NFC BASED PUBLIC HEALTHCARE MONITORING SYSTEM

Apratim Halder[1], Ankit Raj[2], Amit Baran Roy[3]

Abstract - This paper proposes a "NFC BASED PUBLIC HEALTHCARE MONITORING SYSTEM", a three way system between the patient; hospitals and the doctors A patient terminal concept is created based on smart cards/phones on NFC (Near Field Communication) technology for patient identification and uploading bio-history and implemented to establish a versatile and easy to use link between patients suffering from diseases and their attending physicians.

According to a United Nations report, 75% of the health infrastructure in India – including doctors, and other health resources present in the metropolitan part of the cities is inaccessible to around 716 million people. Thus to meet these requirements a patient terminal concept based on interfacing between the Intel Galileo board and medical sensor devices is developed and the data is acquired using the e-health sensor platform. It is further linked to a GPRS based tele -monitoring system. NI LabVIEW is the software chosen to carry out the analysis of the medical data. .It is used to create** the **interface is designed to display various health parameters on the computer Results from medium-scale pilot projects indicate that NFC is an enabling technology and has the potential to reduce the complexity of tele- monitoring applications to a minimum but keeps security on a high level. It helps to deliver intuitive, secure and reliable solutions to people with chronic diseases, even to elderly and technically unskilled ones.

Index Terms:- Near Field Communication; telemonitoring; gprs ; patient monitoring

I. INTRODUCTION

Health is determined not just by medical care but also by determinants and factors outside the medical sector. An effective Public health approach is to deal with all these determinants of health which requires multi-sectorial collaboration and inter-disciplinary coordination. Though India have seen much improvements in public health sector since independence, the burden of diseases, viz. communicable, non-communicable as well as infectious are getting added as India is passing through demographic and environmental transition. This under-development in public health system is attributed mainly to low public expenditure on health, lack of public health institutes in India and inadequate national standards for public education [1]. The main challenges/shortfalls of public health are as follows :-

- Inadequate Medical Infrastructure
- Insufficient Manpower for patients
- Demanding Patient Load
- Ambiguous Quality of services
- High out of pocket expenditure

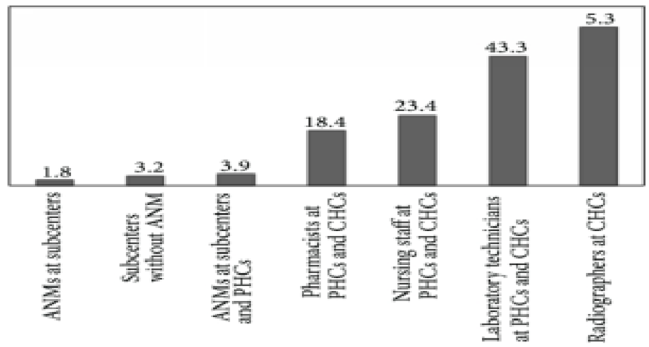

Figure 1: Shortfall in various categories of paramedical staff in rural healthcare set-up, all India

Thus, in our paper, we propose a public health care monitoring system that will deliver a high quality, affordable services to all. It will end the long waits in clinics, electronic health records will be implemented which will contain critical information of patients and will substantially improve the standard of health care by improving the patient-doctor ratio. Inequities in the provision of health will be taken care of and at affordable rate. Combined implementation of information gathering software, mobile devices, e-learning tools and horizon technologies defying human imagination will narrow health disparities, equip health care providers and enable immense leaps in quality of care [2]. Thus the growth of public health is the need of the hour.

