Mobile Patient Monitoring Systems in DigitalIndia with transforming Information and Communication Technologies

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***Abstract*—**Currently India's population is increasing at the rate of 1.2% and to provide good healthcare services to these people healthcare sector needs a transformation. Information and Communication Technology (ICT) revolution has opened up whole new opportunities for developing countries like India to improve the healthcare for the betterment of 1.34 billion lives. With the use of ICT we can provide our patients better and specialized healthcare services at reduced cost. ICT based healthcare initiatives like e-Health, m-Health that includes healthcare centres, mobile telemedicine, electronic patient records, remote patient monitoring, mobile patient monitoring, health surveys, awareness raising and decision support systems can play a crucial role towards accomplishment of development goals to enhance Healthcare services in India.

***Keywords*— mobile patient monitoring, m-Health, healthcare transformation, e-Health, mobile patient monitoring system architecture**

I. INTRODUCTION

Currently world's population is increasing at the rate of 1.2% and so is the number of patients. Disease rates from Poor lifestyle choices such as lack of physical activity, poor diet, stress, smoking and overuse of alcohol are accelerating globally, advancing across every region and pervading all socioeconomic classes. Chronic diseases have become the leading causes of death and disability worldwide. Major chronic diseases currently account for almost 60% of all deaths and this contribution is expected to rise to 73% by 2020. An integrated approach is needed for detection, prevention and monitoring of these diseases. To provide impeccable health care services to people healthcare sector needs a transformation. For better and specialized healthcare services we need to develop a technology that should be fast, reliable, secure, accurate and economical. Such an astonishing expectations can only be contented with Mobile Patient Monitoring Systems (MPMS), which will make use of different ICT based technologies to provide continuous healthcare support to the user. A system which will provide complete mobility, privacy, security and it will take care of the patient even in the absence of a physician. A system which will continuously monitor the patient's biosignal along with the physical activities performed. A system which is designed in such a manner that it will provide complete generosity and will delineate the requisites of broad range of diseases. A system which will make use of different wearable sensors, smartphones, communication and computation technologies to provide healthcare services. In this paper we are going to present the current and future scenarios of Indian healthcare sector. A literature review for mobile patient monitoring systems and an architecture design for these systems.

II. INDIAN HEALTHCARE SECTOR

A. Healthcare Sector in India: Current Scenario

India, with 1,330,116,524 (1.34 billion) people is the second most populous country in the world. The figure shows that India represents almost 17.85% of the world's population, which means one out of six people on this planet live in India. Although, the crown of the world's most populous country is on China's head for decades, India is all set to take the numerouno position by 2030. With the population growth rate at 1.2%, India is predicted to have more than 1.53 billion people by the end of 2030. With increasing population Indian healthcare sector is also expected to grow at tremendous rate. It will play an important role in the GDP growth of the country. But Indian healthcare sector is the one, worst taken care of by the Indian government. The Centre's share of total public expenditure on health has fallen over the years, and India now spends less of its GDP on health than some of the world's poorest countries. Figure 1(A) shows the healthcare spending as a percentage of GDP (2014) by different countries [2].

Union Minister for Health J.P. Nadda released the National Health Profile 2015 prepared by the Central Bureau for Health Intelligence (CBHI) on September 22, 2015, Tuesday along with the officials of the Ministry, the Directorate General of Health Services and the CBHI [1]. According to the report every government allopathic doctor serves a population of over 11,000 people, with Bihar and Maharashtra having the worst ratios. The number of qualified allopathic doctors registered with Medical Councils fell in 2014 to 16,000, or less than half the previous year's number; the data was however provisional, CBHI officials said. India now has cumulatively 9.4 lakh allopathic doctors, 1.54 lakh dental surgeons, and 7.37 lakh AYUSH doctors of whom more than half are Ayurvedic doctors. In India every government hospital serves an estimated 61,000 people, with one bed for every 1833 people.

Following the current numbers the scenario of healthcare in India is heading towards the worst condition. The Doctor-Patient ratio in India is continuously decreasing in such a situation it is necessary to find a more profound solution to change the face of healthcare. It is essential to find a health care solution that will overcome these problems and provide improved and cost effective solutions to the patients.

