Approach For Applying Multi-Agent System into Wireless Sensor Networks

[1]Muhammad Sirajo Aliyu and [2]Muhammad Garba

[1]Department of Computer Science, Faculty of Computing
Federal University Dutse, Jigawa State

[2]Department of Computer Science
Kebbi State University of Science and Technology
Aliero Kebbi State

Corresponding Author: msirajoa@fud.edu.ng

Abstract
Multi-Agent System on wireless sensor network, sensor is a tiny device that uses battery as there source of energy, when a large number of these devices work in a collaborative fashion to carried out a task, they form a wireless sensor network. Multi-agent system paradigms can be applied in to a Wireless Sensor Network (WSN), special focused on how multi-agent system technology's mechanisms and implementations could facilitate the development of systems based on wireless sensor network, and utilization of agents is appealing in a wireless sensor network, because they can combine many features with the attributes that characterize the agents such as reactivity, autonomy, goal oriented, ability to communicate, collaboration and cooperation, mobility subjected the use of agent application in WSN. This paper presents the current issues on Multiagent systems and classical wireless sensor node approaches to design a multi-agent based software system. A brief description on the properties of each approach presented. We strongly believe that the results presented in this paper may provide a foundation in developing a multi-agent system.

Keywords: Agent, multi-agent, wireless sensor, autonomy;

INTRODUCTION

Multiagent systems are systems composed of multiple interacting computing elements, known as agents [1]. Agents are computer systems with two important capabilities. First, they are at least to some extent capable of autonomous action of deciding *for* themselves what they need to do in order to satisfy their design object Lives. Second, they are capable of interacting with other agents not simply by exchanging data, but by engaging in analogues of the kind of social activity that we all engage in every day of our lives: cooperation, coordination, negotiation, and the like. Agents are suitable in an environment which have highly dynamic and limitation of resources, where the information is incomplete and / or imprecise, and agent model present certain similarities with the usual model of a sensor; an agent received a series of stimuli from external world. The data acquired is processed by determining the action to be carried out by the actuators. Similarly the

nodes in the wireless sensor network (one pot) comprised of set of sensors which obtain information from the external world (although they can obtain it from other nodes through exchange of messages) a unit of processing data that manages the environment whether the own node or other nodes, finally a set of commands sent to actuator. Fig. 1 gives an abstract view of an agent. In this diagram, we can see the action output generated by the agent in order to affect its environment. In most domains of reasonable complexity, an agent will not have complete control over its environment. It will have at best partial control, in that it can influence it. From the point of view of the agent, this means that the same action performed twice in apparently identical circumstances might appear to have entirely different effects, and in particular, it may fail to have the desired effect. Thus agents in all but the most trivial of environments must be prepared for the possibility of failure. We can sum this situation up formally by saying that environments are in general assumed to be non-deterministic.

A sensor is a device which responds to physical stimulus (such as heat, light, sound, pressure, magnetism, etc.), and converts the quantity or parameter of a physical stimulus into recordable signals (such as an electrical signals, mechanical signals, etc.) [2]. These signals are then digitalized to produce sensing data. A sensor node normally encapsulates one or more sensor units, a power supply unit, a data processing unit, data storage, and a data transmission unit. A sensor network consists of sensor nodes that are deployed in different geographical locations within a sensor field to collectively monitor physical phenomena. A sensor network also includes one or more sinks which collect data from sensor nodes. A sink can be regarded as an interface between a sensor network and the people operating the sensor network. When a large number of these device work together in a colloaborative way to carried out a task, they form a wireless sensor network [3], it gives rise to a wide range of real life applications in areas like Military, health care, agriculture, and environment etc. Wireless sensor have the ability to adapt dynamic cahnages of an environment, these can respond to the changes in network topologies.These types of networks has no routing IP and is meant to blend with the environment and working together with conventional network. Number of nodes that makes up a network will vary from tens or million, depending on the requirements of the application.

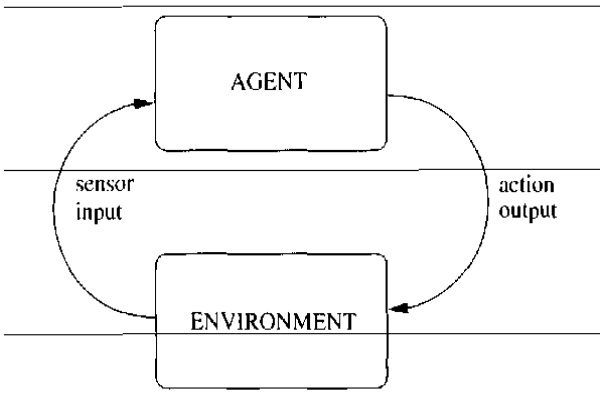

Fig. 1: An agent in its environment.

