RFID/WSN Middleware Approach for Container Monitoring

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INTRODUCTION

Security of intermodal transportation is a serious issue in many countries worldwide and many specific security and safety information systems have been proposed to solve these problems. Practical implementation of intelligent data analysis methods, Radio Frequency Identification (RFID) systems and sensor technologies are best known solutions so far. But even these widely spread technologies have many downfalls related to their real life application. There are several application scenarios and appropriate technologies that need to be considered. Firstly, we have a scenario where containers are stored on a ship. Next, we have a scenario where containers are stored in a container terminal. Finally, these containers are transported via truck and trains to their destinations. So, appropriate technologies are applied at each separate scenario. They include application of Wireless sensor networks (WSN), RFID, GPS/Galileo, video surveillance systems and many other methods and data analysis algorithms.

We briefly analyse each separate scenario and propose a whole new concept for the improvement of the Containers Security Initiative (CSI). A conceptual middleware approach with deployable intelligent agent modules is proposed to be used with the above mentioned scenarios. Middleware examples are visually programmed using National Instruments LabView software packages and Wireless sensor network hardware modules. This research is a contribution to the intermodal transportation and is intended to be used as a means of the development of intelligent transport systems.

BACKGROUND OF CONTAINERS TRANSPORTATION AND THE SUPPORTING TECHNOLOGIES

Intermodal container monitoring is considered a major security issue in many major logistic companies and countries worldwide (Potyrailo et al., 2012, p. 133). Current representation of the problem, we face today, originated in 2002, right after the 9/11 attacks. Then, a new worldwide Container Security Initiative (CSI, 2002) was considered that shaped the perception of the transportation operations. Now more than 80 larger ports all over the world contribute to its further development and integration into everyday transportation operations and improve the regulations for the developing regions. Although, these new improvements allow us to feel safer and secure, constant management of transportation operations has become a very difficult problem for conventional data analysis methods and information systems (Andziulis et. al., 2012, p.40).

Integration of many new Information and Communication Technologies (ICT) and other safety and security regulations into the existing cargo handling operations and processes is likely to be the main solution. As an example, some industrial applications

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already include new RFID ISO standards, but with limited applicability. Early work exploring RFID is the landmark 1948 paper by Harry Stockman, titled "Communication by Means of Reflected Power" (Stockman, 1948, p.1196). The choice of the applied communication technology often depends on the used frequency. Frequency reflects numerous factors, including not only technical considerations, but also international availability and economic considerations. One of the most known monitoring systems is the ConTracer. But even this known product is applied mostly in theory, to evaluate the potential risks and their prevention methods. Research is now being done to estimate the efficiency of the installations in terms of cost. Still, this main solution has many research related communication and data analysis problems.

There are a lot of communication problems that are related to data exchange standards (Lopéz, 2011, p.207). Nevertheless, application of most modern mobile technologies plays an important role in maximizing performance, reducing costs and risks of intermodal containers transportation and raising efficiency of other important transportation services in the supply chain. During the last decade, many technologies have improved and they are mainly related to the following CSI objectives: Safety of cargo and Security of transportation operations. Both these objectives 'use' same ICT. On the other hand, their application differs regarding the needs of the supply chain. There are still many different opinions regarding the priorities of the supply chain and their involvement in the border security. One may notice that safety of the cargo is still the primary objective to the supply chain. This is due to the direct value input. Only the primary objective brings direct value and makes supply chain cost effective. Therefore, some of the adopted CSI regulations are not taken into account. Because, in many cases, their expenses do not exceed the expenses of the possible risks. Nowadays, these regulations are becoming more obligatorily and therefore, in many security and safety applications worldwide, information management during the control operations is becoming the number one priority.

Several key technologies were presented during the years, most of them are systemised and they include:

- **E-Seals and the Supporting Systems:** In reference (Chin & Wu, 2004) authors described basic technical features of RFID systems and their link to practical applications. They also determined how these technologies performed in real-world operational environment and evaluated various trade-offs that exist with e-seal design and the potential impact of those trade-offs on functionality, reliability, utility, and cost. We agree with the authors that any technical possibility must be used to decrease production costs and the diversification of the technologies should have less impact on the market as well.
- **WSN (Wireless Sensor Networks) and RFID Systems and their Antenna Designs:** In reference (Choi et al., 2011) authors presented a planar inverted-F antenna that was intended to be attached to metal containers and the authors in (Ryu et al., 2009) designed a miniaturised RFID tag antenna for an active 433.92 MHz RFID system.
- **Complex Multi-Agent Systems:** Authors in (Yu & Wang, 2006) investigated the use of MAS (Multi-agent system) as the basis for a terminal schedule system and analysed the assignment of berths to arriving container ships at a Container Terminal. The agent arranged proper equipments for ships under various constraints and policies. And authors in (Yan et al., 2008) presented also presented a similar multi-agent-based system approach to resource allocation and operation scheduling problems in container terminals;
- **Active RFID Systems:** Authors in (Mizuno & Shimizu, 2007) developed sensor active RFID with LF (Low Frequency) module and installed these active RFIDs in an actual container to acquire movement history and the sensor data. In (Yunming et al., 2007) authors provided a description of container monitoring RFID infrastructure, which is combined with the national custom monitoring, port monitoring and vessel monitoring centers. In reference (Kim et al., 2008a) authors explored new secure business models, architectures, and emerging technologies and in (Yuan & Huang, 2008, p. 267)