Real time information on fish products during transportation

Tómas Hafliðason[1,2], Guðrún Ólafsdóttir[2], Sigurður Bogason[2] , Gunnar Stefánsson[1]*
*[1.]Industrial Engineering Mechanical Engineering and Computer Science, University of Iceland, 107, Reykjavík, Iceland [2.] ASCS Research Group, University of Iceland, 107, Reykjavík, Iceland. *E-mail: tomash@hi.is*

Introduction:

Perishable goods are still a major challenge for supply chains. It is estimated that over 27% of fish caught is lost before it is consumed, and 9% is lost in the distribution phase. Temperature fluctuations and other disruptions can occur at various stages of a distribution network causing reduction of shelf life. Intermodal and third party transport has risen rapidly in the past decade adding further to the challenges. Tracking of freight movement through the system can provide valuable information about the temperature and location in the whole chain. Delivering products of defined quality is not only a concern of the stakeholder that holds the product at each stage, it is a joint responsibility of the whole chain. If temperature disruptions have occurred in a supply chain of perishable products, it is critical to have this information timely to be able undertake preventive measures and make informed decisions to minimise possible damages of the products. Wireless Sensor Networks (WSN) provide information in near real time, and if equipped with batteries they can report information independent of logistic companies.

Aim: Demonstrate the application of battery driven WSN in chilled fish supply chains and obtain information on location and temperature in near real time, independent of logistic companies. Evaluate the accuracy of the location and assess the reliability of data transmission during logistics.

Materials and Methods:

WSN units (CMS01, Controlant, Reykjavík, Iceland) were implemented in two overseas shipment trials of fresh fish products a) cod from Iceland (IS-FR) and b) salmon from Norway (NO-FR), both with a final destination in France. The sensor network units consisted of wireless sensor network base station and sensors. The base stations had been optimized for low power consumption and contained internal batteries. Sampling rate of the temperature sensors was set to 5 minutes in both shipments.

Figure 2 (above): ***Locations identified from cell-id's during transport of cod (IS-FR). Recordings and transmission every 5 minutes.***

Figure 3 (right): ***Locations identified from cell-id's during transport of salmon (NO-FR). Recordings every 5 minutes and transmission with 2 hours intervals.***

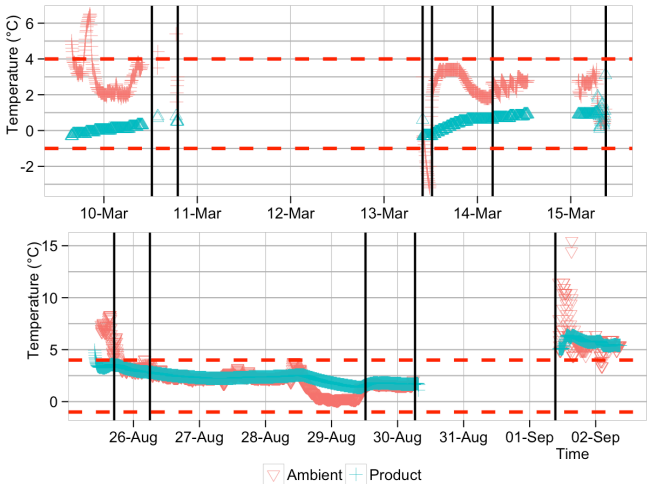

Figure 4 (above): Temperature data from cod field trials (IS-FR). Figure 5 (below): Temperature data from the field trials of Salmon (NO-FR).
The dotted lines show the temperature criteria. Handover points between operators are shown with vertical lines.

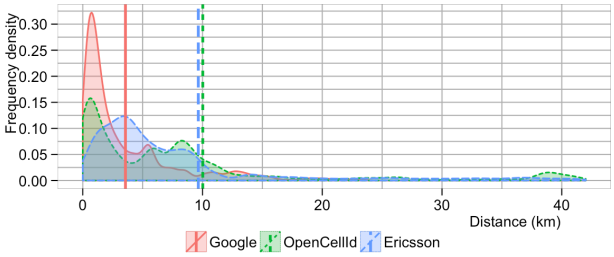

Figure 1: ***Frequency density of calculated distance and average distances (vertical lines) between GPS measured location and the location obtained from the cell-id databases.***

Results

Demonstration of location accuracy:

Location accuracy was tested to demonstrate how the location obtained from the databases would compare to location obtained with GPS in Iceland. Cell-id's locations were obtained from the 3 databases, Google Latitude, Ericsson Labs Mobile Location service and OpenCellID. In total 42.358 location points were collected in Iceland. 310 cells were identified, there of OpenCellid was able to locate 302 cells, Google 167, but Ericson could only provide location of 52 cells. When compared against the GPS data and available cells, Google reported the best results with average difference between 3.56 km, OpenCellId 10.02 km and Ericsson 9.65 km (Figure 1).

Location:

The base station of the WSN was placed with the products during the shipping on top of the palette. Because of limited signal strength it proved impossible to obtain GPS location. It was therefore necessary to rely on secondary location source, i.e. cell-ids. Based on the analysis of location accuracy of cell-ids, a strategy was constructed to select the cell-id database to locate the products during transports. Google provided the best results, but the database did not contain the location of all the cells, therefore OpenCellId was used as secondary database when Google did not report the location. Finally Ericson would be used, however during the process Ericson reported that they would be closing down the location service (Ericsson, 2012). Based on experiments performed in Iceland the average difference in location was approximately 10 km compared to GPS. The upload frequency was different between the two setups, the system that reported every 5 minutes gave accurate information on the location even while the truck was driving (Figure 3). The other setup which reported every 2 hours gave more scattered information (Figure 4). However, while the products were stationary (e.g. in warehouses) there was no difference between the locations reported. Both system could therefore give indication of the location of the products, but with differences in accuracy during transportation.

Temperature:

The WSN recorded temperature every 5 minutes, and data was transmitted at set intervals while the units were connected to the GSM networks (Figure 5 and Figure 6). However the system failed to report data when a) the communication delay (gap) was too large (more than few hours) and b) during the gap in Belgium, where the unit was connected to the GSM system, but still could not upload the data. In food supply chains the temperature criteria is often set at below 4°C, however, some customers demand lower temperature of products (-1°C) to ensure their shelflife, as illustrated for the salmon and the cod (Figure 5 and Figure 6). While the initial temperature of the cod was below 0°C, the high ambient temperature caused the product temperature to rise after the product was packaged. During the salmon trials, the initial temperature was higher than 4°C, but the ice in the boxes, cooled the product to lower temperatures (Figure 6).

During the processing in France (from 30th August in Figure 6), the equipment was removed, while it was sliced and smoked, and then repackaged. The sensors where then reintroduced when the product was ready to be shipped again to the final customer. At that time, the temperature was higher than the temperature criteria and more chilling was required to reach required temperature criteria.

Acknowledgements:

The studies presented herein were part of the CHILL-ON Integrated Project (FP6-016333-2) funded by the European Commission under the Sixth Framework Programme (Project website: www.chill-on.com). The authors would like to thank Controlant and Einir Guðlaugsson for their contribution to the research.

CHILL-ON