Volume 4, Issue 2, February 2014 ISSN: 2277 128X

International Journal of Advanced Research in Computer Science and Software Engineering

Research Paper

Available online at: www.ijarcsse.com

A Review: Architecture of Wireless Sensor Network by using Mobile Agents

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Abstract— In wireless sensor network, mobile agents are computer programs that automatically move between different network hosts and perform various operations according to user's requirements. This paper describes the architecture of wireless sensor network by using mobile agents. In wireless sensor network, every sensor node is capable in sensing, processing and communicating process. In this paper, the architecture show that the mobile agent act as an intermediate between sink node and head node by providing single traffic flow between both of them.

Keywords— wireless sensor network; mobile agent; sink node; head node; source node

I. INTRODUCTION

A. Wireless Sensor network (WSN)

Wireless sensor network consists of tiny sensor nodes that are battery-powered and posses limited communication and computation capabilities [1]. The tiny sensor nodes monitor the physical and environmental conditions such as temperature, pressure, pollutants etc and then send the details of all these parameters to the base station. Wireless sensor network contains multiple smart sensor nodes. The smart sensor nodes are combination of three technologies: sensing, processing and communication. These three technologies work in different ways in which sensing unit sense the change in the parameter values. When the parameter value is sensed properly then signal conditioning circuitry starts to work. It prepares the electrical signals to convert into digital domain format, and then ADC convertor is used to convert analog signals into digital format. After that the converted analog signals are inputted to the processing unit where additional changes in the parameter values are done. Then memory and transceiver unit come into work. Memory helps processing of tasks and the transceiver act as a communication unit between sensor nodes, base stations and sinks.

Wireless sensor networks have gained worldwide attention in recent years, particularly with the proliferation in micro-electro-mechanical systems technology which has facilitated the development of smart sensors [2]. Smart sensors are small in size and they have limited processing and computing resources. The memory capacity of sensor nodes is limited in size. The main power source in a sensor node is battery. The second power source that harvests power from the environment is solar panel. According to the appropriateness of the environment solar panels added to the node where sensor will be deployed. A wireless sensor network has tens to thousands sensor nodes working together to monitor particular region of the environment. Wireless sensor networks are classified into two types: structured and unstructured. An unstructured WSN contains a dense collection of sensor nodes. In an unstructured WSN, all the sensor nodes may be deployed in adhoc manner so once nodes deployed, the network is left unattended to perform monitoring and reporting functions [2]. In an unstructured WSN, network maintenance is very difficult because there are so many nodes in the network. But in case of structured WSN, all the sensor nodes are deployed in the pre-planned manners. So due to pre-planned pattern, fewer nodes can be placed or deployed in specific location to provide coverage. Fig.1 shows the wireless sensor network:

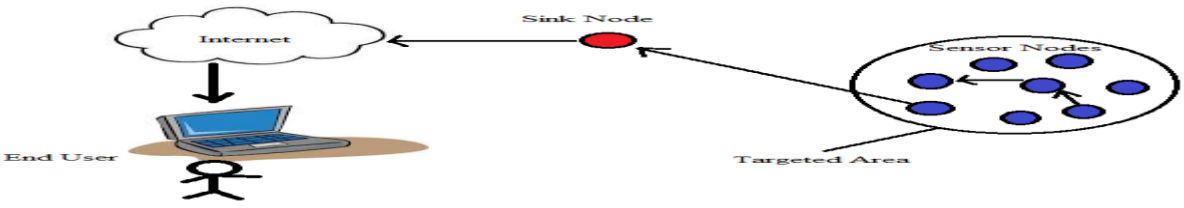


Fig.1 Wireless Sensor Network

A unique feature that sensor network provide is the co-operate effort of sensor nodes. They are fitted with an on-board processor. Instead of sending the raw data to the nodes responsible for the fusion, sensor nodes use their processing abilities to locally carry out simple computation and transmit only the required and partially processed data [3].

