Demo: Opportunistic IoT for Monitoring of Grazing Cattle

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ABSTRACT

Precision livestock farming and other agricultural applications are considered to have great potential to utilise the many benefits of IoT technology. It is however important to maintain low cost and energy consumption to make it feasible in a very competitive market, making opportunistic and D2D communication interesting options. The demo will show a prototype of a system for monitoring grazing cattle in large free-range areas. We will demonstrate the mobile devices collecting data about the animals and their encounters with each other as well as the cloud platform that allows the farmer to access the data for more efficient operation of the farm.

1. INTRODUCTION

The prolifiration of ubiquitous Internet access and cheap components for sensing and communication have given rise to the concept of the Internet of Things (IoT). We are now seeing more and more application domains making use of such technology to improve performance and reduce cost and labour requirements. Agriculture is one such area were farmers are under constant pressure from hard competition from imported agricultural products from countries with less stringent regulations on good animal care. This makes the need to expand to larger farms and improve the efficiency in running them very large. There is therefore large potential to use IoT technology to improve efficiency in agricultural processes. In this work, we have investigated the possibility to improve efficiency in the legally mandated daily inspection of grazing cattle. Many existing solutions require all animals to be equipped with both sensors and components for cellular communication. Such solutions are costly and consume an prohibitive level of energy, reducing their profitability and increasing the required labour. We instead consider the possibility of a daily monitoring system for grazing cattle where each unit has low cost and energy consumption. This is achieved through the use of so called opportunistic communication, where cheap devices transmitting using low energy and short range are used to exchange information directly between the devices. At fixed points in the animal enclosure, base stations are places where all collected information is transmitted when an animal get within communication range. This base station is equipped with long range Internet connection (over the cellular network) and can transfer the collected data to a cloud service where analysis of collected data enables alerting the former if an anomaly is detected as well as visualising the data for the farmer. The system architecture has been developed in collaboration between researchers, systems and product developers, and end users to ensure that it meets the needs of farmers and can make a viable business. An initial prototype of the system has been implemented and evaluated in field tests in an operational farm. This prototype system will be demonstrated at the CHANTS demo session.

2. SCENARIO AND SYSTEM OVERVIEW

In the Swedish law for animal care, daily inspections of grazing animals is prescribed. In cases where animals fall ill or get injured in the pasture, there is a risk that the farmer will not notice this at the daily inspection. The consequence is suffering for the animal and potential economic loss for the farmer as injuries and illness can escalate. This inspection is also very labour intensive, in particular when the pastures are spread over a large area, often in difficult terrain. With the Internet of Things (IoT), there are great opportunities to increase efficiency in agriculture by instrumenting animals and equipment with communicating sensors that can detect behavioural anomalies and collect data to give the farmer an overview over critical processes around the farm. Many solutions require all animals to be equipped both with sensors to measure positions and anomalies as well as components for communication over the cellular network. Earlier studies with GPS on bovine cattle has shown that the effectiveness of detected positions was unsatisfactorily low depending on the position of the device on the animal, forests with dense canopy, and the fact that the battery capacity of the device was not sufficient for a full grazing season. Another problem with these solutions is that the devices that all animals must carry become expensive, which reduces potential savings made through the use of the system in the first place.

We have created an experimental design of a system for monitoring of cows grazing freely over larger pastures where each unit has a low cost and low energy consumption. This is achieved by using opportunistic communication where cheap units transmitting with low power and short range are used to exchange information directly between units. Each animal has sensors collecting information about that animal in order to analyse and find potential problems with the animal. Additionally, it logs whenever another node is within communication range to create a trace of the physical interaction between the animals. Whenever two animals are within communication range with each other, they exchange this information with each other so that all animals have a copy of the collected data. In this way, data is disseminated through the network to an Internet-connected sink/base station, placed for example at the wa-

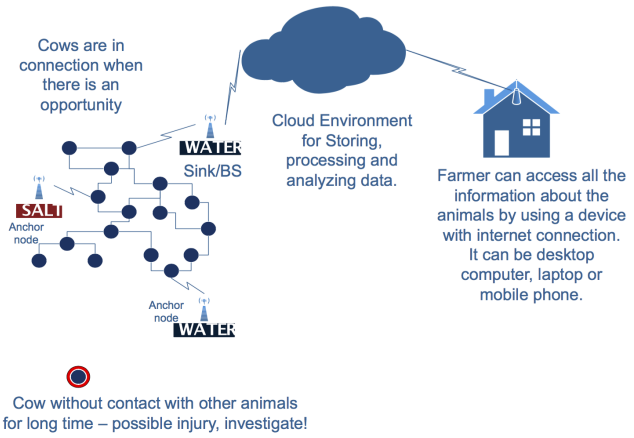

Figure 1: System architecture overview.