Fig 1 shows how a sensory input is taken from the environment, and produces as an output action that affects it. The interaction is usually an on-going, non-terminating one.

CHALLENGES AND ISSUES IN WIRELESS SENSOR NETWORK

Scalability: Sensor network application can have a lot of sensor nodes deployed in the sensing area ranging from hundreds to thousands, the routing algorithm should be scalable enough to handle and respond to the events within the network, since abstraction and simplicity mechanisms are demanding factors, due to the large of amount of data expected to be reduced into a manageable size[4]

Latency : it's the expression of the time it takes for data packet to be transmitted from one node to the sink and vice versa which is either one way, time taken from the source to the sink or round trip, from source to sink and from sink to the source, in which data aggregation and multi hop relays can affect latency[5] ,[6], [7].

Fault Tolerance: Failure of a certain sensor node due to physical damage, power or environmental interference in a network should not affect the overall performance or task handling of the network, in the event of any failure, routing protocol should be able to generate a new route to the sink [8]

Limited Energy Capacity: The process of setting up routes in a network is greatly affected by energy consideration, since sensors are battery powered, they have limited energy which has a lot of challenges in many application of sensor network, application the battle field where it is not possible to access the sensor and recharge its batteries [9].

Sensor Location: Sensor location at the initial stage of route discovery is another challenge in the design of routing protocols, the location aware and location unaware of sensor positioning more especially for the location unaware sensor which have inexact position is a another challenge, determining the position of location unaware sensor in the presence of inexact positions of location aware sensor [10], many suggested protocols assumes that the sensor nodes are equipped with a global positioning system receivers or alternative form of sensing the destination or sink to learn about location [11]

There are certain aspects and features that chracterize particularly, to a wireless sensor network and which should be taken into account.

- All nodes in the network should present low power consumption, as its geographic location may be difficult to access and hence the substitution of feeding cannot be conducted easily.
- The power consumption is one of the main issues therefore data should be processed at the node before transmission, because the higher energy expenditure occurs during communications.
- The spots that form the network should have a low cost of production, because wireless sensor network can consist of thousands or even millions nodes.
- They should be trained and to work autonomy without being under constant supervision. The characteristic, among others reflects the importance of agent integration into this type of technology, as described throughout this work.
- They should be able to adapt easily to the environmental changes.

A wireless sensor network (WSN) maintained an interconnection to the world physically in order to obtain measurements through its sensors, monitoring and managing the data we obtained.

WIRELESS SENSOR NETWORK VS AGENT TECHNOLOGY

The utilization of agents in is appealing in a WSN, because they can combine many features with the attributes that characterize the agents. The agents are suitable in environment which have highly dynamic and limitation of resources, where the information is incomplete and / or imprecise (situation that are very usual in a WSN).

The agent model presents certain similarities with the usual model of a sensor. An agent received a series of stimuli from external world. The data acquired is processed by determining the action to be carried out by the actuators. Similarly the nodes in the wireless sensor network (one pot) comprised of set of sensors which obtain information from the external world (although they can obtain it from other nodes through exchange of messages) a unit of processing data that manages the environment whether the own node or other nodes, finally a set of commands sent to actuator (in the same node to other nodes or to a server see figure 2). A portion of the logical structure, agent show features which characterize it's behaviour [12], [13], [14], [15], many transferable to a WSN.

The following attributes subject to their application in WSN we have.

- Reactivity: Agents are capable of detection and react to stimuli. They are ready to process information they receive from abroad (obtained from sensors in case of a WSN) and respond to them for eg. In the case of a scene of "tracking" they should be able to predict

the location of an object based on its behaviour.

