An electronic framework to shepherd the pastorals livestock

(Resolve Conflicts in pastorals community)

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***Abstract*—This paper proposes a tracking framework based on GPS enabled location sensors, the GSM/WCDMA wireless network, and algorithms running in an edge clouds to resolve deadly conflicts that arise in the Africans pastorals community. The paper also proposes an automatic digital identification mechanism that helps resolve conflicts during animals mix-up. This algorithmic based solution would totally relief the community from using the traditional identification mechanisms such as hot branding which are known to be cruel to animals. To communicate with the pastorals, the framework takes into consideration the low level literacy of the community as well as their use of low end mobile devices. Moreover, very low economy status, different environments of three kinds of livestocks, day and night variations of animal movements are all factored into the design of the algorithms. This paper shows the general architecture of the system and algorithms to shepherd camels. In a subsequent paper we will add algorithms to shepherd sheep, goats and cattle. Moreover, we will evaluate the solution using simulated as well as real deployments.**

Keywords: ***Tracking, electronic shepherd, algorithmic conflict resolution, edge cloud, corrals, sensors, GSM, GPS***

I. Introduction

This document describes a novel design approach to quickly recover stolen animals and resolve conflicts — that happen due to livestock identification problem and grazing land competition — on-the-spot in the pastoral community of Ethiopia. The approach use a modern tracking technology, an existing wireless network, a distributed data store and a simple mobile based user interface which is appropriate for the low literacy level of the pastoral community in the area.

The livelihood of the pastoral community is based on animal rearing. Specifically, they breed camels, cattle, sheep and goats. They don't have a sedentary life. Instead, they drive their animals from place to place in search of water and grass over long distances. Although the area of movement is very large, it occurs in a known and informally reserved for a given community. Most of the time, the area of movement is characterized by hot temperature and distributed small bushes as well as tall and horny trees.

The pastoral communities organized themselves around families and tribes. Usually three to four families in a tribe tend to keep and drive their animals together. The tribes create a system of networks throughout the area, and they use a traditional way of communicating with each other to resolve problems, specially animal rustling. Recently the community started to use the mobile communication service of Ethiotelecom, which is the only mobile service provider in Ethiopia and has a 99% coverage of GSM and WCDMA in most of the pastorals area. The availability of such a network provides an opportunity to establish a tracking and identification mechanism without incurring a big cost to establish a communication infrastructure.

The pastoral communities constantly face conflicts due to animal rustling, animal theft, competition for grazing land and animal identification problems. The conflicts often results in loss of human life. These conflicts occur between tribes and different region peoples. The way the pastorals make their living exacerbates the problem. Pastorals need to feed their large number of animals relatively in a large area compared to sedentary farmers. This mode of animal breeding is highly vulnerable to animal rustling and identification problem due to lack of real time visibility to the animals by their shepherds and owners.

Traditionally, pastorals use traditional mechanisms to resolve conflicts and animal rustling issues. The primary mechanism being mediation through elderly people. The second one is using force to recover their stolen animals. The last option is to get assistance from a nearby law enforcement institutes, if available. All those solutions are not effective in terms of speed of recovery and providing resolution on the spot. In contrast,the solution proposed in this work, addresses theft before the stolen animals are completely disappear from the pastorals vicinity and provide conflict resolution on the spot.

Likewise, pastorals address the identification problem through traditional mechanisms: hot iron branding, ear notches, paint marks, and even tattoos. However, these methods have known drawbacks: first, transferring ownership is very difficult as re-branding is not a simple task; second, these methods damage animal skins (not healthy for animals) and render it unsuitable as a raw material for industry processes. A more modern approach than the above mentioned identifications mechanism is to use numbered ear tags. It provides a healthy method of identification, however, similar to the traditional mechanisms it makes ownership transfer difficult.

The alternative is to use an electronic tracking device which is attached to the animal and which can be monitored remotely. In fact, the thesis of this research is that by using modern tracking devices with a cost effective networking options, it is possible to resolve conflicts and handle animals rustling on-the-spot using algorithms that run in the cloud.

