Chapter 18
Dedicated Networking Solutions for a Container Tracking System

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Abstract Cork Institute of Technology (CIT) researchers in collaboration with Tyndall National Institute, both based in Cork, a city in the southern coast of Ireland, have developed a container management and monitoring system using Wireless Sensor Networks (WSNs), with a support of Cork Port and local industry. The system is designed to seamlessly integrate with existing container management schemes (and with staff procedures) at the port, efficiently, and at low cost, extending its capabilities through remote querying, localization and security. To achieve its goals, the system exploits the capabilities of wireless sensor nodes, used as container ‘tags’, which form a wireless, ad-hoc network throughout the container yard. This chapter will briefly describe the project rationale and the technology development process, which includes hardware solutions built by Tyndall – a dedicated sensor node platform composed from that Institute’s wireless sensor toolkit. It will also discuss the software and networking solutions created and implemented through CIT’s research. This includes specialized graphical user interfaces on portable devices (e.g. a solution was implemented for PDAs, based upon the .NET Compact Framework) and applications for WSN motes, running the TinyOS operating system, to provide full system functionality and multi-hopping communication. The chapter will also describe the work done to overcome the primary project challenges, including the issue of the radio shielding effects of the containers. The final system demonstrates multi-hopping and ad-hoc routing techniques that could exploit the containers, by stack and row, to forward information from one to the next and, in this way, enabling intelligent, reliable communication from anywhere in the port to the management system user.

Keywords wireless networks, sensor nodes, multi-hopping, ad-hoc routing, asset tracking, freight container, TinyOS, radio frequency, tagging, location.
1 Introduction

As Ireland is an island with a significant external trade market, the efficient, low-cost and fast transshipment of goods is a strategic economic requirement. The timely flow of container traffic through Ireland’s ports is of vital importance to maintaining Ireland’s competitiveness as an export driven economy. In this context, Irish ports operate as economic gateways; container traffic is on/off-loaded, then moved and stacked in tiers in storage yards before shipments are transferred to, and from, the rail or road network.

Within ports, the order of on/off-loading, the placement of the containers in the storage yard, the stacking methods and the operating facilities are all central to maintaining an efficient, timely and low-cost operation. Organizational mistakes can bring significant time and labour costs. Four ports in the Republic of Ireland, and two in Northern Ireland, provide load-on/load-off (lo-lo) container services. According to The Irish Maritime Development Office report, published in 2007 [1, 2], total island traffic in 2006 was 1,372,206TEU, representing 60% growth in the 5-year period since 2001 (in 2003 the growth rate was twice the global average). All of the ports have increased their traffic significantly, with Belfast as a leading example in almost doubling its traffic in 2004. The ports vary in throughput from Warrenpoint (41,948TEUs) through Cork (185,002TEUs) to Dublin (680,680TEUs).

As the amount of traffic going through Irish ports increases, so does the importance of an effective (both in terms of operation and cost) container management system, a situation made more urgent by the value of some of the goods held in containers. The trade figures, showing the continuation of a strong import/export business, provide both necessity and the opportunity for ports to invest in their infrastructure. The current container management solutions for these smaller ports can have several limitations; they lack the facility for remote location and identification of a container, or the ability to monitor containers through protection/security features. Thus, these systems are prone to errors (e.g. lost containers) that are time-consuming to recover. In this context, using traditional techniques they may require substantial infrastructural investment to resolve. The solution proposed in this project sought to address these limits with an approach that offers suitable performance and scalability, coupled with both low cost and low infrastructural overhead.

1.1 The Business Opportunity

The European coastline is dotted with a series of small-to-medium trade ports, which provide access to the Europe’s peripheral regions. Within the single economic market,