- The ability to work asynchronously: The agent became operational, upon receipt of a stimulus (eg. Detect motion). In one WSN, this characteristics implementation supports techniques that ensure energy saving of network (eg. State change method "Sleep" and "awake").
- Autonomy: this attribute allows agent maintain a certain kind of "control" over their actions (decides what action to take, detects and resolve conflict etc). In a WSN, this condition is quite useful, since if any node in the network fails (eg. The information provided is not reliable or that your battery is exhausted), the network has to be able to meet its goal without it.
- Goal oriented: It is logical to attribute this property to a WSN because of a software node (in the proposal made in this paper provided by an agent one each node) should manage the information given by the sensors and perform their duties, this characteristic is fundamental to task like aggregation or data processing, since it necessary to filter information not relevant and thus not transfer it to other nodes.
- Ability to communicate: It presents the quality interaction with other agents. In a WSN this ability distribution is reflected in the information collected from sensors or other network nodes.
- Collaboration and Cooperation: The agent should be able to perform task through cooperation with other agents in a WSN this fact manifests when a node must provide and obtain information from other network nodes. Thus form a distributed environment intended to solve a specific problem, through a set of cooperating entities in a distributed physical environment, characterized by a network speckles.
- Mobility: The migration ability of an agent can be applied in a WSN nature unstable network necessitates certain task configuration and topology adaptation hence transfer would be an excellent source solution to this problem.

Table 1: Features applicable to agents node in a WSN

	AGENTS	WSN NODE AGENTS
Autonomy	The capability to carry out a task without any kind of control	Ability to meet with the functionality required without intervention of some components
Capacity working form asynchronous	Capacity makes entering agent receiving operation certain information	Detect stimuli environment to which must respond.
Collaboration and cooperation	Each agent facilitates other information to perform a task jointly.	The node need to work together to reduce the number of communications
Communication	Ability to interact	Capacity to interact between nodes.
Oriented objective	Through this features of agents are capable of carrying out their tasks from some information.	Information provided by the nodes should serve to meet network objectives.
Reactivity	Ability to deliver forecast from certain information.	Ability to anticipate events, normally before any node failure.
Mobility	Ability to migrate one site to another	Ability to move your code or state in tasks reconfiguration.

Table 1 summarizes agent characteristics which are transferable to the functionality of the node involved in a WSN, depending upon the features associated with the various types of agents, we can make a classification of the most suitable for a WSN.

- Information Agents: The ability to manage information on such agents, is useful for a WSN, particularly in the aggregation and filtering of data, resulting to decrease in the number of communications since it must determine which information is important and not prior to delivery.
- Autonomous Agents: These are capable of making decisions by themselves at a certain times. In a WSN agent of this kind are useful, especially to against eventual failure some of the nodes in the network as it may fulfil the objective of the network without any intervention.
- Mobile Agents [16]: Although some authors application that have been performed with mobile agents [12], [17], special attention because the code migration energy has a cost which can be avoided. However its use is required because it provide ease of adaptation to the environmental needs (for example, change in network topology).

Every agent system need a platform that will provide an identification service, mobility communication etc. The reference architecture defined by the working group FIFA (foundation for intelligent Physical Agents) [18] define certain components that could accommodate a wireless

sensor network. It agents assumed to run in nodes WSN.

- AMS (Agent Management System): This component of FIPA structure used in a WSN which topology has a "cluster" could be useful to store the identification of the agents of a specific sector and the sectors considered greater importance to "clusters" neighbour, but not the entire network as being comprised of up thousands of nodes consume a greater amount of memory (limiting feature of this kind of devices). Furthermore, the sensor network routing is by means of identifiers (a system of names based on attributes – values). However, it would be interesting to utilize the management of communication channels and life cycle management of the distributed agents node in the WSN.
- DF (Directory Facilitator): This component is important in a sensor network, as it would relevant information store in the nodes (from other nodes or agents), which decrease the number of interactions between them, the main drawback would consumption memory through the energy savings would guaranteed since it reduces communication between nodes. A similar that provided by this component is described in [19]
- ACC (Agent Communication Channel): Represents the communication channel between agents deployed and as a result WSN utilized in the exchanging information between nodes. The main drawback is that the language used for the development of the application (TCL-Tool command Language), unlike the existing for motes (eg. NeSC or TinyScript) is too heavy. Furthermore in order to deploy an ACC a WSN is necessary to adapt a minimum set of messages that provides to at least satisfy the basic communication in the network for eg. Transfer of information obtained from the environment (or other sensor nodes). Not to mention, the adaptation must perform the communication protocol is "multi-hop".