There are many electronic animal tracking modalities, and in this document we show the different options with their merits and disadvantage in regarding to tracking pastoral livestocks which are semi-wild. In the literature we find many works that address the tracking of wild-animals and domestic animals, but as to our knowledge we didn't come across to any work related to the semi-wild pastoral animals which addresses camels, cattle, ship and goat together and which addresses animal rustling and conflict resolutions.

Once we are able to track the animals, we need to transport the data from the field to the cloud data centres, where they are stored and processed. This process needs to happen in almost real time manner in order to handle animal rustling and resolve conflicts on-the-spot. We have developed algorithms to process the data in real time and systematically alert the communities about on going theft and arbitrate between them right on-the-spot during conflicts. To do this we need a system that has appropriate user interface for the pastorals. As the pastoral community has low level of education, the framework provides audio based interactions for its users for most of the use cases.

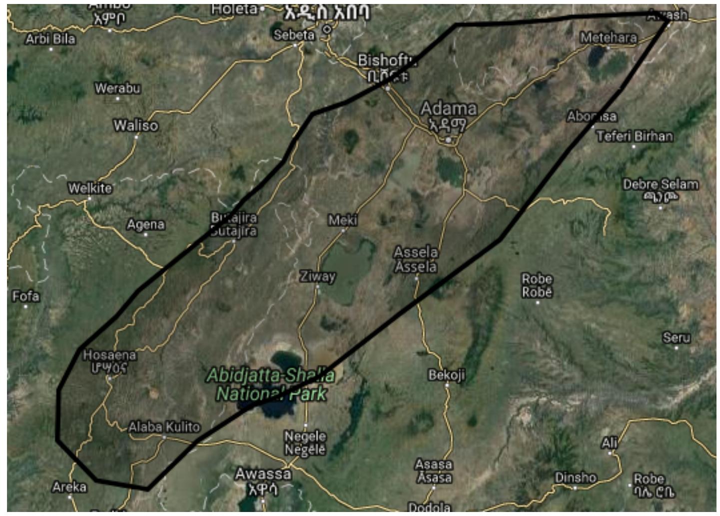
This document is organized as follows: first we describe the data collected that shows the scope of conflicts and animal rustling in the study area. Moreover, it illustrates the volume of livestock, the mobility route, and existing network coverage; The second part of the document gives an overview of the design proposed in this document; The overview section will be followed by the design factors section that lists all the design goals of the system; Next, we describe all the choices we made for the tracking of camels, cattle, and sheep/goats in their respective sections; That will be followed by data store and user interactions designs. Subsequently we display the algorithms we developed to address the issue of animal rustling and conflict resolutions for camels. Finally, we display related works and conclusion.

II. Data Collection and Analysis

As the algorithms to shepherd the pastorals livestocks dependent on the pastorals knowledge(for example, places identification), and the environment, we conducted a thorough data collection to meet the following objectives:

- Understand the volume of conflicts and theft in the pastoral community of the study area and know how and when they occur
- Understand how the pastoral community in the study area organize (group) themselves for security purposes
- Understand the economic status of the majority of the pastoral community in the area so that we know what kind of system is affordable while giving the required functionalities
- Find out the constraints imposed by the animals and their environment
- Find out about all the well known places which are being used as a reference points by the pastoral communities in the study area
- Discover the distances between the well known points

Fig. 1: The Study Area



The required data for our system was collected by presenting questions to the selected pastoralists and farmers who are known in the pastoral community. There was also a discussion with professionals, and animal health workers who work in the different agricultural offices.

A. The Study Area

As Figure 1 shows, the case study involves an area of approximately 5000SqKm. The area is characterized by a hot temperature, which is in average greater than 30^oC.

B. Mobility

Pastorals make regular seasonal movements between different places. The main driver for migration is scarcity of pasture at the current place. The data analysis shows that the pastorals undertake three kinds of mobilities: short range, medium range and long range. Short distance mobility involves only sheep and goats. The medium range mobility involves cattle and it occurs not more than 50KM. The long range mobility involves the camels and they move more than 300Kms in some cases. So any solution to shepherd the pastorals livestock should take into consideration this three mobility models.

