

Real-Time Cold Chain Mapping

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ABSTRACT

This paper presents an investigation of the application of autonomous telemetry sensors for real-time cold-chain mapping and shipment management of temperature sensitive product. New developments in electronic cold chain management pose challenges to organisations and how they engage in inter-organisational interactions. Advanced sensors and wireless monitoring enable the capture of multiple parameters such as temperature and location. A configuration designed to improve data management for real-time analysis of sensor data is presented.

Keywords

Keywords: cold chain, supply chain, autonomous sensors, inter-organizational systems, GPS, GSM, GPRS.

1. INTRODUCTION

The rapid advance of telemetry technology is an innovation driver to the development of new systems for asset-tracking devices and services [1]. This is grounded in several supporting developments: expanding global coverage by GSM carrier networks delivering a common international communications infrastructure, high gain GPS antennas and improved position algorithms provide more reliable position data in built-up environments, improvements in battery life and power management techniques extend operating times, decreasing data transmission and carrier roaming charges improve the economic case. Real-time asset tracking and monitoring is gradually becoming both technologically and economically feasible.

2. REAL-TIME COLD-CHAIN MAPPING PILOT

This pilot study investigated approaches to introducing real-time telemetry services to bulk pharmaceutical shipment systems between upstream and downstream processing facilities. In this case an add-on telemetry device was fitted to generic packages. The pilot project utilized GSM as it is the only extant RF communications network available at nearly all points in an international multi-modal shipment [2]. GSM networks are now ubiquitous in terrestrial locations (Table 1) and may even (in time) be provided in-flight on both passenger and cargo aircraft [3].

Table 1 RF Networks in 3PL Environment

Environment	RF Networks		
	LAN	GSM	GPS
Factory 1	X	X	none
Truck/Road	none	X	X, *1
Truck/Ferry	none	X	X, *1
Truck/Road	none	X	X, *1
Airport warehouse	X	X	X
In flight	none	none	none, *2
Airport warehouse	X	X	X
In flight	none	none	none, *2
Airport warehouse	X	X	X
Truck/Road	none	X	X, *1
Factory 2	X	X	none

Key
X = network available
*1. Vehicle GPS
*2. Aircraft GPS

Manufacturers and Carriers are obliged to ensure the integrity of medicines and their ingredients in transit [4], this implies an overlap between good distribution practice and good manufacturing practice. Good storage and distribution practices are essential for managing and maintaining the package environment within a defined temperature range throughout a supply chain. However pharmaceutical manufacturers carry the ultimate responsibility for establishing and controlling product temperature. Manufacturers will therefore increasingly demand real-time oversight of and proactive input into status and actions in the shipping environment.

2.1 Hardware

An autonomous GSM-GPS enabled cold chain temperature mapping prototype hardware was developed by InnoTec DATA GmbH & Co. KG (Bad Zwischenahn Germany). It consists of an asset tracking (AT) device with internal temperature sensor and an RF receiver for a wireless temperature sensor to access temperature readings distant from the device. The prototype AT temperature mapping device was adapted from an earlier design used to demonstrate the feasibility of multi-modal asset tracking for heavy air cargo and approved for use on Airbus A340-600. The electronics is housed in a fireproof containment to comply with aviation regulations for battery operated RF devices. External indicators provide status information for power, GPS fix, and GSM connectivity.

Telecommunications connectivity is provided by a quad band GSM module (850/900/1800/1900MHz) configured for automated roaming to enable seamless international use. An AT

gateway connects via the Internet the carrier SMS center or gateway that the GSM module is registered to. Temperature readings are stored in internal memory at preset times and transmitted as SMS messages at configurable intervals for example, at 5 minute intervals or continuously if GPRS¹ service is available. The device includes a GPS unit (GSM position update rate 4Hz, high gain antenna -158 dBm) and firmware can be updated via the GSM module. Microprocessor-controlled current management of Lithium-ion polymer batteries and subsystem monitoring minimises device power consumption to enable long field deployments.

2.2 Software

A web enabled software service was developed by arviem AG to interface between the manufacturer of an asset tracking system and a corporate user. The *interoperable service* and its 'dashboard' (termed a TMS or trade monitoring service), is a software stack configured to exchange data with proprietary AT data gateways. The arviem software stack filters hardware specific telemetry² messages (e.g. GPRS data strings). Device specific messages conform to agreed string specifications (see Table 2 for an example of one segment). Data at designated byte ranges is processed and stored using XML schemas. The XML describes the semantic content of AT data to interpret, display, store and exchange with other services (e.g. user's own SAP system). A web server displays device data in real-time using Adobe Flex and accessed from web browsers through Flash Player or thin clients on PCs via Adobe AIR. In summary real-time device data is transmitted by GSM carrier network, forwarded via the carrier message gateway to InnoTec's message server then routed via https to the arviem TMS server. The arviem TMS server processes the data for access via a secure web service and to generate actions using predefined business rules. For example the TMS will send messages – SMS alerts and emails – to designated individuals, or data directly to other information systems such as the user's ERP system.

The Trade Monitoring Services Analytics software can interact with any existing corporate data sources that are accessible via JDBC connectors or SAP JCo, and business modules exist for standard devices such as email, fax, SMS, mobile phones, pagers, and WAP push. Recipients need no additional software or hardware.

Table 2 GTS message string specification

Byte loc.	Meaning	Range/Type	Example
83-93	Lat.	011s	(D5245B36843)
94-105	Long.	012s	(D00747B56727)

3. FIELD TRIALS

Filed trials using the Innotec AT prototype with a development version of arviem's TMS and web dashboard were conducted from November 2009 to February 2010. Cold chain shipments (2-8 degrees C) from an Irish production facility of a multinational pharmaceutical manufacturer were monitored with

¹ GPRS: General Packet Radio Service (and EDGE) used for extended data transmission on GSM networks.

² Telemetry is the transmission of remote sensor readings and data typically by radio.

temperature sensor AT devices. The objective was to obtain shipper and ambient temperatures in real-time. Shipments from Ireland to the US and from Ireland to Germany were monitored. The shipping lane to Germany was by truck and sea; shipments to the US include air legs.

4. RESULTS AND DISCUSSION

This study piloted the provision of an *interoperable service*, providing a common interface between end users and (potentially) a device manufacturer. The interoperable service enables the integration of data from multiple device manufacturers. Future users will inevitably use different AT devices from different designers for specialized needs and will appreciate device independent software dashboards or user interfaces. In essence an interoperable service layer enables compatibility between different devices and the user.

5. CONCLUSION

Innovation in real-time trade monitoring has implications for regulation (e.g. Customs clearance and licensing by aviation and transport authorities), for manufacturing industry (chain of custody, visibility), logistics industry (value added services), telecommunications (increased utilisation), and users. However the practical application of these developments is both disruptive and transformative therefore their future trajectory remains uncertain. Asset tracking devices are but one element in a network of technologies, processes, and skills that must work in concert if new business services like real-time trade monitoring are to be viable.

6. REFERENCES

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