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Designing an Integrated Platform for Real-Time Recommendations Sharing among the Aged and People Living with Cancer

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Abstract**—**The world is expected to experience growth in the number of ageing population, and this will bring about high cost of providing care for these valuable citizens. In addition, many of these live with chronic diseases that come with old age. Providing adequate care in the face of rising costs and dwindling personnel can be challenging. However, advances in technologies and emergence of the Internet of Things are providing a way to address these challenges while improving care giving. This study proposes the integration of recommendation systems into homecare to provide real-time recommendations for effective management of people receiving care at home and those living with chronic diseases. Using the simplified Training Logic Concept, stakeholders and requirements were identified. Specific requirements were gathered from people living with cancer. The solution designed has two components namely home and community, to enhance recommendations sharing for effective care giving. The community component of the design was implemented with the development of a mobile app called Recommendations Sharing Community for Aged and Chronically Ill People (ReSCAP). This component has illustrated the possibility of real-time recommendations, improved recommendations sharing among care receivers and between a physician and care receivers. Full implementation will increase access to health data for better care decision making.

Keywords**—**Recommendation systems, healthcare, internet of things, real-time, homecare.

I. Introduction

THE population of older citizens is expected to rise in the coming decades, and this is will be accompanied by high cost of providing health care services along with dwindling care personnel. [21] The burden of diseases is one of the daunting challenges of ageing. While contending with frail body, these ones must cope with stress of hospital visits for medical checkup or disease management. Besides, the burden of caring for them is very enormous that a group of researchers recommended intervention [6], which technologies can provide. The Internet and wireless technologies have brought about opportunities for unique interventions in caring for the elderly and people living with chronic diseases. Modern technological applications such as the ehealth, mhealth and telemedicine have made remote care giving more realizable and effective. With the use of sensors, data of a sick person can be captured and processed for use in making effective decisions. People receiving care in the comfort of their homes can be monitored and cared for. Care providers can receive recommendations about their state of health real-time from an intelligent system located in the home. This will enhance timely interventions made possible by wireless technology and the Internet.

The Internet of Things (IoT) has brought about remarkable changes to different sectors of the economy. This modern invention has also brought about improvement in care given. It is realistically possible to get data and process them for decision making real-time. In delivering effective care therefore, IoT-based applications have essential roles to play. While it can be reasonably concluded that the IoT is an undeniably better option for the future of healthcare [2], the ageing population and the chronically ill individuals have a lot to benefit from this [15].

Recommendation systems have played and will continue to play important roles in the delivery of effective care. Recommendation system's ability to make personalized recommendations has proved to be an added value in caring for people with chronic diseases. While symptoms of disease may be general in some cases, treatment options may not necessarily be. With the aid recommendation systems, it is possible to make personalized treatments recommendations based on individual's health history and way of life. Therefore, managing people living with chronic diseases will be a lot easier if driven by recommendation systems. Using the IoT, real-time recommendations that can be used in making useful decisions for managing people with chronic diseases is possible.

In this study, an integrated design is proposed for home management of the elderly and people living with chronic diseases. The study proposes two independent systems that can allow data capture and processing for making recommendations in real-time. One is called the home where an individual receives care, and the other a community where people living with the same chronic disease are brought together to share recommendations. The two designs, when integrated, can work seamlessly to complement each other. The community part of the design has been implemented with the development of a prototype mobile app called the ReSCAP. The app has demonstrated the capability of the design to provide real-time recommendations, effective closed communication between a patient and the attending physician, and among people living with chronic diseases.

