Interreg
North-West Europe
REAMIT
European Regional Development Fund

EUROPEAN UNION

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Creation and lanch of interface

Improving Resources Efficiency of Agribusiness supply chains by Minimizing waste using Internet of Things sensors (REAMIT)

Del 4.1: Creation and launch of interface

REAMIT: Improving Resource Efficiency of Agribusiness supply chains by Minimising waste using Big Data and Internet of Things sensors

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Introduction

The use of Internet of Things (IoT) sensors has revolutionized the agri-food industry, providing farmers and businesses with real-time data on their crops, livestock, and facilities. However, this data can be overwhelming without an effective way to visualize and analyse it. This is where a dashboard system comes in. This deliverable outlines the creation and launch of such a dashboard system, specifically designed for REAMIT pilot test companies.

REAMIT partner Whysor were responsible for the development of the interface, referred to as the dashboard, which was utilized by each pilot study in the project. The dashboard serves as a means of data visualisation and provides real-time sensor monitoring functionality for any sensor deployed by the project. Through the implementation of user accounts, permissions could be enabled. This would ensure that pilot companies, or users, would only have access to the data which belonged to them.

The dashboard provides the pilot company with intuitive, real-time visualizations of the data generated by their IoT sensors, empowering them to make informed decisions and take actions to improve their operations.

Design and development

Software development frameworks selected

Bootstrap is a popular CSS framework used for developing responsive and mobile-first web applications [1]. It offers a range of pre-built components and styles that allow developers to create web applications quickly and efficiently. The web dashboard produced for the REAMIT project was built using Bootstrap to ensure responsive web design principles were adhered to, meaning the website and each of the chart elements appropriately scale to the device it is being viewed on. This allows the dashboard to run on both desktop computer and mobile phone, allowing the end user to access it on multiple devices and interpret data in real time.

The dashboard was developed using Node.js [2], a popular server-side JavaScript platform, and utilises Chart.js, a charting library, for data visualisation [3]. By using Chart.js, the dashboard can present data in an intuitive and easy-to-understand way, with options for line charts, gauges, tabular and static text formats. Together, these frameworks ensure that the REAMIT dashboard is responsive, user-friendly, and provides meaningful data visualisation for users.

To ensure timely notification and response to sensor parameter threshold abuse, an alerting system was implemented as part of the REAMIT dashboard. This system provided users with the capability to configure alerts based on specific threshold values and time periods of parameter abuse. The alerting system supported two communication channels for notifying end users: email and SMS messaging. For SMS messaging, Messagebird was utilised [4]. Messagebird allowed for the seamless delivery of SMS messages to end users' mobile devices. One notable feature of Messagebird was the ability to mask the phone number, presenting the sender as 'REAMIT' instead of an unfamiliar number. This masking ensured that the recipient could easily identify the source of the message, promoting trust and facilitating a more effective communication channel. For emailing, SendGrid was used. SendGrid offers APIs and services that allow developers to integrate email functionality into their applications easily. With SendGrid, developers can send transactional emails, such as account notifications, password resets, and order confirmations, as well as marketing emails and newsletters. It provides

features like email template management, recipient management, delivery optimisation, and analytics to track email engagement and performance.

Overview of the data sources and API's used

The REAMIT dashboard is designed to gather and present data generated by IoT sensors deployed by pilot companies in the REAMIT project. The sensors can use either LoRaWAN or cellular technology to transmit data, and, based on the sensor selection, the dashboard retrieves data from one of two primary sources. For LoRaWAN sensor technologies, the datasource is The Things Network, while for cellular sensors, Digital Matter's OEM server is the datasource.

If LoRa sensor technology has been deployed by the company, all data is routed through The Things Network (TTN) [5], a global, open-source IoT platform that facilitates the connection and exchange of data between devices. The dashboard retrieves data from The Things Network through a custom 'Whysor connector' developed in node.js which interacts with TTN API. This provides a simple and standardized way to access real-time data from the sensors.

Alternatively, if the pilot company has opted for cellular connectivity, the data is first transmitted to Digital Matter's OEM server [6]. The OEM server is a cloud-based platform that enables remote device management, monitoring, and data collection of Digital Matter sensor devices. This data is then retrieved and stored for REAMIT dashboard visualisation via the digital matter API.

The REAMIT dashboard aggregates data from both The Things Network and Digital Matter's OEM server, providing a comprehensive view of the pilot company's operations to the end user. By utilizing APIs from both data sources, the dashboard can retrieve real-time data and present it in one centralised location in a user-friendly and intuitive way. This enables pilot companies to make informed decisions based on accurate and up-to-date information on all deployed devices, whether they are LoRaWAN devices installed at the factory site or cellular devices installed in delivery trucks.

User interface design and layout

Upon visiting the dashboard's website, users are greeted with a login screen that serves as the gateway to access the dashboard. The login screen, presented in Figure 1, is designed to provide a user-friendly experience and reinforce the project's identity. To proceed beyond this landing page, authorised users can enter their username and password credentials on the centred login prompt, featuring the REAMIT project logo so that users can identify they are on the correct domain. The background of the login screen contains photos of various fruits and vegetables, in keeping with the projects goal of reducing food waste.

