Live & Web-based Parcel Monitoring with Low-cost Sensors

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There is a strong demand from industries (e.g. insurances, logistics) for being able to monitor the shipping of goods, ranging from small parcels, over-specialized transports (e.g., expensive art work, or medication), to globally transferred shipping containers. Currently, there are a few advanced commercial systems that allow such monitoring of goods. Those systems already offer Web-access to the current status of the parcel within the logistics chain[1]. However, they are based on parcel identification (e.g., via barcode identification and tracking) within the infrastructure of parcel services, and do not offer information about further properties, such as temperature within the parcel. On the other hand, there are solutions[2] which comprise a small sensor device that can accompany freight to measure certain parameters within the parcel or container. However, those systems do not provide an easy integration of measured parameters with applications.

In this work, we are addressing this challenge of enabling live and ubiquitous monitoring and tracking of the shipping process of a parcel which potentially contains sensitive goods. Thereby, a central goal of our approach is to allow an easy integration of the observed parameters into existing systems.

To achieve this overall goal, we have developed a lightweight and cost efficient hardware solution combined with a server-side Web platform. Our hardware prototype, the *Parcel Tracker*, is shown in Figure 1. It can be placed within a parcel that is sent via a common parcel service. The device is capable of monitoring parameters such as temperature and humidity within the parcel through the sensor probes located outside of the device (see Figure 1). Further, the Parcel Tracker is able to detect acceleration and light events, indicating whether the parcel has been exposed to an impact or whether it has been opened during its travel. Importantly, the Parcel Tracker is also able to measure its current position. While GPS reception can be expected to be very weak within a parcel service wagon, GSM-based positioning is also available within such closed rooms. Hence, our sensing device utilizes received tower IDs from the GSM network, to localize the parcel based on GSM cell granularity.

[1] See e.g.: http://www.dhl-usa.com/en/express/tracking.html

[2] See e.g.:

- http://www.transportsecurity.com/GPS-Tracking.asp
- http://www.moog-crossbow.com/products/asset-tracking/products-ilc2000/

Figure 1 - The sensing device that can accompany a parcel to track and monitor its parameters.

To optimize the hardware setup, we have experimented with two different solutions. On one hand, we have created a solution based on an Arduino[3] kit and a custom set of combined additional electronic components (e.g., sensors and GSM connectivity). On the other hand, we have created the Parcel Tracker based on a common, low-cost Android smartphone and attached an IOIO board[4] onto it. The IOIO board can be connected to the smartphone via USB and allows the flexible connection of different sensors. Both prototypes have been successfully tested. While the Arduino-based solution is more flexible and can be optimized for a specific use case, the Android smartphone based approach is more developer friendly and allows for reusing many existing API functionalities.

For the Web platform of our solution, we have applied the Web of Things paradigm (see e.g., Guinard & Trifa 2009, Bröring et al. 2012). That means that: a) the measured parameters of the Parcel Tracker are consumable through a REST (Fielding 2000) interface, and b) each parcel has its own Web representation and capabilities. Thus, a parcel-*thing* becomes a first-class citizen on the Web, which facilitates their integration with existing applications and infrastructures as well as the linking between multiple parcels. To optimize our Web platform setup, we have experimented a) with an existing Sensor Web (Bröring et al. 2011) portal, called *cosm.com*, as well as b) with our own REST Web service implementation. Both approaches have been successfully tested. While cosm provides a ready-to-use interface with many reusable widgets and functionalities that allow for quicker prototyping, our custom REST interface is more flexible, independent of a commercial provider, and can be better adjusted to application needs, such as specific scalability requirements.

Figure 2 shows the tracked positions of the parcel on a map as a view on our Web platform. In this case, the parcel positions were measured during a test ride from Münster, Germany, to Enschede, the Netherlands. As the figure shows, the measured positions differ with a significant distance from the actual travelled route (blue line). This is due to our approach of relying on GSM network towers to localize the parcel.

[3] http://www.arduino.cc/

[4] https://www.sparkfun.com/products/10748

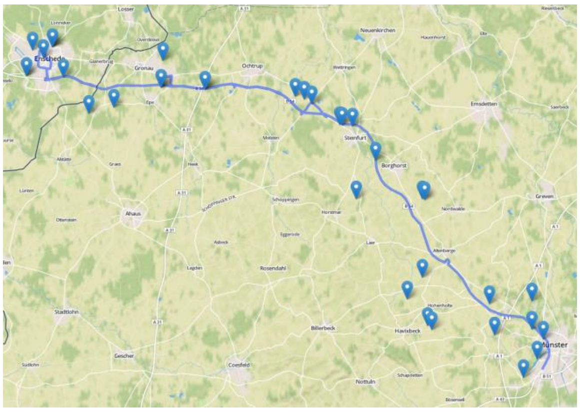

Figure 2 - The tracked positions of a parcel travelling on the test ride from Münster (DE) to Enschede (NL).

Figure 3 shows the view of our Web platform that shows the development of temperature and humidity measured within the device on our test ride. Both, positions and measured parameter values can be viewed on the Web platform in real time. In addition to this view, the Web platform offers functionality to register for light intensity and acceleration events and supports the delivery of notifications (e.g. via email) in case an acceleration or light measurements exceed a predefined threshold.

Figure 3 - The temperature (red) and humidity (blue) measured within a parcel on the test ride.

In conclusion, we have demonstrated in this work an approach for live and Web-based monitoring of parcels. Through this approach, we could measure the position with the parcel service wagon and could observe the temperature and humidity development. The parcels are represented as *things* on the Web which facilitates their integration with existing applications. The approach is low-cost, as our prototype costs around 180 €, a value that could be significantly reduced in case of a larger scale manufacturing process. In the future, we are planning to integrate this work with existing GIS software tools to advance analysis functionality of the system.

References

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