Although the structure of the platforms FIPA compliant can be adapted to the WSN (using a lighter version) even be too heavy for a wireless sensor network, in terms of energy consumption and computation (given characteristics of a speck). There are some jobs where lightness aims to give the environment communication among agents in a WSN ([17]), but seem it does not cover all basic needs of a WSN. LEAP

(Lightweight Extensible Agent Platform) [20], [21] is a FIPA platform [22], [23], may be adapted for use in a WSN, since it is designed for Java devices present resource limitations. But we must not forget that the use of Java on the nodes of a WSN, is still research.

Moreover, the concepts and fundamentals of MASIF (Mobile Agent System Interoperability Facilities) [24] are more suitable for application in Wireless sensor network since they define a series of ensuring interoperability interfaces agents (location system naming system, control of agents, information transfer). However, its main drawback is that the communication between agents meet the standard CORBA (Common Object Request Broker Architecture), which is inadequate for a WSN, due to the necessity of many resources to be put into operation (eg memory and processing). Also, it is noteworthy that the system named used in a WSN is based on a IP address, if not in an identification system attribute-value, which is a disadvantage when carrying the MASIF practice established by a WSN.

In summary, aggregation and filtering information provided by agents. when the purpose is to ensure, to the network, fault tolerance into action and autonomous agents, when done be rescheduled and locate the nodes that must execute a change in functionality, by Mobile agents (and some authors consider suitable [12],[25], [26],[27]).

The "fitting software for agents" (middleware) is responsible for adapting and delivering the information to the agents for further processing intelligent (the information is obtained from the messages received by other agents or information obtained via sensors in every node). Through their service agent log, maintains information on their (agents) neighbors, within the network, to avoid interactions unnecessary. The information stored is: location of agents, agent identifier, its status and information domain dependent application (eg a system of "tracking" the identifier of a target - an intruder). This information will be updated in case of occurrence some change (eg change of the sector by the object follow). Similarly, operators should inform neighbors of the changes in the "cluster" that are handled (ie a cluster-head).

Through the server (typically applications) a user can perform tasks such as: network reprogramming by injecting new agents, and removing the existing control information acquired through the nodes, thanks to the use of graphical tools that allow interpret this information easily and in overall network management, among others. It is noteworthy that one of the advantages, mainly using agents in a WSN is because agents are able to adapt to changes dynamic network, are able to carry out its tasks (or satisfy the functionality to be provided by the network) from partial information and / or imprecise and, they may be

adapted for execution on devices have limitations (energy, memory, etc.), such as nodes in a WSN (specks).

From the above perspective, the proposed architecture has been conceived and designed to allow execute tasks in a WSN domain regardless of the application. Suffice to reprogram the network by injection of new players that they can adopt the required functionality. For the particular case of this work, we have applied our model to an architectural monitoring and control stage, which will be described in the next section. This scenario has been chosen by providing reliability and robustness that agents bring to the WSN, to be able to fulfilled its objective through the fault tolerance (produced in network nodes), and the market interest WSN can awaken to offer an integrated perimeter security and reliable.

CONCLUSION AND FUTURE WORK

The advantage of using solutions based on agents wireless sensor network (WSN), defines solutions with an incremental programming model and ensures efficient use of resources, since agents only require resources (processing power and sending information) of the node in which they reside. The Agents can assume different roles in supporting several functions simultaneously. different agents can work distributed and coordinated to carry out a common task (load distribution). The asynchronous operation of reducing agents network traffic. This is because not transmit information continuously, which saves energy, vital factor in the networks of motes, and prevents network overload. Among other uses, through the injection of agents can reprogram the network, thereby facilitating the network adaptation to changes that may occur. This is useful due to the possibilities of configuration and deployment can have a WSN, especially in those application domains in where access to the nodes of the network is difficult, manually reprogramming that would not be a viable option. The use of existing agents platforms not WSN suitable for due to their high consumption of resources (memory, processing and power). WSN and multi-agent technologies. In general, it is assumed that the energy consumed by the wireless communication in a network of sensors, is always greater than the processing consuming within the nodes. Therefore, one of the tasks of agents should perform a pre-processing, aggregation or filtering information before so that the transmission data volume exchanged as light as possible. Our feature research work is to verify the optimization of resources in a WSN to From the simulation service "tracking" proposed. To perform this adaptation are developing a series of components that play functions for agents.

REFERENCES

[1] M. Wooldridge, *An introduction to multiagent systems*: Wiley. com, 2008.

