Healthcare Monitoring System using Near-field communication

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***Abstract*—**In this paper, a new healthcare system has been proposed that will provide patients with a NFC tag. The NFC tag contains patient information. NFC smart tag can be used when patients and Elderly People go to hospitals or emergency units. Instead of carrying many files they can simply carry the smart tag. Such smart tag can be read using a reader either using smart phone or a reader connected to PC in order to retrieve patient information when placed near NFC tag. This tag can be assigned to patient with a unique ID at the time of registration. Every time the health checkup is performed, it will be updated. This improves patient's identification by eliminating the paper based documentation work by decreasing mistakes in healthcare. Pharmacist can also view medicine prescribed by the doctor. Data log are stored on centralized cloud server NFC can be used also to identify, query, and update patients data form the server. Doctors can view medical records by tapping his Smartphone that is enabled with a NFC reader over the NFC tag. Such system will improve the quality of healthcare sector by reducing clinical errors resulting of lack of medical information and prescriptions.

***Keywords*—**Near Field Communication (NFC), NFC reader, Patient health record.

I. Introduction

In recent years many recognition systems have been proposed and used. But these systems have been applied for patients. In this project, a mobile patient recognition system is implemented for Android Operating System (OS). Where the medical center employees or general physicians writes the patient information on the NFC tag through the android application GUI (Graphical User Interface); the information includes the vehicle type, model, color, registration expiration date (validity date) and the plate number. The medical center or emergency units will read the stored (written) information on the NFC tag. All needed is approaching the android device (must be supported with NFC) to the NFC tag and the application will display the stored information.

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The advancement of technology has definitely changed the way people live their lives. Cellular telephones, laptop computers, wireless technology, and digital music players have all affected modern society in ways unimaginable just 15 years ago. The Hashemite Kingdom of Jordan suffers from absence of electronic system to monitor sick. The current system relies on direct visit of the patient to the doctor. Current system doesn't provide an electronic system that combines the patient's data such as laboratory tests results, X-rays, procedure done by physicians and medication taken by patients. Lack of such data complicates the job of physician in diagnosing patient cases. Current System is using bar code scanners which rely on unchangeable information stored in the bar code. Scanner could not read the data when the barcode is being damaged. This will cause failure patient identification.

In this paper, an NFC based Android application is implemented that can extract patient information. The doctors writes the patient information on the NFC tag through the android application GUI (Graphical User Interface). The medical information of the monitored elderly people may include Blood pressure Levels, Blood Glucose Levels, Cholesterol levels, Temperature, Heart rate, Oxygen level in blood, and other laboratory tests such as Creatinine Laboratory Test and Potassium Laboratory Test. Creatinine Phosphokinase (CPK) Laboratory Test and Transaminases Laboratory Test (either ALT or AST). The doctor will read the stored (written) information on the NFC tag. All needed is approaching the android device (must be supported with NFC) to the NFC tag and the application will display the stored information. Having such system will faster and improve the communication between different units in the health system of Jordan. This will help physicians in hospitals by faster the access to the updated patients' data and enhance the diagnostic stage in real time. Hospitals and medical providers will also benefit from the proposed system in exchanging patients' data and medical knowledge at much faster rate.

Near Field Communication or NFC is an emerging technology for electronic devices which allows them to communicate with each other by simply touching or bringing them very close to each other. This act of communication is called 'to tap and go' or 'tap-in'. Using NFC, communication could take place between two active devices such as cell phones or even between a NFC device and a passive (or unpowered) 'tag'(Fig 1). Currently, NFC has applications mostly in the field of contactless electronic payment.

Figure 1: Tap- in concept.

NFC as one of the enablers for ubiquitous computing is a combination of contactless identification technologies which requires bringing two NFC compatible devices close to each other essentially touching them. User first interacts with a smart object (either an NFC tag, NFC reader, or another NFC enabled mobile phone) using her NFC enabled mobile phone (NFC mobile). After touching occurs, NFC mobile can make use of received data, or can use provided mobile services such as opening a web page, making a web service connection etc.

NFC is a bidirectional short range, wireless communication technology. The communication occurs between two near devices within few centimeters. 13.56 MHz signal with a bandwidth not more than 424 Kbit/s is used. NFC technology is based on Radio Frequency Identification (RFID) technology and can operate in card emulation, reader/writer, and peer-to-peer operating modes where communication occurs between a mobile phone on one side, and an NFC reader, a passive RFID tag (NFC tag), or a mobile phone on the other side respectively. Up to now, many NFC trials are conducted over the world, especially in payment domain. All trials conclude the fact that with the development of NFC technology, mobile phone is subject to become safer, more convenient, speedier and more fashionable physical instrument.