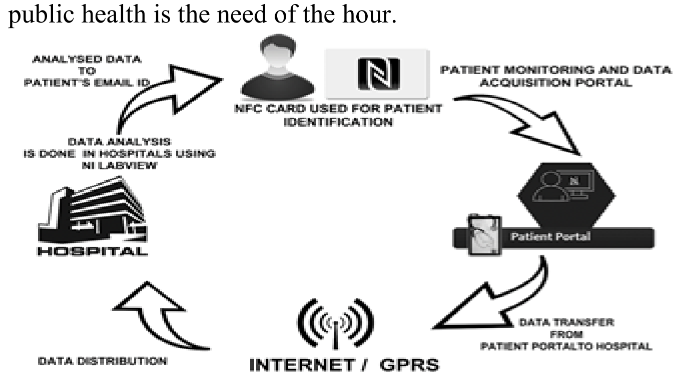

Figure 2: Block Diagram

II. METHODOLOGY

A. Unique patient Identification System

The unique patient identification system is supported using NFC Smart Card/ Enabled phones and a NFC Reader for detecting mechanism. As soon as the card is detected; the patient history and details would be uploaded in the system thus ending hassles of entering patient data every time one visits a clinic.

1) NFC Smart Card (Mifare Contactless Smartcard) - NFC is a set of short-range wireless technologies, typically requiring a distance of 10 cm or less. NFC operates at 13.56

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MHz on ISO/IEC 18000-3 air interface and at rates ranging from 106 kbit/s to 424 kbit/s. NFC always involves an initiator and a target; the initiator actively generates an RF field that can power a passive target. This enables NFC targets to take very simple form factors such as cards that do not require batteries. As with proximity card technology, near-field communication uses magnetic 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 [3].Most of the RF energy is concentrated in the allowed ±7 kHz bandwidth range, but the full spectral envelope may be as wide as 1.8 MHz when using ASK modulation.

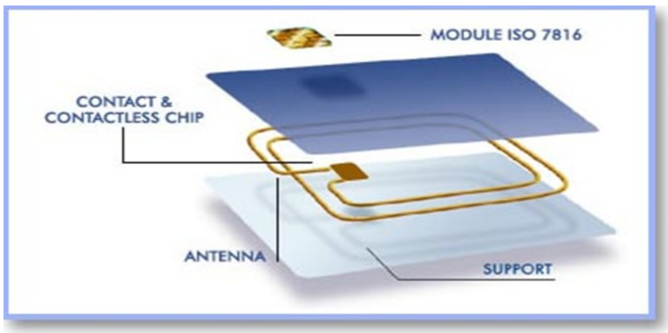

Figure 3: NFC smartcard structure

2) The ACR122U NFC Reader - The ACR122U NFC Reader is a PC-linked contactless smart card reader/writer developed based on the 13.56 MHz Contactless (RFID) Technology. Compliant with the ISO/IEC18092 standard for Near Field Communication (NFC), it supports not only Mifare and ISO 14443 A and B cards but also all four types of NFC tags. ACR122U is compliant with both CCID and PC/SC.[4]
Thus, it is a plug-and-play USB device allowing interoperability with different devices and applications .It allows us to connect this NFC Reader to the computer to be present at the patient terminal. With an access speed of up to 424 kbps and a full USB speed of up to 12 Mbps, ACR122U can also read and write more quickly and efficiently. The proximity operating distance of ACR122U is up to 5 cm, depending on the type of contactless tag in use.

Figure 4: NFC Reader ACR122U

B. Data Acquisition Platform

In this paper and as a part of our research we have used Intel Galileo Microcontroller is used as a data acquisition platform in the area on health .But it can be noted that any microcontroller could be used in that respect. Data acquisition (DAQ) is the process of measuring an electrical or physical phenomenon using a computer. The complete DAQ system consists of sensors, DAQ hardware, and a computer with programmable software. The sensor performs a conversion of the physical phenomenon into an electrical signal. This signal is further converted into digital numeric values by DAQ hardware, which is controlled by a software program. In addition to the hardware control, such DAQ software usually also includes data analysis, data visualization, and data storage algorithm.[5]
Nowadays, very simple and low cost DAQ devices could be realised using microcontrollers with integrated analogue-to-digital converters (ADC). Similarly; in our paper we have used Intel Galileo as the microcontroller and using e-health sensor shield as the data acquisition device.