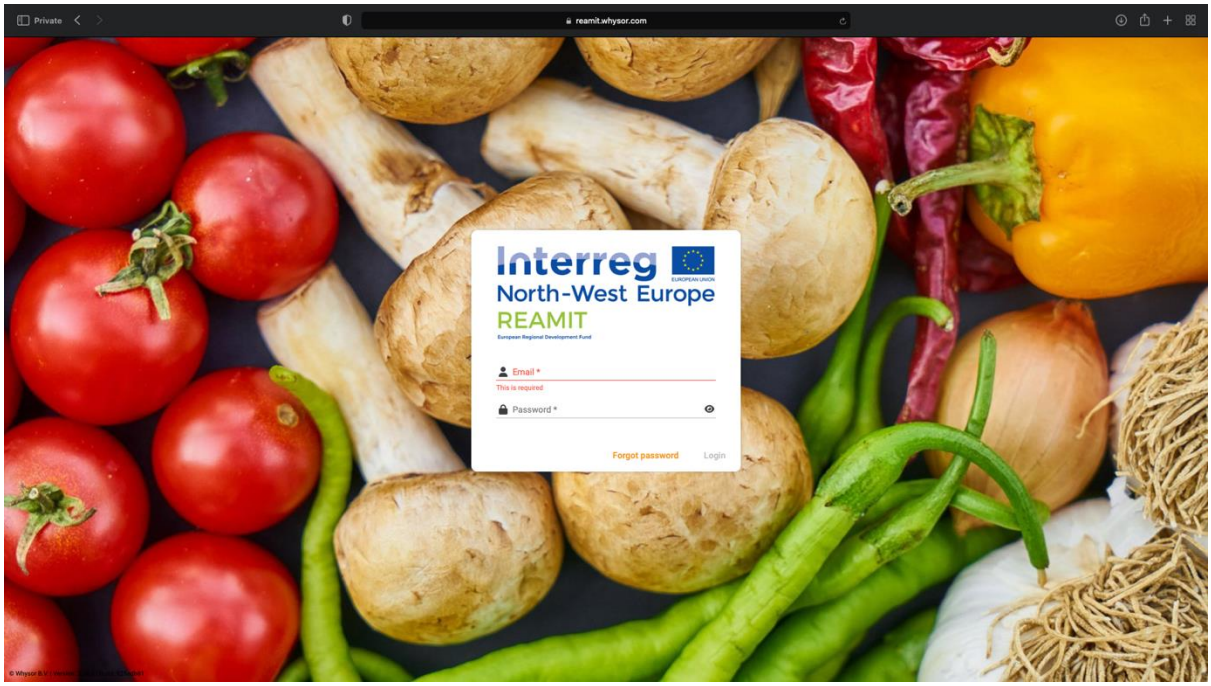


Figure 1: Login screen for the user interface

After entering valid login credentials, users are brought to the main dashboard interface, which has been thoughtfully designed to provide an intuitive and user-friendly experience. The User Interface (UI) design of the REAMIT dashboard follows best practices to ensure that end-users can easily navigate and interact with the system. To maintain a consistent visual identity that aligns with the sustainability focus of the REAMIT project, the dashboard design incorporates the project's primary colour, green. The use of this colour throughout the interface reinforces the project's theme and creates a cohesive visual experience. The layout of the dashboard has been carefully planned to be simple and straightforward to use. The goal is to enable users to quickly access the information they need without any unnecessary complexity or confusion. Upon logging in, each user and pilot company is presented with a customized view of the dashboard tailored to their specific needs and requirements. The main dashboard view provides an intuitive visualization of all available sensors, accompanied by their current status. This allows users to have an overview of all of their organisation sensors at a glance. Additionally, users have the ability to select specific time and date ranges for each sensor, allowing them to access more detailed information as needed. The design of the dashboard interface ensures that users can efficiently monitor and analyse real-time sensor data. By following UI best practices and incorporating a visually appealing and user-friendly design, the REAMIT dashboard aims to enhance the overall user experience and facilitate effective decision-making based on the provided data. An example of the interface which loads upon login for Rent-A-Fridge is shown in Figure 2.

Figure 2: Example of the interface which loads upon login for Rent-A-Fridge

The dashboard's navigation menu is located on the left-hand side of the screen and allows users to easily access different sections of the dashboard. The location of the menu button aligns with the principle of familiarity and user expectations. The left-hand side menu button, also known as the "hamburger menu," is a common design pattern for collapsing and expanding a navigation menu on smaller screens or mobile devices. The placement of the menu button on the left side has become a widely adopted convention due to its association with popular mobile apps and responsive web design frameworks like Bootstrap. Users have become accustomed to looking for the menu button in the top-left or left-hand corner of the screen when using mobile devices or when browsing responsive websites. By adhering to this convention, sites like the REAMIT interface ensure consistency and a seamless user experience across different platforms and devices. First time users can easily find the menu button where they expect it to be based on previous websites visited, allowing them to access navigation options and other site features without training, confusion, or additional effort. Options available from the menu, presented in Figure 3, include viewing other organisation dashboards that the current user has permission to access, updating username, password, and phone number credentials, changing the default dashboard displayed upon login, and more. The menu button also allows the current user to log out of the system. The overall UI design and layout of the REAMIT dashboard were designed to provide a streamlined and user-friendly experience for end-users.