C. The community structure

When we closely look at how the pastorals solve animal rustling, we found that they mobilize a closely located related tribes to recover a stolen animals. Most of the time these close tribes settle them selves within a close proximity during

Fig. 2: Network coverage-GSM

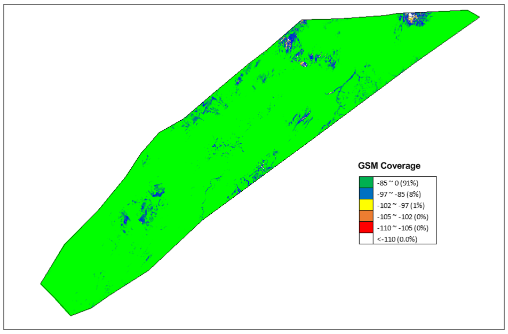
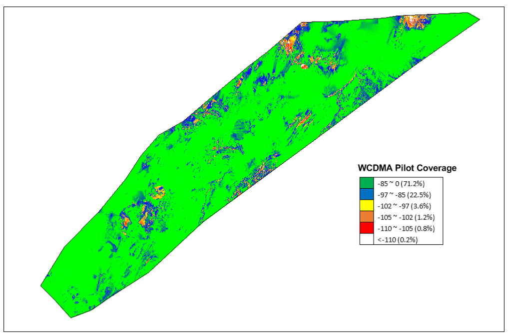


Fig. 3: Network coverage-WCDMA



migrations period as well as when they settle for a long time interval at one place.

D. *Existing Network Coverage*

As Figure 2 and Figures 3 shows ninety nine (99%) percent of the area is covered with either a GSM or GPRS wireless infrastructure. As a result, using GSM/WCDMA is one option to be used as the data transport mechanism. The Design section shows how it is compared to other alternatives in terms of cost.

III. Problem Description

Our goal, given the system model described in the previous section, is to be able to handle animal theft and animals ownership conflicts at the right time and place. Specially, the system needs to handle theft before it disappears from the place where it is initiated, and ownership conflicts should be addressed before they claim human casualties. Doing so requires collecting location information of each and every livestock in a real time. The real time data collection requirement demands deciding on what type of tracking technology is suitable for the different types of livestocks. Moreover, the decision needs to take into consideration the cost effectiveness of the selected technology for the pastorals, otherwise it wouldn't be a sustainable solution.

Tracking an animal involves a corral device attached to an animal to gather the location data, a network to transport the data, and a receiving station to store and process the data. In all of these cases, we need to design or choose the most cost effective options. As to the corral devices they need to meet the environment and the technical literacy level of the pastorals.

Once data is collected and stored in the data centers, we are required to process it in a scalable way, as the number of animals whose data need to be processed in a real time is in hundreds of thousands, and as there is a high resource constraint to be cost effective. The processing should be done in a way that it reveals the current situation of the animal. The main difficulty here is to differentiate between animal rustling activities and normal activities algorithmically. Moreover, we need to tell algorithmically who is the owner of an animal in case of ownership conflicts during animal mix-ups.

In addition, most pastorals have a low level of literacy and they use a simple mobile devices. As a result, the proposed system needs to interact with the pastorals using voice only communication.

IV. Design Overview

In this section, we give an overview of the framework. The framework basically consists of the following components as depicted in Figure 4: Tracking (sensors), Data Transport, Data store, and User manager components. The Tracking component is responsible for field data collection. The Data transport moves data from the tracking device in the field to the edge clouds on the Internet. The Data store receives the data from Data transport and persist it on storage devices in a distributed manner. Finally, the User manager assumes responsibility for everything related to user interaction. User manager component runs both HTTP and SMS services.