The codes developed for e-health sensor shield were run using Arduino IDE. They were compiled. The e-health library was imported and used for the various sensor inputs. A snapshot of the compiled program is shown below

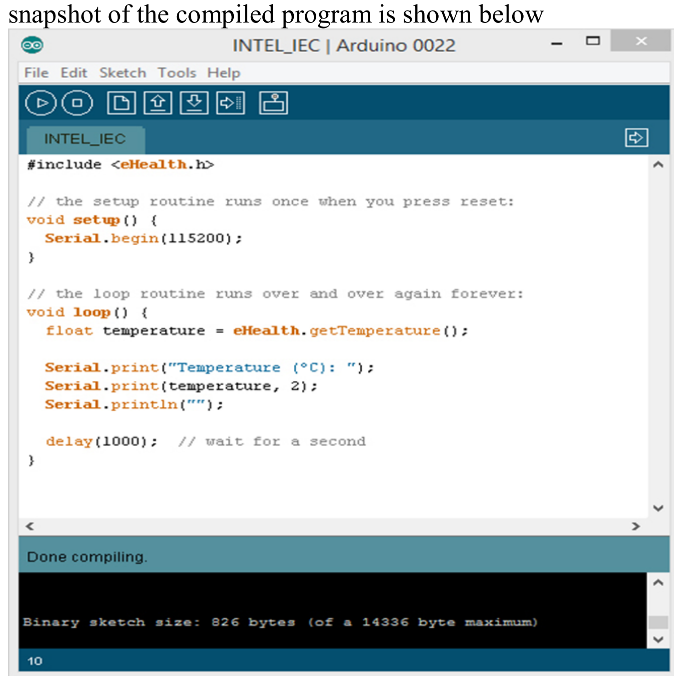

Figure 5: Arduino IDE e-Health compiled program sketch

The e-Health Sensor Shield V2.0 developed by Cooking Hacks allows Intel Galileo users to perform biometric and medical applications where body monitoring is needed by using 10 different sensors: pulse, oxygen in blood (SPO2), airflow (breathing), body temperature, electrocardiogram (ECG), glucometer, galvanic skin response (GSR - sweating), blood pressure (sphygmomanometer), patient position (accelerometer) and muscle/ electromyography sensor (EMG). The below diagram shows how ECG electrodes are connected to the shield.

For communication between the microcontroller and the desktop; Intel Galileo gives us that extra edge to carry on serial mode of communication using UART or using X-Bee Shield. Galileo provides UART TTL (5V/3.3V) serial

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communication, which is available on digital pin 0 (RX) and 1 (TX). In addition, a second UART provides RS-232 support and is connected via a 3.5mm jack. The USB Device ports allows for serial (CDC) communications over USB. This provides a serial connection to the Serial Monitor or other applications on your computer.

Finally LabVIEW is a well-known, industry-proven, block programming environment, commonly used for data acquisition, instrument control, and industrial automation on a variety of platforms (Microsoft Windows, Linux, and Mac) is used for data analysis.

Figure 6: Pulse Oximeter Data Acquisition using Intel Galileo and e-sensor shield

C. Patient Terminal Concept

The Patient terminal concept can be visualized using the diagram shown below. It shows a patient being connected to all the sensors and interfaced using the microcontroller Intel Galileo.

Figure 7: Patient terminal Concept

D. Parametric Analysis

The basic health parameters were chosen as to give a more general medical supervision. Body monitoring is needed by using 10 different sensors: pulse, oxygen in blood (SPO2), airflow (breathing), body temperature, electrocardiogram (ECG), glucometer, galvanic skin response (GSR - sweating), blood pressure (sphygmomanometer), patient position (accelerometer) and muscle/electromyography sensor (EMG).[6] The codes for various parameters are available and can be integrated on a single platform.

1) Airflow Sensor- Abnormal respiratory rates and changes in respiratory rate are a broad indicator of major physiological instability, and in many cases, respiratory rate is one of the earliest indicators of this instability. Therefore, it is critical to monitor respiratory rate as an indicator of patient status. Airflow sensor can provide an early warning of hypoxemia and apnea.

2) Blood pressure sensor- Monitoring blood pressure at home is important for many people, especially if you have high blood pressure. Blood pressure does not stay the same all the time. It changes to meet your body's needs. It is affected by various factors including body position, breathing or emotional state, exercise and sleep. It is best to measure blood pressure when you are relaxed and sitting or lying down.