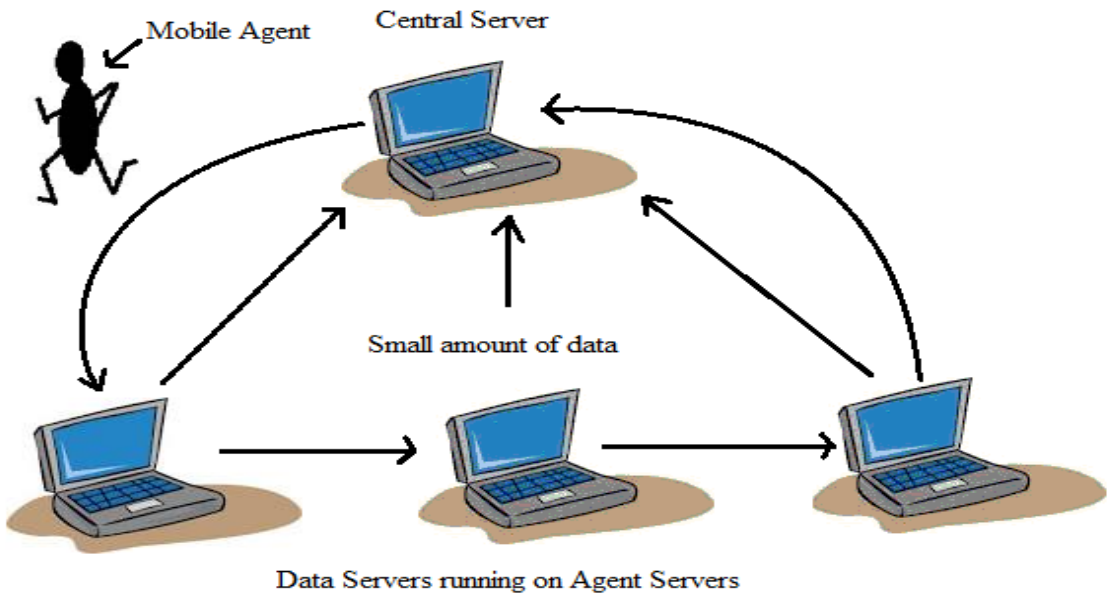


Fig.2 Mobile Agent(In data collection mode)

B. Mobile Agent

A mobile agent is a special kind of software or computer program that migrates between the nodes of a network to perform a task autonomously and intelligently in response to changing conditions in the network environment to realize the objectives of the agent dispatcher [5]. Mobile agents help to reduce bandwidth consumption in WSN. Mobile agents can reduce bandwidth consumption by moving the data processing elements to the location of the sensed data. In general, mobile agent is a special program which can be executed autonomously [6]. Fig.2 shows the mobile agent. Sometime mobile agents are considered as an entity that follows four attributes: agent identifier, data space, and method and migration table. Agent identifier is used to uniquely identify each agent. Data space carries out all the integrated results. Methods deals with execution of codes and migration table contain detailed information's about routing of an agent. Mobile agents can be classified into two types:

1). Mobile software agent: Mobile software agent is a computer program that decides time and place for migration between the sensor nodes. When the agents decide to migrate to another node in the WSN, it logically transfers its state and code to the destination and then starts the process of migration between nodes.

2). Mobile hardware agents: These can traverse the network to collect information from sensor nodes. The hardware agents consists three classes that are communication protocol, localization and energy harvesting algorithms. Here communication protocol help in migration process, the localization help in placement of the nodes in the network and energy harvesting algorithm help in energy consumption issues.

Mobile agents also allow WSN's to be dynamically reprogrammed by enabling users to inject new agents into the network and allowing old ones to die [7]. The functioning of mobile agents can be categorized into three major levels or groups that are user level, network level and connection level. The user level is also called secretary function. A secretary function allows a user/customer to command a mobile agent that does a specific job within a given time and with the best result or performance [8]. Network level is also called network management function, it allow mobile agent to collect network information by travelling around the network. Connection level is called maintenance function. It maintains connection and data transportation between agents.

II. CHARACTERISTIC FEATURES OF SENSOR NETWORKS

A. Scalability

Sensor networks should be scalable or flexible. Sensor networks dynamically adopt changes in node density and topology. Sometimes few nodes are added to the sensor networks existed nodes for the purpose of coverage issue. So sensor network is flexible to adapt these changes.

