IJST EXPLORE International Journal of Science and Technology
CENTRE OF PROFESSIONAL RESEARCH PUBLICATIONS
ISSN 2049-7318

International Journal of Science and Technology Volume 2 No. 6, June, 2013

Mobile Healthcare Solution: Using Mobile Phones to Improve Healthcare Services in Zanzibar

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ABSTRACT

Technology is the important tool today to improve our lives and solve the problems of the world. It has a crucial role to play in achieving the development. The mobile technology has great potential to solve the social, political and economic matters. This study has aim to improve the healthcare services using new and more flexible mobile third generation technology. The study presents the implementation of reasonable solution that allow patients to access the medical services through his/her mobile phone at anytime, anyplace and everywhere in the locally relevant. The research's data were collected in both primary and secondary methods. Where the primary data were collected straight from the sources and were gathered through the survey. The totals of 77 respondents were participated to answer the questionnaires which were selected randomly and the secondary data were collected from related literatures. The findings indicated that the popularity of using mobile phones is on the rise in developing countries including Zanzibar, while the healthcare services are still more challenging. The finding data were observed there is necessity to use mobile technologies in order to improve the healthcare services to the people. The two mobile services Short Message Service (SMS) and Multimedia Message Service (MMS) were reviewed and were recommended to be used for providing the healthcare services. The contribution of this study in mobile health is that the communication between user and hospital server were done through the mobile phone provider compared to reviewed studies where communication made using wireless network.

Keywords: *Technology, healthcare service, mobile technology, patient, mobile phone*

1. INTRODUCTION

ICT can be defined as an umbrella term that includes any communication device or application such as radio, cellular phones, computer and so on (Pannu and Tomar, 2010). ICT have a crucial role to play in achieving social, economical and political development. The objective of the ICT for social development initiative is for generating and supporting collaborative activities among academia, industry, government, and communities to promote social development (Pannu and Tomar, 2010; Schiller, 2003). ICT combined with recent advances in networking and mobile technology offers great potential to support healthcare quality (Schiller, 2003). Mobile phones, for example, have become one of the most indispensable accessories of professional and social life (Pannu and Tomar, 2010). However, the ICT has great potential to solve the social, political and economical matters, recently; the world is facing the challenge of delivering high quality of healthcare at an affordable cost, while the population continues to grow at an increasing rate. Improving the quality healthcare service for illness of treatment, illness prevention and patient services is difficult for most countries because the hospitals lack sufficient resources and staffs. In order to provide better healthcare service for patients, mobile technology can be used to manage healthcare in a way that provides the optimal healthcare service for patients (Martins, 2009; Zielinski et al., 2006). Zanzibar is located in the Indian Ocean about 30km of the east coast of Africa, between latitude 5 and 7 degrees south of the equator. The population of Zanzibar shows an increase from 640,685 in 1988 to 981,754 in 2002 to 1,303,563 in 2012 (Mohsw, 2009; Nbs, 2012). Due to the aging population, deaths, chronic diseases and healthcare costs are also on the rise in Zanzibar. The current healthcare delivery model is far from ideal to address the challenges ahead. The hospital infrastructures in Zanzibar are not planned considered by populations and locations, evidently many hospitals are found in town areas and very few in rural areas. In Zanzibar Mnazimmoja is the main referral hospital which located in Stone town area and other few major public and private hospitals are located in each district (Usaid, 2009). Usage of mobile phones is so popular in Zanzibar, at this time proximately more than 61.2% of people aged above 12 have mobile phones (Mpd, 2007). The mobile phone operator can be used to provide the communication infrastructure which enable patient to access healthcare using any available mobile device.

In the developing countries the mobile phones have become sophisticated computing devices today that allow users to manage their personal, social and professional

lives (Pannu and Tomar, 2010). Therefore, due to the high cell phone usage, mobile devices have become necessary tools in our daily life. And it is time to make use of mobile phones for providing healthcare services. Based on the advantages of mobile technology, the researchers seen there is a need to use this advantage in order to improve the healthcare services to the people.

