The Integration of Ontologies and RFID NFC in Healthcare

Author

Darcy, Peter, Binnewies, Sebastian, Stantic, Bela

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The Integration of Ontologies and RFID NFC in Healthcare

Peter Darcy, Sebastian Binnewies, Bela Stantic

Griffith University, Institute for Integrated Information Systems
Brisbane, Queensland, Australia
E-mail: {P.Darcy, S.Binnewies, B.Stantic}@griffith.edu.au

Abstract: **Radio Frequency Identification (RFID) Technology uses wireless technology to seamlessly identify a large amount of tagged objects within a close proximity. With the increase of Smart Phone adoption and the continual advances in the technologies present for users, there have been many applications available to the public. One of the recent additions to mainstream Smart Phones is Near Field Communication (NFC) technology which will allow the devices to read RFID tags allowing it to become a cheaper and mainstream alternative for RFID readers. In this paper, we propose a methodology that takes advantage of NFC capabilities and intelligent ontology software to provide health professionals with an efficient method of delivering treatments to patients. We then conclude this study with a discussion of the strengths and potential drawbacks of the proposed methodology.**

1. INTRODUCTION

In recent years, many RFID applications have been used in various environments using hardware-specific devices capable of scanning multiple items for tracing in warehouse-like scenarios. One of the major drawbacks to investing in these architectures are the costs associated with the devices needed to properly build a RFID-enabled environment. Fortunately, smart devices have recently had NFC technology integrated into its hardware allowing the device to read tags. This has also opened up a new area of research for all researchers investigating novel concepts of RFID integrated applications.

In this paper, we propose a system that utilises RFID technology found in common Smart Phones and intelligent ontologies to conveniently improve the efficiency of diagnosing and recommending treatments to patients. We have found that the core strengths of this concept are the potential worldwide audience and the mobile nature of the devices. The potential drawbacks hindering our concept are the limited range of NFC and hardware-specific tags, however we have devised our concept to not be influenced by these problems. With regards to opportunities, we would like to integrate our concept with already available Smart Phone automatic diagnosis software which will then add another level of integrity to the treatements recommended. Potential threats include wrong conclusions arrived by the device, however we believe that we can counter this problem by integrating intelligent classifiers and up-to-date ontologies thereby limiting this issue.

The remainder of this paper has been organized as follows: Section 2 will discuss RFID and NFC technologies, and provide the reader with an overview of ontologies. Section 3 will contain the concept overview of the main contribution proposed in this paper including a what the software will contain and a breakdown of how the software and hardware technology will interact. We will then provide an analysis of the strengths and potential drawbacks of the proposed methodology in Section 5 before concluding and providing a discussion of future work we will be investigating with the proposed concept.

2. BACKGROUND

Recent advances in Smart Phone technology have integrated Near Field Comunication technology into the hardware of the device. This has allowed RFID researchers the opportunity to implement and study applications using mobile devices and to employ the technology in scnerios that would not originally be possible several years ago. In addition to the advanced hardware embedded in Smart Phones, there has also been an increase in storage with most devices having 8GB-16GB onboard memory with 32GB expandable memory allowing advanced intelligent software such as ontologies to be integrated into the software.

2.1 Radio Frequency Identification (RFID)

Radio Frequency Identification (RFID) technology allows a large amount of tagged objects within a certain proximity to be scanned and automatically identified. It is currently employed in various commercial sectors such as pet identification, airport luggage tracking and postal package tracing [6,7]. As seen in Figure 1, the basic architecture of

RFID technology contains a tag which will be attached to an object, a reader that will interrogate the tag, the middleware that filters any easily detected anomalies and the RFID Centralised Data Warehouse that stores the massive amount of data.

