Integration of RFID and Cellular Technologies\textsuperscript{1}

Dora Karali  
UCLA Anderson School of Management

\section*{Introduction}

Radio Frequency Identification or RFID, is a method of identifying unique items using radio waves. The technology has been in the spotlight since Wal-Mart announced its decision to require its suppliers to be ready to track goods using RFID tags in 2005. Other large companies as well as the DoD also made similar announcements.

RFID is a promising technology for many corporations that seek to improve their processes, increase productivity and achieve a competitive advantage. However, RFID cannot provide the fullest benefits as a standalone technology. Corporations look for an integrated solution of RFID with their existing infrastructure and wish to smoothly incorporate RFID into their mobile enterprise applications.

This report presents an analysis of market potential that emerges from the integration of RFID readers and the wireless phone devices and network infrastructure. The following sections give an overview of the technology, present some example applications, describe the benefits and the challenges for integrating RFID with cell phone technology and discuss the business model and the market landscape.

\section*{Technology Overview}

There are two main ways to integrate RFID with a wireless smartphone: “\textit{A smartphone with RFID tags}” and “\textit{a smartphone with an RFID reader}”.

\textit{A smartphone with an RFID tag} is a handheld device that can connect to GSM or another wireless phone network and has embedded or attached an RFID chip with some identification information programmed on it. Apart from the cell phone antenna used to connect to the wireless network operator, the device also contains an RF antenna to allow for communication with the RFID reader. When the smartphone with the RF tag and the RFID reader are within range they can communicate; the RFID tag information is sent to the reader and the reader can write some information back to the smartphone’s RFID tag.

\textit{A smartphone with an RFID reader} is a handheld device that can connect to the wireless phone network and contains an RFID reader that can collect data from various RFID tags. The smartphone should also include and RF antenna. In the typical RFID scenarios (e.g in supply chain), the RFID reader is a fixed, static device while the RFID tags are mobile passing through

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the RFID readers active range. In this case though, the RFID reader is a mobile device that can collect info from mobile or fixed tags. The rest of the report focuses on smartphone technology that is integrated with RFID readers. Exhibit 1 shows the communication network among the different devices. The RFID Tag sends identification data using RF frequencies the RFID enabled cell phone transmits it over the GSM and phone network where it finally reaches the centralized management station. Using LAN technologies the data is finally stored in the centralized database.

Exhibit 1

Hardware Design
The RFID reader should be closely integrated with the rest of the smartphone components. In terms of hardware, the RFID reader IC and the RF antenna should fit to the size of a handheld device. The power consumption of the reader should be kept in reasonable levels and the RF antenna should not interfere with the smartphone antenna or other devices.

Software Design
The RFID enabled smartphone should include software that will be able reading and writing RFID tags. In addition, it should be easily integrated with call initiation or wireless data transmission so that data collected via the RFID reader can be transmitted over the wireless phone network to a centralized database. It may also require special provisions from the smartphone operating system, to generate alerts, SMS messages etc.

Security is also a big concern that the RFID enabled smartphone should address through its software suite. The communication between the RFID tags and the RFID enabled
smartphone should be secure. CryptoRF is a company that has developed technologies to address RF security issues using cryptography and authentication.

Standards
There are four frequency bands for RFID communications: Low Frequency, high frequency, ultra-high frequency and microwave. The appropriate frequency for the RFID enabled smartphone depends on the range required by the application for which it is going to be used. In the common case, high-frequency bands that allow communication in a few meters are expected to be appropriate for the RFID enabled smartphone.

Different bodies specify the appropriate frequency ranges in different parts of the globe causing incompatibility issues between tags and RFID readers. For example, European standards bodies like ETSI, have set different frequency requirements for RFID from USA for health and safety reasons. Hence it is harder for multinational firms to have a consistent infrastructure across the globe [1]. In order to address this issue, RFID-enabled smartphone manufacturers should support multiple standards.

Apart from the frequency standards RFID enabled smartphone manufacturers should comply with RFID data standards. The EPCglobal industry consortium has released the Electronic Product Code (EPC) specification that describes the data stored in a tag [2]. ISO 14443 is another standard used for RFID communication.

Applications
The applications of RFID-enabled smartphones span across multiple areas including the enterprise and the consumer market. The main focus of this report is on the enterprise market, however a few consumer applications are presented to show the potential of the technology in the consumer market.

