PETRAS Sector: Agritech

FARM: Formal methods for Agritech Resilience Modelling

University of Glasgow Team

Dr Yue Gu
Dr Blair Archibald
Dr Michele Sevegnani
Professor Dame Muffy Calder

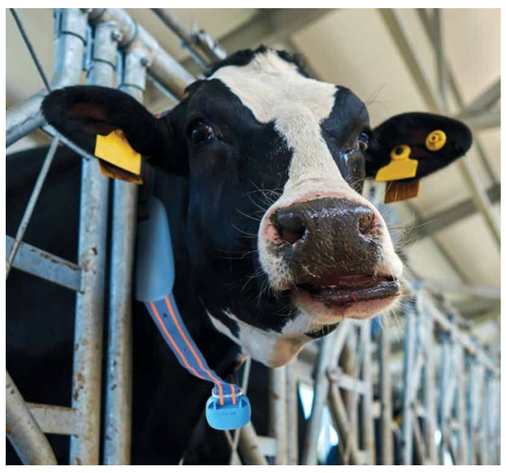
Project Overview

Resilience is essential in the food supply chain. IoT technologies can revolutionise this field but only if we can **understand** these complex systems. **FARM** tackles this by building novel **Digital Twins** based on formal (logical) methods that allow runtime monitoring, dynamic forecasting, and process optimisation.

Case Study

Afimilk[1] provide dairy management solutions, through IoT-enabled collars, allowing health and heat monitoring of herds.

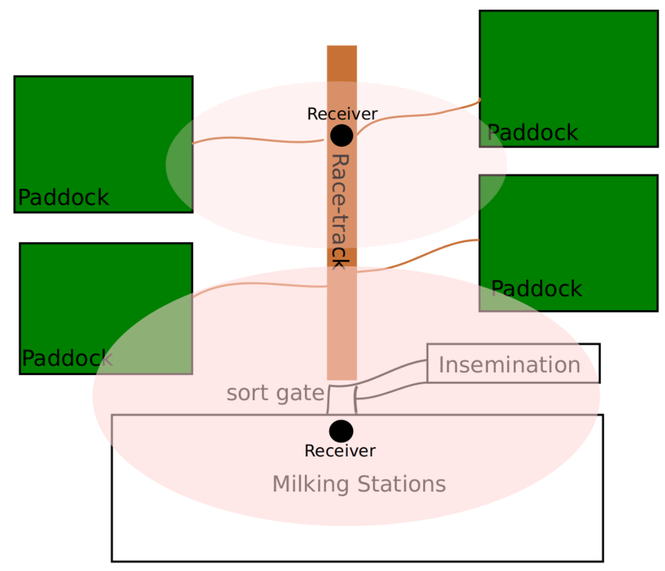
Heat must be detected during milking. Missing a heat detection reduces milk output resulting in profit loss and supply issues.



Research Question: *Can we predict and minimise the **probability** we miss cows in heat? (hard real-time constraint)?*

Farm Setup

- **100's - 1000's** of cows over **1k - 3k** acres
  Split into herds of 200-600 cows (in paddocks)
- Each cow has an IoT collar with long-life battery
- Several hours of collar data (rumination etc) required to detect heat
- To save energy, analysis of when cows are in heat is performed in the cloud.

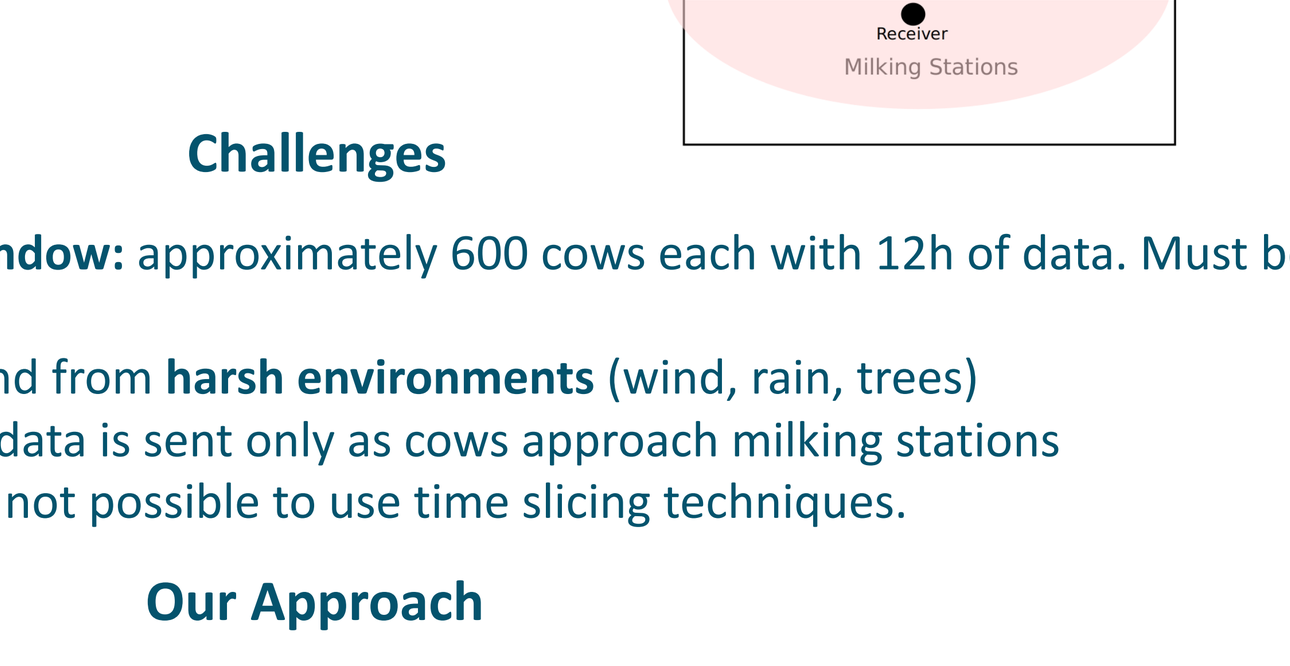


Challenges

- **Large amount of data per milking window:** approximately 600 cows each with 12h of data. Must be sent within 15 minutes
- **Radio interference:** *between* cows, and from **harsh environments** (wind, rain, trees)
- **No full radio coverage (large farms):** data is sent only as cows approach milking stations
- **No synchronisation between collars:** not possible to use time slicing techniques.

Our Approach

We model and verify the radio protocol for farms in **UPPAAL**[2] to optimise parameters (time windows/receiver placement etc). Several **timed automata** modules each represent a transmission step, enabling **radio interference** to happen at any step.



Interval Timer

Listen Before Talk (LBT)

Transmission Sequence

Sources:

1. Afimilk. 2022. *Advanced Dairy Management Solutions*. Available at: <https://www.afimilk.com>
2. UPPAAL. 2022. Available at: <https://www.uppaal.org>

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