

Real Time Anomaly Detection in Cold Chain Transportation using IoT Technology

REAMIT Pilot study with Musgrave Marketplace

Gillespie, J.¹, Cadden, T.¹, Condell, J.¹, Ramsey, E.¹, Gallagher, R.², Ramanathan, R.³. <http://reamit.eu>

Interreg 
North-West Europe
REAMIT
European Regional Development Fund

 **RESOURCE & MATERIALS EFFICIENCY**

We are REAMIT

REAMIT is a transnational European territorial cooperation project funded by Interreg North-West Europe (NWE) Programme aiming to reduce food waste. The project focuses on fruits, vegetables, meat, and fish supply chains as these are wasted in large quantities. It is being carried out in Ireland, Germany, France, UK and the Netherlands due to the amount of interconnected food supply chains and huge food waste in these countries. The REAMIT project is using existing Internet of Things and Big Data technologies to best fit the needs of the food supply chain management system in the NWE region. Through testing and adaptation, these technologies are being enabled to continuously monitor and record food quality and signal potential food quality issues. Through analytics, owners of 'food at risk of becoming waste' are provided with decision support options to minimise food waste including redistribution to nearby customers. As part of the technology demonstrations, the REAMIT project team is working with Musgrave, helping to reduce food waste.

Who are Musgrave?

Musgrave Group Ltd. is an Irish food wholesaler, founded in Cork by the Musgrave brothers, Thomas and Stuart in 1876. It is currently Ireland's largest grocery distributor, with operations in Ireland and Spain, and have estimated annual sales of over €4 billion. The company is still largely-owned by the Musgrave family. Musgrave Northern Ireland

is headquartered in Belfast, Northern Ireland. Musgrave clients include local restaurants, fast-food outlets, and convenience shops in Northern Ireland, and also operate multiple large cash and carry facilities for the general public. Musgrave maintain their own fleet of delivery vehicles to facilitate deliveries to their business customers.



The Problem at Musgrave

While performing deliveries to their business customers, Musgrave noticed that the refrigeration units in the delivery vans operating in the greater Belfast area would occasionally break down, without any indication to either the driver or the logistics staff at the warehouse. The temperature of the chilled and frozen food products inside the van would increase, surpassing the food storage temperature safety threshold, resulting in a van load of spoiled stock. Musgrave sought a system which would perform the following:

1. The vans should be connected to the cloud to allow for real-time data reporting / monitoring while the vans perform deliveries
2. The vans have both a chill and a freeze zone, both of which should be monitored throughout a journey
3. An alerting system should send SMS messages to drivers and warehouse logistics staff notifying if any anomalies occur
4. Alerts should not be sent when the van is stationary e.g., parked overnight, performing a delivery, etc.
5. The power consumption of the proposed system should be such that maintaining the equipment does not become an arduous task.