1. Use a product’s tag to connect real time to the item’s entry in a centralized database: A smartphone with an RFID reader can be placed on a tag located on machinery and use the wireless network to browse on the specific item’s web pages [3].
   - A service technician touches the machine to service with his smart-phone. Up-to-date service information is downloaded at his smartphone. E.g last service date, what service was performed, instructions for additional service etc.
   - A machine operator uses his smartphone RFID reader to get the tag info attached to a machine and a new work order is available from a web page.
   - An engineer uses his smartphone RFID reader to get the tag info that links to a page to enter the reason of failure.
   - A technician uses his smartphone RFID reader to get the tag info and get linked to a page to enter the materials used.

2. Collect real-time information: Use a cell phone that is equipped with an RFID reader to send specific time and location information about a position or status to the center
• A security firm has fixed the tags at points along its security guards' patrol routes. The employee touches his handset to a tag, and his boss immediately knows where he is and whether he is on schedule.
• A tag is attached on a meter and by touching with the cell phone, the measurement is sent to a centralized database.
• Record Travel Expenses: Attach a tag on the car dashboard and send the starting and ending mileage for an expense report.
• A technician “scans” the temperature/humidity of a remote site and uses his cell phone data network to send the real-time measurements to the control station.

3. **Automatic asset tracking:** Instead of manual counting devices on remote sites, an administrator with a RFID enabled mobile phone can collect info from the RFID tags on all the relevant equipment, PCs, routers, even mundane things such as desks and chairs and use the wireless phone network to send up-to-date information back to the centralized tracking application [4].

4. **Consumer marketing:** Point the RFID reader of your cell phone onto a poster promoting a new single and your customers can get info on the singer, watch the video clip, even buy the song. The same technology could be used to inform the customer about the digital rights and other song info [17].

5. **Use RFID technology to initiate a call:** Attach a tag behind a person’s photo to initiate a call to him/her. A visual phone directory can be created for children or disabled persons. Similar technology can also be used to initiate emergency calls.

**Benefits**

The integration of RFID and cellular technologies is a compelling value proposition for enterprises since it offers significant benefits:

1. **Significant Competitive Advantage:** Companies that will quickly adopt this new technology will be able to get real-time information and hence make more informed decisions in their business. For example, a technician servicing a machine will be able to collect all relevant information for this equipment before servicing. He will then be able to make more educated decisions about the required service. RFID enabled cellular devices also allow for improved visibility of the company’s assets.

2. **Increased Productivity:** Using the RFID tag to uniquely identify an item drastically reduces the chance of human errors. RFID allows for quick automatic machine-to-machine updates and reduces the technician’s error prone work of typing long identifications codes. It also reduces the risk of misplacing information on an item, since the RFID tag info can be directly stored through the wireless phone network at the centralized database. Avoiding errors can be translated into less time spent on unnecessary actions and increased process efficiency thus increasing productivity.

3. **New opportunities:** RFID enabled cellular devices open new opportunities for services and products. Passenger-car-sharing company Flexcar exists only
because of its remote vehicle-usage monitoring system. The company found it impossible to build a profitable business model on a manual system that used people to collect vehicle usage data for billing. Using automatic machine-to-machine systems, Flexcar has grown in three years in 20 cities with estimated annual revenues of 10 million [5].

4. **Benefits for the Telecom Companies:** Cellular Telecommunication Operators have seen decreasing growth in their revenues due to the market saturation. About 75% of the European population owns a cell phone. RFID enabled cellular technologies are a new opportunity for cellular telcos for continued growth. The human communication market has reached a saturation point but machine-to-machine communication is still untapped [6]. If cellular telcos offer packages to enterprise customers for “invisible mobile”, non-human services, they have an new opportunity for growth that is not constrained from the population.

**Hurdles – Challenges**

The combination of RFID with cellular technologies can offer exciting benefits to enterprises and cellular telecom companies. However there are still many issues that need to be addressed for the above mentioned applications to take off:

1. **Cost of Materials:** Although the price of RFID tags and readers has been significantly decreasing, the RFID readers are still expensive to combine with a cellular handheld. Currently RFID readers cost between $400-$2000 significantly increasing the cost of a smartphone.

2. **Lack of quantifiable results:** Much have been said about how RFID and cellular technologies can improve productivity. However, it is not yet clear exactly how should this new technology be deployed and managed to obtain a significant ROI [8].

3. **Non-existent Interoperability:** RFID communication standards are still pre-mature especially for applications other than supply chain. If there are no standards, enterprises will be more reluctant to lock themselves on a single vendor’s proprietary technology. In addition, different countries adopt different standards making it harder for manufacturers to comply to all requirements.

4. **Privacy Fears and Wary People:** Many employees and unions protest that this technology will infringe on their privacy rights. Unless there is a legislation framework on what data can be collected using RFID technology, companies are reluctant to invest in order to avoid legal consequences [9]. RFID may also trigger distrust among employees who fear that improved visibility will disrupt the status quo. For example, if RFID sensors do not send data to the control room, past noon on Friday, the manager may think that the employee started the weekend early rather than thinking it could be some malfunction of the system [10].