The main advantage of NFC is that NFC devices are often cloud connected. "Connected" credentials can be provisioned over the air unlike a standard card (Hotel or visitor applications). All connected NFC enabled smartphones can be provisioned with dedicated apps, which gives any application hundreds of millions of potential dedicated readers in opposition of the traditional dedicated infrastructure of ticket, access control or payment readers. All NFC peers can connect a third party NFC device with a server for any action or reconfiguration [1,2].

NFC technology covers a wide range of applications and these applications provide real implementations or prototypes with experimental evaluations or testing studies. Since NFC applications became an attractive research area, several promising applications are proposed up to now. Some studies have observed NFC applications according to their operating modes [3]. With the exploding growth of NFC applications, the proposed NFC applications in one service domain may operate in one of the operating mode or may support more than one operating mode. Thus, observing NFC applications in service domain aspect provide more challenging insights.

One of the key elements of NFC, near field communications technology is the ability for NFC enabled devices to be able to be touched onto passive “NFC tags”. This facility of NFC technology is a key enabler for many applications. The NFC tags are now being manufactured in very large volumes and they are being deployed in a number of areas of the world. Already many millions have been deployed and as NFC gains further momentum, tags will be seen in many new areas.

NFC tags (shown in Fig. 2) are passive devices that can be used to communicate with active NFC devices (an active NFC reader/writer). The NFC tags can be used within applications such as posters, and other areas where small amounts of data can be stored and transferred to active NFC devices. Within the poster the live area can be used as a touch point for the active NFC device.

Figure 2: NFC tag.

The stored data on the NFC tag may contain any form of data such as debit and credit card information, PINs and networking contacts, among other information. But common applications are for storing URLs from where the NFC device may find further information. In view of this only small amounts of data may be required. NFC tags may also be used. In order that the communication between the active NFC reader/writer and the passive NFC tag was defined.

As with proximity card technology, near field communication uses electromagnetic induction between two loop antennas located within each other's near field, effectively forming an air-core transformer. It operates within the globally available and unlicensed radio frequency ISM band of 13.56 MHz on ISO/IEC 18000-3 air interface and at rates ranging from 106 kbit/s to 424 kbit/s. NFC involves an initiator and a target; the initiator actively generates an RF field that can power a passive target (an unpowered chip called a tag).This enables NFC targets to take very simple form factors such as tags, stickers, key fobs, or cards that do not require batteries. NFC tags contain data (currently between 96 and 4,096 bytes of memory) and are typically read-only, but may be rewriteable.

NFC tags have the potential to replace many existing technologies, from bar and QI codes to the Bluetooth wireless standard. NFC tags are considered passive devices, which means that they operate without a power supply of their own

and are reliant on an active device to come into range before they are activated. The trade-off here is that these devices can't really do any processing of their own; instead they are simply used to transfer information to an active device, such as a smartphone [4].

In order to power these NFC tags, electromagnetic induction is used to create a current in the passive device. The basic principle is that coils of wire can be used to produce electromagnetic waves, which can then be picked up and turned back into current by a another coil of wire. This is very similar to the techniques used for wireless charging technologies. The active devices, such as the smartphone, are responsible for generating the magnetic field. This is done with a simple coil of wire, which produces magnetic fields perpendicular to the flow of the alternating current in the wire.

The strength of the magnetic field can be adjusted by varying the number of turns in the wire coil, or increasing the current flowing through the wire. However, more current obviously requires more energy, and very high power requirements would not be desirable for use in battery powered mobile technologies. Hence why NFC operates over just a few inches, rather than the many meters that we're used to with other types of wireless communication.

The passive device works in the same way, just in reverse. Once the passive device is in range of the active device's magnetic field, the electrons in the receiving coil of wire begin to produce a current that matches that in the transmitting smartphone. There is always some power lost during transmission through the air, but over short distances the current generated is enough to power the circuitry in the NFC tag. These circuits are fine tuned to a certain frequency, which increases the device's sensitivity to signals at a specific frequency. This allows for a maximum transfer of energy across the air.

NFC Forum defines four types of tags that provide different communication speeds and capabilities in terms of configurability, memory, security, data retention and write endurance. The Forum also promotes NFC and certifies device compliance and if it fits the criteria for being considered a personal area network. NFC tags communicate using the ISO 14443 type A and B wireless standards, which are the international standard for contactless smartcards, used on many public transportation systems. This is why NFC devices can be used with existing contactless technologies, such as card payment points.

There are a range of different tag types available, each offering different storage levels and transfer speeds. Tag types 1 and 2 come with capacities between just a tiny 48 bytes and 2 kilobytes of data, and can transmit that information at just 106 kbit/s. Although that may sound quite small, especially compared to your typical SD card, that's enough data for some very simple pieces of information, such as a website URL, and is all you need for most basic NFC tags. These tags are designed to be highly cost effective, and can also be re-used if you want to change the data stored on them.