B. Maintenance

The only desired form of maintenance in a sensor network is the complete and partial update of the program code in the sensor nodes over the wireless channel [4]. The functioning of the network is halted by unavoidable failures of single

node which may occur due to various reasons just like power consumption, coverage and connectivity issue. So the sensor network provides updation features to its nodes.

C. Data collection

Data collection is linked to network connectivity and coverage. In the sensor network, all the nodes are placed in the pre-planned manner to cover whole area of the network. This whole coverage of network helps to collect data in the particular environment.

D. lifetime

Lifetime is extremely critical for most applications and its primary limiting factor is the energy consumption of nodes, which needs to self-powering [4]. To reduce energy consumption, developer should have to consider the existing interdependencies between individual layers in the network protocol stack.

III. CHARACTERISTIC FEATURES OF MOBILE AGENTS

A. Programmability

The programming feature allow mobile agent to program or code an agent to adapt the changes that are produced by the underlying environment.

B. Mobility

With the help of mobile agents, mobility feature is provided to enables better bandwidth usage by moving the processing element to the location where the data to be analysed resides [5].

C. Dynamic reprogramming

Mobile agent provide dynamic reprogramming feature in which new agents can be easily injected into the wireless sensor network and also it allow old ones to die.

D. Optimal path

Mobile agents provide optimal path through single traffic flow. In single traffic flow, the mobile agent is dispatched into the area of interest when particular event is as observed.

IV. ARCHITECTING DATA DISPERSION SCHEMES IN WIRELESS SENSOR NETWORK USING MOBILE AGENTS

According to WSN's configuration, we classify the MA-based architecture into two types: Hierarchical architecture, Flat architecture. In Hierarchical architecture, all the nodes in the network play different roles but in case of Flat architecture, all the nodes have equal roles or they can play similar roles in all cases.

A. Hierarchical WSN architecture

In general, the operations of an MA-based solution are simplified in hierarchical WSN deployments, such as in the clustered topology [5] that promotes intra and inter cluster hybrid methods. In the clustered topology, cluster head created by combining multiple nodes. In case of intra hybrid method, every cluster head dispatches an MA to all cluster members for collecting and combining data. After collecting data, the MA send back the result to corresponding cluster head, then the MA with the corresponding cluster-head, send back the result to the WSN's gateway for further processing. In such case, few MA operations performed inside the cluster. In case of inter cluster hybrid methods, mobile agent uses planned route to reach all cluster heads, until the WSN gateway is reached. In case of intra cluster method, all the cluster heads are reasonable small.

B. Flat WSN architecture

In this architecture, we can use mobile agent based WSN approach. In this approach, a single "mother" MA is dispatched to the target area from WSN gateway and that MA remain temporarily stationed at that target region waiting for a command or any triggering event. The dispatched MA performs its task in that region in which it is transferred because it carries codes to perform particular task. When commanded mother MA dispatched one or more child agents that carry out the tasks, Child agents visit each source of data. Then send data back to the mother or WSN gateway. In such case, several child MA's can be launched by mother MA concurrently to perform one or more task parallel y to reduce latency.

V. STRATEGIES FOR NODE PLACEMENT IN WSN ARCHITECTURE

Node placement strategies are used to represent the way that positions the sensor nodes in the network. Basically, wireless sensor network consist of hundred of nodes. Each node operates on small batteries. When nodes of the WSN go out of energy, they structurally damage the wireless sensor network. So to manage the structure of WSN, accurate positioning of nodes plays an important role. In this paper, we categories the node placement strategies into two types: Static and Dynamic strategies. Node placement is used basically into two cases: At the time of deployment of nodes and at the time when network is operational.