2. ZANZIBAR HEALTHCARE SECTOR

Zanzibar is a developing country; the healthcare status of this country is unsatisfactory compared to other nations. Bad infrastructure, lack of hospitals, and a few of specialists are the main challenges which hinder the country to deliver the quality of healthcare. Currently, Zanzibar government has recognized the need to address the health status of citizens, and has begun to implement several health sector reforms and initiatives aiming to improve the health of its population. The reforms including the development of a health sector strategic plan, emphasis on decentralization, and the preparation of a poverty reduction strategy paper. Zanzibar has pledged to achieve Millennium Development Goals (MDGs)[1] in health for reducing to less than five mortality rate by two – thirds between 1990- 2015 (WHO, 2009; Varshney, 2009). Despite these reforms, Zanzibar's health system faces a number of challenges to improving and strengthening its immunization program. Some of challenges are limited government contribution to the immunization program, heavy donor dependency to implement the program and inadequate human resources both in terms of capacity and staffing (WHO, 2009; Gellert, 2004).

The developed countries such as UK, USA have great potential to improve healthcare system using mobile technologies. The UK has improved to enabling the patient to provide healthcare service from hospital through wireless connection (Steinkrug, 2009). According to Steinkrug (2009) the wireless healthcares in UK hospitals are provides information on the ehealth market to the healthcare providers and seeking to reduce costs and broaden the range of services they offer patients. Therefore it is a time for developing countries to develop the mobile healthcare system that helping the people providing easy healthcare services (Gellert, 2004).

3. MOBILE TECHNOLOGY IN ZANZIBAR

In Zanzibar mobile communications are extended in everywhere, the use of mobile phone has great potential to simplify the everyday activities and easier to get services such as transportation, billing, news, etc. The communication as well served by the newly restructured, public Tanzania Telecommunication Company Limited (TTCL) and four privately owned mobile systems; named Zantel, Vodacom, Tigo and Airtel have changed life system within the country. Through these systems the whole of Zanzibar is widely covered and connected to most parts of the world. Zanzibar Telecommunication Limited (Zantel)[2] was the first telecommunication company in Zanzibar since 1999 and now has more customers in Zanzibar compared to other Tanzania telephone companies (Zantel, 2009). Zantel was recorded as the fastest growing network in Tanzania in 2007 (Etisalat, 2009), currently Zantel have more 2 million subscribers in Tanzania and more than 640,000 customers in Zanzibar out of 1.3 million of people (Tcra, 2009; Etisalat, 2009; Nbs, 2012). The Zantel has become a rising star. Today, Zantel's network covers all cities, major towns, high ways and rural areas in Tanzania as well as Zanzibar (Etisalat, 2009). This suggests that a substantial sample of Zanzibar mobile phone users is covered by the dataset. At the time being, Zantel is using 3G technology which provides wide area wireless voice telephone, video calls, and wireless data, all in a mobile environment. Compared to 2G and 2.5G technologies, 3G allows simultaneous use of speech and data services and higher data rates. (Brans, 2002; Mallick, 2003). The Zantel also provides other services such as global system for mobile communications (GSM) services, MMS makes it possible for mobile users to send and receive multimedia (graphics and animations) messages (Zantel, 2009). The existing GSM networks can be used to provide monitoring and healthcare for patients using any available mobile phones. In this research the Zantel was suggested to be used as a mobile phone operator which can be hooked up the communication between patient's mobile phone and hospital server.

4. METHODOLOGY

The data to be utilized in this research were both primary and secondary data which is to ensure that the process was comprehensive. Where the primary data were collected straight from the sources and were gathered through the survey, this was the key research tool, and the secondary data for this study were collected from current related literatures. It attempted to gather and analyze information related to the study from other researchers have been done in order to figure out concepts of the reproduction and identify appropriate methods and

[1] The Millennium Development Goals (MDGs) are eight international development goals that all 192 United Nations member states and at least 23 international organizations have agreed to achieve by the year 2015. They include reducing extreme poverty, reducing child mortality rates, fighting disease epidemics such as AIDS, Malaria, and developing a global partnership for development

[2] Zantel is a Zanzibar telecommunication company limited offering fixed, mobile and data services; it is one of growth and ability to deliver the tremendous benefits of mobile communications in Tanzania.

technologies for the proposed solution. In addition, literature review was collected by gathering and analysis of data from different sources, which included research papers, academic findings, conference proceeding etc. The researchers have been decided to gather data which has aim to obtain more comprehensive view of the factors that determine the perception of the users. The primary source of data came from researchers made survey questionnaire, which was given to the respondents. It is used to gather significant information such as user perception about services and to define their preferences for the proposed solution. The questionnaire was prepared and distributed among targeted population (Zanzibar people) by paper based and by e-mail.