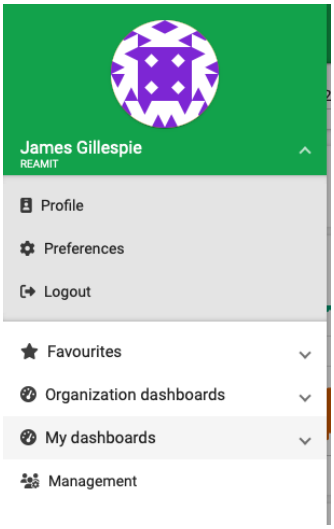


Figure 3: Menu interface

Features and functionality

The dashboard system is comprised of the following key features:

1. Sensor monitoring: The dashboard's primary purpose is to provide a real-time monitoring interface that allows users to visualize data generated by their IoT sensors. This enables them to track changes and identify trends in their data over time. The dashboard allows for monitoring of both LoRaWAN and cellular based sensors, providing one centralised location for end-users to view all of their data in real time.

2. Data visualization: The dashboard is completely customisable by the end-user, who can choose how they wish to visualise various sensor data. The system utilizes the chart.js library to provide intuitive, real-time visualizations of this data. The library provides a variety of chart types, including line, gauges, tabular, and static text, which can be customized to suit the needs of each pilot company. End users can choose to visualise their sensors in as many ways as they wish by adding extra widgets to their dashboard. This is achieved by clicking the 'pencil' icon and then the '+' icon in the top right-hand corner of the screen. A complete list of available widgets from the dashboard is visible in figure 4. Also presented in Figure 4 is an example of a complete dashboard for Musgrave Northern Ireland employing the Dashboard date filter, Gauge, Line chart, Text (static), and Text widgets to summarise the information in real time of one of the last-mile delivery vehicles which had a REAMIT cellular sensor installed.

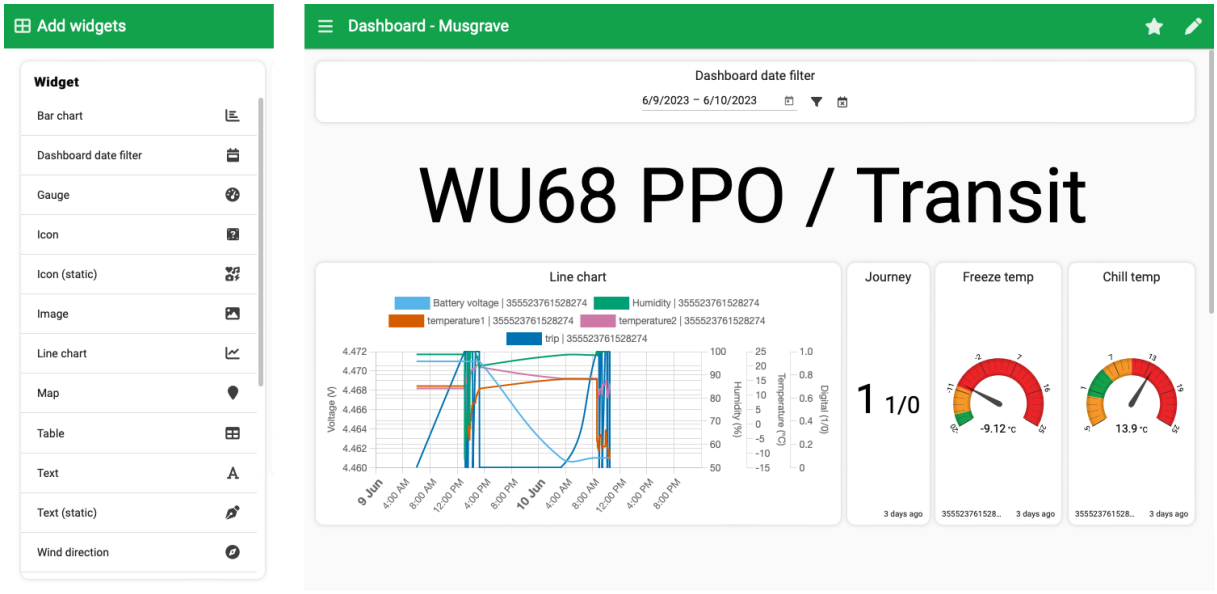


Figure 4: (Left) All available widget options on the REAMIT interface for sensor data visualisation and (Right) Dashboard date filter, Gauge, Line chart, Text (static), and Text (for journey info) all used to construct an informative dashboard for Musgrave Northern Ireland.

By utilising the Chart.js gauge extension, boundary data can be added to the 'speedometer' so that end-users can assess from a quick glance the current status of their produce. The gauge visualization incorporates a three-tier colour scheme to effectively communicate the status of different parameters. Green is used to indicate that the parameter is within the expected range, signalling that the produce is in good condition. This colour provides reassurance to the user that everything is operating as intended. Orange is utilized to represent the "caution" or "warning" zone. When a parameter falls within this range, it suggests that the produce is approaching a critical threshold or may be at risk of deterioration. This prompts users to closely monitor the situation and take appropriate actions to mitigate any potential issues. In contrast, red is used to indicate that a parameter has exceeded the predefined threshold. This colour signifies a critical condition where immediate action should be taken to prevent spoilage or any further deterioration of the produce. The red colour serves as a clear visual indicator, ensuring that users can quickly identify and respond to critical situations.

3. User accounts: The system supports the creation of user accounts, which can be used to grant permissions to specific users or groups. This ensures that pilot companies only have access to their own data. User accounts can be customised to provide access to specific data and functionalities based on user roles. To register for a user account, clients should contact support@whysor.com. There are 4 levels of access available for each user account:

    - Activate: Users with the Activate access level have the ability to activate or deactivate reports and rules for a specific user ID. While they cannot view the dashboard online, they can still receive alerts if their profile is active. This level of access is typically granted to users who need to manage and control the activation status of reports and rules.
    - Read: Users with the Read access level can view the data recorded by the sensors. However, they do not have the ability to adjust the dashboard layout or components.