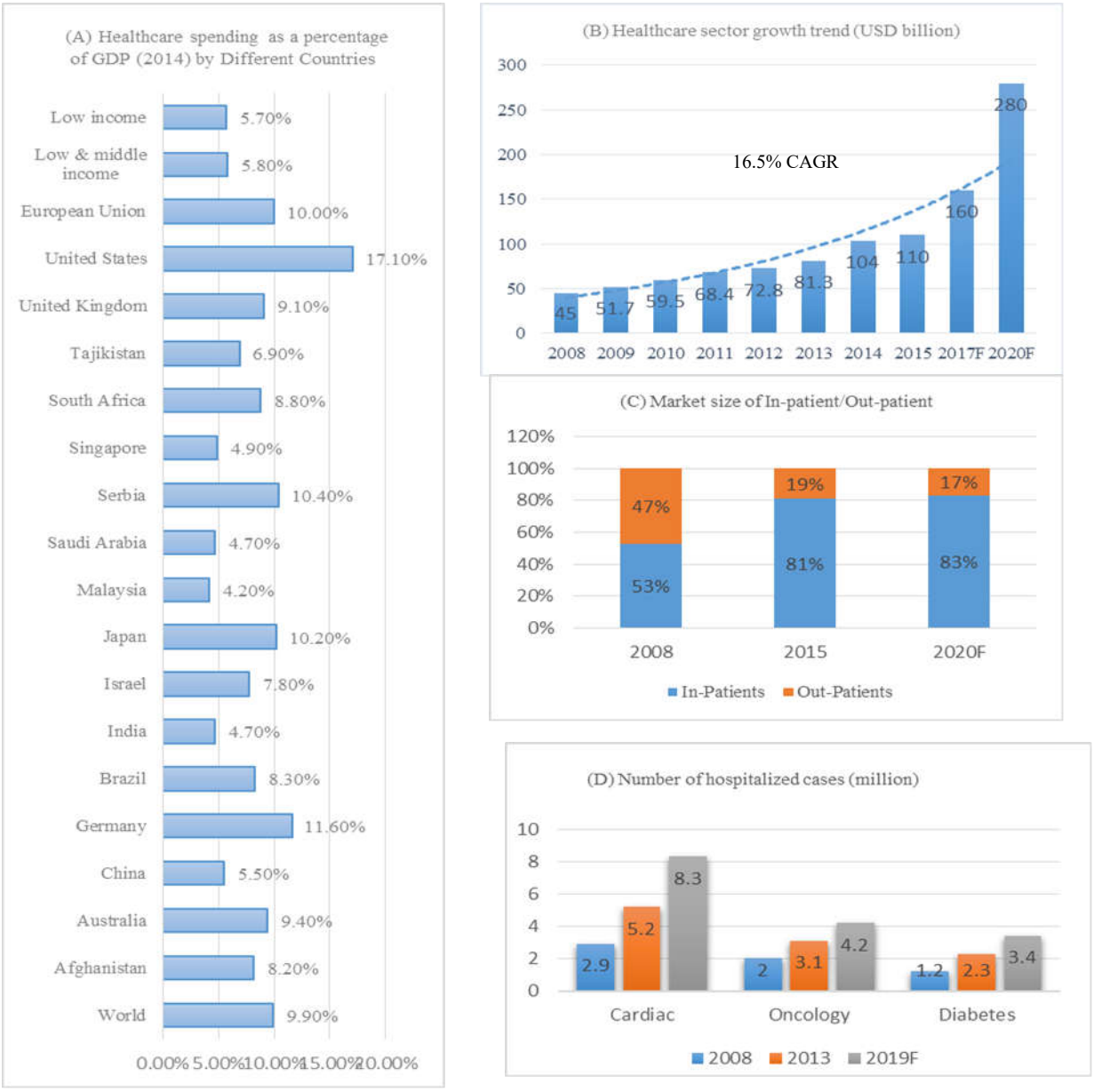

Fig. 1 (A) Healthcare spending as a percentage of GDP (2014) by different countries. (B) Healthcare sector growth trend (USD billion). (C) Market size of In-patient/Out-patient. (D) Number of Hospitalizedcases (millions)

Apart from these shortcomings, the current healthcare sector also has some positive takeaways like strong demand, attractive investment opportunities, policy support and support for innovation & modern technology.

B. Healthcare Sector in India: By 2020

The Indian healthcare industry is growing at a tremendous pace owing to its increasing expenditure, services and strengthening coverage by public as well private players. It is expected to become one of the India's largest sectors both in terms of revenue & employment by 2020. During 2008-20, the market is expected to record a Compound Annual Growth Rate (CAGR) of 16.5 per cent. The total healthcare industry size in India is expected to touch USD160 billion by 2017 & USD280 billion by 2020. Figure 1(B) shows the healthcare sector growth trend from 2008 to 2020 in USD [3].