A sample size of 85 participants was chosen to ensure that the selected sample group provides a reasonable representation. The data was collected by spreading questionnaires to the target people, which were Doctors, Nurses and Citizens whom were chosen based on the groups' sample, and were divided into four age's groups, below 12 years, between 12 to 18, 19 to 60 and greater than 60 years (see table 1, 2 and 3 below). The researchers decided to use the questionnaire as the main data collection tool due to its easy and flexible nature. The questionnaire is easily customizable and the manner of its construction is easy to follow which is only very practical in the nature of the research (Kothari, 2004). Questionnaire copies may easily reach almost any number of respondents either by mail or by personal distribution. Generally, responses to a questionnaire are objectified and standardized thus allowing responses to be entered and tabulated easily (Alreck and Settle, 2003). This also provided instantly results ready for the analysis. More importantly, the respondents' replies are of their own free, because there is no interviewer to influence them. This is one way to avoid biases. According to Dawson (2007) the questionnaire is the best way used to collect data compared to the interview, because particularly the interviewers' bias.

5. RESULTS AND DISCUSSION

In the total of 85 questionnaires were distributed to different areas within the country. Therefore 77 questionnaires were completed and collected, however, during the validation process which was carried out before the data analysis it was found that 8 questionnaires were not collected, this due to the unusable of respondents which caused to some respondents refuse to continue and some of them are not marked properly. Meanwhile, the percentage of collected questionnaires is (77) 91% compare to the uncollected questionnaires which is (8) 9%. The Ms Excel software was used to illustrate the statistical findings in the graphical form.

The demographic profile of participants who replayed the questionnaire was presented in the followings way.

Table 1: Gender of Respondents

Characteristics	Frequency	Percent
Male	46	60%
Female	31	40%
Total	77	100%

Table 2: Age of Respondents

Characteristics	Frequency	Percent
Below 12	2	3%
12 – 18	21	27%
19 – 60	38	49%
61 and above	16	21%
Total	77	100%

Table 3: Status of Respondents

Characteristics	Frequency	Percent
Doctors	9	12%
Nurses	27	35%
Other Citizens	41	53%
Total	77	100%

A table 1 above shows the 60 percent of the respondents who participated to fill in the questionnaires were male compare to the 40 percent of female, even though the respondent's gender was not exactly the same but at least the ratio was reached. The majority of respondents were age between 19 to 60 which were 49%, followed by 27% of them were age between 12 to 18. Next 21% of respondents were age between 61 and above and last group of respondents aged below 12 years were 3% as shown detail in the table 2. A table 3 shows the majority of respondents participated in this study were normal people which is 53%, followed by nurses were 35% and doctors were 12%.

Questionnaires were contains three sections, first section was asked about respondent's demographic information, second section was general awareness of uses the mobile phone and healthcare situation in Zanzibar, and third section was inquired on an importance of mobile healthcare service. The below two figure (figure 1 and figure 2) shows an example of the results who obtained from respondents after analyzed of questionnaire's results which has been used to develop the prototype of proposed design. A result of question was asked on "Do you have a mobile phone" the result of that question were obtained as shown in figure 1 below where the majority of respondents have mobile phones (92%). Meanwhile, the result of a question wanted to know the number of people who their mobile phones have cameras, the results of that question obtained that the majority of them their cell phones (64%) do not have camera that support MMS

messaging compared to 36% of mobile phones that have cameras as shown in a figure 2 below.