This access level is commonly granted to most users who primarily need to access and review the sensor data without making changes to the dashboard itself.

- Rule ownership: Users with Rule ownership access have the capability to create, edit, and delete rules. This means they can define their own alerting logic in addition to viewing the sensor data. This access level is usually reserved for more technically proficient users who have a deeper understanding of the system and need to customize the alerting rules according to their specific requirements. Creating rules can be complex, so this level of access is not typically granted to all users.
- Owner: The Owner access level grants full ownership access to the dashboard. In addition to all the features available to Rule ownership users, owners have additional management privileges. They can add more users to the dashboard, perform administrative tasks, and access other management features. The Owner access level is typically reserved for administrative personnel who have overall responsibility for the dashboard and its users. This level of access is rarely granted to regular company users.

The REAMIT dashboard provides the flexibility to set an expiry date for user accounts, giving administrators the ability to manage access for personnel who only require temporary or contract-based access. By setting an expiry date for a user account, access to the dashboard is automatically revoked after the specified date. This feature is particularly useful for granting access to individuals who are involved in short-term projects, consultants, or contractors who have a defined period of engagement with the company, ensuring that their access is automatically terminated when their employment period ends. Setting an expiry date for user accounts helps maintain data security and access control by ensuring that only authorised personnel have access to the dashboard at any given time.

4. Alerts and notifications: The dashboard supports the creation of alerts and notifications based on user-defined thresholds. This enables users to be alerted to potential issues or anomalies in their data, allowing them to take proactive measures to address them. Alerts can be issued via SMS or email. Users have the flexibility to set threshold values for each sensor parameter, specifying the level at which an alert should be triggered, and can define the duration of parameter abuse that will activate the alert. Figure 5 and Figure 6 demonstrate an alert being configured for temperature abuse at Burns Farm Meats. From Figure 5, it is observed that multiple sensors can be used to create alerting logic. In this instance, three different temperature sensors are used to create a temperature abuse rule to ensure that detection anomalies do not lead to false alerting. Additionally, information from the binary door contact is used to ensure that the alert is only generated if the door is closed during the temperature abuse period. This allows a specific alert to be sent to Burns Farm Meats indicating that a refrigeration problem has occurred. A second alert could be produced, this time based on the door being open, with the custom message in the alluding to this error. This would allow Burns Farm Meat to distinguish between a user error in leaving the door open and an equipment failure, which could in turn affect how they decide to respond to the notification.

   Figure 6 shows what the rule creation dialogue box looks like. For each sensor used in constructing a rule, the threshold value and count must be specified in this menu. Note that count is used as a proxy for time passed before the alert is sent. In the given example, considering that the sensors upload data every 10 minutes, a count of 3 implies that three recordings (or 30 minutes) must elapse before the alert is sent. It is important to note that if

the threshold is breached twice and returns to normal conditions, the counter will reset to 1 when temperature abuse occurs again.