C. *Trends in the Indian Healthcare Sector*

With increasing urbanization and Expansion of tier-II & tier-III cities problems related to modern day living in urban settings has increased. Figure 1(D) shows the increased number of cases of chronic diseases since 2008 [27]. Currently about 50 per cent of spending on in-patient beds is for lifestyle diseases. This has increased the demand for specialized care.

The increased number of hospitalization cases as shown in Figure 1(C) is supporting the fact that, in India lifestyle diseases have replaced traditional health problems [3]. Most lifestyle diseases are caused by high cholesterol, obesity, high blood pressure, poor diet and alcohol. To adopt with the current changes technologies like Digital Health Knowledge Resources, Electronic Medical Record, Mobile Healthcare, Electronic Health Record, Hospital Information System, PRACTO, Technology-enabled care, telemedicine & Hospital Management Information are gaining wide acceptance in Indian healthcare sector. The Mobile health industry in India is expected to reach USD0.6 billion by 2017. It is expected to be driven by the strong mobile technology infrastructure and launch of 4G.

D. *ICT Based Technologies in Indian Healthcare*

India is a well-known nation around the globe for its export-oriented ICT service industry. Indian healthcare industry is effectively using ICT based technologies like Electronic Health Records (EHR), Chronic Disease Management Systems, Computerized Practitioner Order Entry (CPOE), Clinical Decision Support, Electronic Transfer of Prescription, Electronic Appointment Booking, Personal Health Record and Telemedicine. But as per increasing demands of stakeholders in the healthcare environment, patients, professionals and funder significant healthcare improvement is needed. Enhanced ICT based technologies are needed for increasing chronic disease patients that can effectively monitor their health conditions and provide specialized services. The technology should be fast, reliable, secure, accurate, economical and time saving by effectively reducing hospital visits and hospitalization for regular health check-up and monitoring.

III. MOBILE PATIENT MONITORING SYSTEM LITERATURE REVIEW

During last few years, mobile patient monitoring has evolved as the most promising and active application area [3] in the domain of mHealth. As a result a number of mobile patient monitoring systems have been proposed by various researchers. These systems are either designed for a specific community or for people suffering from a specific disease such as cardiovascular disease [4], depressive illness [5], dementia [6], hypertension [7], and diabetes [8.]. Few of these systems are dedicated to the older age group patients [9] and mass casualty victims [26]. The basic functionality provided by these systems include continuous monitoring and delivery of bio-signals [11] [12] and real time signal detection [13]. These systems vary in terms of non-functional features supported by them. For example, few systems provide interoperability between the various heterogeneous medical information servers by adopting Service-Oriented Architecture (SOA) [14] [15] for application deployment and adopting HL7 standards [16] [17] for data encoding. Some of the additional functionalities realized by these systems included to predict current health status [18] through various data mining techniques, to provide secured access to the monitored data [20] through password authentication, to interpret medical data and to make decisions [22].

Figure 2 shows a comparison of MPM systems, in which various systems have been compared against the following functionalities: to process bio-signals (FR1), to deliver bio-signals(FR2), to raise emergency alarm (FR3), to interpret bio-signals (FR4), to perform differentiation of bio-signal (FR5), to acquire data (FR6), to communicate bio-signals (FR7), and medicine infusion (FR8).

Figure 2 also compares these systems against a set of non-functional parameters such as Genericity (NFR1), Security (NFR2), Unique Patient Identification (NFR3), Interoperability (NFR4), Privacy (NFR5), Intelligence (NFR6), Availability (NFR7), Response Time (NFR8), Easy Wear-ability (NFR9), Graphical interface (NFR10), Accuracy (NFR11), Data loses (NFR12) and adoption of standards (NFR13).

