FOREST GUARD: A complete safety for Wildlife using Mobile Agents and Sensor Clouds in WSN

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Abstract

With growing human population and search for new habitus and unsustainable use of natural resources, over exploitation of forests and wildlife is taking place world over. This is resulting in drastic decline in the number of essential flora and fauna. We propose a complete safe guard model named *Forest Guard*, for saving wildlife from human as well as their own collisions. This model will not guard them directly; rather it will help in collecting vital information about their real-time condition and will alert the institutional mechanisms to take corrective initiatives. The paper mentions this indirect support in the form of wireless sensor networks (WSN). In WSN, our proposed model uses mobile agents (MAs) for handling huge area communication and injecting them for different guarding issues of different species of wildlife. A novel concept of Virtual Sensor Cloud (VSC) is being discussed to trace different group of endangered wild animals such as Tigers, Lions, Elephants, etc.

Keywords: *Wireless Sensor Networks, Mobile Agent, Virtual Sensor Cloud.*

1. Introduction

Species of wildlife know adequate survival techniques for themselves as well as their sense to survive themselves and their progeny. They find suitable safe places for sleeping, eating, and roaming around. Their sitting postures, roaming in herds and making unique sounds help them to protect themselves from enemies, both poachers and hostile animals. Despite facing odd survival challenges, the endangered animals are able to survive and breed their generation. Survival challenge from human beings in the form of poachers is becoming grave in recent years as interference of humans in forests has increased. In the lust of doing illegal business from endangered animal's skin and bones, peaceful wildlife is being destroyed. Cutting of forest trees, hunting protected animals, release of harmful chemicals in the environment by industrial activities, increasing global warming, disturbing the natural sanctity of wildlife while trying to help them, etc., are some of the major reasons for wildlife disturbance. This is high time to save them otherwise wildlife may gradually vanish.

A lot of state and civil society supported programs and activities are underway in different countries to protect the wildlife from illegal human interference. Some of the wildlife species have become extinct and many of them are on the verge of extinction. Since development in human civilization is continuously destroying the wildlife despite having statutory provisions in place, it requires a series of fresh initiatives supported by innovations in science and technology to restore and maintain the natural habitus of wildlife. Using recent innovations in technology, we can help them with the help of sensor motes in a WSN, without interfering their natural living.

WSN is an emerging network which manages, communicates and controls the real environment with the help of tiny sensor motes or simply motes [1] [2]. The motes have many constraints like limited energy, less memory capacity, slow computation, small covering frequency range etc, which make WSN different from other networks.

For covering a huge area like forests and sanctuaries, we are using mobile agents which are well suitable in WSN with some special features such as migrating their state, code and data from one mote to another with single or multi hop communication [3] [4] [5]. These MAs are handled by a middleware. Our proposed model uses AGILLA middleware, which has suitable features for implementation [6]. We can inject many MAs after deployment of WSN in the forest with the help of Agent Injector in the AGILLA middleware.

Covering wildlife in a forest is a very difficult task, since they are moving from one place to other in herds or alone. For solving this problem the paper introduces a concept of Virtual Sensor Cloud (VSC) in WSN environment. Clouds of sensor motes are handled by MAs and keep changing or sliding over the WSN network

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virtually without knowing the configuration of sensor motes and their formed clusters. Simulation results of our prototype implementation of *Forest Guard* validate our proposed model to implement in forest with the help of WSN.

Further we discuss literature survey in section 2, which describe some hardware and software issues. After that the design of the model is mention in the section 3. Implementation of the model is described in the section 4 and their simulation result shown in the section 5. At the end conclusion are discussed.

2. Literature Survey

AJ Garcia-Sanchez et. al., addressed some problems, including animal classification, detection and tracking their positions [8]. Targets detection is carried out by a passive Infrared sensor (PIR sensor) an infrared motion sensor, specifically AMN41121 a Panasonic sensor. Camera sensors are in charge of information gathering for the identification of targets. Motes can be deployed either in a hexagonal or in a grid (square) layout. One-hop transmission mechanism is used for sending messages, which is appropriate for the considering dimensions of the observation area. This hardware future may be extended up to our desire hardware goal in future, which supports our software implementation completely.

