Mobile RFID based Traceability for Tracking Seeds and Fuzzy Logic Applications

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ABSTRACT
mAgriculture is a subset of eAgriculture, referring to the delivery of agriculture- via mobile communications technology.Agricultural traceability refers to the collection, documentation, maintenance, and application of information related to all processes in the supply chain.Innovative technology of integrated RFID and mobile computing are fast being used for integrated traceability systems.This paper proposes to provide a model of communication which would harness the capabilities of RFID technology and mobile technology to provide agricultural vendors and institutions to track the seeds purchased by farmers from them (the RFID tagged seed bags) to find how they are being used for cultivation and get feedback from the farmers about the health of the crops after seed utilization and provide various advisories to them if required.Also the RFID data accumulated over a period of time can be used for analytics and a fuzzy approach to analyze the data using the concentration of the seed purchasers in particular areas which would enable the vendors to establish an effective network of their customers. The paper envisages providing an overview methodology for the same**.**

General Terms
mAgriculture, Agricultural traceability, Fuzzy Logic

Keywords
Traceability in agriculture, RFID systems, Analytics, fuzzy logic based decision making

1. INTRODUCTION
Information and communication technology have played a vital role in agriculture in most parts of the world. Recent studies indicate that mobile phones like other digital technologies have proliferated the agricultural scene [2]. This has helped the farmers in many ways such as helping them to get information at lower costs, make agri-marketing more efficient, reduces transportation costs at a platform to deliver services and innovate.

In the future, internet will not only connect people and data but also objects (anything). That is, the communication on the internet may no longer be only at the machine level,but at even more micro-level. An Internet can detect and monitor changes in the physical status of connected objects through sensors and RFID in real time.[1].

In this paper, we propose a methodology to apply the mobile based communication technology and RFID based system for a case study for seeds tracking which can enable the agricultural vendors/institutions and farmers to communicate with each other effectively in the supply chain.The paper also suggests also how data analytics based on fuzzy logic techniques can provide an insight to improve the same.

2. BRIEF REVIEW OF THE TECHNOLOGY AND APPLICATIONS
The proliferation of mobile phones across the globe has impacted on agriculture in various ways. Mobile applications for agricultural and rural development (m-ARD apps) could provide the most economic, practical, and accessible routes to information, markets, governance, and finance for millions of people who have been excluded from their use. An example is where a farmer can get commodity prices in various urban markets through a simple request made on a mobile phone. Apps that require a low level of literacy to understand m-ARD apps,can provide farmers with direct, immediate benefits such as timely and improved access to rural extension and advisory services and market links.

Traceability is the new buzzword in agriculture and it refers to the ability to record or document the information about each and every step in the agriculture process chain [3]. New opportunities for traceability come from the RFID technology. Unlike barcode technology, RFID has several advantages such as multiple reading at a rate of 1000 tags per second that makes it not only a feasible and cost-effective candidate for object identification but also a significant tool to provide visibility along different stages of the supply chain [4].

RFID technology in recent times is fast being deployed in awide variety of applications such as health-care,agriculture,transportation etc.this can be attributed to the recent advancements in in chip manufacturing and also open standards(ISO/IEC 18000) and its sustaining ability in extreme enviroments

2.1 Storage and Retrieval of Data in RFID Systems
There are three key components in RFID systems [5]:

- Tags or transponders which carry object-identifying data,

- Readers which read/write tag data and
- Databases which associate record swith tag identifying data.

Tags offer different functionalities such as Datalogging Electronic article surveillance, environmental sensors and Ad-hoc networks.

They have different power sources-active,semipassive and passive, sensor tags etc and can operate at different radio frequencies(Low Frequency (LF)(120-140KHz) to Ultra-Wide Band(UWB) (3.1-10.6Ghz))

Readers act as interrogators and intercept the tags using simple ping or more complex multi-round protocol.Also they may be required to perform anti-collision protocol.They can also be integrated on hand-held mobile devices and also cellular phones(Nokia).They energize the tags(passive) and can operate at various frequencies and may also offer network connectivity.

Databases map tag-identifying data to records which contain product information, sales/patient datatracking logs, expiry dates etc. By using a Object Naming Service it can be easy to locate a database for the reader.

Several different possibilities for seperating the data between the transponder/tag and the database depending on the application and type of data–the degree of structuredness,complexity and sensitivity of the data have been suggested in [6]

The EPC schema to encode a GTIN (Global Trade Item Number)is the SGTIN which consists of the GTIN plus a unique product or serial number. The SGTIN scheme has three different encodings 64, 96, and 198T. The EPC Tag URI denotes the specific SGTIN encoding (SGTIN-96) as well as introduces the Filter Value which denotes the packaging level of the item. The figure below shows a sample tag-scheme.