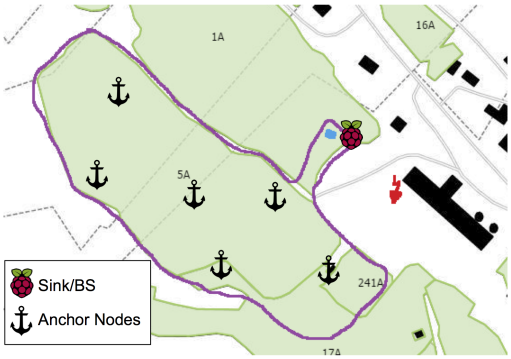

Figure 2: Deployment area.

tering trough. Since data is disseminated between animals, data will also be retrieved from animals that themselves do not come in range of the base station. The base station transfers the collected data to a cloud platform for further analysis and visualisation to be presented to the farmer in an actionable manner. By analysing the sensor data and connectivity patterns between the animals, anomalies in social interactions between the animals, which can indicate health problems, can be detected. An overview of the system design and its components is shown in Figure 1.

An initial version of the system was deployed and tested at an operational farm in Northern Sweden in July 2016. During the field tests, 10 cows were equipped with communication devices while grazing in the enclosure shown in Figure 2 with a 3G connected base station next to the watering trough and six anchor nodes deployed as shown in the map.

3. IMPLEMENTATION

As outlined in the previous section, the system has three main components, *mobile nodes* attached to each animal (same devices also used for *anchor nodes*), a *sink* or *base station* at the water trough for communication with the Internet, and a *cloud platform*. The implementation of the different components is described below.

Mobile nodes and anchor nodes.

The mobile nodes are implemented using the Contiki operating system [1] running on Texas Instruments SensorTag hardware, with an IEEE 802.15.4 compatible radio. Each mobile node has the following functionality:

- Collect ambient sensor data (currently temperature and accelerometer data to determine animal activity).
- Record interactions with other animals through periodic transmissions of beacons.
- Opportunistic synchronisation of the information above with other nodes (including to the base station and anchor nodes) when within communication range.

The SensorTags are attached to a collar around the neck of the animal. The anchor nodes are nodes that are identical in functionality to the mobile nodes, but they are deployed stationary in interesting and strategic locations in the grazing enclosure. Since all animals log interactions with other devices, by knowing the locations of these anchor nodes, this can provide the farmer with coarse-grained location information about the mobility of the animals and can also help data dissemination.

Sink/Basestation.

The basestation is placed in a fixed location and can have a better power supply than the mobile devices. In our system prototype, the basestation is built with one TI SensorTag and one Raspberry Pi that are connected together. The SensorTag runs the same protocol as the mobile devices to communication over the IEEE 802.15.4 channel and receive the data collected by the mobile nodes and sends it over USB to the Raspberry Pi which uses a 3G network connection to upload the data into the cloud platform.

Cloud platform.

SicsthSense [1] [2] is a platform for storing and retrieving IoT data streams in the cloud in a generic and customisable manner. We are currently using this as our main backend where we store the data collected from the mobile network of animals. In addition to the storage of data in SicsthSense, we have built a web-based interface to allow the end-user to easily access the data from the system in an easy way. We are working with end users to design manners of viewing the data that makes sense from a farm operational point of view. The user can view the raw data in different ways, but also get an alarm if it is suspected that an animal is injured or some other problem has arisen. At the moment, we only support simple alarms that alert the user to extended period of inactivity or lack of interaction with other animals in a particular animal, but we are hoping to add more advanced anomaly detection possibilities when we have analysed the collected data further. In addition to SicsthSense, we are also experimenting with integrating our data into existing commercial data solutions for smart farming.

4. REFERENCES

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[2] L. McNamara, B. Al Nahas, S. Duquennoy, J. Eriksson, and T. Voigt. Demo abstract: Sicsthsense - dispersing the cloud. In *Proceedings of European Conference on Wireless Sensor Networks (EWSN 2014)*, 2014.

[1] http://docs.sense.sics.se/