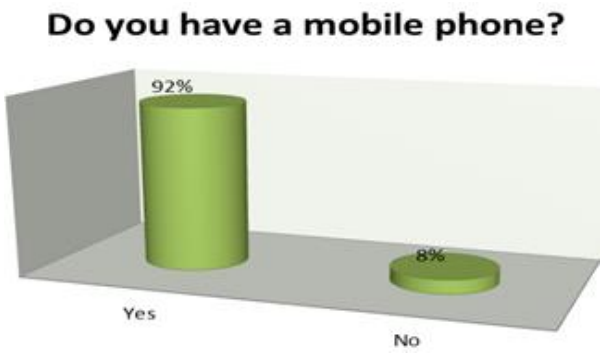

Figure 1: A result from respondents 1

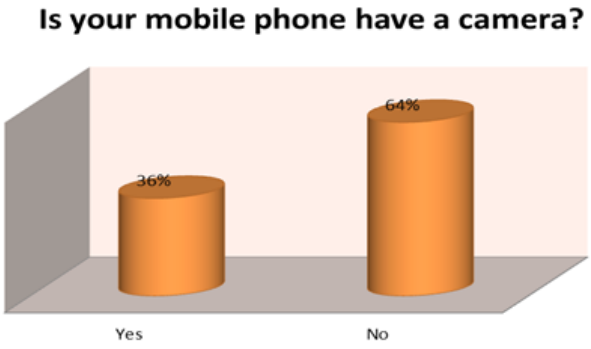

Figure 2: A result from respondents 2

Moreover a figure 3 below shows the result of mobile phone operator that respondents have been used for communication and majority of them (61%) found that they had Zantel SIM card as their mobile network provider. From that, the researchers observed that this telephone provider (Zantel) has many customers in Zanzibar as the same results found while reviewed the literature, so that the Zantel mobile provider will be proposed as network provider to handle all communications between user and hospital side.

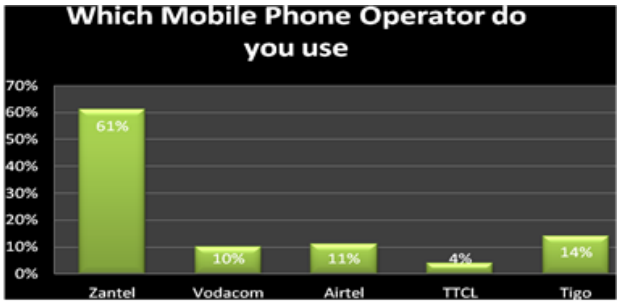

Figure 3: A result from respondents 3

Furthermore, a technical question was asked as showed in figure 4 below, the question was asked about the willing of proposed system to people "Are you agreeable your country to shift from currently healthcare system to the medical expert system where patient can provided the healthcare services through his/her mobile phone?" The findings of that question obtained that the majority of respondents were agreed compare to 2% that were not agreed see figure 4. Therefore based on the obtained findings from target users and from literatures showed that there are necessitate implementing the medical expert system in Zanzibar where user can use his/her mobile phone to provide the healthcare service.