Byungrak Son, et. al., have accepted that much wild fire's cause to damage of forests and mountains which have valuable natural resources [10]. Current surveillance systems use a sensor camera, an infrared sensor and a satellite system. Real-time surveillance, monitoring and automatic alarm cannot be supported by these systems.
The authors discussed a forest-fires sensor network, which uses the routing protocol using Minimum Cost path Forwarding (MCF). It finds shortest paths from all the sensor motes to the Base Station (BS) and requires no routing tables to maintain each mote explicitly. They suggested that routing all the messages along a shortest path might drain all the energy from upstream motes and gives a method by limiting the amount of energy each mote and can spend in a round. In our proposed model, we are using mobile agents for solving these problems.

Yanjun Li, et. al., have also accepted that traditional technology for fire detection using GPS, GIS, and GPS remain problems of inaccuracy, expensive cost, and non-real-time response [11]. Misjudgment or failure of fire detection happens frequently.

There proposed system should be able to detect a small fire and determine its position with accuracy. The system makes possible to fast intervention and provides fire spread limitation using a mobile base-station to periodically gather real-time information. These strategies include global spatiotemporal query (query of all sensors), local spatiotemporal query (query of spatial neighborhood), and border query (query of the border of danger fields). Through in-network processing, the authors suggested that the region of the fire can be calculated easily and even roughly predict the catching and spreading trend of the fire. Protecting wildlife is not only protecting them from fire rather we discuss much more.

3. Forest Guard Design

Proposed model is designed into two tiers architecture. First tier handles Cluster Heads (CHs) and their motes. These are constant and remotely or self reconfigured according to need. While second tier is configure according to movement of species, called Virtual sensor Cloud, with the help of first tier architecture. Virtual Sensor Cloud are defined in two ways, first Herd Cloud (HCL) is including those animals who believe to lives in a herds while the second clouding is covered those animals that lives lonely and called Scatter Cloud (SCL). In our proposed model second tier i.e., VSC is sliding onto first tier according to movement of species independent from the first tier architecture. The proposed model architecture is illustrated in the figure 1. Clusters are self-organized in the WSN environment just after deploying them such as cluster 1. Clusters have cluster heads and some sensor motes as normal WSN requires, while Virtual Sensor Clouds are not organized only one time rather they are regularly organized virtually according to animal's movement. Virtual Sensor Cloud (VSC) is discussed in more details further.

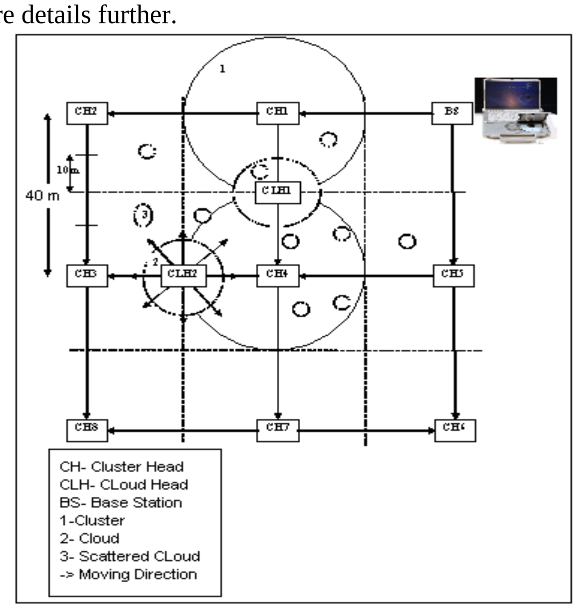

Fig. 1 Sample Architecture of *Forest Guard* Model.

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a) First Tier Architecture

After deployment of motes into a forest in a WSN, the Base Station (BS) sends the CHs configuration message through MAs in the predefined direction and range. We assume the sensing range of CHs and motes are 40 and 10 meters respectively. For unorganized scattered sensor motes, the CHs are organized in square form with maximum sensing rang of CHs, say 40 meters. Cluster areas are defined circular with the radius of maximum mote's sensing range multiply by 2 i.e. 2*10 = 20 meters. The BS may reconfigure according to need or failure of some CHs with care of their direction and sensing ranges. First tier helps the BS to find the location of different clusters.

b) Second Tier Architecture

This tier introduces Virtual Sensor Cloud (VSC) with the help of MAs. Clouds are virtually created by CHs in the circular form with radius of maximum sensing rang of a mote for different group of wild animals. One of a mote among the circular clouding region will be chosen as a Cloud Head (CLH). The clouding areas are sliding over the first tier according to wildlife species moving direction virtually and absolutely free from WSN configuration. Main purpose of VSC is to continuously guard them in the forest. In general protection cycle in our proposed model is illustrated in figure 2.