3) Galvanic skin sensor- Skin conductance, also known as galvanic skin response (GSR) is a method of measuring the electrical conductance of the skin, which varies with its moisture level. This is of interest because the sweat glands are controlled by the sympathetic nervous system, so moments of strong emotion, change the electrical resistance of the skin. Skin conductance is used as an indication of psychological or physiological arousal, The Galvanic Skin Response Sensor (GSR - Sweating) measures the electrical conductance between 2 points, and is essentially a type of ohmmeter.

4) Patient Position Sensor: - The Patient Position Sensor (Accelerometer) monitors five different patient positions (standing/sitting, supine, prone, left and right.)

In many cases, it is necessary to monitor the body positions and movements made because of their relationships to particular diseases (i.e., sleep apnea and restless legs syndrome). Analysing movements during sleep also helps in determining sleep quality and irregular sleeping patterns. The body position sensor could help also to detect fainting or falling of elderly people or persons with disabilities.

5)SPO2 Sensor-A pulse oximeter sensor is useful in any setting where a patient's oxygenation is unstable, including intensive care, operating, recovery, emergency and hospital ward settings, pilots in unpressurized aircraft, for assessment of any patient's oxygenation, and determining the effectiveness of or need for supplemental oxygen. Acceptable normal ranges for patients are from 95 to 99 percent, those with a hypoxic drive problem would expect values to be between 88 to 94 percent, and values of 100 percent can indicate carbon monoxide poisoning.

6) Body Temperature Sensor- The commonly accepted average core body temperature (taken internally) is 37.0°C (98.6°F). In healthy adults, body temperature fluctuates about 0.5°C (0.9°F) throughout the day, with lower temperatures in the morning and higher temperatures in the late afternoon and evening, as the body's needs and activities change.

It is of great medical importance to measure body temperature. The reason is that a number of diseases are accompanied by characteristic changes in body temperature. Likewise, the course of certain diseases can be monitored by measuring body temperature, and the efficiency of a treatment initiated can be evaluated by the physician.

7) EMG sensor- Electromyography (EMG) is a technique for evaluating and recording the electrical activity produced by skeletal muscles. An electromyograph detects the electrical potential generated by muscle cells when these cells are electrically or neurologically activated. The signals can be

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analysed to detect medical abnormalities, activation level, and recruitment order or to analyse the biomechanics of human or animal movement. EMG signals are used in many clinical and biomedical applications. EMG is used as a diagnostics tool for identifying neuromuscular diseases, assessing low-back pain, kinesiology, and disorders of motor control. EMG signals are also used as a control signal for prosthetic devices such as prosthetic hands, arms, and lower limbs.

8) Glucometer sensor- Glucometer is a medical device for determining the approximate concentration of glucose in the blood. A small drop of blood, obtained by pricking the skin with a lancet, is placed on a disposable test strip that the meter reads and uses to calculate the blood glucose level. The meter then displays the level in mg/dl or mmol/l.

The following diagram shows a collage containing all the sensors:

Figure 8: e-Health Sensors

E. Medical Data Analysis

LabVIEW is the software chosen to carry out the analysis of the medical data.[7] An interface is being created to show the levels of the parameters chosen; for e.g. Body temperature on the screen.

The interface can be described in following steps.

- The LabVIEW software has an inbuilt GUI for web services. Using this inbuilt GUI we can configure the web services.
- So basically this interface is designed to display various parameter on the computer screen. These parameters include ECG data, EMG data, pulse, blood pressure, oxygen level etc.
- So parameters which we have to show is configured in such a way that these can take input from the web and display the patient data.
- The interface is designed in such a way which makes it easier to read the patient data from the computer screen.
- The interface is user friendly and can be stopped at any moment.

Online Interface:

- When the system is deployed and the VI is published, we have to pass data to the VI.
- The passing of data is done using XML commands from a web browser.
- A XML web-form is designed were we can input the data and see the passing of the data to the main VI.
- This XML form can be accessed using any device (mobile, pc) which supports webpage View.
- The data passed can be viewed on the Main VI.