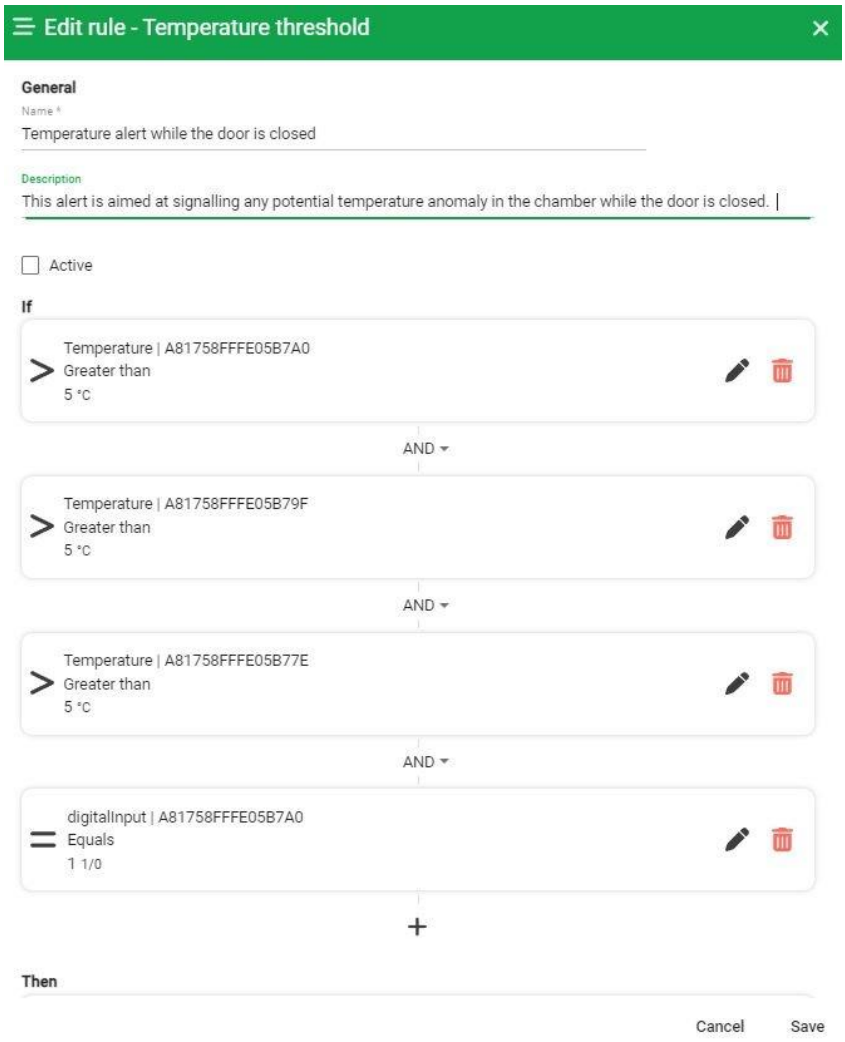


Figure 5: An example of the alerting logic applied to a dry-ageing fridge at Burns Farm Meats. In this case, an alert is sent if the temperature is greater than 5oC after 30 minutes and the door is closed, indicating that there is an issue with the refrigeration unit. Three sensors are chosen (front left, mid right, back left) in case one is not working correctly.

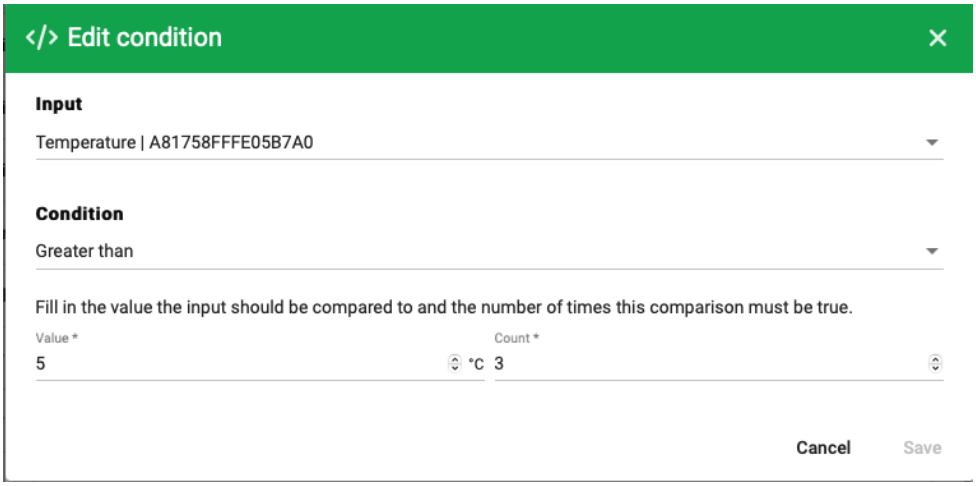


Figure 6: Detailed look at the alerting condition for the parameters. Notice that the 'count' setting can be adjusted to define the period passed before an alert is sent.

The alerting system supported two communication channels for notifying end users: email and SMS messaging. For email notifications, users would receive an email directly to their registered email address, providing them with information about the parameter abuse and the affected sensor. For text notifications, users receive an SMS message from the sender 'REAMIT', detailing similar information about the parameter abuse. The use of both email and SMS notifications ensured that end users could receive alerts in a timely manner, allowing them to take immediate action to address any issues and prevent food waste. Email notifications were particularly beneficial in scenarios where the end user may not have cellular signal but is connected to Wi-Fi. This feature ensured that even in areas with poor cellular reception, as long as there was a Wi-Fi connection available, users could still receive alerts via email. This feature is particularly important for end-users who work in warehouses as these are notorious for having poor cellular reception but are likely to have company-facilitated Wi-Fi to cover other equipment operating in the warehouse. Figure 7 shows an example of an SMS alert received based on exceeding a user-defined temperature threshold. Notice that the text message, as well as providing specific details about the sensor location and the rule that has been breached, links to the dashboard so the user can easily click and view further details about the status of the sensor.

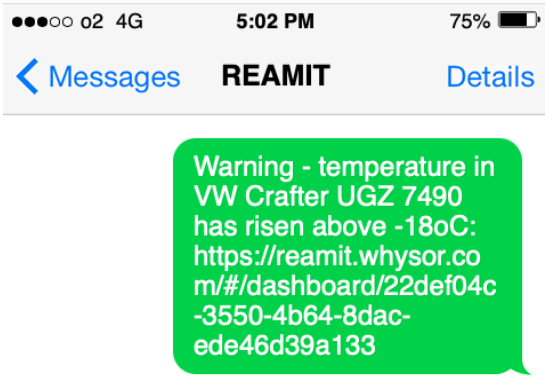


Figure 7: An SMS alert received based on temperature threshold abuse.

5. Historical data analysis: The dashboard also allows users to access historical data, enabling them to analyse trends and patterns over longer timeframes. This can be useful for identifying areas for improvement and optimizing operations. Viewing historical data is possible via the dashboard date filter widget, which can be added to each dashboard created for the end user. This filter widget, depicted in Figure 8, expands to a date picker once the user clicks on the calendar icon. The user can then select a date range and once entered, the dashboard updates to display all the data recorded during that period. Using this one filter widget ensures that all dashboard widgets, graphs, and visualizations update to reflect the selected date range, providing a comprehensive view of the user's operations during that time span. One notable feature of the REAMIT dashboard is that there is no expiration date on the recorded data. This means that all data, including the data captured at the start of the project, remains accessible and available for analysis within the dashboard.

