory, battery and transceiver for communication [3]. A high number of these sensor nodes are deployed across the geographical area to achieve great accuracy of WSNs. These sensor nodes are self-ordinate elements. They can re-arrange themselves to perform a common task, and collaborate to measure the conditions of their surrounding environment [4].

On the other side, topology of WSNs changes very frequently and the communication between the nodes mainly use broadcast paradigm. Sensor nodes are limited power, computation capabilities, memory and usually the batteries of the nodes are not rechargeable [5].

The WSNs can be effectively used in many monitoring applications in military, fire detection, security, habitat monitoring, industrial automation, earthquake, agriculture irrigation, radiation, health applications, etc. [6].

On the other hand, WSNs are faced with some limitations, such as: (1) increases in the number of applications, (2) increase the complexity of their design, (3) the difficulty of the runtime interaction.

To overcome these limitations, researchers have suggested a solution to these problems by using more useful designed and distributed systems' algorithms. But, this type of algorithms is very complex and high costly. Therefore, more recently, a new solution is suggested by creating an autonomous wireless sensor network. It can react dynamically to changes when required. Also, autonomous WSN increases the system longevity and the coverage density [7]. So, using the agents-based approach for WSNs can improve their performance that has been applied in the proposed system.

The reminder of this paper can be organized as follows: Section 2 provides an overview of agent-based architecture for wireless sensor Networks. While, section 3 deals with the related work. Section 4 represents the proposed agent-based WSN system. Section 5 explains the applicability of the proposed agents based system for three WSNs applications and their results. Finally, section 6 handles some concluding remarks.

2. An Overview of Agent-based Architecture for Wireless Sensor Networks

The intelligent agent is a new software entity. It is an autonomous software program that can collect information about its surrounding environment through its sensors. Then, based on this gathered information, it takes action suitable for achieving the goal [8].

For multi-agents systems, coordination of the agents is one of their main properties. On the other hand, any WSN has sensors those have co-operated actions to achieve the system's main goals.

While, WSNs are characterized by several features, such as: physical distribution, resource boundedness, uncertain information, large scale, decentralized control and adaptiveness [9]. These properties can be handled by agents in the agent-based systems. Therefore, the agents-based methodology has been successfully applied in developing the WSNs for many engineering, coordination, and negotiation applications [10].

The present research proposes new system that uses the agent-based methodology in modeling and simulating the wireless sensor networks.

3. Related Work

Researchers have developed a lot of work in the area of wireless sensor networks to deal with their great spreading in all areas of our daily life. They recently have concerned on providing high level abstractions of complex low level concepts to application programmers.

C.Fok et al., have proposed Agilla system that is a sensor network middleware uses an agent based approach [11]. A. Boulis, et., al., have proposed the UCLA's SensorWare system. It is an active sensor framework very close to the mobile agent based approach [12]. Y. B. Reddy has decreased the packets transfer in wireless sensor networks using the agents [13]. S. Vupputuri et al., has introduced the uses of agents to improve network lifetime of wireless sensor networks with reliability constraints [14].

4. Proposed Agent-based WSN System

In the recent years, wireless sensor networks area is become one of the main widely used techniques in real-time life. Therefore, there is a great work has been developed to overcome the drawbacks of the WSNs and improve their performance. But, there are still some open challenges till now those can be concluded as: (1) complexity of their designs to deal with many different types of applications, (2) high cost of the modern designs, (3) decreasing the lifetime of the network, and (4) high power consumptions of WSNs' processes.

The suggested system is considered one member in the family responsible about solving these problems. It introduces the uses of the agents-based approach for the wireless sensor networks (WSNs). Its main ideas based on using the agents enable the system to:

1. Decrease the bandwidth consumption. As, the agents can move the data processing elements to the location of the data as shown in fig. (1). The sensors are usually deployed on a low bandwidth wireless link. So, moving the data must be as minimum as possible.

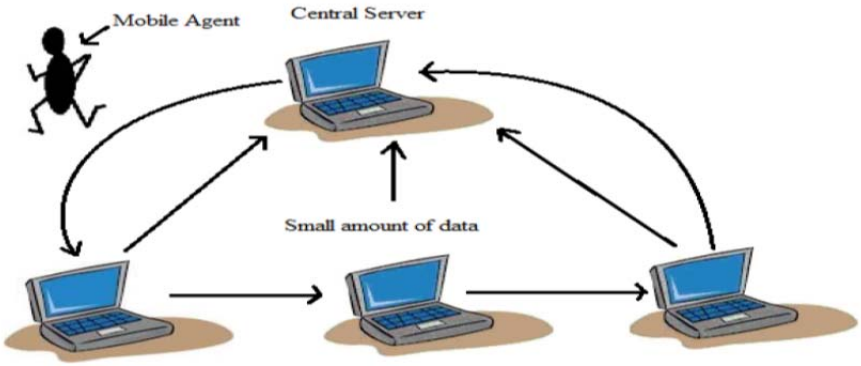

Fig. (1): Agent moves to the nodes

2. Based on inter node distance of the deployment strategy, there is a lot of redundancy in the collected data. By moving the software agent itself to the data, a large amount of the redundancy in closely located nodes can be eliminated.
3. Besides, the proposed agents-WSN system can increase the lifetime of the WSN by decreasing the power consumption of its batteries. As the lifetime of any sensor node depends on its level of the battery power. While, using the WSN systems without the agent can transmit and receive the data among nodes and the processing elements cause high consuming of this battery's power.
4. On the other side, using a single WSN for multiple applications, the system flashes all the nodes with the same code and update them remotely from time to other. This causes complexity, high cost and delay time of the WSN operation. So, to overcome these limitations, a dynamic approach to programmability is needed. However, using the agents-based approach, the system can achieve this main feature.
5. The proposed system enables the users to inject new agents into the network and allowing old ones to die. Therefore, the network can be extended and scalable. The agents can be reprogrammed to adapt the network load balancing.
6. Besides, the agents-based approach can improve the security of WSN by eliminating the motion of the data.