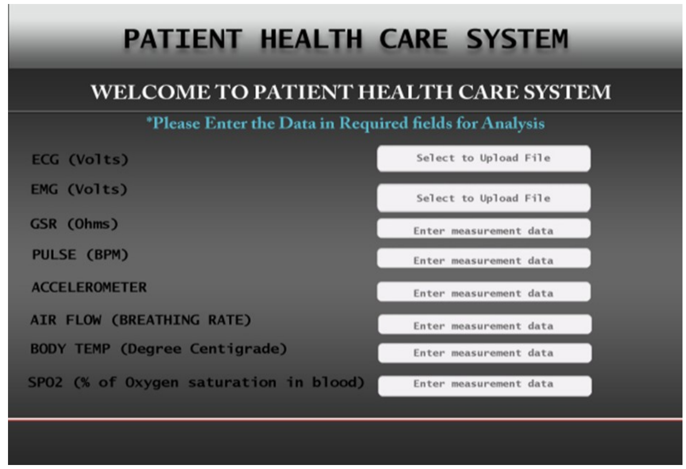

Figure 9: Web-Form for patient healthcare system

The block diagram and the output interface are as follows:-

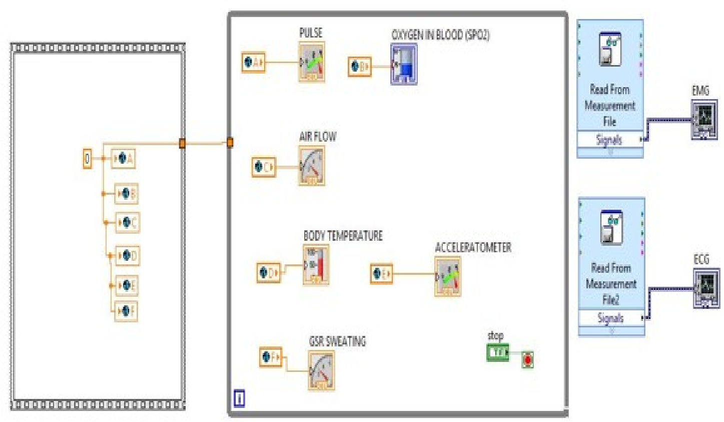

Figure 10: Labview Block Diagram

How the interface works?

The working of the interface is as follows:

The Inputs and outputs:

- A project is created were we have defined a main VI, a Global VI, and an Input VI
- The main VI contains the display parameters and the user interface
- The Global VI contains the global parameters which we need for web services
- The input VI contains the input parameters which is used to pass data from the web

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- In web services we have to define a HTTP GET method VI, where in this VI we have to define all the global parameters which will take input from the web.

The interface is then configured with a port and IP address. The IP address assigned is the address provided by our ISP. The port has to be configured in the router for access.