Type 3 uses a different Sony FeliCa standard, and can transfer data at a slightly faster 212 kbit/s. These tend to be used for more complicated applications, but sadly can't be rewritten. Similarly, type 4 is again read-only, but has a larger memory capacity of up to 32 Kbytes and communication speeds of between 106 kbit/s and the maximum NFC 424 kbit/s. Tag type 4 works with both type A and B of the ISO14443 standard.

II. Software Development

The Project is developed in Java Programming Language by using the Eclipse Ganymede Integrated Development Environment (IDE). Android Software Development Kit (SDK) is used which includes a variety of custom tools that help us develop mobile applications on the Android platform. The most important of these are the Android Emulator and the Android Development Tools (ADT) plug-in for Eclipse.

Android powers hundreds of millions of mobile devices in more than 190 countries around the world. It's the largest installed base of any mobile platform and growing fast every day another million users power up their Android devices for the first time and start looking for apps, games, and other digital content. Android gives you a world-class platform for creating apps and games for Android users everywhere, as well as an open marketplace for distributing to them instantly.

Android is basically an operating system for smartphones. But it's found now integrated into touch pad or televisions, even cars (trip computer) or net books. Developers create applications in Java

Android application components are the basic building blocks required to develop an Android application. Through these components a system can have a connection with an application. The integral building blocks are Activities, Services, Content Provider and Broadcast Receiver. Each of these components has its own role and is used to start an application or connect one application with the other application.

- The first component is Activities: which is also the starting point of an application. As single activity can be an application or a single application can sometimes contain many activities. Each activity represents a single screen and has a user interface. This component interacts with a user responding to the events. For example a contact application can have one activity for calling people, second activity for viewing people and third for sending a Short Message Service (SMS).
- The second component is Services: which represents the background process without a user interface. It also has its own life cycle. Generally operations taking a long time such as fetching data over the Internet, loading games or playing music can be done using the Services. This component enables one to perform different operations even when some other applications are active.

- The third component of an application is the Content Provider: This component is created in order to share data between the Activities and Services that are stored in devices by any means. Moreover using this component a user can query and even modify the data For example contact names in the phones are available to all applications.
- The last component is the Broadcast Receiver: which acts as a system's event listener. This component creates alerts or broadcasts whenever it detects a change in the system such as battery low or screen turn off.

The Android application framework provides everything necessary to implement the average application. The Android application lifecycle involves the following key components:

- Activities are functions the application performs.
- Groups of views define the application's layout.
- Intents inform the system about an application's plans.
- Services allow for background processing without user interaction.
- Notifications alert the user when something interesting happens.

Android Applications can interact with the operating system and underlying hardware using a collection of managers. Each manager is responsible for keeping the state of some underlying system service. For example, there is a "Location Manager" that facilitates interaction with the location-based services available on the handset. The "View Manager" and "Window Manager" manage user interface fundamentals.

III. PROPOSED ARCHITECTURE

Monitoring health condition of elderly people is complex medical problem since it involves different hospitals, departments and medical centers. The lack of interactions between these units is an important factor in deteriorating the health conditions of elderly people. Multi-agent systems offer an implementation that not only providing ways of interaction and communicating between medical provider units but also provides medical decisions and alert about the patient medical situation.

There are five agents in the preliminary proposed MAS system. Fig. 3 gives the general organization model of the proposed system. Within each health organization, there would be a unique Health organization Agent (HOA) that have many Department Agents (DAs) and many Physician Agents (PAs). Different HOAs and PAs can communicate with each other and not necessarily from the same medical network.