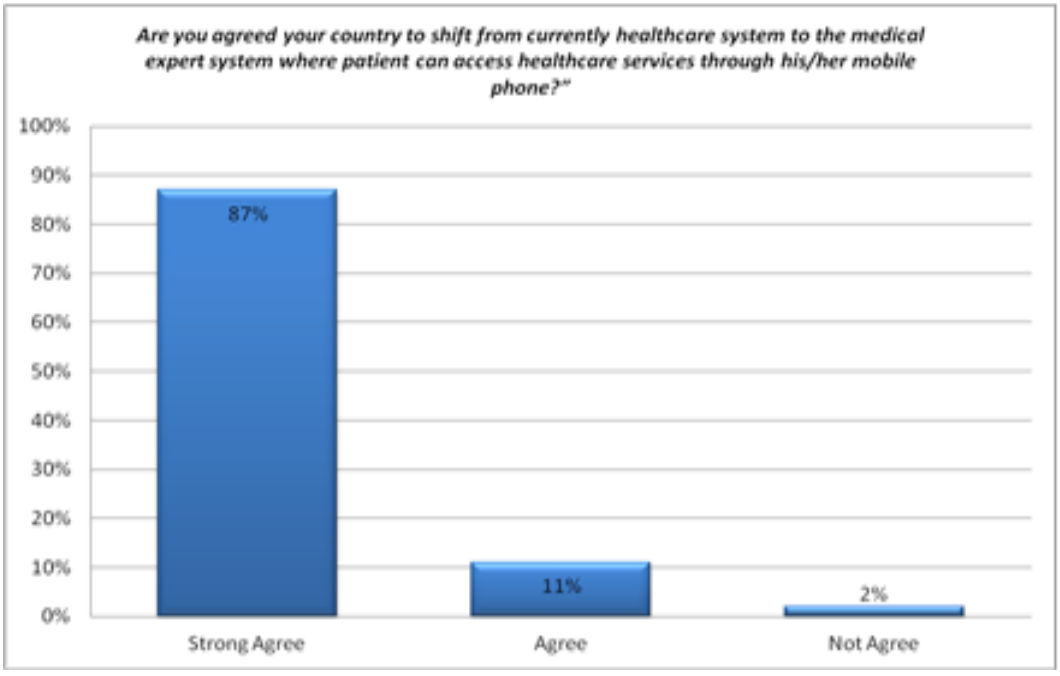

Figure 4: A result from respondents 4

6. PROPOSED DESIGN

The architecture of proposed mobile technology is shown below

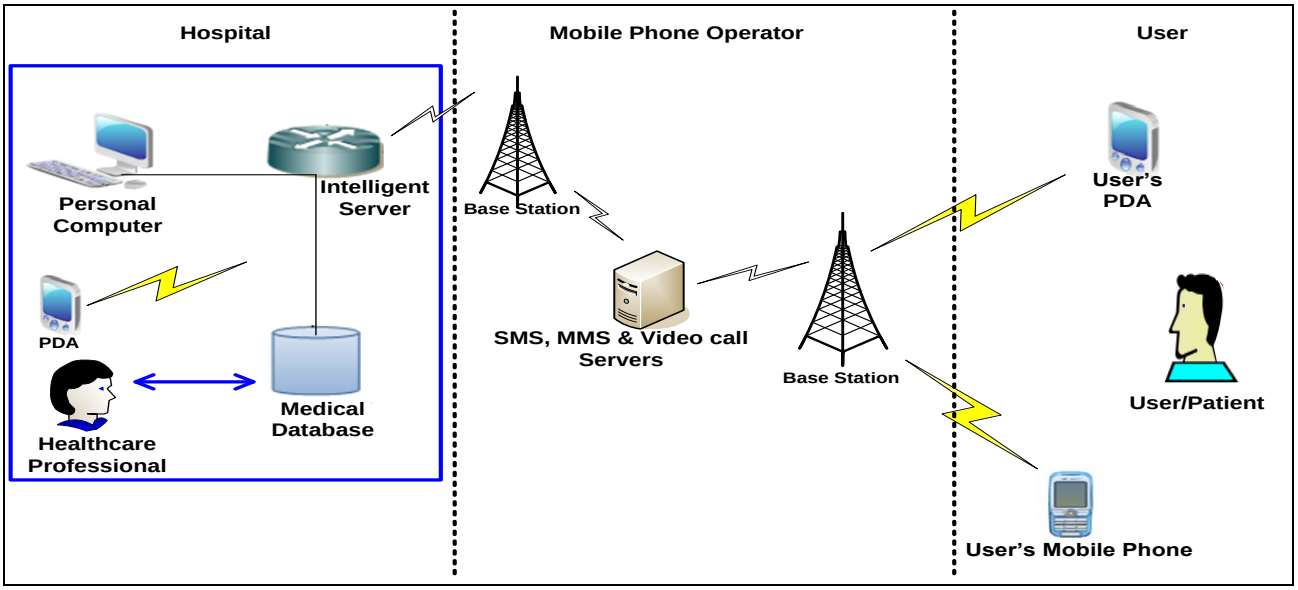

Figure 5: Overview of the mobile service Architecture

There are three domains in this architecture these are User (Patient), Mobile Phone Operator and Hospital.

6.1 User Domain

User who initiate the service by sending either SMS or MMS which contains his/her demographic data to the medical system through mobile phone operator, when it is a first time for user to access the service should dial approved number (i.e. *110#) by USSD (Unstructured Supplementary Service Data) service for requesting the permission to register in medical system. After Patient registered into the system could send SMS or/and MMS to the hospital server. When the patient chosen to send the SMS service after login in (refer figure 8) he/she should require complete to fill in his/her personal information such as name, gender, age and etc (see figure 9). The patient will also necessitate to identify his illness by providing either symptom or disease type. Then the medical database will compare the user data and knowledge base stored in the medical expert system for decide the proper medical recommendation. The important thing here the medical's advices generated from expert system will not replayed to patient before approved by health professional who will be approved after receive an alert from system via his/her mobile device. On the side of MMS, patients could capture his infected area such as face, eye, ear, mouth, etc (see figure 11) using his multimedia mobile phone's camera. Then the patient should send an image to the hospital in the format of multimedia message. This MMS will forward to the health professional for proper medical advice then a doctor will replay the medical recommendation to the patient's cell phone (see figure 12).