Therefore, the agents' methodology is considered a powerful solution for improving the performance of the wireless sensor networks.

To implement the proposed system, the designer must use different types of agents that are classified based on the needed function of the WSN's system. The proposed system has organized these agents in an architecture form. The sensor nodes of the network are divided into several regions depending on the spatial, topological,

and deployment conditions. Each region is decomposed into several clusters according to the queries, the hardware of the nodes, and data acquisition mechanisms.

The architecture of the agents can be explained as follows:

1- Deployment agents: These agents are responsible of the deployment, reorganization and update of the WSN. These agents need to acquire information about the other agents and all nodes, control other agents to perform specific tasks such as localization, positioning and clustering.
2- Interface agents: the interface agent enables the user to interact with the sensor network.
3- System management agents: These agents are the principal controller of the system. It can behave according to the state of the system. So, it can make the suitable decisions and order the other agents of the system to perform some tasks.
4- Data processing agents: The system can perform some data processing (analysis, compression, encryption, etc.) before being sent the acquired data to the user or for helping the System Management Agent to make the required decisions.
5- The cluster agents: the cluster agent performs query dissemination and efficient in-network processing.
6- The query agents: the query agents are used to collect the required data and execute the local computation by the sensor nodes.

In general, the proposed system based on uses the hierarchical WSN deployments as the clustered topology. However, the operation of the proposed system can be explained in the following steps:

1- Creating the cluster head that is achieved by combining multiple nodes.
2- Each cluster head moves the agents to all the cluster members for collecting and processing the data.
3- The agents send back the obtained results to their corresponding cluster head.
4- The agents used by the cluster-head send back the results again to the WSN's gateway for further processing.

5. Applicability of the Proposed Agents-based System

The proposed agent-based architecture system is used to design three wireless sensor applications. The first one monitors radiation level, light, and security gates for different buildings in a radiation centre. The sensors are placed in four sites: gamma building (GB), accelerator building (AB), Control Room (CR), and Management Room (MR).

The proposed system divides the area of sensors' deployment between the four buildings into two regions: region R1 includes GB and AB, and region R2 includes CR and MR. The suggested system defined the regional agents for the deployed sensors in GB and CR. The interface agent is deployed on a PC in CR. The data of the proposed system is obtained from the sensors.

On the other hand, the second WSN has been applied as a part of a security system used by an industrial company. While, the third WSN application has been used for a university camp.

To evaluate the performance of the proposed system for these three different sites, its obtained results are compared with the results gotten from two traditional WSN systems that have not used the agents [15,16].

Table (1) shows comparisons between the results of the proposed agents based system, an Agilla system and two traditional WSN systems when they applied for the three WSN applications [11, 17, 18]. It is found that, the proposed system can increase the lifetime and the security of the WSN systems, and decrease the complexity and the power consumption of the system. Also, the proposed system can increase the scalability and extendibility of the WSN system.

Table (1) shows comparisons between the results of the proposed system, two traditional WSN systems have not used the agents based approach for three sensor wireless networks.

Systems	Lifetime of the network	Security	Power Consumption	Transmitted Packets
Wireless Sensor Network 1				
Proposed agent based system	400 H.	93%	110 W	235 P.
Agilla system	350 H.	86%	185 W	270 P.
Traditional system1	315 H.	76 %	243 W	374 P.
Traditional system2	298 H.	79%	273 W	394 P.
Wireless Sensor Network 2				
Proposed agent based system	453 H.	95%	134 W	328 P.

Agilla system	387 H.	86%	185 W	370 P.
Traditional system1	322 H.	74 %	265 W	434 P
Traditional system2	354 H.	72%	263 W	416 P.
Wireless Sensor Network 3				
Proposed agent based system	389 H.	94%	123 W	288 P.
Agilla system	323 H.	83%	215 W	322 P.
Traditional system1	281 H.	73 %	254 W	395 P.
Traditional system2	276 H.	71%	237 W	374 P.

6. Conclusion

Recently, there are a great widely spread for the wireless sensor networks in many daily life applications due to the continuously decreasing in the cost and simplifying the deployment methods. But, on the other hand, there is a great complexity of WSNs' structure and distributed processing capacity by increasing their number of nodes. This research has suggested the uses of the agent based architecture for the wireless sensor applications.

The proposed system has been applied for three WSNs applications for monitoring the radiation levels of a radiation site, monitoring the security state for both an industrial company and a university camp. The performance of the proposed system is compared with those gotten from two traditional WSN systems, and one of the common agents-based WSN systems. The obtained results have proved that the proposed system has a significant impact on the WSN' performance. The suggested system can increase the lifetime, reliability and the security of the network. While, it can decrease the number of the transmitted packets through the network and the power consumption of the network by moving the agents that can execute the required tasks and processes for the data instead of moving the data for the sensor nodes responsible about the required tasks. Besides, the proposed system can enhance the performance of Agilla system that is one of the common agents-based WSNs systems. Therefore, the suggested system has good performance for applying in the real situations.

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