	FR1	FR2	FR3	FR4	FR5	FR6	FR7	FR8	NFR 1	NFR 2	NFR 3	NFR 4	NFR 5	NFR 6	NFR 7	NFR 8	NFR 9	NFR 10	NFR 11	NFR 12	NFR 13
IMHMS	✓	×	✓	✓	✓	✓	✓	×	✓	✓	✓	✓	×	✓	×	✓	✓	✓	×	×	×
MHCS	×	✓	×	✓	×	✓	✓	×	×	×	×	×	×	✓	✓	✓	✓	✓	×	×	×
MTDDS	×	✓	×	✓	×	✓	✓	×	×	×	×	✓	×	×	×	✓	✓	✓	×	×	×
WISS	×	×	×	✓	✓	✓	✓	×	×	×	×	×	×	×	×	✓	✓	✓	✓	×	×
MCWA	✓	✓	×	✓	✓	✓	✓	×	×	×	×	×	×	✓	×	✓	✓	✓	×	×	×
PHM	✓	✓	✓	✓	✓	✓	✓	×	×	×	×	×	×	✓	×	✓	✓	✓	✓	×	×
MHS	×	✓	×	✓	×	✓	✓	×	✓	×	×	×	×	×	×	✓	✓	✓	×	×	×
THC	✓	✓	✓	✓	×	✓	✓	×	×	×	×	×	×	✓	×	✓	✓	✓	×	×	×
UMHMSE	✓	✓	✓	✓	×	✓	✓	×	×	×	×	×	×	✓	×	✓	✓	✓	×	×	×
PBEHS	×	✓	×	✓	×	✓	✓	×	×	×	×	×	×	✓	×	✓	✓	✓	×	×	×
CS	✓	✓	✓	✓	✓	✓	✓	×	×	×	×	×	×	✓	×	✓	✓	✓	×	×	×
AID-N	✓	✓	✓	✓	×	✓	✓	×	×	×	✓	×	×	✓	×	✓	✓	✓	×	×	×

Fig. 2 Comparison of mobile patient monitoring systems

This comparison reveals that numerous MPMS exist but there is an absence of a reference architecture against which these existing systems can be compared. One reason behind the absence of reference architecture is that, most of the time MPMS products are developed and they are rarely engineered by following systematic development process. A systematic approach to product development typically includes adoption of engineering processes of requirements, analysis and architecture design. While comparing these MPMS, it has also been observed that few approaches exist that perform requirements analysis for MPMS [23] and architecture design for MPMS [24] [25] [26] [6]. However, they overlook the aspect of capturing variability and commonality among numerous MPMS products. One of the consequences of adopting adhoc approach to MPMS development is that the design information and knowledge about the MPMS is distributed and scattered all over the existing implementations.

IV. MOBILE PATIENT MONITORING SYSTEM

A. Mobile Patient Monitoring System for Chronically ill Patients

To meet such an extraordinary expectation Mobile Patient Monitoring Systems (MPMS) are most viable option. MPMS will make use of different ICT based technology to provide 24*7 continuous healthcare support to the patient. The system will provide complete mobility, privacy, security and it will take care of the patient even in the absence of the physician. The proposed system is architectured [28] [29] in such a manner that it will provide complete generosity and will delineate the needs of broad range of patients. The system will make use of different Wearable sensors, Smartphone, Communication, and Computation technologies to provide healthcare services as shown in Figure 2.