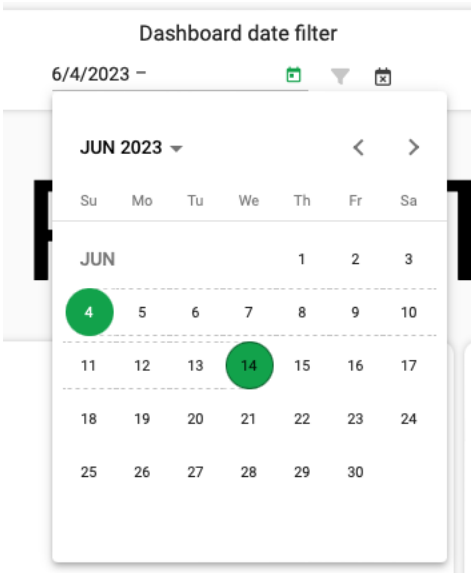


Figure 8: Global dashboard date filter which updates all widgets in the currently selected dashboard to display the data for the selected time span.

6. Support for multi-device access: Support for multi-device access is a crucial aspect of the REAMIT dashboard's design. By incorporating Bootstrap CSS, the dashboard is responsive and adapts seamlessly to different devices, providing an optimal user experience across desktops, tablets, and mobile devices. When the dashboard is accessed on different devices, such as a desktop computer or a mobile phone, the layout and sizing of the widgets are adjusted dynamically to ensure readability and ease of interpretation for the end user. This responsive design approach allows users to access the dashboard from their preferred device without compromising the quality of information presented. Figures 5 and 6 showcase examples of the same dashboard viewed on a desktop and a mobile device, respectively. When viewed on a desktop device (Figure 9), the widgets appear side by side, allowing the complete overview of monitored parameters for one vehicle at Musgrave Northern Ireland to be visible at one time. The static text displaying the registration of each van acts as a separator on the dashboard. The full screen is therefore able to display the complete overview of two vehicles at one time. Conversely, when viewed on a mobile device (Figure 10), each widget is designed to fill the width of the screen, ensuring that they remain large enough for the user to read and interact with comfortably. This responsive behaviour enables users to access real-time data and monitor the status of their produce conveniently, regardless of the device they are using. For elements like the line graph, specific interactions are optimised for touch-based devices. Users can use familiar touch gestures such as pinch and zoom to zoom in and examine specific time ranges on the graph. Additionally, users can drag their finger across the graph to reposition the date axis, allowing for easy navigation and exploration of data.

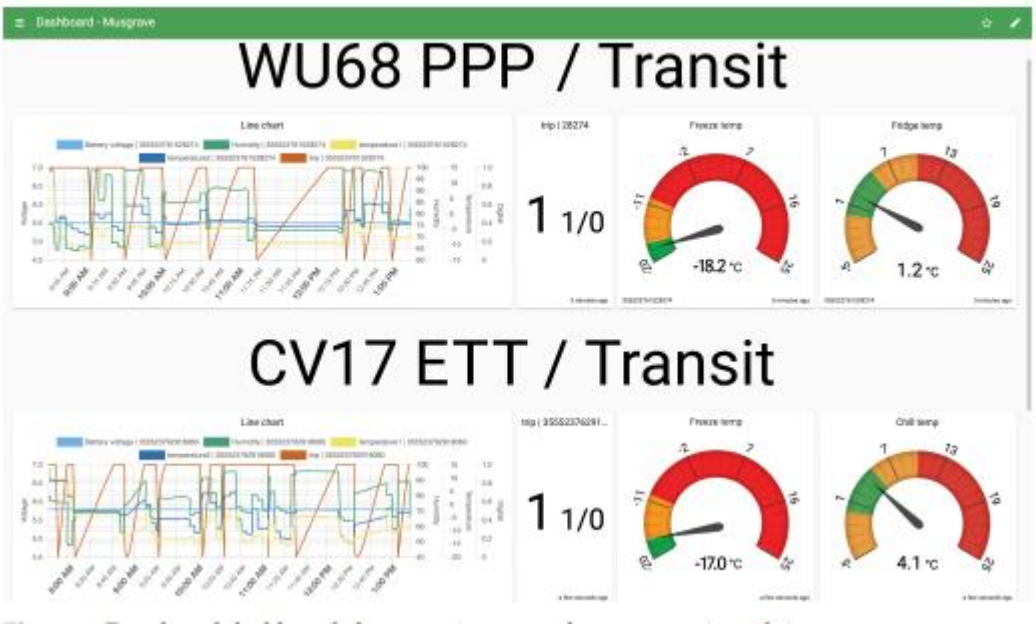


Figure 9: An example of the developed dashboard viewed on a desktop device.