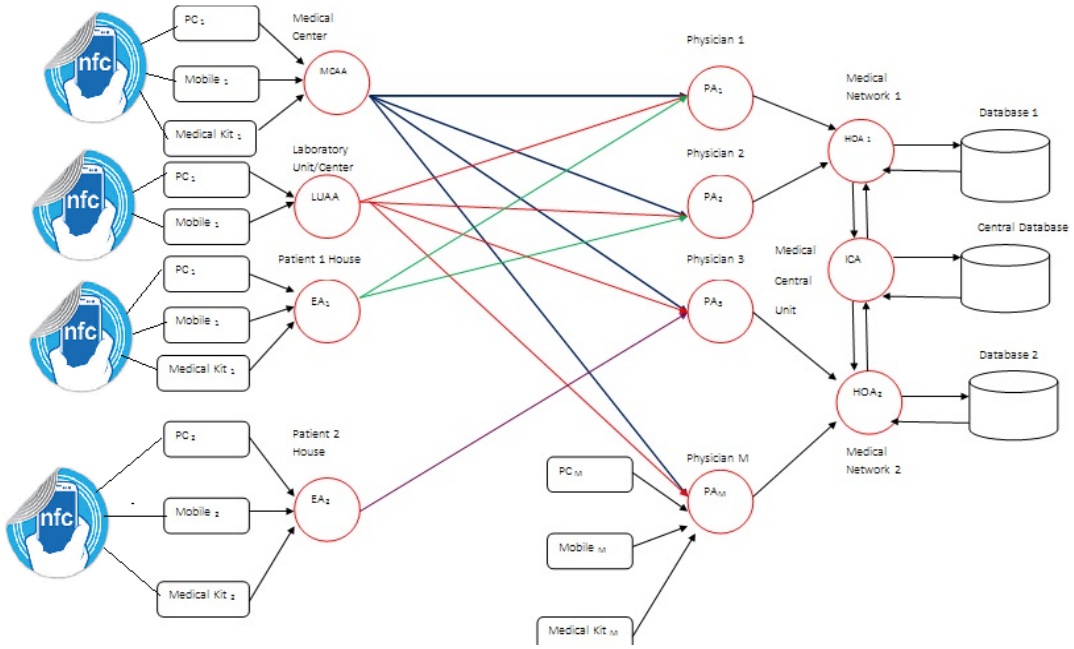

Figure 3: The Structure of the distributed intelligent network for monitoring the health conditions using NFC tags.

Fig. 3 shows the general structure of the developed intelligent network. Agents work with each other in a cooperative way to complete certain task that cannot be done with single agent. Each elderly agent can be connected to personal computer unit, Mobile phone and Medical Kit through NFC reader.

The Personal Computer and Mobile contain a GUI. Patient data will be entered in GUI as shown in Fig. 2 either from Personal computer or Mobile phone. The proposed system will connect patients and their physicians beyond hospital doors regarding their geographical area. Patients will be able to seamlessly and from anywhere track their healthcare records

and be monitored for unusual health issues. Using such system with the ability of making medical decisions, the quality of medical care in Jordan is expected to be improved. This will provide more accurate, effective, and reliable diagnoses and treatments especially if the physicians have insufficient knowledge

Physician Agent (PA) helps a physician acquire useful information of the elderly people and make initial decisions about the medical situation of the patients. The PA will perform according its knowledge. The PA could also ask other agents about the rules they are using in evaluating a medical condition of an elderly person so that the agent can updates rules. The PA has the ability to track the further development of the suspected cases under the help of other agent available in the system. The PA will keep all the cases seen by or forwarded to its physician in electronic records and such records will be updated when new information is being available. The PA can decide to take any of the following actions depending on the decision reached, i.e.:

- To order some extra clinical tests.
- To continue the same medical treatment or to modify it.
- To schedule another visit for the future or transfer the patient, for example, hospitalize him if his health has deteriorated too much. Patients can also be transferred from one of the health centers to another according to the patient needs.

Physician can easily access full information about the patient by viewing the medical information stored in NFC tag instead of going through classical paper reports.

Elderly Agent (EA) gathers certain medical information of the monitored elderly people such as Blood pressure Levels, Blood Glucose Levels, Cholesterol levels, Temperature, Heart rate, Oxygen level in blood, and other laboratory tests such as Creatinine Laboratory Test and Potassium Laboratory Test. Creatinine Phosphokinase (CPK) Laboratory Test and Transaminases Laboratory Test (either ALT or AST). These laboratory tests are mainly used evaluating the medical condition of the elderly people. Most people with adverse event in the early stages feel well and have no clear symptoms that would lead a health care provider. This place a large emphasis on laboratory tests to diagnose, predict or evaluate a medical problem since they are indicative of extensive problems in the patient. When a patient visits to the hospital, the health information of the patient will be accessed through there NFC tags which will be stored the database. The patient information which have been updated in the database will be uploaded to patient NFC.

IV. Implemented Android application GUIs

In This Paper NFC based Identification system has been developed using Android platform. Patients will be provided with NFC tag (i.e. wrist band that has NFC tag), and doctors and other medical units will be provide with NFC enabled Smartphone. NFC technology will be used for identification wherein once a person is identified, the ID will be sent to Server to retrieve all the data about the patient. When Smartphone are placed near the NFC tag data will be read mobile and this unique ID will be sent to server to select the appropriate record. Whenever doctor logged in through NFC tag, he can add health record, prescription, laboratory tests and view patient history.

V. Conclusion

The android application could be improved by adding more features such as store medical information in the NFC tags which make the process of patient monitoring more easily.

1. The advancement of technology has definitely changed the way people live their lives
2. NFC technology simplifies the human environment interaction in diverse service domains and enables users only to touch their NFC mobiles in order to trigger intelligent services.
3. The Android system besides the NFC technology would give an opportunity to the police to check the vehicle's license plate number in minutes.
4. NFC tags don't need to be powered as the RFID tags.
5. NFC tags save the data for a long time.
6. NFC tags are water proof. This makes the system working effectively in all weather.
7. The proposed solution doesn't need a connection to a server, so it would work anytime and anywhere.

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