The Impact and Challenges of Livestock Tracking in Internetless Environments with Tiny ML

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Introduction

The use of technology within the area of Farming is becoming a more widely discussed area usually referred to as Smart Farming. As more technologies are being introduced into the area and more proposals are made, the area of smart farming is allowing farmers to increase their overall yield.

The use of tinyML could bring real benefits to smart farming, specifically within Livestock tracking and monitoring. The concept of processing data in real-time on devices makes sense within this area, as the communication is naturally limited.

This is because outside the range of Wi-Fi our devices rely on cellular masts that are provided by telecommunications companies. Telecommunication companies will normally conclude that masts in urban areas such as a town or city are more valuable to them as a company, as they are more likely bring in new customers and clients. While in rural areas they may conclude a mast is unlikely to bring in barely any new clients. From a business perspective, this makes complete sense as there would less use of the mast to justify the upkeep and maintenance of it.

This leaves rural areas with either limited or no internet access across large areas of land and due to this, farms that could benefit from new and upcoming technology could be missing out.

There are several benefits that tinyML could bring to farming, especially in the area of livestock monitoring. Benefits such as animal behavioral analysis, fall and accident detection, abnormal temperature detection and other potential anomalies within animals.

Solutions that take advantage of tinyML within farming already exist in the area of arable farming (crops and gain) [1, 2]. Many solutions have been created that make use of edge devices, but they often assume that there is an internet connection available in these areas. This is often not the case and farmers investing in the technology to improve their yield may be left with partially working technology because of this assumption.

How can we bring edge computing to the area of farming with the assumption that there is no internet connection present? Because farms are often large areas of land that span acres, the communication methods used in devices would need to span large and wide. Several different communication technologies exist but each of them have their own pros and cons.

Could different communication technologies coupled with tinyML help bring these benefits to the farms within these connection-less areas?

The Potential of tinyML in Livestock Tracking

The ability to process information from sensors quickly without the need for external communication could introduce a range different possible solutions to livestock tracking. One possibility could be the introduction of fall detection. Animals are very unpredictable and may run into issues that require a farmer's immediate attention.

Another area where tinyML may come in use is with alerting farmers to when their livestock has moved into the birthing phase. tinyML could be used to train the model on several different animals and use other sensor data. The biology of what happens to animals when giving birth would need to be researched to ensure the correct sensors are utilized, one example might be a temperature sensor.

Another use case could be if an animal is showing an abnormal temperature, it could be detected and reported to the farmer so they can take the appropriate action. tinyML could be coupled with multiple sensors such as temperature sensors and accelerometer sensors to achieve this. By coupling both sensors for example, the model could detect the animals body temperature and if they are moving. If both the movement and temperature are out of the ordinary, it could be reported to the farmer.

Communication Methodology

Given the size of farms usually span acres of land, one gateway will not be sufficient to cover the entire area so multiple gateways may need to be deployed to sufficiently cover the entire farm. However, there is then an added challenge of getting the gateways to be able to communicate with each other. To solve both problems, a mesh network could be deployed to move messages between gateways by using the collar devices themselves as seen in Figure 1.

This would allow for communication between the gateways to take place without the for them to be within range of each other, which allows for more freedom of where they can be placed.

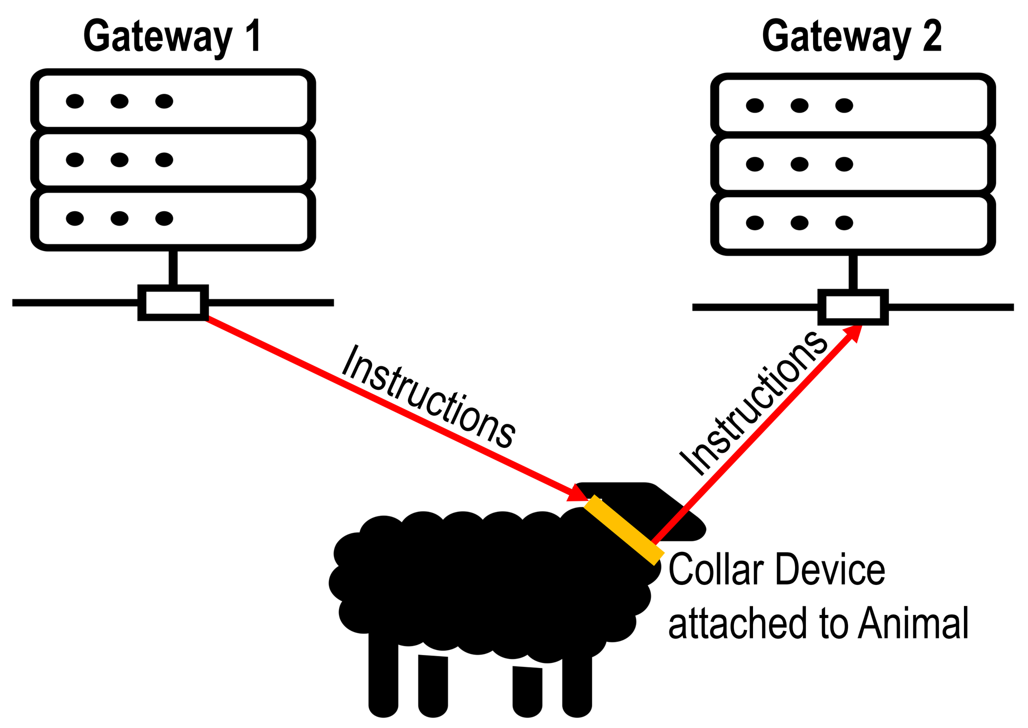


Figure 1: Mesh Communication using Collar Devices

Available Communication Methods

Wi-Fi
Range: up to 100 meters
Coverage: Deployable as Required
Pro: Fast, Reliable and Common
Con: Short range