A. Static node placement stratergy

Node placement schemes prior to network start up usually base their choice of the particular nodes position on metrics that are independent of the network state or assume a fixed network operation pattern that stays unchanged throughout the lifetime of the network [9]. Static node placement stratergy can be categorized into two deployment methodology: Controlled and Random. Controlled deployment methodology is used for indoor applications of WSN's. Deterministic and controlled deployment node placement is used in various applications like: range-finders, video sensors or

underwater acoustics. Random node distribution is often looking optional. In case of random node distribution, the nodes are deployed randomly and their density can be controlled to some extent. Random node distribution has three deployment patterns: simple diffusion (2D normal distribution), uniform and R-random pattern. In such deployment pattern, the nodes are uniformly scattered with respect to the radial and angular directions from the base station or the R-random node distribution pattern, resembles the effect of an exploded shell and follows the following probability density function for sensor positions in polar co-ordinates with in a distance R from the base-station [9]:

$F(r, \theta) = 1/2\prod R, 0 \leq r \leq R, 0 \leq \theta \leq 2\prod$

In static node placement, the nodes are placed either by relay node placement way or either by placement of data collectors way. In relay node placement, the intermediate nodes are placed (named as relay node) between base station or sensor node. Sometimes in two-tier sensor network architecture the sensors are split into groups and aggregation-and-forward node led them. When a sensor node collects the data from all sensors it sends back its report to the assigned aggregation-and-forward node (AFN). Then AFN sends the aggregated data report to the base-station over a multi-hop path.

In case of placement of data collectors, clustering concept is used. In case of clustering, every cluster usually has a designated cluster-head (CH) [9] unlike relay nodes, which forward data from some sensors; cluster-heads collect the data from their individual clusters. Careful positioning of cluster-heads in a hierarchical network has been deemed as effective stratergy for establishing an efficient network topology [9].

B. Dynamic nodes repositioning stratergy

In case of static node placement, optimal location of the nodes is computed and once the location is find out, the nodes cannot move to one location to another. To place a node in its proper place, all placement decision is made at the time of network setup and no dynamic changes are considered during such network operations. Sometimes when new nodes joins the network or the old one goes out of energy then new resources may be affected. So to hold or handle such changes in the network resources, dynamic repositioning of the node is required to improve the performance of the network. Sometime when sensor nodes go out of energy, they are declared dead and they are replaced by new sensor nodes such replacing process is called dynamic relocation of the node.

The process of dynamically positioning the sensors into the network can be categorized into two groups: Post-deployment and On-demand relocation.

1). Post-deployment sensor relocation

This type of relocation is pursued at the conclusion of the sensor deployment phase when the sensor nodes are being positioned in the area [9]. Mostly in WSN, all the deployment of the nodes in the network must be done randomly because of inaccessibility of the monitored areas. However in a random configuration we cannot cover whole the area, so to cover whole area we have to deploy excessive number of nodes. Three methods are used to reposition a sensor: vector-based (VEC), voronoi-based (VOR) and minimax. In vector-base method, nearby particles are used in the network that subject to an expelling force that keep them apart. In case of VEC, the nodes are pushed away from the densely populated area, but VOR is opposite to it, it pulls the sensors node to few populated areas.

The minimax scheme is more conservative in the sense that it avoids creating coverage holes by going far from the closet vertices, leading to a more regularly shaped voronoi polygon.

2). On-demand repositioning of sensors

On-demand repositioning of sensor node is the best way to improve the network lifetime or performance because in such case we can only reposition the nodes if they are required on-demand, we cannot reposition them at the time of deployment phase. In such case, when a node is required for coverage purpose, it is repositioned at that particular place and it helps to reduce energy consumption in order to reach the best efficient topology.

The information presented in [9] performs sensor relocation to counter holes in coverage caused by sensors failures. In such case, multiple spare nodes are placed on the network and they are required at the time of the recovery. Here, to detect the closest redundant sensors, grid-based approach is used. In such approach, the region is divided into cells and each cell has designated head. Each cell head request for redundant nodes in the network when any one node is destroyed when redundant node is find out it is moved to appropriate cell without affecting the network.

In such case, when a node is moved to the particular position to save the energy consumption, cascaded movement is proposed. In cascaded movement, first of all intermediate nodes are identified and then those nodes are replaced gradually. In such case, first of all redundant nodes replace first intermediate node, then replace second intermediate node and so on.