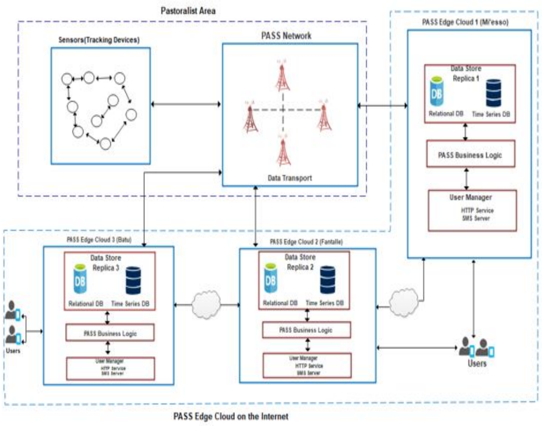
In this solution we chose to deploy the system in edge clouds. Edge clouds give the benefit of being small and near to the users, in our case the pastorals. When we are near to the users, we reduce latency between users and the centers. This is very important for our case as the system need to handle theft and conflict resolution in near real time. Moreover, the idea of distributed small data centers serves best when we have partial network failures which are common in many developing countries due to many reasons including rampant power failures. We will describe each component in a little bit more detail in the solution section after we describe the system design factors.

V. System Design Factors

From the data gathered on the field, we have put forward the following system design goals.

- **Location accuracy** the system should provide an accurate location of an animal. To provide on-the-spot resolution over ownership conflicts and handle theft before the animals are taken far from their normal areas. Therefore, it is important to get detailed and accurate location information.
- **Near real-time location delivery [determines frequency of collection]** In this system, latency, in addition to accuracy, is very important design factor of the system. Finding a lost pastoral animal in the quickest time possible is our main mechanism to resolve conflicts and

Fig. 4: Displays the high level relationship between the different components of the framework



handle theft cases. If we consider the time needed for an animal rustler to stole and disappear from a normal grazing site, the system should provide location readings at least in each 5 minutes. This also entertains if the thief uses vehicles to carry away the stolen animals. 5 minutes interval also helps to tackle the problem of collar break. An animal can not be far from the searching capacity of the animals shepherd in those minutes. The system always should give the last accurate positions.

- **Long term collar use** Devices attached must work for long terms without human contact. It is inferred from the interviews and the data that pastorals keep their livestocks for 5 years in most of the cases. So any device that works for such a length is suitable for this research study case.
- **Less technical requirements from pastorals** It is important to meet the current literacy level of the pastoral community in the study area.
- **Low cost** As the system to be used by animal herders, it should not cost the user more than the price of one camel per year. According to current market, the price of one matured camel is estimated to be 1,000USD. For the cost and license purposes, the system should use open source technologies.
- **Scalable** When a new pastoral community wants to be included in the system, the system should allow simple scalability.
- **Device weight** Device to be attached to the animals should not be more than 5% of animal weight. They should have the capacity to hold the identification information and the Geo-location of the animals. It is an advantage to have basic vital health signs data collecting features in the device. Depending on the animal type, there is an energy efficiency requirement of the device.
- **Support semi-wild short, medium and long distance partial mobility** It is important that the proposed solution to take into consideration the different movement types in the life of pastorals. As indicated, these movements are dependent on the livestock types.

VI. Towards Solution

With the requirements from the System Design Factors in mind, many design decisions have been made about the devices to be attached on the animals, the transport network, the data store, and the user interaction interface; and most importantly we created algorithms, which are the main contributions of this work, that enable the system to resolve conflicts and handle animal rustling in real time. Due to space constraint we provide brief description of each.

A. The Collar devices

The collar requirement is different for the different livestock kinds. The selection of the collar devices should take into consideration the system design factors, the mobility type of each livestock, the weight and the maximum speed of an animal and the field type in which each animal spends most of its day time. Accordingly, our study of camels shows that they require a collar device that has location accuracy of less than 200meters, weigh not more than 22500g, can be attached to back of hump or neck, withstand a relatively dense, horny forest and bushes, and be able to accurately catch location at a speed of 40-50km/h. For the cattle, a maximum speed of 15km/h, a weight of 12250g and a location accuracy of 50meters is required. For the sheep and goat, a maximum speed of 10km/h, a weight of 3509g and a location accuracy of 20meters is required. All collars are expected to support peer-to-peer networking.

