Chapter 10
Exploring Value-Added Applications of Chipless RFID Systems to Enhance Wider Adoption

Ming K. Lim
Aston University, UK

ABSTRACT
Radio-frequency identification technology (RFID) is a popular modern technology proven to deliver a range of value-added benefits to achieve system and operational efficiency, as well as cost-effectiveness. The operational characteristics of RFID outperform barcodes in many aspects. Despite its well-perceived benefits, a definite rationale for larger scale adoption is still not so promising. One of the key reasons is high implementation cost, especially the cost of tags for applications involving item-level tagging. This has resulted in the development of chipless RFID tags which cost much less than conventional chip-based tags. Despite the much lower tag cost, the uptake of chipless RFID system in the market is still not as widespread as predicted by RFID experts. This chapter explores the value-added applications of chipless RFID system to promote wider adoption. The chipless technology’s technical and operational characteristics, benefits, limitations and current uses will also be examined. The merit of this chapter is to contribute fresh propositions to the promising applications of chipless RFID to increase its adoption in the industries that are currently not (or less popular in) utilising it, such as retail, logistics, manufacturing, healthcare, and service sectors.

INTRODUCTION
In the last decade, radio-frequency identification technology (RFID), which is one of the most promising automatic identification and data capture (AIDC) technologies, has been increasingly popular due to its ability to achieve system and operational efficiency, as well as cost-effectiveness. RFID technology uses radio frequency waves to transmit data between data carrying devices (known as RFID tags or transponders) and data receiving devices (RFID readers/interrogators).
When the RFID reader receives data from the tag, the data will be passed on to the RFID middleware for use in various applications, in most cases, integrated with other systems (e.g. Enterprise Resource Planning, Warehouse Management System, and Customer Relationship Management). Each RFID tag consists of unique data about the item to which it is attached to, e.g. date of production, shipping detail, expiry date, depending on the intended applications. For instance, when a carton within a shipment is tagged, it can be easily tracked in the supply chain and its information, such as destination, customer detail, value, contents, etc., can also be seamlessly traced to avoid wrong shipments or shrinkages.

In general, there are three types of RFID tags (Hunt et al., 2007; Brown et al., 2007): passive, semi-active and active. Passive tags are most commonly used and they only transmit information to the reader when they receive a radio wave signal from the reader (through the antennas connected to the reader). Semi-active (or sometimes called semi-passive) tags consist of an internal battery that is only used to perform tasks, such as recording temperature readings or moisture levels. The battery does not initiate communication with the reader. In contrast, active tags initiate communication with the reader as specified by the users. They are generally more powerful than passive tags in terms of read range, information content and data transmission rate. RFID tag selection is dependent on its application and the level of technological capability required. In recent years, as more vendors entering the RFID market, more advanced RFID features have been introduced, such as WiFi-, GPS-, sensor-enabled and battery-assisted passive tags. For example, if a GPS- and sensor-enabled RFID tag is attached to a consignment, the haulier is able to accurately monitor its real-time location and status throughout its delivery, and the customer can be certain, from the RFID data, of more accurate arrival time and if the consignment has been tampered or exposed outside optimum temperature range.

RFID technology promotes a new way of identifying objects and its operational characteristics outperform barcodes in many aspects, such as no direct line of sight is required, multiple tags can be read simultaneously, tags are durable and capable of withstanding harsh conditions, and data is re-writable on the tags (Daniel Hunt et al., 2007; Holmes, 2005; McFarlane & Sheffi, 2003). The proven benefits include unique identification of tagged items and status monitoring, improved stock visibility and traceability at any stage in the supply chain, automated inventory counts, automated operations, increased product availability, reduced shrinkages, and so on (Ferrer et al., 2010; Ngai, 2008; Daniel Hunt et al., 2007; Holmes, 2005; Luckett, 2004; Finkenzeller, 2003). Each industry has a unique interest in the technological benefits for their business. It can be seen that the benefits of RFID were well-perceived in the early years when it was introduced, especially by the retail and logistics industries (Holmes, 2005; Finkenzeller, 2003; McFarlane & Sheffi, 2003). Due to its robustness and flexibility in application, the realisation of benefits have spread across manufacturing (robotics and M2M communications), healthcare (real-time location system and patient treatment/safety), pharmaceuticals (anti-counterfeit and status monitoring), and more recently service sector, such as through smart phones, social networks, resorts, amusement parks and restaurants (Wasserman, 2011; Edwards, 2011; Wessel, 2010a; Butner, 2010; O’Connor, 2010; Thuemmier et al., 2009; Wei et al., 2009).

Despite it is proven that RFID technology does bring benefits to businesses in terms of operational efficiency and costs saving, a definite rationale for larger scale adoption is still not so promising. For any technology to be adopted, there are issues that need to be carefully investigated. The issues related to RFID technology are associated with cost, technicality, implementation, integration, standards, privacy, and security (Daniel Hunt et al., 2007; Wu et al., 2005; Weinstein, 2005; Berthiaume, 2004). At present, although RFID
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