5. **RFID Data Manageability and Integration:** Once enterprises start collecting automatically RFID data, there is an issue on how to manage this enormous amount of bytes and transform it into useful information. Companies like IBM, Accenture and Oracle are developing RFID management products that will facilitate this process, however these are new offerings requiring a lot of fine-
tuning and are usually custom made. In addition, the information collected from the RFID tags should be integrated with the rest of the IT infrastructure to offer some significant benefits and applications like this are still immature.

6. **RFID Reliability:** Although RFID system integrators like R4 Global Services, have tested RFID tags and found that the read rates of UHF RFID tags are between 95%-98%, the market still perceives that RFID reader rates are about 80% today. Enterprises require higher reliability to invest in this new technology. [11].

7. **Lack of marketing commitment:** This is a new technology that requires significant product commitment and advertising dollars to explain to the customers the benefits of the solution and how it improves existing processes [7].

**Market Landscape**

The market for products that combine RFID readers with cell phone technology is currently under development. Regardless of the challenges listed above, these technologies can open new opportunities to businesses and many corporations are researching at the right product and service mix to offer to their customers.

First, Nokia has launched its mobile RFID kit compatible with the Nokia 5140 phone, which is available separately. The kit contains two RFID readers, 20 RFID tags and the software for the phone tag reading, service initiation and configuration and is ISO 14443A compatible. The RFID reader is attached to the cell phone and can launch services and access phone functions by touching an RFID tag. Nokia’s first RFID and cell phone combination targets the mobile professionals that require up-to-date information or wish to log real time stamped data like meter readings [3][12].

Minec also sells handhelds that are GSM-enabled and can be equipped with an RFID reader. Minec is a Datalogic Group Company based in Sweden that specializes in complete systems for data collection in a wide range of industries. Its Minec 4x can be equipped with either a low frequency or a high frequency RFID reader [13].
Magnatec Technologie based in Germany, sells the “mobile scanner” for reading RFID codes and transmitting them over a GSM network [14].

Symbol, the leader in mobile IT solutions is lacking behind in RFID solutions. It has not yet launched any RFID product but is working on an RFID pilot program using prototype RFID enabled handhelds based on its MG9000-G model. It will send RFID data wirelessly to a centralized database. The main focus of Symbol’s RFID efforts is in RFID integration with existing identification solutions such as barcodes. Communication is achieved using a wireless LAN. The company plans to make the product widely available in 2005 [15]. Exhibit 2 shows some of the products available in the market.

GSM enabled handhelds equipped with an RFID reader typically sell for $1,200 to $1,500 however the Nokia kit should be less than that since the GSM-enabled phone is sold separately and does not have all handheld computer functionality [12].

### Competitive Solutions

Depending on the application, RFID enabled cellular technology competes with different technologies. The main competitor though is using RFID in conjunction with Wireless LANs and the Internet, instead of the wireless phone network to connect to the management station. This solution requires different, possibly cheaper, hardware but assumes that a Wireless LAN is available at the places where RFID tags are placed. WLAN coverage is not as spread as the wireless phone network hence for some applications that apply to the mobile professional, RFID on a cell phone will be the appropriate solution.

Concerning location based applications RFID competes with GPS. There are quite a few differences between the two technologies hence the appropriate solution depends on the application. RFIDs can give relative position in contrast to GPS that provides absolute position. With RFID the reader has to be relatively close to the tags hence users have to be conscious of the tagged object. In GPS, there is a mapping between a GPS value and a location (a park, a campus, a home etc). This mapping becomes complicated when objects move around. GPS is more expensive to add on a handheld device than an RFID reader. In addition, sometimes GPS has bad indoor reception, while RFID tags do not have this problem. However location based applications using RFID technology limits the extensibility of a network on the physical tagging of spaces and objects. If the tag is lost or removed the accessibility to this location’s services is lost.
Business Model

RFID-enabled cell phones is a combination that can simplify the way people perform several activities in their personal and professional life. The short-term economic benefits though, reside on the enterprise market hence the suggested business model focuses on this area.

Companies involved in the RFID-enabled cell phone market can have quite different business models, depending on their offerings. Handheld manufacturers will generate additional revenue by selling new RFID enabled cell phones. The telecom operators will be able to offer new added-value services on top of their phone network. Machine-to-machine communication can be a considerable source of increasing revenues for the years to come. In addition, other companies that will provide integration of this new technology with the existing IT systems will also receive additional revenues for software integration, consulting, support and maintenance.