B. The Network

Our objectives in the design of the pastoral network is to be able to track all the animals while meeting all the above mentioned design factors. Accordingly we tried to theoretically match all the available networking options with the design factors. The networking options tested theoretically were Automated Voice Recognition [1] [2], Automated Visual Recognition [3], Global Positioning System (GPS) Networks [4] [5],Satellite Networks [6] [7], Very High Frequency (VHF) Networks, Global Location Service/Light level geolocation, Harmonic Radar, and Passive Radio Frequency Identification (Passive-RFID), and GSM/WCDMA networks. Among all these GSM/WCDMA with a GPS enabled collar happened to meet the cost requirement of the system. A simple calculation for camels is displayed in Table I. This does meet the 10% requirement of the system. For the other systems establishing the non-existing infrastructure make them invisible for the system.

C. The Data Store

The main goal for our database design is to decide which database types to use to store the animal tracking data and animals owners and related data. Most of the owners related data is static where as the tracking data is dynamic and involves the ability to handle extremely high velocity data

TABLE I: The Camels Collars/Criteria Matrix

Item	Cost
Collar	$25-40
5 years payment per camel for GSM service, one sms (less than 140 characters) per 10 minutes	0.05*6*24*365*5=13,140ETB(455.8USD)
Total	14,190.00ETB(492.25USD)

collection in sequence and which size is estimated with the following equation:

$$D = \sum_{t} \sum_{i=1}^{N} a_i$$

where D is the total data in the time interval t, N is the total number of animals being tracked, and a_i represents an animal. Thus, we need to have databases that are appropriate for both relational as well as a time series databases. Accordingly we picked the Apache Cassandra data store which is suitable for both cases. Moreover, it is highly available and scalable system.

D. The Users Interactions

This framework is required to provide a simple interface to the pastorals community. Accordingly we provided a hierarchical voice menu based interaction system. So whenever a pastoral wants to communicate with the system, he/she calls to a short code mobile services (for example, 1122). Immediately the system lists in voice what number to push for what service. The system continues this until it sorts out the required service. In the other case, when the system initiates the communication it sends a message whose content is a number. The pastorals should be trained to identify what each number means.

VII. The Algorithms to Shepherd the Animals and to Resolve Conflicts

Once the data is in the datastore we need to run algorithms to detect theft, and resolve conflicts. In this section we describe our algorithms to handle both theft and conflict resolutions.

A. Theft/loss detection algorithms

The theft detection algorithms are responsible to raise suspicion alert when a theft activity is detected. The following clues are used to detect animal rustling that make the system to alert owners, their neighbors and other pastorals who should involve in recovering the stolen animals:

- If no data has been sent in the last round (raise suspicion level)(may be a collar is cutoff from the animal). The system expects a location report in each 5 minutes interval.
- fast changing of location in the same direction for the last one to three reporting intervals. For camels we use the speed 25Km/hr, for cattle 10km/hr, sheep/goat 5km/hr to calculate the distance traveled. We let these speed to be administrator configurable to address different scenarios.
- If an animal is out of expected area and away from other livestocks owned by the same owner by more than 200meters for camels, 50 meters for cattle and 10 meters for sheep and goat.
- If an animal is approaching a border (cross-border cattle rustling)
- If night movements out of temporary fences detected. Fence sizes are automatically computed by the algorithms based on animal sizes

If the above activities are detected, the system alerts or give a timely information to the owner and other people who are known to be in the tribe network of an owner of a livestock whose animal is in under active theft process. In the case when there are no enough member of the tribe, the system considers other pastorals in the area. First, all the pastorals in a radius of 5km, then 10km etc until the animal is recovered or reported lost. We have created two algorithms to properly shepherd camels during day and night times. All the algorithms are displayed in algorithms 1 and 2.

B. Conflict resolution algorithm

Conflict resolution is about resolving disputes that arise when people are unable to identify their animals. This may occur in different situations: when animals of different owners meet at a water or grazing point; when animals are mixed up in a market place; When animals pass through other people territories during seasonal migration. We use the following algorithms to handle conflicts.