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II. Literature Review

Recommendation systems have proved to be very important tools in healthcare and wellbeing. The opportunities made available by recent advances in the Internet and communication technologies are making it possible for health recommendation systems to make personalized recommendations [22]. Tremendous benefits can accrue from health recommendation systems with the integration of electronic health records. [8] Recommendation systems have been found to be effective for wellness therapy [14]. The use of a recommendation system in healthcare addressing specific challenges facing healthcare professionals will obviously facilitate its acceptability to these individuals [25], [27]. It is especially obvious that they are useful in the care of the older citizens and nutrition recommendations [5], [18]. People living with chronic diseases can monitor and control their cases [9] providing patient and care providers with the best treatment course [26], which results in a personalized treatment recommendation [10]. Many other recommendation systems provide disease-specific approach to recommendations [19]. Recent focus on recommendation systems for nutrition and dietary health is a good way to indicate the capacity of recommendation system in improving general health and wellbeing [3]. Some of chronic diseases can be managed using dietary restrictions or personalized dietary prescriptions such as the introduction of a personalized expert recommendation system for optimized nutrition [4], helping users adapt their behaviours to healthier nutrition [12], and intelligent recommendation of dishes [13]. These efforts are an indication that recommendation systems driven by modern technologies have the potential for addressing the care needs of the elderly and people living with chronic diseases.

The IoT refers to network-enabled technologies, including mobile and wearable devices, with the capability for sensing and actuating as well as interacting and communicating with other similar devices over the Internet [17]. The IoT-based healthcare systems have tremendous capability to provide supportive and assistive care beyond the four walls of the hospital or hospice. This will involve movement of data from various devices from one place to the other for real-time processes. Although this requires enhanced data processing, security and energy conservation [23], [20], much can be achieved with the IoT driven healthcare. IoT-based healthcare applications and services can be useful in caring for the elderly and people living with prolonged diseases [16]. The capacity of an IoT-based application for use in monitoring multiple diseases has been reported [1]. Real-time monitoring system which is IoT-enabled has also been shown to be possible [7]. IoTsbased healthcare applications have been reported widely such as in early prediction of heart disease [11], collision alert system for the visually impaired [24].

III. Research Design

Two steps namely identifying the stakeholders and gathering specific requirements are involved. In identifying the stakeholders and a simplified Training Logic Concept was used [28]. The simplified Training Logic Concept is based on the simple approach to training which is similar to simple school system. In the universal training system approach, trainees, the persons for whom the training is organized along with the goal of the training, are most often first to be identified. It is logical to conclude that tutors are only sought after trainees and the purpose of training are identified. The Training Logic Concept has four major components or legs when depicted like a tree. They are Trainee, Goal, Tutor, and Mean (Trainee-Goal-Tutor and Mean (TGT-M)). This concept was used essentially as a guide for stakeholders and requirements identification. Illustrating with a typical school system, there are people who need to be trained (Trainee). There is a purpose for which they are going to be trained (Goal). It is necessary to resolve how these can be trained and who can be used to train them. Qualified teachers or trainers (Tutor) are identified and recruited. There are other materials and non-materials needed to assist teachers and students achieve the identified goal, namely government, school building, white board, non-teaching staff, chairs and tables among others. This approach can be applied to stakeholders and requirements identification in healthcare system because of similarities in needs assessment. Patients need care. The goal is to help them get better or successfully manage their conditions. Physicians are trained to give these services. However, they cannot do these alone, Nurses, Medical and laboratory scientists along with other material and non-material equipment are needed. Therefore, in applying the TLC, the first derivation looks like the following.

- Trainee = {chronically ill people, elderly}
- Goal = {Effective care, better condition management}
- Tutor = {Physicians}
- Means = {Other Medical personnel, non-medical personnel, medical tools.)

Each of the above can be dissolved further leading to more derivatives until all stakeholders and requirements are clearly identified.

- Medical personnel = {Nurses, Laboratory technologists etc.}

The second step is the identification of specific requirements from the primary users. These are the requirements that address the needs of the primary users directly. A survey-style approach was used to gather requirements from volunteers on the specific health and technology needs of people living with cancer. The survey-style requirements gathering involved 20 individuals living with cancer. To avoid any breach of confidentiality their personal data were not taken. An expanded survey that will include more chronic diseases across different geographical boundaries is underway.