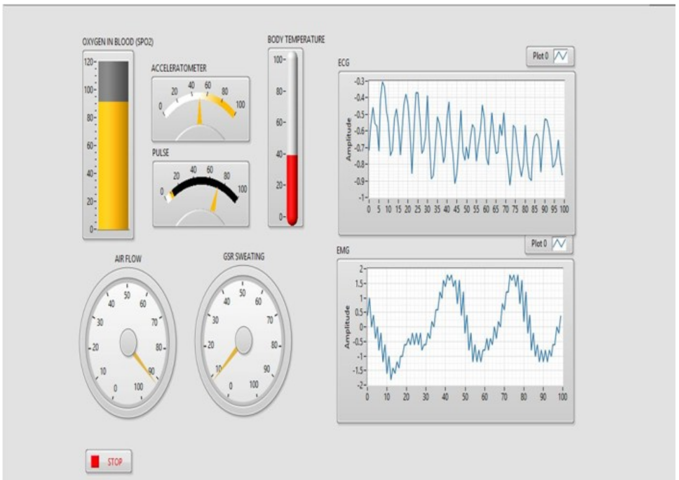

Figure 11: Labview Output Interface

III. IMPACTS AND FUTURE WORK

The impacts of the project on successful implementation are given below:-

- **Increased health care access –** People who have limited ability to travel to see a care provider or who lives in rural areas can have the luxury of remote consultation and remote health monitoring.
- **Higher capacity of clinicians –** Physicians can efficiently handle the email requests for information regarding follow-up care, prescriptions renewals and other non- urgent matters which will save their time spent on communication loop, and increase time available to access knowledge resources.
- **Enhanced patient outcomes -** E-mail exchanges can strengthen the patient-physician relationship and engage the patient more fully in his or her care.[8]
- **Reduced costs of care –** Physicians can be provided with an "early detection system" with the advent of remote monitoring which will reduce the higher and more costly health care interventions. It increases the interaction between the clinical team and patient family.[9]
- **Personalized health care –** The use of interactive web applications, online support groups and forums, automated tracking tools and alerts, medication and treatment plans will cater to the patient needs more effectively.
- **Increased patient participation and self-management of health –** The facilities like e-mail, PHRs (Personal health records) and remote-monitoring programs can motivate an individual in self-management and participation in medical decision.
- **Development of virtual care teams –** Further form of communication between physicians/specialists and patient family members can be done in the form of teleconference
- **Increased work productivity, reduced lost work time, decreased return-to-work time.**

Our future work would contain the following points.

- Access to everyone overcoming geographical barriers
- To collaborate in assessing need, designing and optimizing eHealth tools
- To enhance data systems and methods to measure adoption and use of eHealth
- To understand patient and provider healthcare resource utilization
- To enhance patient-provider communication through secure messaging
- To create an app for mobile applications and viewing results of the data analysis

IV. SIGNIFICANCE

1. *Telemedicine activities* it is defined in their initial phase of development as remote monitoring and now more generally known as e-Visits, includes secure messaging between patients and their physicians to further preventive, acute, or chronic care or to effect or improve care coordination. E-Visits allow the secure exchange of clinical information, such as text, photographs, and data from biometric devices, and often involve multiple physicians, with one serving as a coordinating intermediary.[10]

2. *Patient use of online health-information sources,* which may be self-selected or recommended and vetted by his or her physicians.[11]

3. *Patient use of an interactive Patient Portal or Personal Health Record (PHR).*

These types of applications are relatively new to the care delivery system, and definitions of their functionality are constantly evolving as knowledge of and experience with these tools increase. Nonetheless, such applications typically provide access to patient-oriented views of the physician's EHR with selected views of health information retrieved from multiple sources. These consumer-oriented applications may also support the ability for patients to contact their physician's office or clinic via secure e-mail for administrative or non-medical reasons, and provide links to vetted health information sources [12].

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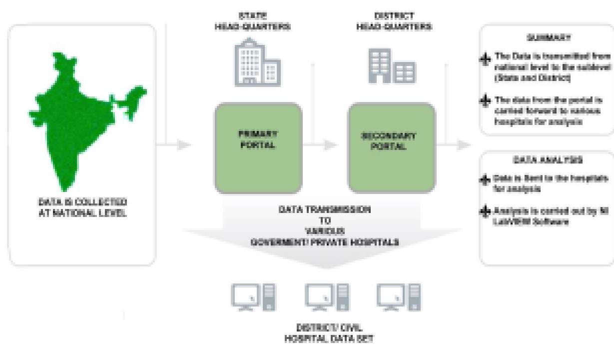

Figure 12: Dataflow Analysis

4. ***Prediction of Epidemics*** :- Early warning systems can be implemented which will allow hospitals to more easily and quickly locate domestic epidemics, such as influenza outbreaks, enabling hospitals to manage and contain these situations more efficiently [13]. The systems can also spot epidemics caused by bioterrorism.

5. *Right to health*: - An e-health network can be established which will be a voluntary network of representatives from all national authorities in our nation. It will draw up guidelines, for example, on 'how to apply patients' rights in cross-border healthcare'. In general, the network will aim to enhance interoperability between electronic health systems and continuity of care and to ensure access to safe and quality healthcare.

6. *Health awareness*: - In the development of our health management systems, the concept of 'awareness level' may be introduced.[14] This is based on factors such as the location and actions of the user involved. It can help to achieve cooperation by providing the right awareness levels at the right time. The improved awareness levels allow health professionals to provide patient care with better quality and efficiency. Our health systems have the potential to take over the mundane tasks of the doctor so that better quality health services can be provided.

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