1) Automatically tell whose animal is mixed with whose herd
2) If the above technique doesn't solve the problem, the system asks the animal to be isolated from the rest of the herd for upto 5minutes and at a distance of at least 10meters. Then the system identifies the animal and inform the owners.
3) If the conflict is not resolved, we repeat the second step for an extended time and distance.
4) If there is a GPS enabled mobile phone in the pastorals, the pastorals will be asked to put on the animal and then the system match the phone location with the animals location. Then inform the disputing parties who the owner is.
5) Repeat the different steps from 1-3

VIII. Related Work

In this section we put our work in context with existing works in the literature. Most works in the literature consider tracking of wild animals. In this study, we consider animals that are semi-wild that belongs to non-sedentary pastoralists. Pastoralists animals, even though they wandered over long

Algorithm 1 Cattle Rustling Handling- Day Time

```
procedure HANDLE_CAMEL_THEFT_DAY(owners, camels)
    while true do
        dn ← dayOrNight()
        if dn == Day then
            for all owner o: owners do
                for all camel c: camels do
                    loc[] ← tdb.getLastTenLocations(o, c)
                                        ▷ tdb represents time series DB
                    ref ← loc[1]
                    disp1 ← |loc[0] − ref|
                    if disp1 > 2km then
                        neigh ← rdb.getPastoralsNear(loc[0])
                        raiseMajorAlert(o, c, neigh)
                    else
                        disp2 ← |loc[0] − loc[2]|  ▷ Last 10 minute progression
                        disp3 ← |loc[0] − loc[3]|  ▷ Last 15 minute progression
                        if disp2 > 1km and disp3 > 2km then
                            if approachingDusk() or downIsEnding() then
                                raiseMinorAlert(o, c)
                            else
                                neigh ← rdb.getPastoralsNear(loc[0])
                                raiseMajorAlert(o, c, neigh)
                            end if
                        end if
                    end if
                end for
            end for
        end if
    end while
end procedure
```

Algorithm 2 Camels Rustling Handling- Night Time

```
procedure HANDLE_CAMEL_THEFT_NIGHT(owners, camels)
    initialization
    for all owner o: owners do
        for all camel c: camels do
            loc[] ← tdb.getLastTenLocations(o, c)
        end for
        loc2[] ← get10%Locations(loc)
        diff ← getDiffOf95percentile(loc2)
        if diff > 1m then
            call handle_camel_theft_day(o)
        else
            fork the following code :
            size ← rdb.getNumberOfCamels(o)
            nightShelter ← defineCenter(9m^2 ∗ size, loc2)
            dn ← dayOrNight()
            while dn == Night do
                for each 5 minute interval: do
                    for all camel c: camels do
                        loc[] ← tdb.getLastLocations(o, c)
                                        ▷ tdb represents time series DB
                        ref ← nightShelter
                        disp ← |loc[0] − ref|
                        if disp > 2 ∗ nightShelter then
                            neigh ← rdb.getPastoralsNear(loc[0])
                            raiseMajorAlert(o, c, neigh)
                        end if
                    end for
                end for
                dn ← dayOrNight()
            end while
        end if
    end for
end procedure
```

distances, they are usually accompanied by a shepherd who look after them. As a result the solutions proposed to track wild animals are much more expensive than our solutions. Even if we are different in cost related issues we share the same idea of using collar peer-to-peer networks and GPS enabled collars with the pioneer work ZebraNet [8] [9] [10] and all of its descendants [11].

The other works with which we share similar ideas are those works that use GSM as their data transport network [12] [13] [14]. Most of these works design their own GSM enabled collar devices.

Our most important difference from both works that use collars in a peer-to-peer network and those that use GSM enabled collars is that none of these works use the data collected either for conflict resolution or animal rustling handling, which are the main contributions in this work.

Wamuyu [15] proposed a tracking framework based on wireless sensor networks (WSN), mobile communication, and unmanned aerial vehicles (UAVs). The researcher claim availing timely information could facilitate the quick recovery of stolen animals, but the framework didn't develop any algorithm to detect theft activity and left this task to the data users.

IX. Conclusions and Future Directions

The contribution of this work is the design of a tracking system that helps to handle animal rustling and resolve conflicts that arise among the pastorals community of Ethiopia. The study identified all the components that are necessary to build a cost effective and scalable system. Moreover it indicated how collars that are GSM/GPS enabled and that supports a peer-to-peer network work best for the pastorals.