6.2 Mobile Phone Operator Domain

Another domain of the proposed architecture is mobile phone operator. Mobile phone operator also known as mobile network operator is a telephone company that provides services for mobile phone subscribers (Schiller, 2003). Mobile network operators deploy different types of services including Voicemail, SMS, MMS, and Video call. The mobile phone operator suggested in this study is Zantel. Zantel Telephone Company provides the SMS and MMS services to cover whole Zanzibar in high speed. The mobile operator will be responsible to send and receive all information from user's mobile phones to hospital server and vise versa.

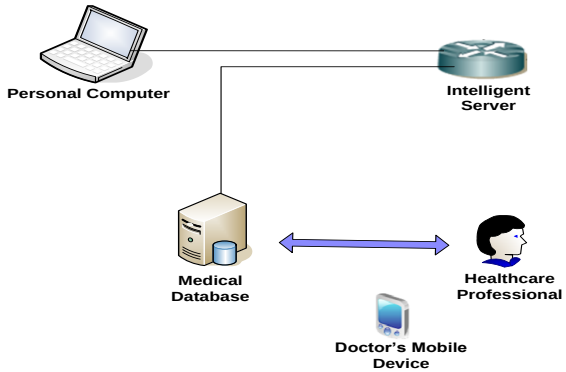

Figure 6: The Components of Hospital domain

6.3 Hospital Domain

The third domain of the propose system is hospital domain. This domain contains the three main components these are Intelligent Server, Healthcare Professional and Medical Database, as shown in figure 6 below.

6.3.1 Intelligent Server

The intelligent server is responsible to control all incoming and outgoing information inside and outside the hospital, the server should have intelligent feature which provides priority conditions. According to Hac (2000) the intelligent server provides a safe and not intrusive way of using Artificial Intelligent technology to add value to conventional processes and applications. Hence, after patient's data received in this component, the data will be converted into PDU[3] format. The Server will then forward the patient's data to the medical database as shown in figure 6 above for the medical recommendations. The server also should have features which makes possible to handle large number of patients even who will access the services at the same time.

6.3.2 Healthcare Professional

The second component of hospital domain is HealthCare Professional (HCP). HCP is the healthcare qualified person, who is responsible to ensure that medical expert system is working properly all the time (Hac, 2000). HCP who is responsible to define the symptoms, disease type and their treatment and then who store that facts in the medical database. On the other hand, a doctor should have the PDA (Personal Digital Assistant) or mobile phone which supports multimedia system in all time. The device will allow receiving the image sent by patient in the format of MMS for medication request. Once the doctor received the MMS he will then find the proper medication and replayed to the patient.

6.3.3 Medical Database

Another component of hospital domain is medical database. In this study medical database is the one of the main targets. It will contain medical expert system which will used to assist in decision making. The expert system is a computer application that performs a task that would otherwise be performed by a human expert (Hac, 2000; Giarratano and Riley, 1998). Expert systems are extensively used in the medical fields. It provides expert advice and guidance in a wide variety of activities, from computer diagnosis to delicate medical surgery (Giarratano and Riley, 1998). The medical expert system will be used to produce the medical advices by contrast between patient's diagnostic data and medicinal data which are stored in the system.

The basic structure of the expert system will look as shown in the figure below.

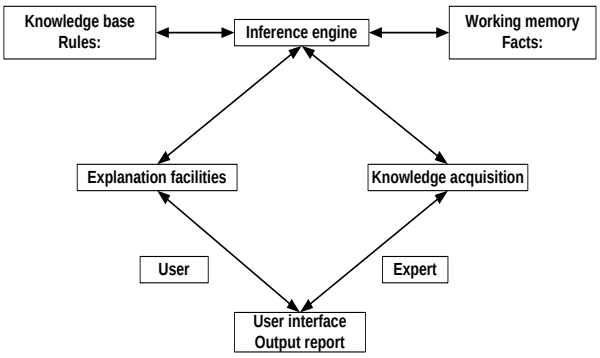

Figure 7: The Basic Organizational Structure of Expert System; source (Giarratano and Riley, 1998)

The expert system contains three distinct components these are Knowledge Base, Working Memory and Inference Engine.