Cellular (3G/4G/5G)
Range: N/A
Coverage: Out of user control
Pro: Fast, Reliable and Common
Con: Requires 3rd Party Coverage

Bluetooth
Range: up to 100 meters
Coverage: Deployable as Required
Pro: Direct Communication
Con: Short range

LoRa / LoRaWAN [3]
Range: 8Km
Coverage: Deployable as Required
Pro: Low Power and Long Range
Con: Slow Speed

Sigfox [4]
Range: N/A
Coverage: Out of user control
Pro: Low Power
Con: Requires 3rd Party Coverage

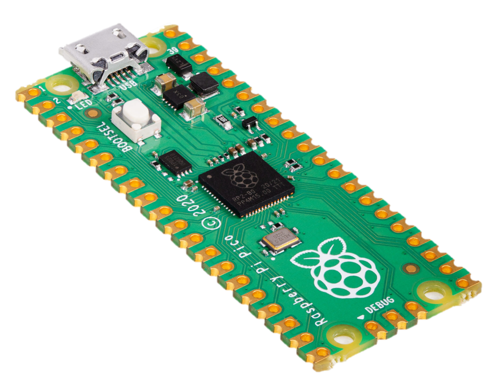
Zigbee [5]
Range: 150 meters
Coverage: Deployable as Required
Pro: Low Power
Con: Short range

Requirements

Devices used in outdoor environments with animals must be:

- **Robust:** Strong enough to withstand the damage that animals may inflict on the devices.
- **Waterproof:** Electronic Edge devices are not often compatible with water, and outdoor environments have plenty of it. The electronics need to be protected from water.
- **Animal Safe:** Collar devices will be placed around the animal's neck, which may get caught and if no quick release is implemented, may impact the animal's livelihood.
- **Cost Effective:** The Devices should be cost effective to justify the value of the devices when comparing to the overall yield.
- **Battery Efficient:** The Battery life of the devices being placed on animals should last for months, as removing devices from animals to charge them would be a large workload.

Challenges



The **Raspberry Pi Pico** is a cost-effective edge device currently being experimented with to put together a mesh network for use on a farm. However, it has several limitations in terms of power, mainly the devices dual core processor.

Figure 2 shows the architecture of the Pico currently making use of both threads (meaning the limit of threads has been reached).

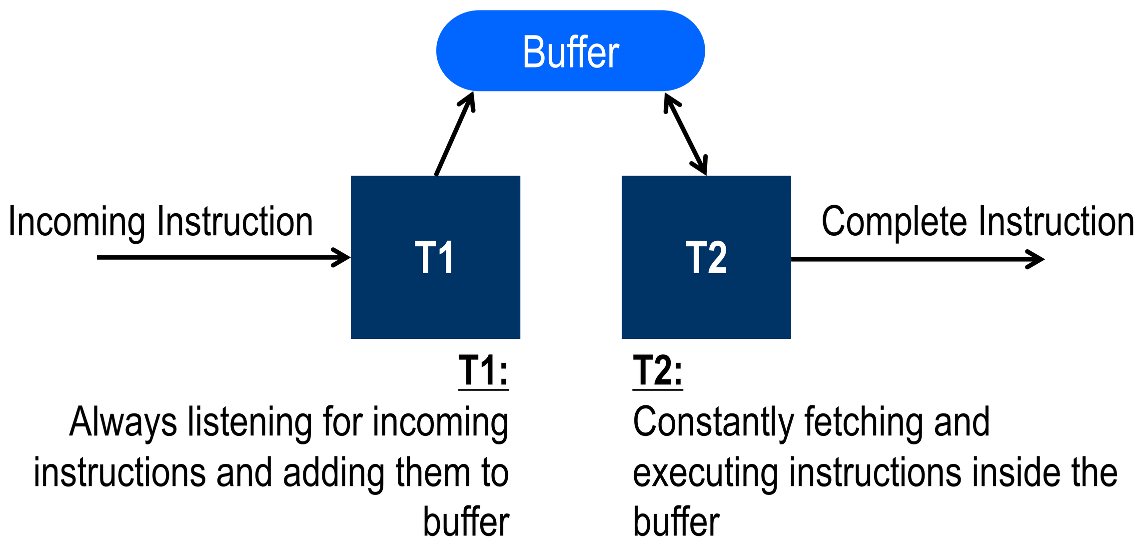


Figure 2: Current Architecture for Communications System on the Mesh Network.

As both cores are in use, some threading management with interrupts would be required to accommodate for additional sensors and ML, but the interrupts would likely cause issues with performance on the communications.

References

[1] C. Nicolas, B. Naila, and R. C. Amar, "Tinyml smart sensor for energy saving in internet of things precision agriculture platform," vol. 2022 July. IEEE Computer Society, 2022, pp. 256–259.
[2] V. Tsoukas, A. Gkogkidis, A. Kampa, G. Spathoulas, and A. Kakarountas, "Enhancing food supply chain security through the use of blockchainand tinyml," Information (Switzerland), vol. 13, 5 2022.
[3] "Lora alliance®." [Online]. Available: https://lora-alliance.org/
[4] "Sigfox." [Online]. Available: https://www.sigfox.com/en/sigfox-story
[5] "Zigbee." [Online]. Available: https://csa-iot.org/all-solutions/zigbee

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