The algorithms that shepherd the animals and that resolve ownership conflicts take into consideration many factors: walking and running speed, time of day (day or night), time interval, seasons, community structure, direction of movement, and types of livestock. During lost/stolen animals recovery, the algorithms mobilize the community in a concentric circle fashion. This is specially useful when the animals have already lost their attached devices.

The proposed system has some limitations. At this stage,it doesn't apply the concept of virtual fence to restrict animals movements in a certain place. It also doesn't use machine learning approaches, which can help detect abnormal activities based on the animal behaviour. So our future endeavours will focus on improving the system in those directions. We are also aiming to deploy and evaluate the system both on the field and in the lab using simulated data.

References

[1] Y. C. P. U. Alkon and P. A. Jordan, "Towards an acoustic biotelemetry system for animal behavior studies," *The Journal of Wildlife Management*, vol. 53, no. 3, pp. 658–662, 1989.

[2] D. N. P. U. Alkon and P. Krausman, "Using acoustic telemetry to monitor foraging by penned mule deer," *Wildlife Society Bulletin*, vol. 30, no. 2, pp. 302–303, 2005.

[3] N. C. I. C. C. R. B. S. T.Burghardt, P. J. Barham and T. M. Leshoro, "A fully automated computer vision system for the biometric identification of african penguins (Spheniscus demersus) on robben island," in *6th International Penguin Conference (IPC07)*, 2007.

[4] S. Tomkiewicz, "GPS Application for Wildlife A Review," *Telonics Quarterly*, vol. 9, no. 1, 1996.

[5] M. S. D. R. C. Coelho, L. de Melo and R. Young, "A note on the use of GPS collars to monitor wild maned wolves Chrysocyon brachyurus," *Applied Animal Behaviour Science*, vol. 105, no. 1-3, pp. 259–264.

[6] "Overview of the argos system." [Online]. Available: http://www.argos-system.org/

[7] M. R. F. J. J. S. V. B. W. S. Seegar, P. N. Cutchis and J. G. Wall, "Fifteen years of satellite tracking development and application to wildlife research and conservation," *Johns Hopkins APL Technical Digest*, vol. 17, 1996.

[8] Y. W. M. M. L. S. P. P. Juang, H. Oki and D. Rubenstein, "Energy-efficient computing for wildlife tracking: design tradeoffs and early experiences with ZebraNet," in *ACM SIGPLAN Notices: Session on Emerging Systems*. ACM, 2002.

[9] P. Z. T. Liu, C. M. Sadler and M. Martonosi, "Implementing software on resource-constrained mobile sensors: experiences with Impala and ZebraNet," in *MobiSys 04: Proceedings of the 2nd international conference on Mobile systems, applications, and services.* Mobisys, 2006.

[10] S. A. L. P. Zhang, C. M. Sadler and M. Martonosi, "Hardware design experiences in ZebraNet," in *SenSys 04: Proceedings of the 2nd international conference on Embedded networked sensor systems.* SenSys, 2004.

[11] "Turtlenet: Umass outdoor mobile environment." [Online]. Available: //prisms.cs.umass.edu/dome/index.php?page=turtlenet

[12] V. L. D. C. M. R. Cesare Alippi, Roberto Ambrosini, "A Lightweight and Energy-efficient Internet-of-Birds Tracking System," in *IEEE International Conference on Pervasive Computing and Communications*. IEEE, 2017, pp. 1–14.

[13] P. C. S. Prof. Joshi V.V., Prof. Bhange S.S., "Wildlife Animal Location Detection and Health Monitoring System," *International Journal of Engineering Research & Technology*, 2014.

[14] K. S. Sahebrao, "GPS/GSM BASED ANIMAL TRACKING AND HEALTH MONITORING SYSTEM," *International Journal Of Engineering, Education And Technology (ARDIJEET)*, 2015.

[15] P. K. Wamuyu, "A Conceptual Framework for Implementing a WSN Based Cattle Recovery System in Case of Cattle Rustling in Kenya," *MDPI*, 2017.