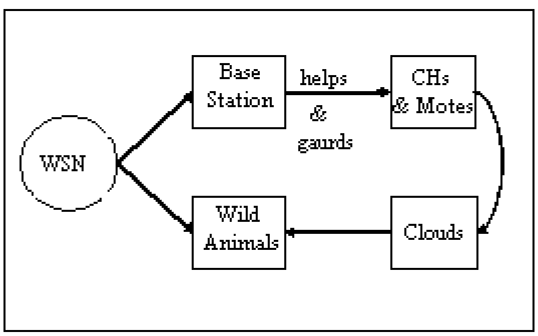

Fig. 2 Protection Cycle of the proposed model.

The protection cycle of figure 2 shows the main components of our proposed *Forest Guard* model. The ultimate goal of WSN environment is to help and guard wildlife and the base station.

4. Forest Guard Implementation

We propose some basic Mobile Agents (MAs) to implement our proposed model, although we can add more MAs for enhancing wildlife safety in future. The paper implements the proposed model with the help of some MAs they are- *Count.ma, Safety.ma, Alarm.ma, Fire.ma, Human.ma, Attack.ma, AnimalID.ma, Cloud.ma, SplitClouds.ma and Update.ma*. These MAs can be injected, fired or migrated among motes, CHs, CLHs and the BS for the managing of wildlife in a WSN. There are some MAs which are fire from the BS, such as

a) Count.ma

One of the major tasks of our proposed model is to count the different types of species in the forest. Figure 3 illustrates the Count.ma MA, which is software part. While hardware part is detect different species of wildlife, which is out of scope for this paper. We assumed that our motes are capable enough to detect the different species of wildlife along with their physical movements and structure. Cluster1 to 6 are Herd Clouds (HCL) for different types of species, say CL1 and 3 for Elephants, CL2 for Dears etc. Now BS fires or injects Count.maMA to count the appropriate CH1, since CL 1 and 2 for Elephant exist in this cluster. After receiving Count.ma, CH1 migrates to CLH1 and 2. Now the CLHs broadcast the MA to all their clouding sensor motes. We assume the motes are able to count and send the value to their respective CLH. After receiving the counted value from CLH1 and 2 the CH1 sends the data directly to the BS. If other CHs include the cloud for Elephant, they have to count and send the values to their respective CHs. After getting counter values, the BS adds all of them to find the total number of Elephants in the forest. This way we can know the number of different species.

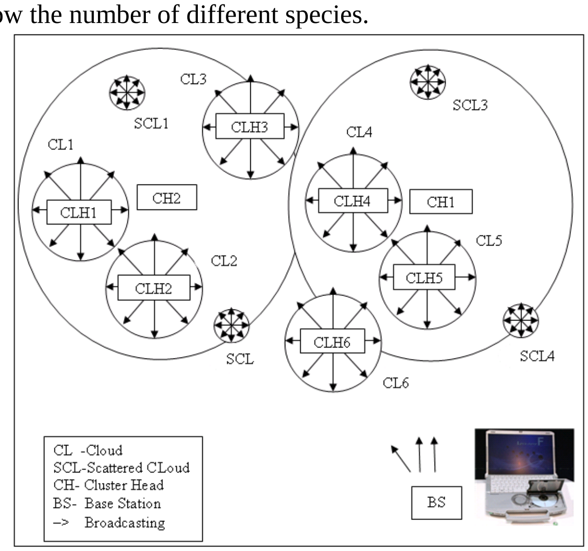

Fig. 3 Sample model of the Count.ma Mobile Agent.

Count.ma MA helps to analyze the population condition of different species of wildlife, after analyzing the collected data the appropriate action will be taken through injecting different MAs in our proposed model.

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b) Safety.ma

The purpose of the MA to safe wildlife which are about to extinct or decreasing their number rapidly. After finding the victim group of species, the BS injects Safety.ma MA into their respective CLHs via CHs. CLHs have responsibilities to provide safety through their clouding motes which may create some strange sounds. This activity alerts the victim species and due to natural phenomenon they will run far from the strange sounds or at least alert.

We have other types of MAs which are fire from CHs, such as

a) Cloud.ma

CHs injects Cloud.ma MA to their second hop cluster motes to become a CLH if species of wildlife exists in their cloud range otherwise it will migrate to other second hop motes. CLH may be a CH in some case. After configuring the CLH the MA sends the CLH acknowledgement to their respective CHs.

b) Alarm.ma

CHs regularly communicate their clouds and their neighbors CH's clouds. The purpose of this MA is to divert the clouds from one another. In some cases, this MA is very useful in our proposed model to safe identified species of wildlife.