IV. Results and Discussion

Using the TLC, it was easier to identify the stakeholders such as people living with cancer, which is the “trainee”. Qualified physician is the care provider, the “tutor”. The word “qualified” implies that the design must include the means to confirm the qualification. The goals are to provide effective care (which involves good communications between the care provider and care receiver), managing the condition (which will involve real-time monitor and response in cases of sudden needs, preventing the situation from deteriorating). The means of achieving these goals may have many legs such as the need for care givers (in order to achieve effective care-Goal 1) and sensing devices along with IoTs (to provide real-time monitor and response to sudden needs – Goal 2).

A. Getting Specific Requirements

Capturing the requirements for designing the system was in no way easy because people living with chronic diseases are hesitant to volunteer information first because of stigma and second because of confidentiality. As a result, the data collection method was devoid of biodata. Any personal information that could link the patient to the data was not collected. In the survey-style method of specific requirements gathering, 66.7% are between the ages of 50-59 years while 33.3% are above the age of 65. 83.3% of these would appreciate a system that will enhance physician guidance while 50% of them would prefer a system that will help them cope with their conditions. On the need for continuous education about their condition, 66.7% responded positively to this while 50% of them wanted to be aware of recent updates that could help in the management of their conditions. With regards to sharing information with others in a community of people living with the same disease, 50% of the respondent indicated their interest.

The following deductions can be made from the analysis of data collected from the survey:

1. Regular interactions between patients and their physicians
2. Interactions with other people living with same condition to share recommendations.
3. A design that will enhance effective care for the sick elderly living at home

B. A Design that Will Enhance Effective Homecare

Further analysis of the deduction from the requirements gathered indicated that a design of two components that could function independently and seamlessly when integrated was obvious. Therefore, the decision was to design a home component and community platform. Fig. 1 shows the proposed holistic architecture of real-time recommendation system for people living with chronic diseases and the elderly. The home is a unit of activities which includes the care receiver, monitoring sensors, and communication channel to care providers. All activities in the home are monitored and controlled by an artificial intelligent system called Moderating Artificial Intelligent System.