Table1:EPC SGTIN-96 sample format 1

Header	Filter	Partition	Company Prefix	Item id	Serial #
8bits	1(3 bits)	5(3 bits)	12345(24 bits)	67890(20 bits)	10479832 (38 bits)

2.2 Some Examples of Mobile-based RFID Applications

The use of RFID throughout supply chain provides manufacturers ,suppliers and retailers unprecedented potential benefits and uses. The design and implementation of an RFID-based reliable and efficient solution to track lost kids in a large open area has been provided in [7] .The system allows e.g. security officersto monitor the position of "tagged kids" from a sufficientlylarge distance that reveals the position of a kid at anytime and anywhere in the coverage area. Using Internet-enabled mobile phones, farmers can easily input records about farm activities and material applications during outdoor work. In order to identify individual products on the distribution process more efficiently, small RFID tags are attached with unique ID numbers. Each RFID tag on a product relates to its production data on the database. In the distribution process, workers read the RFID tags using RFID readers, and transit records of the products are inputted to a database this has been suggested in [1].

3. PROPOSED METHODOLOGY FOR THE RFID AND MOBILE BASED SYSTEM

The proposed system is based on the model suggested in [7,8]

- The hardware architecture consists of an RFID active tag, RFID tagreader, web server and database server.
- The web server and database server would be located in the master station.
- The tags would be attached to the seedbags as they are transiting from the datawarehouses at the site of agricultural institutions/vendors.They would be containing the necessary profile information about the purchasers such as the Name of the purchaser,time stamp, place it where would get delivered (village/taluk/city)which would give an initial lead in the traceability of the seedbags. The system requires the usage of RF (Radio Frequency) active readers The tag readers would be distributed across the strategic locations (locations where the seed purchasers are located.).
- The system shall be able to provide the user with the following information, at any time, when required: Reader ID and Tag ID, detected at anytime by any reader.
- The system shall have an Application Programming Interface that will open the serial port between the reader and the PC.
- The system shall have an Application Programming Interface that will enable readers and will enable tags
- The system shall be able to state whether the seedbags is in the area covered by two readers or more.
- The system shall be able to mention which reader(s)detected the seedbags
- Communication module that handles all the communication functions that are done at the Master station using a wireless access point that links the tag reader with the monitoring station and database server.
- The Graphical user Interface (Web-enabled/Mobile application) would have the features to interact with Farmers/purchasers for sending and receiving the advisories and feedbacks and also perform the operations related to traceability such as Enable and disable tags and Get the status of the tags.
- The Database server would consist of the appropriate data tables to keep information about the tags themselves ,the readers and the timing information when the tags are detected.

