

# Determining technology trends and forecasts of RFID by a historical review and bibliometric analysis from 1991 to 2005

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## Abstract

Radio frequency identification (RFID) has been identified as one of the ten greatest contributory technologies of the 21st century. This technology has found a rapidly growing market, with global sales expected to top US \$7 billion by 2008. An increasing variety of enterprises are employing RFID to improve their efficiency of operations and to gain a competitive advantage. To shed light on RFID trends, and contributions, a historical review and bibliometric analysis are included in this research. The bibliometric analytical technique was used to examine this topic in SCI journals from 1991 through November of 2005. Also, a historical review method was used to analyze RFID innovation, adoption by organizations, and market diffusion. From the analysis of the study's findings, supply chain management (SCM), health industry, and privacy issues emerge as the major trends in RFID. Also, the contributions of the RFID industry and forecasts of technological trends were also analyzed, concluding that RFID will be more ubiquitously diffused and assimilated into our daily lives in the near future.

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*Keywords:* RFID; Historical review; Bibliometric

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## 1. Introduction

The advantage of radio frequency identification (RFID) tags is that they use a memory storage device to store a certain amount of data such as the product identification number, price, cost, manufacture date, location, and inventory on hand. This information can quickly be read by a wireless scanner, so RFID can process large volumes of multiple data sets at the same time and improve efficiency of operations by using identification tags to accurately monitor processes for time, place and person. This technology has been adopted by and diffused into a variety of enterprises to achieve cost-savings and increased efficiency. Many business enterprises and the health industry are applying the advantages of RFID to experimental projects to improve operational efficiency and to gain a competitive advantage (Bilge and Ozkarahan, 2004).

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Many information systems are old, do not meet existing demands, and will soon become obsolete. Therefore, technology is evolving on an almost daily basis and managers must continuously look for new ways to utilize resources (Kodama, 2005). Therefore, it is anticipated that it will become increasingly important for organizations to create new ways of thinking and job processing (Carayannisa and Coleman, 2005). Organizations are not only investing in knowledge capital and information technology (IT) to improve their operational weaknesses (Macpherson, 2005), but managers are also trying to resolve sequential operational crises. They are devoting resources and knowledge to reconfiguring and creating innovative new structures and systems in order to overcome the crises (Li, 2005), pursue more efficient operations (Munday et al., 2005), and gain an economic advantage (Szántó, 2005). Therefore, organizations are integrating learning and teamwork cohesion with innovative technologies to adapt to the changing needs of the business

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environment (Lloréns Montes et al., 2005). Creativity and innovation are leading customers into new experiences and creating new needs (Rose-Anderssen et al., 2005). Thus, to survive, organizations are counting on the integration of innovative technologies with business management processes (Kumar et al., 2005).

Enterprises are applying advanced information systems to strengthen managerial ability to enhance organizational change and growth for better operations (Lin, 1991). Hospital administrators are aware that using new technologies is essential to surviving and succeeding in the competitive health care environment (Uslay et al., 2004). Therefore, the health care industry is also beginning to employ RFID to solve operation problems such as fighting drug counterfeiting (Koleszar, 2004) and tracking blood products from donor to patient, and are applying new innovative systems and models to meet knowledge and economic demands (Cooke, 2004). Hospitals are adopting RFID tags to prevent medical errors by ensuring the delivery of correct medicine dosages to patients (Cline, 2004). The US Food and Drug Administration expects drug makers to have RFID tracking in place by 2007 for nearly all pharmaceuticals to control counterfeiting (Gebhart, 2004), and it is even testing the technology on several types of viruses. There are RFID-enabled resource and workflow management solutions being designed to optimize asset utilization, reduce operating costs, and improve care quality in the healthcare industry (Kohn and Henderson, 2004), and for a variety of other medical applications (Costlow, 2004). Hospitals are utilizing RFID for tracking injection IV bags, blood bags, cancer medicine, and wounded soldiers and their treatment.

In this paper, we explored RFID technological trends and forecasts by means of bibliometric and historical reviews from 1991 through November, 2005 to elucidate the RFID technology trends in adopting enterprises, contributions that RFID is making, and forecasts for RFID growth.

## 2. Material and method

All documents used in this study were accessed from the database of the Science Citation Index (SCI), obtained by subscription from the ISI, Web of Science, Philadelphia, PA, USA. In this study, we only discuss the papers published in the period beginning 1991 because there were less data regarding RFID prior to that year.

To shed light on RFID trends and contributions, both a bibliometric analysis and a historical review were conducted in this research. For the bibliometric analysis, the SCI was systematically searched for RFID-related materials published from 1991 through November, 2005. Selected documents included “RFID” or “radio frequency identification” in the title, abstract, or key words. Analyzed parameters included authorship, patterns of international collaboration, journal, language, document type, research address, number of times cited, and reprint author’s

address. Citation analysis was based primarily on the impact factor as defined by the *Journal Citation Reports* (JCR) and on *Citations Per Publications* (CPP), which are used to assess the impact of a journal relative to the entire field and is defined as the ratio of the number of citations the publication has received to the length of time since publication. A historical review was also performed. The historical method proposes that historical phenomena can be rich and complex and that we can gain a better understanding by reviewing and investigating the time(s), place(s) and context(s) in which events occur and develop. The historical method was employed in investigating the initiation and development of RFID as documented in publications in the SCI from 1991 to November, 2005.

For a longitudinal literature review, we employed bibliometric and historical review methods to explore RFID technological trends, and based on this review, we forecast possible future developments.

## 3. Results and discussion

### 3.1. RFID historical analysis

The key words “RFID” or “radio frequency identification” were used to search SCI entries from 1991 to 2005 (updated December 16, 2005). The RFID SCI article distribution status was used for trend analysis. As detailed below, all 316 papers found in the search were analyzed.

#### 3.1.1. Distribution by country/territory and institution name

Table 1 shows the distribution of publications by country and territory. The US, Japan, Germany, Switzerland, South Korea, Canada, the UK and Finland were the top eight countries publishing RFID articles. Listing publications by institution name, Table 1 shows that the Massachusetts Institute of Technology, University of Washington, and Agriculture & Agriculture Food, Canada, are the top three RFID research institutions.

#### 3.1.2. Distribution by publication year, document type and language

Table 2 displays RFID-related publications by year, document type, and language. Fig. 1 shows the number and percentage of annual publications output. There have been an increasing number of RFID publications since 2003. In the SCI, and SSCI, articles comprised the majority of published RFID document types (Table 2 and Fig. 2). As for distribution by language, we see from Table 2 and Fig. 2 that the majority language of RFID research is done in English. One interesting finding is that there has been an increase in RFID research since 2002; it is clear that RFID technology is becoming ever more important.

#### 3.1.3. Distribution by source title

Table 3 shows that “Microwaves & Radio Frequency,” “Microwave Journal,” and “Communications of the

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