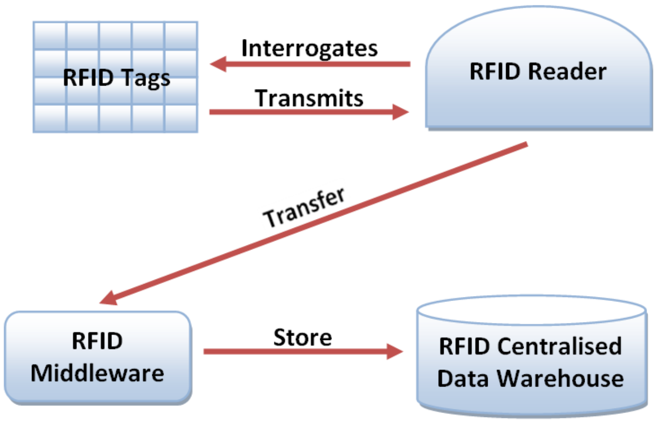

Figure 1 – General RFID System Architecture

There are several types of tags available to the user for RFID integration which are classified into either: active, semi-active and passive. Active tages use battery power to enhance the signal strength and range of the tag, Semi-Active also uses a battery but only to enhance the range resulting in a longer life span and the passive tag which uses the power from the electro-magnetic pulse of the scanning reader to beam back its identification details. While all three tags have been integrated into various applications, of the three, the passive tag is the easiest and most cost effective to implement due to its reasonable price and no battery being required [3].

2.2 Near Field Communication (NFC)

Near field communication (NFC) is a set of standards for smartphones to establish short-range wireless communication with each other by bringing them into close proximity. Applications include contactless transactions, data exchange, and more complex communications such as Wi-Fi [10]. Communication is also possible between an NFC device and an unpowered NFC chip, called a "tag". NFC always involves an initiator and a target; the initiator actively generates an RF field that can power a passive target.

In contrast to Bluetooth, NFC automatically establishes connection between two NFC devices at a faster rate. NFC standards cover communication protocols and data exchange formats, and are based on existing radio-frequency identification (RFID) standards such as ISO/IEC 14443 and FeliCa. NFC have already been implemented in many applications such as mobile payments and loyalty card systems [5].

2.3 Ontologies

In essence, an ontology groups entities of some domain under consideration and relationships between them into categories. Depending on the ontology specification language, we can express different kinds of entity and relationship constructs in the ontology. An ontology that models entities as classes with only a subclass-superclass relationship between them (i.e., all entities of some category are contained in another category) is equivalent to a taxonomic hierarchy [11].

The main purpose of an ontology is to establish a common terminology in a domain in order to facilitate knowledge exchange and reusability [8]. This is realized, for instance, in the internationally used ontology SNOMED CT (Systematized Nomenclature of Medicine - Clinical Terms), which contains a terminology of clinical terms in several languages [9].

3. METHODOLOGY

In this research, we are proposing a concept that integrates three novel research areas together to deliver a revolutionary means of diagnosing and delivering a treatment. Using Smart Phone technology, we intend to wirelessly input medical drug information using RFID/NFC technology and intelligent ontologies to not only diagnose a patient's treatment, but also develop alternatives with the information available.

3.1 Motivation

With the exponential rise of Smart Phone adoption among the modern society, there has not only been a decrease in the costs of such devices, but also a steady increase in advanced hardware integration. Already, there have been novel research contributions that have been developed specifically for smart devices that would not have been possible several years ago. As a result, we are finding that it is possible to distribute software easily worldwide that could potential benefit society as whole. With this in mind, we have decided to develop software that will allow users to not only easily diagnose themselves with the current state-of-the-art medical ontologies, but also conveniently suggest alternative treatments when the primary treatment is unavailable.

3.2 System Architecture

As seen in Figure 2, the proposed system is broken up into three fundamental stages of data transfer, the Input, the Processing and the Output. The input requires the user to