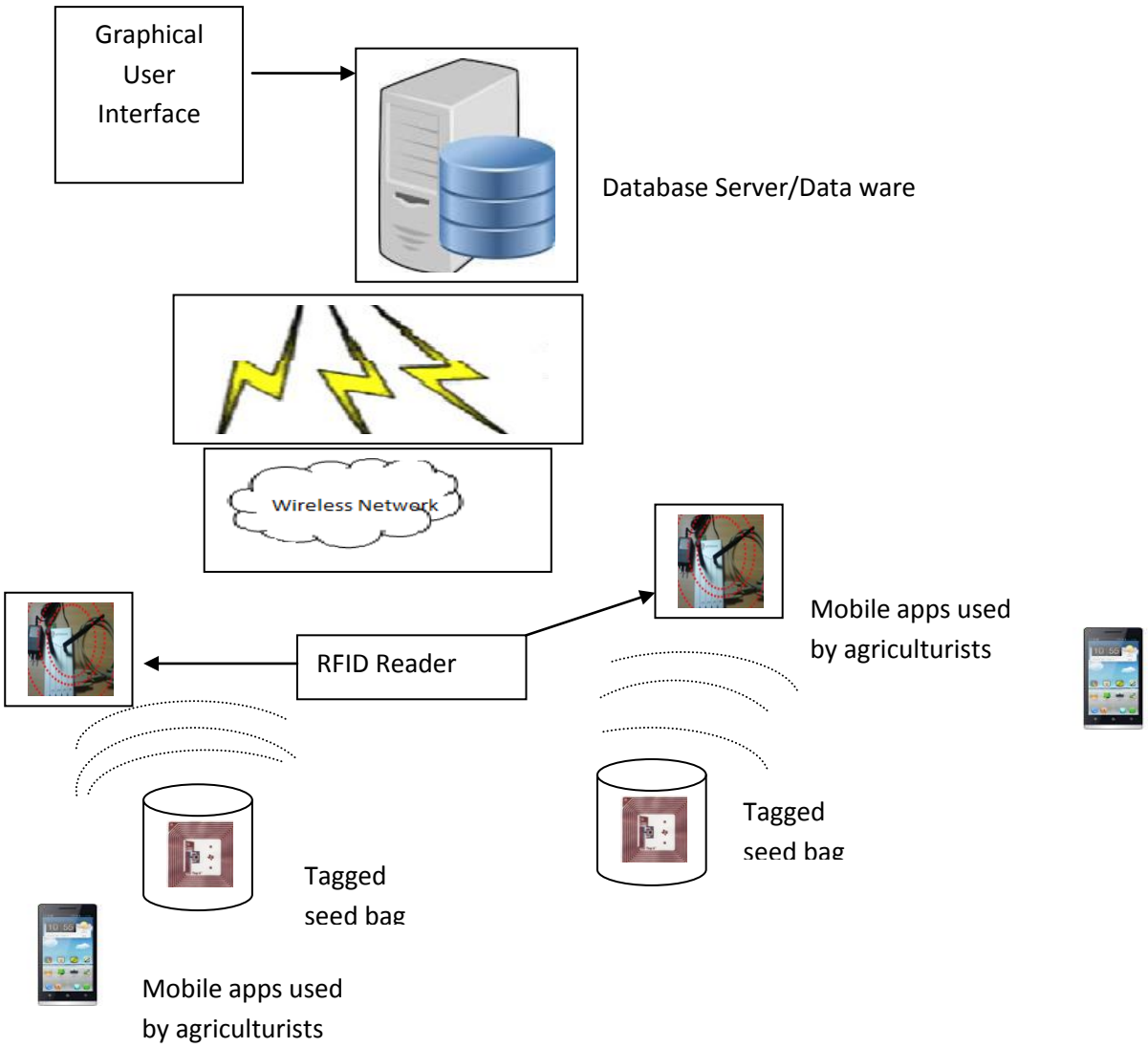

Figure 1:An architecture for the proposed Methodology

4.ANALYSIS OF RFID DATA

The RFID data contains two basic categories of data, corresponding to *static* and *dynamic* data. The static data is related to commercial entities such as location information, product level information, and serial information. There are two kinds of dynamic data: (a) The first corresponds to *instance data* such as serial number and the date of manufacture;and (b) The second corresponds to *temporal data* such as location observations and temporal changes in the containment of objects. In the RFID system, entities are static, but the relationships between them are dynamic[9].

In[9,10] the authors have described the integration techniques of data from various sources and also proposed algorithms which can be used for refining and filtering the data of redundancy.

The general scheme of storing the data each time the tag is sensed can be represented as a tuple (EPC_i,loc_i,t_i) which are buffered in the local memory of the data readers until they are transmitted to the next stage.

One common approach to eliminate the multiple occurrences of the same data would be to maintain a temporal window of

size m and by introducing four parameters in the tuple (EPC_i,loc_i,t_{start},t_{end}) where, t_{start},-t_{end} is the epoch duration.

RFID assimilation involves creating a RFID enabled environment which includes data analytics and deriving a business value through properinsight.For example in recall management cases can be tracked, visibility needed to know whether shiiping was accurate and inventory accuracy etc. as mentioned in [11]

3.1 Fuzzy Bayesian Decision Making of the RFID Data

The Bayesian method of decision making is based on predicting the future states of nature by characterizing them as probabilistic events. This can be extended to include the possibility that the states of nature are fuzzy and the decision makers' alternatives are also fuzzy. In the present case study of our consideration we make a theoritical application of the Fuzzy states decision making[12].

Let us assume that the RFID data accumulated in the database is cleaned and filtered and we need to take a decision based on, which location farmers or agriculturists are transacting more in terms of the queries/advisories(which is coupled with the RFID data).

Assume that we have the case that there are n *fuzzy regions*: $\underset{\sim}{R1}$, $\underset{\sim}{R2}$ ... $\underset{\sim}{Rn}$ and the *fuzzy states* characterizing the fuzziness in the transactions made are represented as : $\underset{\sim}{A1}$, $\underset{\sim}{A2}$ ... $\underset{\sim}{An}$ where $\underset{\sim}{Ai}$'s could represent fuzzy values such as Poor ,Low, Moderate ,High,Veryhigh,defined on a universe of numerical rate of transactions say S={s1%,s2%,s3%,s4%,s5%}.The fuzzy states have to be orthogonal sets with the condition $\sum_{1}^{5} \mu \underset{\sim}{Fs}(si)$ =1.

A utility matrix to express the value of all Fuzzy regions-states can be as follows:

Table 2: Utility values for Fuzzy Region/ States of nature

	$\underset{\sim}{A1}$	$\underset{\sim}{A2}$	……	$\underset{\sim}{A5}$
$\underset{\sim}{R1}$	*u11*	*u12*	…….	*u15*
$\underset{\sim}{R2}$	*u21*	*u22*	…….	*u25*
……	…….	……	…….	…….
$\underset{\sim}{Rn}$	*un1*	*un2*	…….	*un5*

This could be a measure of how much a particular region is a potential user of the seeds .

The expected utility of alternative fuzzy state of nature $\underset{\sim}{Ai}$ can be calculated as $E(u_j) = \sum_{1}^{5} u_{js}\, p(\underset{\sim}{Fs})$ *where* $p(\underset{\sim}{F_s}) = \sum_{1}^{n} \mu \underset{\sim}{Fs}(si)\, p(si)$ and maximum utility is $E(u^*)=\max_j E(u_j)$

By computing the maximum utility the vendors can get an idea where the seeds are cultivated to a large extent and also can get a proper feedback on the quality of the seeds.

who have contributed towards development of the template.

4. CONCLUSION

In this paper a brief discussion on the potential application of mobile and Rfid technology has been made. Also a case study of application of these technologies to tracking seeds used in agriculture for traceability has been presented. Finally an attempt has been made for applying fuzzy logic to analyze the data has been made which is based on theoretical method .However the experimental study has to be carried out and this is being considered for future research work with real time data.

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