Conclusion

RFID and cellular technologies is a promising combination that can increase productivity and give a competitive advantage to those that endorse it first. However, there are still some economic and standardization issues that need to be addressed before the technology sees wide acceptance. Mobile enterprise applications are going to be the first beachhead of RFID enabled cell phones followed by consumer applications in the long term. Cell phone and mobile IT solutions companies have just started introducing their RFID enabled handheld offerings with Nokia being a leader in this area. Finally telecom operators will also see significant increase in revenues if they promote the “invisible mobile” applications where RFID and cellular technologies are used.

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Dora Karali
UCLA Anderson School of Business
Introduction

- RFID in the spotlight since WalMart and DoD announced RFID mandates for their suppliers
- Useful in Supply Chain and Retail
- BUT… also useful to improve business processes, especially when integrated with existing infrastructure
- Focus on combination of RFID and cellular technology
Outline

- Technology Overview
- Applications
- Benefits
- Challenges
- Market Landscape
- Competitive Solutions
- Business Model
Technology Overview

- Smartphone with embedded RFID tags
  - Used for credit cards and other user identification applications
- Smartphone with embedded RFID reader.
  - Main focus of the project
Smartphones with RFID readers

- Can connect to a GSM or other wireless phone network
- Embedded or attached RFID reader
- 2 Antennas: RF + GSM
- Power consumption
- Reader should fit the size of a handheld
- HF ~15Mhz
Software and Standards

- Cell Phone should include SW to read/write RFID tags, initiate calls, send SMS alerts etc.
- Security, basically for RF transmission
  - Short Range
  - CryptoRF specializes on encryption and authentication of RF transmissions
- Standards
  - Different Frequency standards in Different Countries
  - EPCglobal set the RFID tag format
  - ISO 14443 RFID communication spec.
Applications

- Use the product's tag to connect real time to the item's entry in a DB
  - A technician touches the machine to service with his RFID smartphone and gets up-to-date info on the last service performed, service instructions etc.
  - An engineer uses his RFID smartphone to get the machine's tag info that links to a page to enter the reason of failure.

- Automatic Asset Tracking
  - Count Devices in a remote site
Applications cnt’d

- Collect Real Time Info
  - Location Based Services – Security firm monitors the guard patrol’s routes
  - A tag is attached on a temperature meter, by touching with the cell phone the measurement is sent to the DB.
  - Record Travel Expenses

- Consumer Marketing
  - Place the RFID cell phone on a poster promoting a new single and watch the vide clip or buy the single

- Use RFID to initiate calls
  - Emergency Calls
  - Calls for children or disabled
Benefits

- Significant Competitive Advantage
  - Real-Time info -> Better Decisions
- Increased Productivity
  - Avoid Human Errors, Machine to machine communication
  - Less Errors -> Time spent more efficiently
- New opportunities
  - Flexcar
- Benefits for telecom companies
  - Saturated market
  - Invisible Mobile services new!
Challenges

- Cost of Materials
  - Cost of an RFID reader: $400-$2000
- Lack of Quantifiable results
- Non-existent interoperability
- Privacy Fears – Wary People
- RFID Data Manageability and Integration
- RFID Reliability
- Lack of Marketing Commitment
Market Landscape

- New products just being introduced
- Nokia RFID kit on 5140 phone
  - 2 RFID readers, 20 tags, SW, ISO 13334A
- Minec (Datalogic Group) Minec 4x
- Magnatec “Mobile Scanner”
- Symbol in prototype: MG9000-G RFID combined with WLAN
- Cost: $1,200-$1,500, Nokia Kit less
Competitive Solutions

- RFID combined with WLAN -> Internet
  - WLAN not always available
  - May be cheaper

- Location Based Services: RFID vs GPS
  - GPS absolute location RFID relative
  - GPS mapping between GPS value and a location/object hard to maintain if object moves
  - GPS indoors reception weak
  - If RFID tag is removed, location based services are lost
  - Need to add a tag for every object/space participating in the network
Business Model

- Short –Term Economic Benefits from Enterprise Market
- Long –Term Benefits from Consumers
- Revenues from:
  - Manufacturers: Sales of RFID enabled cell phones
  - Telcos: Invisible Mobile Services
  - Revenues from offering integration with existing IT infrastructure, software, consulting, support and maintenance
Conclusion

- RFID and cellular technologies is a promising combination
- First the enterprise market then consumer
  - Can offer to enterprises competitive advantage and increased productivity
  - Economic and standardization issues to be resolved
- Nokia leader in the area
- Telcos will see significant revenues from the adoption of the technology