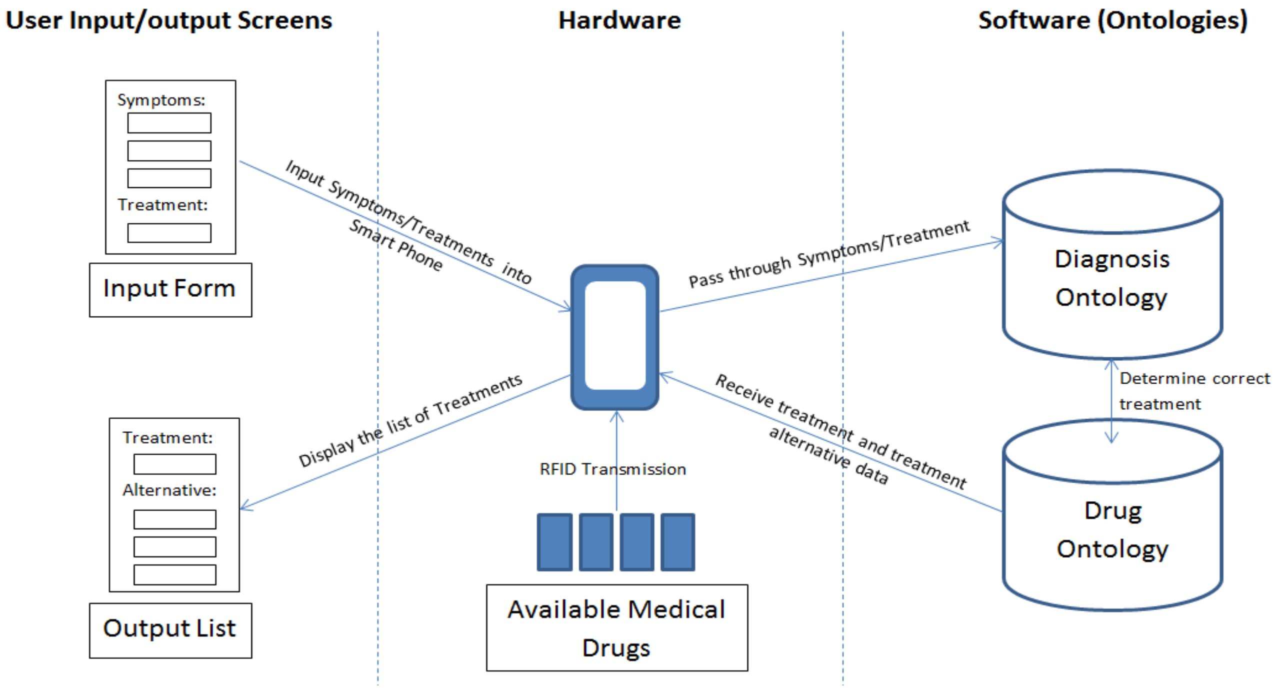

Figure 2 – The Proposed System's Architecture

interact with the Smart Phone by inputting the symptoms/treatment. After this input has been received, the software will interact with the diagnosis and drug ontologies to first determine the treatment, then output the correct treatments with the available information. Finally, the Smart Phone will display all available options from most to least relevant to the user along with the reasons as to why it was chosen.

Input

The interface will be a standard form where the user can input multiple data fields to determine the treatment or alternative treatments best suited for the situation. This specific fields that will be available to be input include the symptoms of the disease (up to 3 can be chosen) or the treatment itself if an alternative is only required. For scenarios in which time is not critical, a second form is available for user to specify allergies, heart rate/pressure and other information that may be needed in determining the optimal treatment.

In addition to the manual input needed for the diagnosis, the NFC technology will be used to input the medical drugs available to the user. This would involve waving the device over the containers which will contain RFID tags uniquely identifying it. The phone will then use a look up table to match the identification number present on the tag with the drugs kept in its memory. This will then be used with the ontologies to extract further information about the formula of the drugs.

Processing

Once the software has received the information from the symptoms, treatments and all the medical drugs available to the user, the system will interact with the diagnosis ontology. This will be primarily used to define the problem with the patient and then determine what treatment would be most effective to help the person. The information taken from the diagnosis ontology will then interact with the drug ontology to determine which medical treatment would be applicable to the user.

In the event that the immediate treatment is not applicable to the patient, for example one of the drugs are unavailable, the ontology will also be used to derive alternative treatments such as a combination of available drugs to produce similar effects that the immediate solution would have given. This will be accomplished by first taking the data gained from the RFID tags identifying which drugs are currently available. Given the list of available drugs and using the drug ontology, the software will examine the brandname, formula and properties to suggest intelligent alternatives that may be used in place of the first suggestion. We intend to integrate already established and state-of-the-art ontologies that have already been utilised to diagnose and identify or manage medical drugs [2].

Output

The resulting list from the software will contain an easy to read list of most to least relevant drugs optimised for mobile phone devices. From this list, the user can then click on one of the suggested treatments to find the formula properties and general information about the drug with an included statement as to why it was chosen as an alternative treatment. From designing this process to be user friendly, we believe that there will be a definitie increase in efficiency for the time between the diagnosis and treatment suggestion.