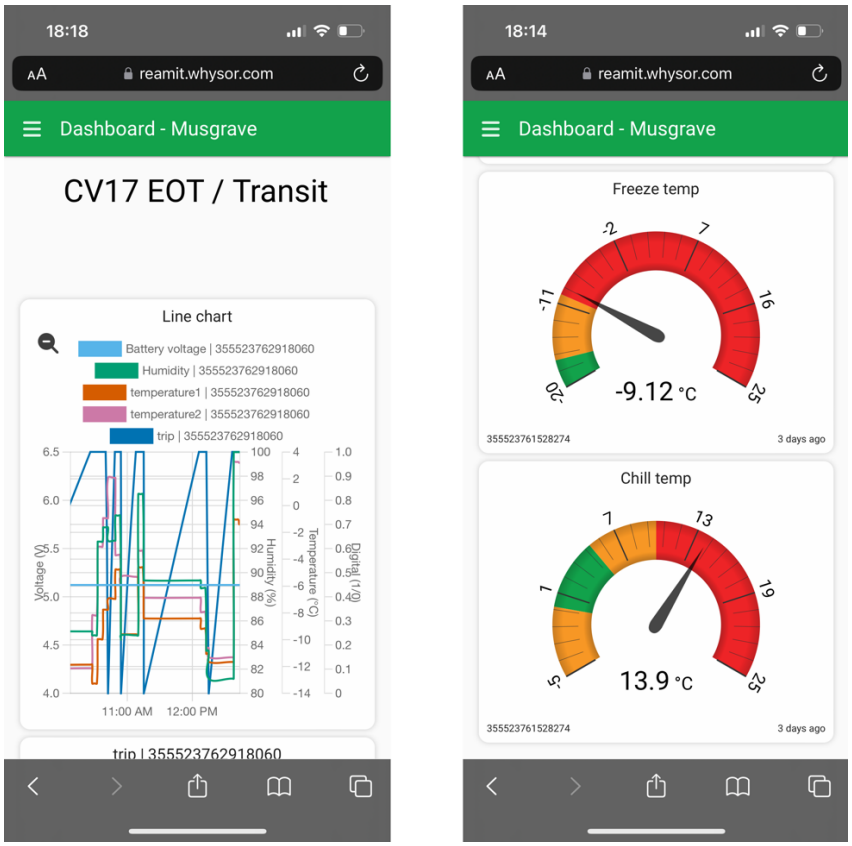


Figure 10: An example of the same dashboard viewed on a mobile device.

Launch of interface

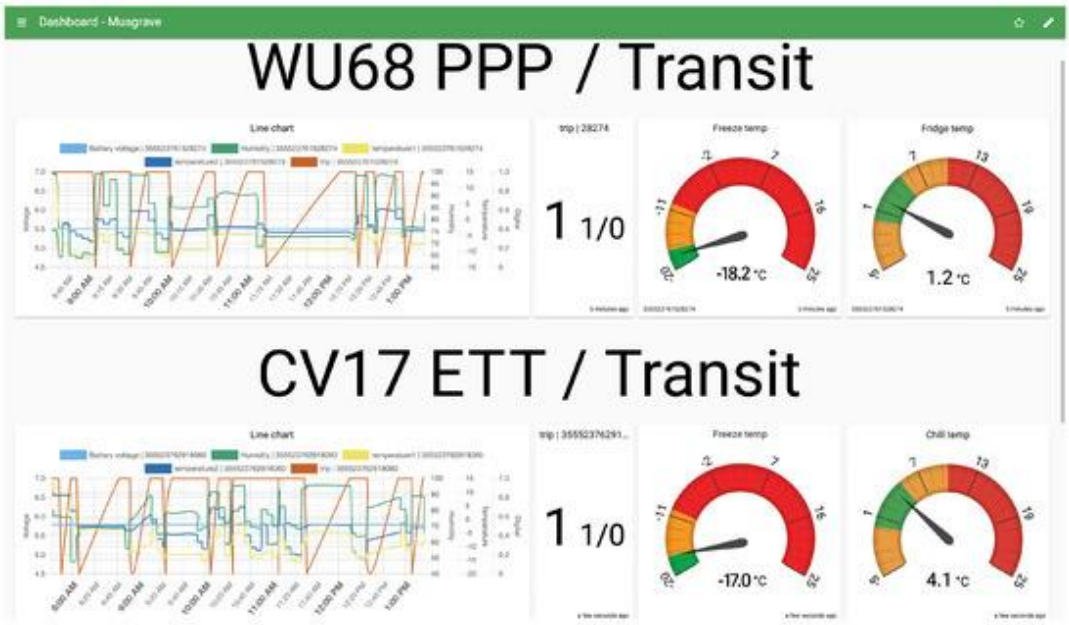
The dashboard was launched in June 2021 ahead of the deployment of sensors with the first pilot test company in July 2021 (WD Meats). The dashboard is accessible via http://reamit.whysor.com. To register for a user account, clients should contact support@whysor.com. The current dashboard revision is 3.26.3.

Appendix

The interface was modified according to each pilot needs. The details of dashboards of five of REAMIT pilots is given below to demonstrate the versatility of this interface.

1. Musgrave Group Limited

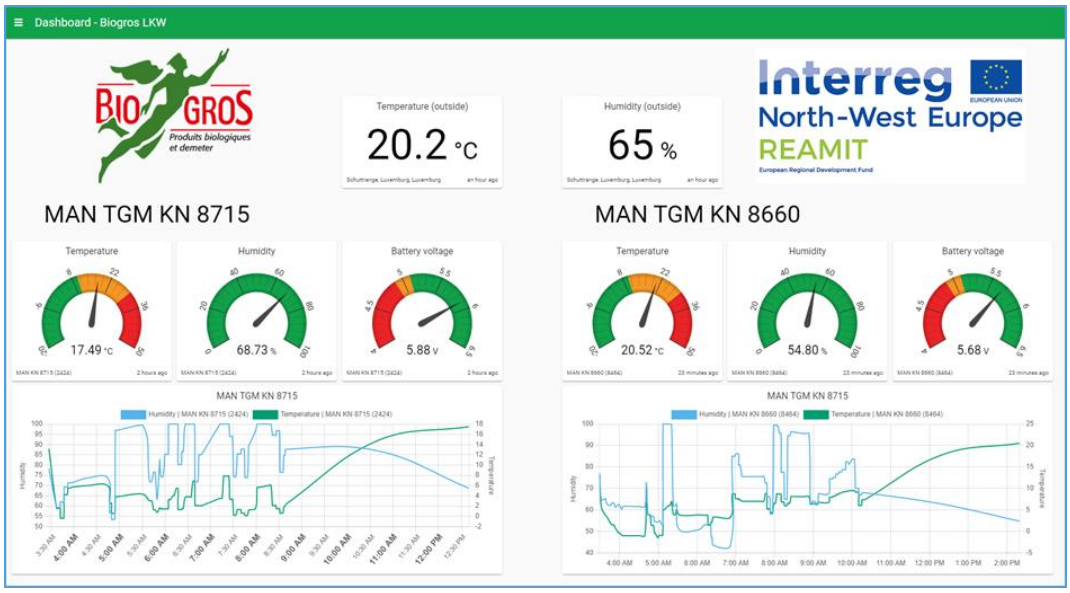
Each member of the logistics management team at the grocery distributor was given user credentials to access the monitoring dashboard. The dashboard allows its users to view and gain insights on the real-time data associated with all the users' assets in one centralized location. Once logged in, users can see the dashboard shown in Figure below.