The model has some MAs which are fire from CLHs, they are

a) SplitClouds.ma

If clouds slide onto more than one cluster regions, CLH has responsibility to fire SplitClouds.ma MA to their all respective CHs. In this situation the CHs communicate among themselves to handle the split clouds as a one cloud.

b) Update.ma

CLHs regularly check the cloud region and update if the region exceeds one hop communication distance. Firing of this MA depend the movement speed of the species in their cloud.

There are some MAs which are fire from Cloud Motes in this model. Cloud motes fire or compel to fire MAs such as Fire.ma, AnimalID.ma, and Human.ma etc. These motes are really sense the real environment of the wildlife. We can know the information from this model such as the human interference, fire, collision among species of wildlife. According to situation we can help them through MAs which can be deployed or injected inside the motes.

5. Simulation Results

Our simulation is performed in the sensor lab with 100 motes. We simulate the performance of different Mobile Agents which are used in our proposed model. Real simulation with species detector modes is our future work. We are using TinyOS operating system, AGILLA middleware for MAs with AgentInjector. Different MAs of the proposed model are calculated the average of 5 simulations result each for 60 seconds. They are shown in the table 1 and their comparison in the figure 4.

Table 1: Consumed Energy in different MAs of *Forest Guard*.

The Proposed FOREST GUARD MAs	Count.ma	Safety.ma	Alarm.ma	Fire.ma	Cloud.ma	Update.ma
Consumed Energy (mJ)	98.625	74.528	40.368	10.724	90.693	93.158

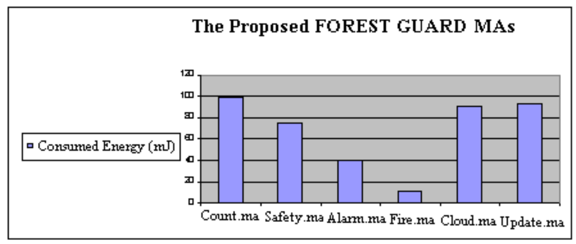

Fig. 4 Comparison of some MAs of *Forest Guard*.

Each MA in our proposed *Forest Guard* model can be injected independently any time for getting wildlife information. Adding new features in the proposed model is absolutely independent from WSN motes configuration i.e. without redeploying we can inject new features in the proposed model which saves money and time.

These features cannot possible without MAs. We have to redeploy the sensors motes configured with new features in the WSN. Due to comparing with our proposed model we have implemented some MAs activities in WSN without using MAs features. The simulated results are shown in the table 2 and their comparison is depicted in the figure 5.

Table 2: Results of *Forest Guard* through MAs and without MAs.

The Proposed FOREST GUARD Implementation	Through MAs	Without MAs
Consumed Energy (mJ)	864.749	2284.845

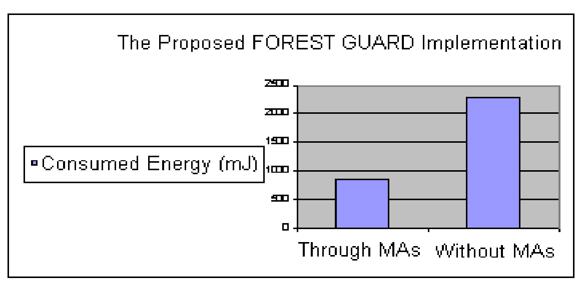

Fig. 5 Comparison between through MAs and without MAs

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7. Conclusion

Human beings have created enumerable problems for wildlife. Now the humanity should save their lives, otherwise this may disturb the ecology of the atmosphere and ultimately human life will suffer the most. The paper has introduced a technical intervention in the form of an innovation named *Forest Guard* model that can indirectly guard the wildlife by providing real-time information to the institutional authorities, which can directly intervene to protect the wildlife from poaching and other life threatening disturbances. We assumed that the hardware of sensor motes is capable to detect different species. The proposed model uses AGILLA middleware, which has features to inject different Mobile Agents according to need. With the help of MAs our model creates clouding, which is unique feature of the model to capture different species of wildlife. The simulation results show that the model would work perfectly in its stated objectives. The captured information from the model may be misused on species of wildlife in future; therefore the proposed model must be implemented under the guidance of institutionally authorized body.

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