VI. ITINERARY PLANNING APPROACHES FOR AGENT MIGRATION IN WSN

In WSN, the mobile agent travel through the network to perform particular task. Agent migration planning is required to find out the shortest way to reach the particular destination. When the path of the MA is on planning stage, two steps are followed either by WSN or by MA.

1). Defines all the sub nodes of the main node.

2). Identify the actual path that helps to preserve bandwidth.

The second step plays a major role to save energy problem because energy consumption is a biggest problem in the case of WSN. It has also been seeing that finding an optimal sequence for visiting the respective nodes of such a path is non-deterministic task that can be solved in polynomial time of the factorial of the number of nodes to visit that is; it is an NP-Complete problem [5]. When we start to plan a path for agent three approaches are used that are static, variable, hybrid.

A.) Static MA itinerary planning

In such case, the travelling path is fixed and the entire agent migration itinerary is determined by the WSN gateway before dispatching the MA [5]. In such case, all the information regarding agent migration path are taken from the global network before an MA is dispatched. Basically two methods are used to find out the nodes or path in the network. That methods are (LCF) local closest first and (GCF) global closest first. In these methods, closest node to the gateway is visited first. Out of all the nodes, the executing one is the closest node to the gateway. Sometime genetic algorithm is used to find out the path. In such case, each sensor node can be visited only once.

B.) *Dynamic MA itinerary planning*

In such case, the travelling path is variable and the MA decide which nodes it visit first, depend upon the particular situation that are produced in the current network execution progress. Static MA itinerary planning cannot work to get information if they are available at the outside. In such dynamic MA itinerary planning can work, it enables MA to determine which node to visit as it hops through its migration path [5]. The dynamic itinerary planning approaches ensure that the visited sensor nodes have enough power energy, minimum energy consumption and have significant information gain.

C.) Hybrid MA itinerary planning

In both cases, either static or dynamic, the WSN and MA can take decision individually. But in case of hybrid planning, the decision taken by the both WSN and MA. In this approach, we have static set of sensor nodes that should be visited, leaving the migration sequence open to change [5]. In such case, the packets are send to the WSN's gateway and then gateway show the migration path for MA as it visit a WSN node subset.

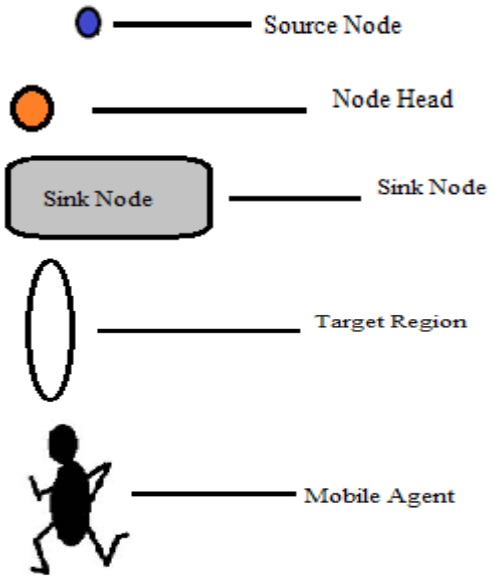
VII. PROCESS MIGRATION

Basically we know that the MA travel on the WSN network and they perform task on agent hosting capability machines. Here, when the MA start to collect the data, a process is migrated. In process migration, processes are migrated from one computer to another then they are split into sub processes to perform task on particular machine after that they return back to origin. When process migration is done in the mobile agents few things are always remembers. The first thing is the execution language. If a process is migrated from one host to other, migration language is check out whether it is common or different. After that process persistence is checked out. The process persistence show the process capability to save the execution state and spawning a new process whose execution state will be saved. Then communication mechanism is checked out between MA where they communicated through TCP/IP, HTTP or some other way. In the communication mechanism, the codes are transferred from one state to other we need to protect and secure those codes on the network, so the security is also a very important thing in process migration. Sometime process migration is achieved to fulfil the following goals [10]:

1). Exploitation of resource locality
2). Accessing more processing power
3). Resource sharing
4). Fault resilience
5). System administration
6). Mobile computing

VIII. PROPOSED ARCHITECTURE OF WSN BY USING MA

In our architecture, we are using few symbols that help to identify the network diagram easily. The symbols are:



In the architecture, the target region is the place where all the sensor source nodes are available. The source nodes contain data or information that is required by the mobile agent in future. Here we create a node head, the node head deal with all the source nodes and get required information from them. When a sink node require information, it send mobile agent to the node head, the node head collect the desired information and send back the result to the sink node through mobile agents. Due to such working process, data redundancy is reduced because the mobile agent is only contact to the head ode, the head node, the head node give mobile agent accurate information and this architecture also help in saving bandwidth because the mobile agent only communicate to head node , it cannot contact to all source nodes. In wireless sensor network various simulation tools are available for its design like: MATLAB, NS-2, CLOUD SIM etc. Here currently we are working on MATLAB tool. In future according to our satisfaction or simplification we can change the tool to create our architecture. Fig.3 shows our current proposed wireless sensor network architecture by using mobile agents:

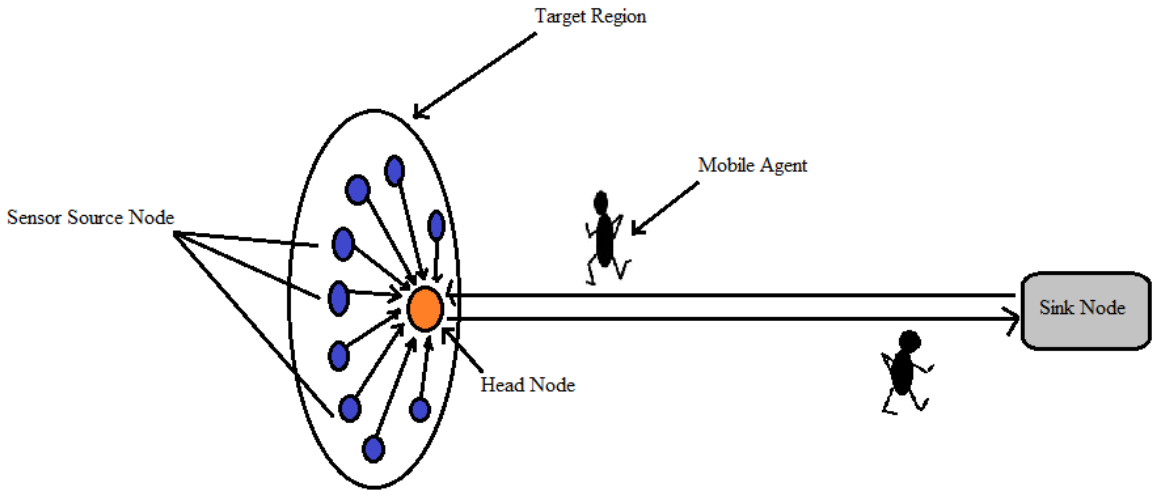


Fig.3 Proposed Architecture of Wireless Sensor Network by Using Mobile Agents

IX. CONCLUSION

In this paper, we proposed a mobile-agent based architecture for wireless sensor network where mobile agent collects the valuable data to the node head. Regarding wireless sensor network and agent technology, we are working on building architecture for wireless sensor network with mobile agents that help to solve many wireless sensor network issues. The study of mobile agent in wireless sensor network opens up a new area to researcher that is rich in theory and applications. Here, we conclude that the study of mobile agents in wireless sensor network help to save bandwidth and energy consumption by direct communication between node head and sink node through mobile agent. As future works, we will create our architecture and try to validate our architecture with real case study applications.

ACKNOWLEDGEMENT

It gives me immense pleasure to express my deepest sense of gratitude and sincere thanks to my highly respected and esteemed guide (Mrs. Sonia Jangra) for their valuable guidance, encouragement and help for completing this work. Their useful suggestions for this whole work and co-operative behavior are sincerely acknowledged. I also wish to express my gratitude to (Er. Dileep Adabala)for his kind hearted support. I am also grateful to Dr. Manish Mann for his constant support and guidance. I also wish to express my indebtedness to my parents as well as my family member whose blessings and support always helped me to face the challenges ahead. At the end I would like to express my sincere thanks to all my friends and others who helped me directly or indirectly during this project work.

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