3.3 Environment

The propsed concept in this paper has been designed to be created and executed on a mobile device. In particular, we have chosen an smart phone running the Andoid operating system (Ice Cream Sandwich 4.0.4) due to its ability to compile Java programs and its free Play Store distribution. In addition, it was important to have NFC capabilities in the phone to allow for reading of RFID tags. The Android phone also provides NFC abilities in the form of its Android Beam technology [1]. To create the program itself, we have chosen to compile and execute the Java program using the Eclipse IDE. Eclipse also simulates a virtual Smart Phone allowing us to experiment with the functionality of the software before loading it onto the physical hardware device. For all physical testing of the software, we have used the Samsung Galaxy S3 smart phone device due to its relative small cost and extensive hardware capabilities.

4. ANALYSIS

To analyse the significance of the concept presented in this paper, we have provided a SWOT (Strength, Weaknesses, Opportunities and Threats) highlighting the novelty of the metodology. For every weakness and threat identified, we have also provided reasoning as to how our approach addresses these shortocmings.

4.1 Strengths

The fundamental strengths of this concept is that the technology is available worldwide and the software can be distributed free of charge. Smart Phone technology has been integrated into the majority of society due to its advanced capabilities and fast connection speeds. This benefits our concept as the software can potentially be run on devices worldwide being distributed to a larger audience than computer-specific software.

In recent years, the Smart Phone market has been dominated by both the Apple iPhone and Android devices leading to them becoming the dominant distributor of modern mobile phones. One of the biggest advantages of the Android business architecture is its open and free marketplace (recently renamed Google Play Store) which allows aspiring software developers to create their programs using Java, upload their code to their phones for testing and distribute it without having to pay for licensing fees. This would allow us to not only create and distribute the software, but also continual updates in real time with improvements made to the ontologies or software architecture based on feedback. This also would increase the shelf-life of the software allowing for new advances in medical science to be integrated into the software as they become available.

4.2 Potential Weaknesses

Near Field Communication unfortunately has a limited range for reading tags rendering large scans of tags not possible. However, we have considered this limitation in our research and have specifically developed the approach to read each tag one-by-one which will decrease the efficiency but enhance the integrity of the readings. Additionally, from early experimentation of the NFC technology, we have found that the device will not read every RFID tag available, however this can be addressed by specifically developing the tags.

4.3 Opportunities

With the increase of hardware integration into smart devices, there is a potential opportunity to improve the software to automatically detect input using the sensors on the device. In particular, we would like to investigate the possibility of integrating already existing research into medical scanning smart phones into our architecture to improve the treatment detection [4, 12]. For example, if the device could detect the amount of red blood cells present and take this into consideration when diagnosing the patient leading to a higher level of integrity in the treatment or treatment alternatives. We would like to inverstigate this potential of technology integration in future research.

With regards to the potential drawback of the limited range of NFC technology, we would like to investigate the possibility of extending the range allowing for group scans of the medical drugs available. We would specifically like to investigate this through enhancement of the signal or with further iterations of the Smart Devices having larger scopes for RFID interrogation zones.

4.4 Potential Threats

While intelligent ontologies will be used to determine the diagnosis/treatment of an individual, there is a possibility that the wrong conclusion will be derived for the individual. To counter these potential issues, we intend to introduce intelligent techniques to further enhance the ontologies such as Non-Monotonic Reasoning or Support Vector Machines. With these classifiers in place, we believe the conclusions derived from the ontologies will have sufficient intelligence to deliver a valid treatment/alternative treatments.

5. CONCLUSION

In this paper, we have discussed the importance of modern day smart phones and have provided a novel concept of applying it to enhance healthcare. We have done this proposing a system that will first record symptoms, treatments and available medical drugs, then using intelligent and state-of-the-art ontologies, arrive at a set of treatments to administer to the patient. We believe that the wide-scale audience and the mobile nature smart phones will allow this approach to enhance the efficiency of diagnoses for individuals that need to determine a set of treatments.

With regards to future work, we plan to completely implement the concept we have discussed. This will be done by first using the Eclipse IDE to develop the relevant software that interacts with the ontology API and then uploading it onto the smart phone. After this, we would like to run pilot trials with over-the-counter drugs to demonstrate the significance of our methodology. Eventually, we would like to distribute this software on the Google Play Store. Finally, as stated before, we would like to integrate existing medical smart phone applications to enhance the integrity and functionality of our core concept.

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