The interface shows the real-time readings of the environmental parameters (temperature and humidity), battery voltage and trip detection. A 1 reported by trip tells the user the vehicle is currently in motion, while a 0 tells the user the vehicle is stopped. In the corner of each element, the time of last update is visible. The interface shows the temperature in all zones where sensors have been installed as well as the thresholds for the gauges (red-orange-green). The temperature thresholds were set according to the company's needs. The gauges provide a quick, easy to decipher visualisation into the transportation condition of the food. Green indicates that the food is being transported correctly, yellow indicates that the temperature is above the ideal temperature range but still does not compromise food quality and red indicates alarming status, and an automatic notification is sent to personnel for timely necessary action.

2. Biogros Pilot

Temperature alerts were defined using the thresholds defined by Biogros, for both the sensors inside the Biogros warehouse and inside the trucks. For example, for Truck MAN TGM KN 8715 the Temperature alert is set if temperature is greater than 10°C is measured for 6 executive measurements in a row AND the truck is in a trip for 6 executive measurements in a row. The alert is sent via an e-mail to the Biogros technician. Biogros dashboard is shown below:



3. Picnic Pilot

The dashboard below shows 9 sensors data displayed for Picnic pilot

4. Yumchop

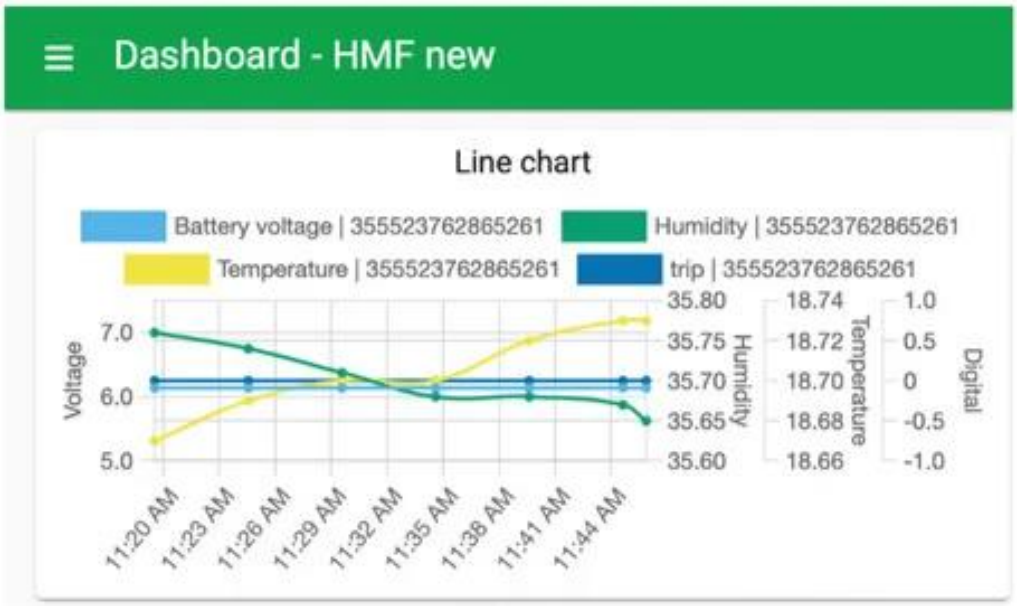
The dashboard for Yumchop below shows the temperature in all zones at Yumchop where sensors have been installed, as well as the thresholds for the gauges (red-orange-green). The temperature thresholds can be set according to Yumchop's need, if the pointer in the meter dial is within the range of the green zone, no action is needed. If the pointer is in the orange zone, caution is essential to be

ready to tackle problems. If the pointer is in the red zone, immediate action is required from the operations team of the case company. Preset alerts from the system will help to monitor the temperature to ensure quality.

5. Human Milk Foundation (HMF)

Data collected with sensors at HMK are uploaded to the REAMIT project cloud via an internet connection and administered by partners at the Whysor company. The sensors are configured to record data every 5 min while in a trip, or every 12 h outside of a trip.

A special feature of the dashboard and the data analytics algorithms employed for analytics is that they have been designed to send alerts when the temperature of the milk is above the prespecified threshold instructed by the HMF and above −20 °C. The alerts are sent via email and as a smartphone message. These alerts are crucial in ensuring that the temperature of milk is kept at optimal levels during transportation. If the temperature is consistently within the allowed threshold throughout a journey, then it can be assumed that the quality of milk is maintained at optimal levels.



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