[2] J. S. Wilson, *Sensor technology handbook*: Access Online via Elsevier, 2004.

[3] E. Guney, *et al.*, "Efficient solution techniques for the

integrated coverage, sink location and routing problem in wireless sensor networks," *Computers & Operations Research,* vol. 39, pp. 1530-1539, Jul 2012.

[4] F. Çelik, *et al.*, "A survey on swarm intelligence based routing protocols in wireless sensor networks," 2010.

[5] A. O. Bicen, *et al.*, "Delay-sensitive and multimedia communication in cognitive radio sensor networks," *Ad Hoc Networks,* vol. 10, pp. 816-830, Jul 2012.

[6] Z. Noor and A. Azween, "Energy efficient routing in wireless sensor network: research issues and challenges," 2010.

[7] P. Thulasiraman, *et al.*, "Multipath Routing and Max-Min Fair QoS Provisioning under Interference Constraints in Wireless Multihop Networks," *Ieee Transactions on Parallel and Distributed Systems,* vol. 22, pp. 716-728, May 2011.

[8] T. M. Chiwewe and G. P. Hancke, "A Distributed Topology Control Technique for Low Interference and Energy Efficiency in Wireless Sensor Networks," *Ieee Transactions on Industrial Informatics,* vol. 8, pp. 11-19, Feb 2012.

[9] R. Cerulli, *et al.*, "Exact and heuristic methods to maximize network lifetime in wireless sensor networks with adjustable sensing ranges," *European Journal of Operational Research,* vol. 220, pp. 58-66, Jul 1 2012.

[10] W. Y. Chiu, *et al.*, "Robust relative location estimation in wireless sensor networks with inexact position problems," *Mobile Computing, IEEE Transactions on,* vol. 11, pp. 935-946, 2012.

[11] Z. Zhong and T. He, "Wireless Sensor Node Localization by Multisequence Processing," *Acm Transactions on Embedded Computing Systems,* vol. 11, Mar 2012.

[12] R. A. Flores-Mendez, "Towards a standardization of multi-agent system framework," *Crossroads,* vol. 5, pp. 18-24, 1999.

[13] S. S. Manvi and P. Venkataram, "Applications of agent technology in communications: a review," *Computer communications,* vol. 27, pp. 1493-1508, 2004.

[14] S. J. Russell and P. Norvig, *Inteligencia Artificial: un enfoque moderno*, 1996.

[15] M. Wooldridge and N. R. Jennings, "Intelligent agents: Theory and practice," *Knowledge engineering review,* vol. 10, pp. 115-152, 1995.

[16] U. a. o. a. available, *ttp://www.cetus-links.org/oo_mobile_agents.html*.

[17] C.-L. Fok, *et al.*, "Rapid development and flexible deployment of adaptive wireless sensor network applications," in *Distributed Computing Systems, 2005. ICDCS 2005. Proceedings. 25th IEEE International Conference on*, 2005, pp. 653-662.

[18] F. Bergenti, *et al.*, "Deploying FIPA-compliant systems on handheld devices," *Internet Computing, IEEE,* vol. 5, pp. 20-25, 2001.

[19] V. Lesser, *et al.*, *Distributed sensor networks: A multiagent perspective* vol. 9: Springer, 2003.
[20] L.E.A.P. available, *http://www.leap.crm-paris.com.*
[21] G. Caire and F. Pieri, "Leap user guide," *TILab, Jan,* 2006.
[22] F. f. I. P. A. available:, *http://www.fipa.org*.
[23] J. A. D. F. available:, *http://www.jade.tilab.com*.
[24] O. M. G. available:, *http://www.omg.org*.
[25] C. L. Fok, *et al.*, "Rapid development and flexible deployment of adaptive wireless sensor network applications," in *Distributed Computing Systems, 2005. ICDCS 2005. Proceedings. 25th IEEE International Conference on*, 2005, pp. 653-662.
[26] L. Szumel, *et al.*, "Towards a mobile agent framework for sensor networks," in *Proc. of the 2nd IEEE Workshop on Embedded Networked Sensors*, 2005.
[27] H. Qi, *et al.*, "Multiresolution data integration using mobile agents in distributed sensor networks," *Systems, Man, and Cybernetics, Part C: Applications and Reviews, IEEE Transactions on,* vol. 31, pp. 383-391, 2001.