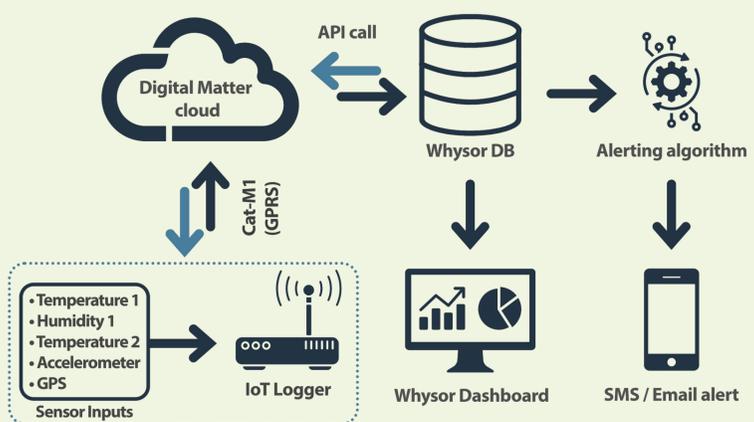
REAMIT's solution

The REAMIT team at Ulster University examined the system requirements by Musgrave and proposed a real-time monitoring and alerting system for anomaly detection during cold-chain transportation. The Eagle datalogger (Digital Matter, South Africa) was selected as the platform for the development of the REAMIT solution. The logger is an IP67 rated rugged cellular IoT device, supporting a range of inputs for various IoT applications. The Eagle runs on either 4x C Alkaline or LTC batteries, or can be wired to permanent power, and contains I2C, SDI-12 and RS-485 interfaces as well as 2x analogue inputs, 3x digital inputs, 2x switched ground inputs, and 2x 4-20mA inputs. It contains a GPS module and an accelerometer for geofencing and movement detection, and is equipped with a sim card allowing the device to perform as an IoT gateway, running on the CAT-M1 GPRS network. The Eagle offers third party cloud integration via HTTPS webhook.

For the Musgrave pilot, we fit the logger with a T9602 T/RH I²C sensor (Amphenol, USA), and a DS18B20 temperature probe (Maxim Integrated, USA) to allow monitoring in both chill and freeze zones of the van.

REAMIT partners Whysor (Netherlands) developed the REAMIT dashboard for real time monitoring and alerting, which was utilized by each pilot study in the project. The dashboard runs on both desktop computer and mobile phone. SMS alerting was provided by Amazon Simple Notification Service (SNS).

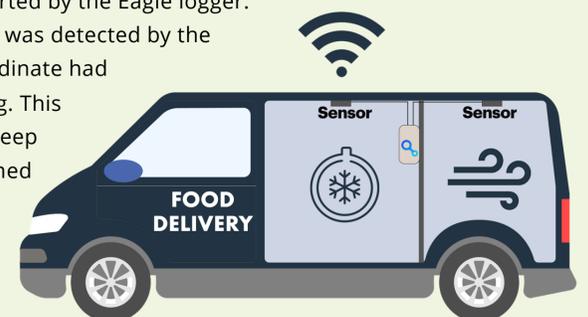
System Architecture



Alerting logic. The threshold values for the alerting system were defined by the logistics and warehouse manager at Musgrave. Text messages are sent when the van is performing a delivery and either the chill zone rises above 5°C, or the freeze zone rises above -8°C. To avoid false alerts, the system records 6 values above the threshold before sending the alert. The values are recorded every 5 minutes by the logger.

Trip detection. A trip detection algorithm was developed based on accelerometer measurements and GPS data reported by the Eagle logger.

A trip would be reported if motion was detected by the accelerometer and if the GPS coordinate had changed from the previous reading. This algorithm allowed the system to sleep when trips were not being performed to conserve battery life, as well as avoiding sending false alerts while vans were parked overnight.



Results and Conclusion

The IoT anomaly detection system was deployed with Musgrave Marketplace in April 2022 in three delivery vans operating in the greater Belfast area. The system monitors both the frozen and fresh produce refrigeration areas of each van in 5-minute intervals while deliveries are being performed. Logistics staff at the warehouse were given access to the Whysor dashboard for real-time monitoring of the vehicles, and were added to the alerting service. This allowed them to receive text messages to their mobile phone if an anomaly was detected. Early results show that the system is robust and avoids sending false alerts due to the trip detection algorithm which was developed. At the time of writing (July 2022), the batteries have not needed replaced in the loggers yet, proving that the bespoke system developed with trip detection technology is energy efficient and of minimal maintenance. After successful initial testing, two more of the IoT temperature

monitoring systems have been prepared and are due to be installed in Summer 2022.

Conclusion. We have developed an IoT solution which monitors in real time the temperature of cold chain delivery vehicles transporting perishable items. The end-to-end solution provides decision support options if anomalies are detected, helping staff redirect the delivery to a closer drop-off point and thus reducing the spoilage and waste of food.

Additional Information

¹Ulster University, Northern Ireland, United Kingdom ²Musgrave Northern Ireland, Northern Ireland, United Kingdom. W: <http://musgravegroup.com> ³University of Essex, Colchester, United Kingdom

For further information about the REAMIT project, please visit <http://reamit.eu>