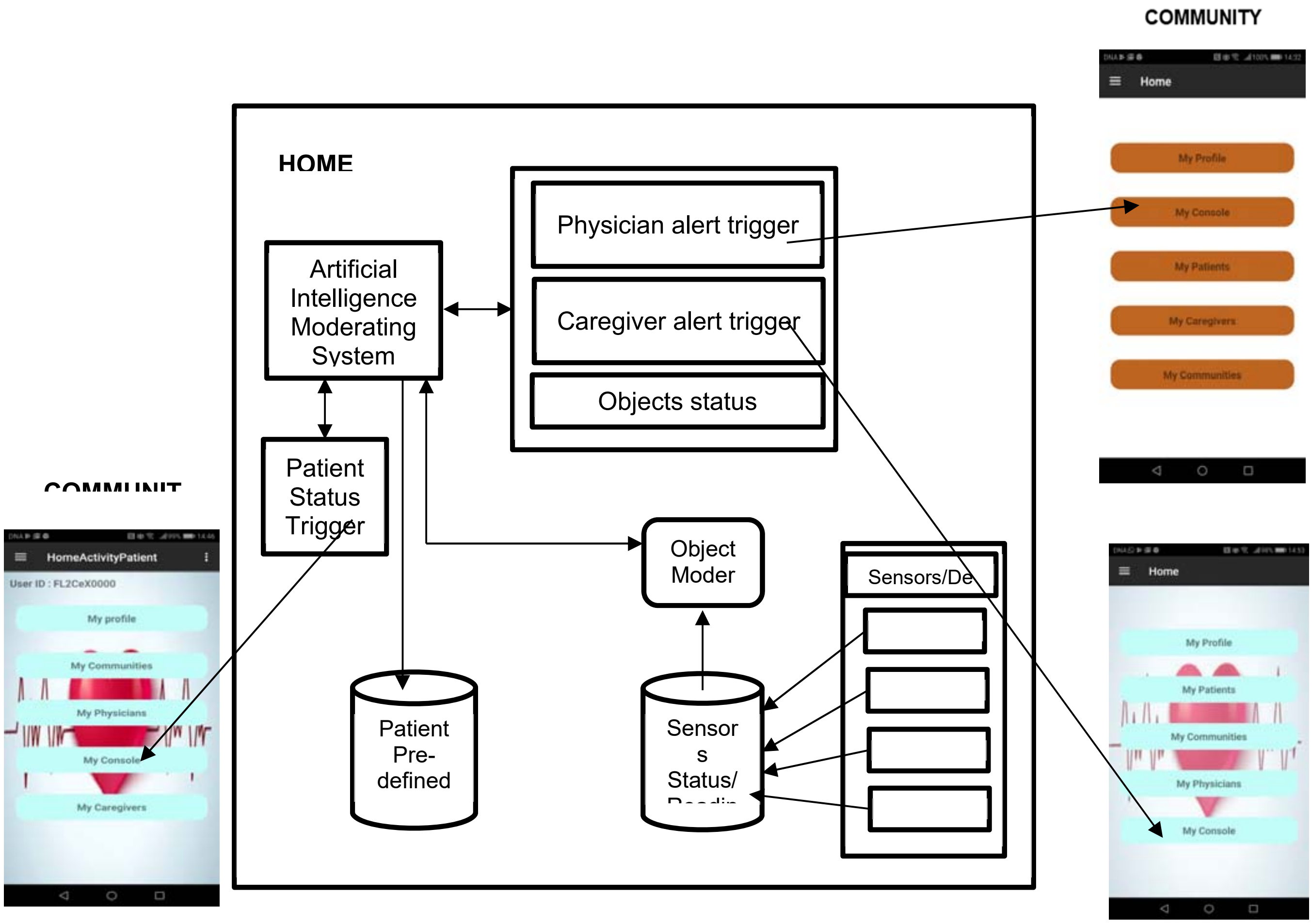

Fig. 1 The architecture of the system showing the connection between the Home and the Community

The moderating system does not only control the activities within the home but also regulates what comes into the home and what goes outside the home. The moderating system uses data from sensor database and pre-defined register to make decisions. These decisions are communicated to either the care providers or the patient. Another function of the moderating system is to ensure that all objects (such as sensors) maintain their pre-defined status and that they are functioning. For instance, suppose a sensor is not expected to function continuously, the moderating system must ensure that such a sensor maintains that status. However, the moderating system should be able to make certain decisions on the status of a sensor based on the prevailing situation around the care receiver, even if it is contrary to the pre-defined status. The moderating AI system does not interact with the sensors directly but through the object/sensor moderator. The object moderator keeps track of all objects attached to the home to capture data directly from the patient at home or other objects around the patient. The object moderator intermittently reports the status of the sensors to the moderating AI system which uses the information to make decisions. These decisions are passed to the object moderator to execute on the sensors and other devices. If there are urgent recommendations from the moderating AI system, they are passed to the console of either the physician or caregiver, which can be accessed on the community platform. Any recommendation from the physician is also passed through the moderating AI system to the patient at home. However, some of these recommendations can be executed by the moderating AI system itself. For instance, if a patient heartbeat suddenly increases abnormally and physician gets a notification, the physician can make a recommendation to the moderating AI to make changes to certain devices or a recommendation can be made directly to the patient advising the course of action to take. This communication is expected real-time based on the design

C. Interactions with Care Providers and the Community

The community component of the design addresses what happens between a care receiver and care providers. It also allows interaction and recommendation sharing among different players on the platform. These are the care receivers, physicians and care givers. Each of these has roles defined for them on the platform which also guides their access to care receiver's data. This community component has been implemented with the development of a prototype mobile app called ReSCAP. It provides a good platform for individuals with same illnesses to share treatment methods, drugs and dietary advice real-time regardless of geographical locations. It also allows real-time interactions among patients thus enhancing their cognition and social value. The physicians can be able to share research and treatment ideas among themselves based on consent obtained beforehand. Fig. 2 shows the recommendation sharing that can be possible between a physician and his patients and how recommendations can be shared among people in the community.