The knowledge Base: This is a nuclear of an expert system. The knowledge base is a special kind of database for knowledge management, providing the means for the computerized collection, organization, and retrieval of knowledge (Hac, 2000; Giarratano and Riley, 1998). The collection of patient data representing related experiences, the medical treatment is related to the patient problems and stored solutions. The knowledge base is usually stored in the form of if –then-type rules, such as **if** the patient diagnostic is malaria **then** its treatment is chloroquine. If a fact exists that the patient diagnostic is malaria, this matches the pattern "malaria" then rule is satisfied and performs its action of "chloroquine".

The Working Memory: This part represents relevant data for the current problem being solved. It contains the data that is received from the patient during the expert system session. As described by Giarratano and Riley (1998) the Values in working memory are used to evaluate antecedents in the knowledge base. Consequents from rules in the knowledge base may create new values in working memory, or update old values. That means that when the patient wants to access into the medical expert system at the first time, he should create his session (account) and send his personal information to medical database then the system will store the patient's information for further uses. In the next time when the patient wants to access the service no need to fill his

[3] PDU stand for Protocol Data Unit is information that is delivered as a unit among peer entities of a network and that may contain control information, such as address information, or user data.

demographic information (i.e. name, address) instead the patient will require to update his diagnostic data only (i.e. symptoms or disease name) for medical advices.

The Inference Engine: Is the control mechanism that organizes the problem data and searches through the knowledge base for applicable rules. As illustrated by Giarratano and Riley (1998) an inference engine is the heart of the expert system. This component is essentially a computer program that provides a methodology for reasoning based on information already gathered in the knowledge base and acquires information from the user. The conclusions drawn by the inference engine may be based either on uncertain knowledge or deterministic knowledge (Giarratano and Riley, 1998). *Uncertain knowledge* can occur in a concrete knowledge base (for example, when the patient is not sure about his symptoms) or in an abstract knowledge base (for example, a given combination of symptoms occurs in a given disease very frequently but not always). *Deterministic knowledge* can occur when the patient entered mismatched or invalid information (for example patient typed a word "malorie" instead of "malaria"), the medical expert system will fail to produce medical recommendations and the result, the system will forward the guidance which wants patient to make sure that all information entered is correct or to see the doctor personally for further medicinal (Zielinski et al., 2006; Giarratano and Riley, 1998).

The Inference Engine contains three sub important elements these are Explanation Facilities, User Interface and Knowledge Acquisition (as showed detail in figure 7). The **explanation facilities** Subsystem provides an explanation of the conclusions drawn or of the actions taken by the expert system. This makes it possible to trace responsibility for medical solutions to their diagnostic problems, both in the transfer of expertise and in problem solving (Zielinski et al., 2006). This part will only conclude medical treatment X because of diagnostic Y. The explanation facility depends on the kind of knowledge base which is stored into the system. It might not produce the suitable solution, if it would not find the similar knowledge, for example if the patient fails to understand or accept explanation, the system can't re-explain in another way (as human can). Another sub element of inference engine is **user interface** subsystem. The user interface is the interface between the expert system and the user. In order for any expert system to be an effective tool, it must incorporate efficient mechanisms to display and retrieve information in an easy way (Castillo et al., 1999). The user interfaces of the proposed system were developed in both user mobile phones's interfaced (refer figure 8 and 9) as well as in medical databases interface for HCP knowledge entry. User interfaces prototype was developed in this study are user friendly as shown in the screen shorts section (6.4) below.

The **knowledge acquisition** is another subsystem of inference engine. This part accumulates transfers and transforms problem solving expertise from knowledge sources (patient's medical problems) to a medical expert system in order to construct or expand the knowledge base (Zielinski et al., 2006). The knowledge acquisition involves determining the factual knowledge and the heuristics used by an expert to manipulate that knowledge, these heuristics can only be obtained from an expert.