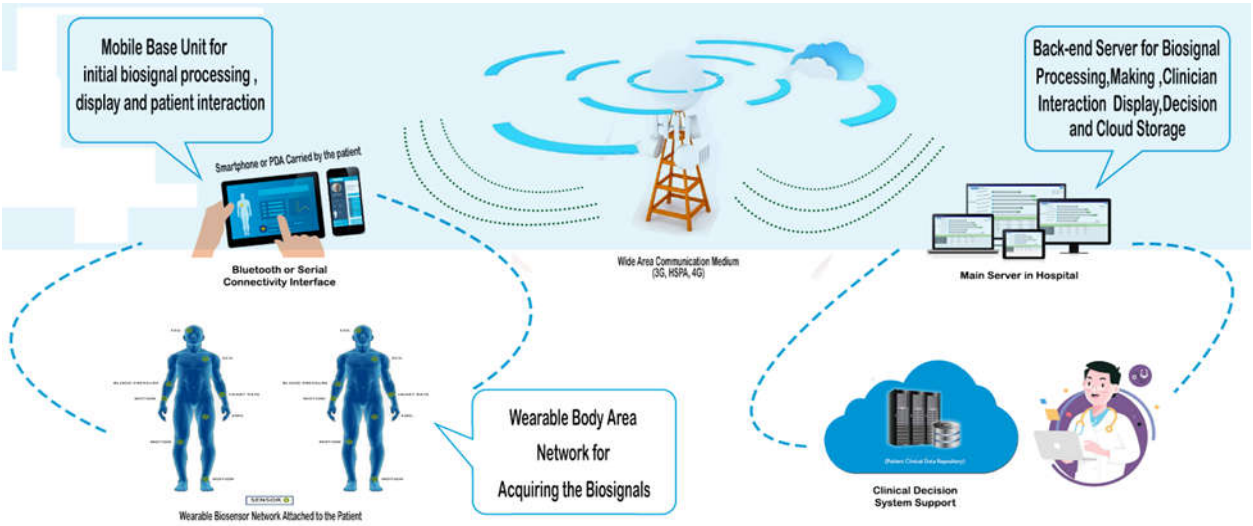

Fig. 2 Mobile Patient Monitoring System

B. *Mobile Patient Monitoring System Architecture*

The system is architectured using the Software Product Line Architecture to decrease the design and development time and achieve a high quality product with low cost [30]. We have designed the system with two different perspectives that is product and process. From product perspective our architecture is having three layers, consisting of three different subsystems as Wearable Body Area Network (WBAN), Mobile Base Unit (MBU) and Back-End Server (BESys) as shown in Figure 3. Whereas the process perspective consists of the Data acquisition, Initial Data Processing & Transmission, Bio signal Interpretation & Processing, Notification and Intervention.

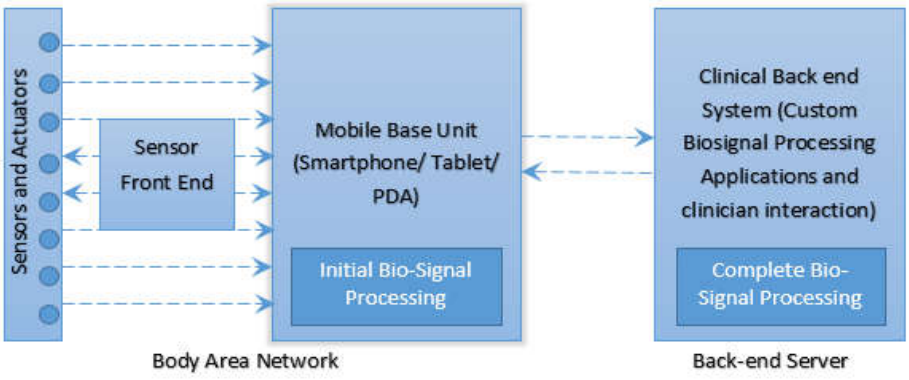

Fig. 3 Generic Architecture of Mobile Patient Monitoring Systems

The first layer of our system includes wearable biosensors like pulse oximeter, glucometer, EGC, motion sensors, EEG, EMG, blood pressure and moisture sensors. The sensors will be modified according to the patient and disease monitoring needs. We have also kept a provision for automated drug delivery using sensors like artificial pancreas but it requires the use of invasive sensors. The WBAN also consists a central node to acquire the biosignals from sensors and deliver them to MBU. Smartphones will be proven to be very effective MBU because of good data processing capabilities, storage, easy availability, and low cost. The MBU will process the Biosignal data on initial level for any discrepancies and will transfer the data to BESys for further processing. The BESys will store and mine the data for knowledge abstraction and decision making. It will assist the physician in making decisions. The designed BESys will be provided with advance algorithms to process the data and make decisions based on the gathered knowledge.

The system will provide prominent features like Biosignal encryption, Biosignal compression, primary Biosignal processing on MBU, notifications & alarms on threshold, Biosignal analysis & display, Smartphone app, clinical knowledge library, knowledge discovery, decision support, threshold determination, algorithmic learning, clinical fact base, data storage and mining, cloud backup, data requisition, clinical server applications, data lose recovery and emergency control. The system will also follow IHE DEC PCD-01 Technical Framework, HL7 V 2.6 Messaging [31], IOS/IEEE std 11073-20601 [32] and ISO/IEEE 11073 Semantics to provide globally acceptable standardized data, devices and services.

C. *Advantages of Mobile Patient Monitoring Systems*

The effects of these new opportunities produced by the dispersal of information and communication technologies in the hardware, software and IT-enabled services sectors are brilliant. This advance healthcare technology will reduce the cost, provide complete mobility to the patient, reduce time spent doing paperwork, increase the accuracy of the data collected and supplied, ensure availability of specialized care at village level & healthcare data in electronic form, and provide information that helps to provide more effective services.An easy way to comply with IJRASET paper formatting requirements is to use this document as a template and simply type your text into it.

V. CONCLUSIONS

With increasing population and healthcare cost, India is facing a challenge of accessibility & affordability to deliver quality healthcare services for masses. Technology will play a key role in improving the health outcomes of the country. The government needs to develop an appropriate vision to mobilize and use ICT tools in order to create outcomes. Technology will also improve transparency in the costs along with co-ordination and management to improve the access to quality and affordable healthcare. Mobile Patient Monitoring Systems will play a crucial role in the current changing scenario. These systems have both, proficiency and potential to change the way Healthcare works and accomplish all the ambitious expectations that healthcare sector is foreseeing from the ICT technologies.

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