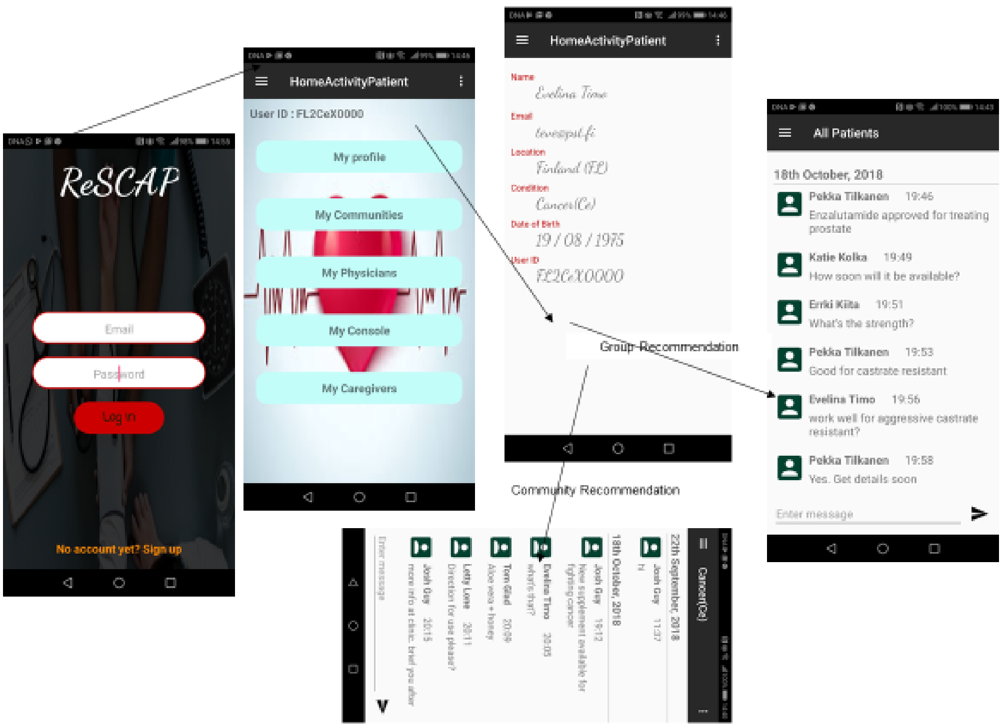

Fig. 2 Illustration of community interactions on recommendations sharing

V. Conclusion

The older people battle with frail and weak body compounded, most often, by chronic diseases. Some of these can be better cared for while living in the comfort of their homes. In addition, having regular interactions with and close monitoring by their care providers can help them live longer and happier. Interactions and recommendations sharing among people living with the same disease can increase their cognition and improve their attitude to living. All of these are possible with the recent advances in technology. An IoTs driven recommendation systems for healthcare can successfully care for these needs.

In this study a design has been presented with two independent components that can function seamlessly when integrated. The design was made using the requirements gathered from users. The viability of the design what tested by developing its community component called ReSCAP. This mobile app provides a platform for individuals living with chronic conditions to interact and share recommendations real-time. However, the home component is yet to be implemented because it is hardware intensive and costly. This notwithstanding, the implementation is planned with the availability of funds. When both components are fully implemented, it will be possible for physicians and other relevant caregivers to have access to data generated at home for effective care decision making.

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