6.4 Screen Shorts of Proposed System

The screen below shows the prototype of the proposed mobile healthcare system, a Wireless Toolkit 2.5.2 was used to develop the prototype. Figure 8 shows a login screen, once a user has been registered to the system the system will capture the user's username and password. Every patient should be allowed entering his/her username and password in order to continue providing the services. Figures 9 and 10 show the example of SMS service, a figure 9 shows the user's data entry once patient sent the information to hospital the medical expert system will compare users' data and knowledge base then after the medical advices will be generated. A figure 10 shows the example of medical recommendation that system advised. The recommendations then should approve by health professional before sent back to the patient. The figure 11 and 12 show an example of MMS service, after user logged in to the system and captured his/her infected area (refer figure 11) then user could send the captured image to the doctor's mobile device. The figure 8 shows the sample of medical recommendation from specialist based on the image sent in figure 12.

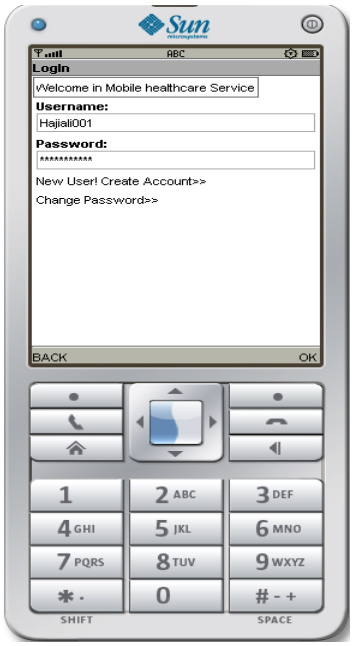

Figure 8: Patient's Login screen

Fugure 9: Patient Dem. Data

Figure 10: medical advises

Figure 11: Image which show patient infection

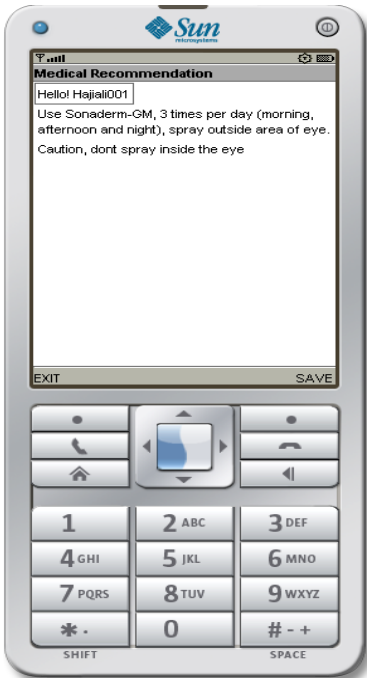

Figure 12: Medical recommendation

7. CONCLUSION AND FUTURE WORK

This study reflected the initiative for improving the healthcare service in Zanzibar using third generation mobile technology. Presently, mobile technologies have played an important role in the diffusion of information as well as medical activity. At the beginning of this study the overview and background of the research was given in order to provide simplicity in understanding the basic functions of the research study. The researchers also investigated the current healthcare system and mobile healthcare service and identified the difference between them. The contributions of related works in this area were also reviewed in depth. The sampling technique used for data collection is through questionnaire. Furthermore the proposed mobile architecture was created and presented based on the user findings and literatures; all the components related to the proposed solution were described in detail. The researchers believe that this research will help the country and people as well to improve the healthcare service. Currently the country suffers to find the means in order to deliver the quality of healthcare service. The problems of diseases like malaria and tuberculosis are wide spread and increases day by day with population increase, while the government healthcare strategies are still the same. Therefore this research will act as a catalyst to improve the healthcare status in Zanzibar, and it will help the government utilize its healthcare budget which is currently spends in bad healthcare system result. However the two mobile services (SMS and MMS) were reviewed well and were recommended to be used in the proposed system, the findings observed that the MMS service have limited number of users as showed in the figure 2 where there are only 36% of people who have multimedia phones that support MMS service.

The Future work should focus on latest generation of technology which supports extremely high speed and it

will also focus on video call technology, because a video call provides opportunity for patient and doctor to see each other on real time using mobile phone's camera.

ACKNOWLEDGEMENT

We will like to use this medium to thank all who participated in this research, direct or indirect and those who participated to answer the questionnaires without forgetting all specialists who were participated to test our work.

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