Policy Driven Management System for Personal Health Monitoring:

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The objective of this research project is to implement a policy driven management system for tele-health applications. With healthcare becoming progressively digitalized and smartphones getting more and more common, this research/project aims to create a system that uses wearable body sensors to collect patient's body signals, utilize a web-based application to monitor the data, and also transfer it to a secure database in a hospital.

I. INTRODUCTION

Healthcare is becoming more digitalized as professionals rely on remote sensors to monitor bodily functions of the patients. This research project aims to simplify the monitoring process by integrating body sensors with smartphones and using the internet to send the sensor outcomes directly to the authorized personnel and a database. Research that had been done previously on wearable sensors showed that mean age of participants using body sensors was 54, with a standard deviation of 12.5 [1]. As the sensors are more widely used with older patients, this brings patients the burden of constant travel to the healthcare centers. There are also many cases where patients have to travel a considerable amount of distance to access healthcare, either because they live in rural areas or in countries that lack the technology. This research aims to decrease the amount of hospital travel required to monitor the patient's signs. In addition to increasing access for diagnosis this research also aims to address treatment issues. The doctors can set up policies to call services like 911, activate insulin pumps or various other electronic treatment devices attached to the patient.

It is anticipated that robust health monitoring systems needs to be adapted regularly to account for the individuality of the physical system, the metabolism and physical activities of the patient. Hence, we propose the development of a *policy driven management* system that will allow administrators to easily and quickly change how sensor system components interoperate. The sensors often need to adapt their behaviors to changes in patients' medical condition or activity, and they should be configured accordingly to reflect such changes. For example, there is a need to adapt the frequency of measurements on a sensor depending on the activity and clinical condition of the patient. This enables optimizing power consumption of the sensor device whilst ensuring that important episodes are not missed. Similarly, the use of variable thresholds for transmitting sensor readings reduces the need for communication and thus power consumption. Typically, sensor configuration may also change depending on the user's context, e.g., location, current activity and medical history. Physiological parameters such as heart rate thresholds or glucose levels for hypoglycemia and hyperglycemia limits (for patients with diabetes) need to be configured and customized accordingly.

The first phase of this research has been focused on developing a system and utilizing Ponder2 object management software. Due to the outdated software and compatibility issues with Ponder 2, the second phase of this research was focused on finding an alternative for Ponder 2. The third and ongoing phase is to write a program for android that will use both the remote sensors and the phone's sensors for android.

II. METHODS

Policies "define management goals of the system and events that trigger reactions" [2]. *Policy-driven management* is an important technology for managing distributed systems. By separating policies from the system implementation, a policy-driven system can adapt to changes by dynamically altering policies instead of the implementation. Security is essential for the deployment of sensor networks and electronic health records where privacy concerns about access to patients' data are important. Only authorized access to health sensors will be permitted for both accessing data and performing actions**.** With the policy driven management system, fine-grained access control can be created by making use of authorization policies.

For the first phase the Policy Management Software Ponder2 was chosen for this research. Ponder2 is an environment to develop policy based applications that "emphasizes simplicity, flexibility and extensibility" [2]. Ponder2 includes policies and events in its Self-Managed Cell. A Self-Managed Cell is "defined as a set of hardware

and software components forming an administrative domain that is able to function autonomously and is capable of self-management". Ponder2 includes 2 types of policies. These are authorization and obligation policies.

Authorization policies grant access to different aspects. The main use of authorization policies is to prevent unauthorized users or intruders from interfering with the system.

Obligation policies allocate tasks to different parts of the system. They can be seen more as function parameters.

Ponder2 uses a language named PonderTalk. PonderTalk is a Java based high level object oriented language. It includes many different aspects of another object oriented language called SmallTalk.

To build a Ponder2 program, Apache's open source build tool Ant was used. The programs and policies created were tested using the command prompt on Windows 8.1. Notepad++ was used to create and edit programs which were run using Ant. Telnet was used to create servers in which self-managed cells were hosted. Tutorial files and programs were downloaded from "ponder2.net" (currently unavailable). Most of the programs developed were based on tutorial examples.

When trying to develop policies through Ponder2 a general plot for the system was developed in Java. Similar Object Oriented program samples were used to develop and experiment with the system on a sample program.

The biggest problem with Ponder2 was the connection with Telnet Servers. Despite experimented on 3 different computers and 3 different operating systems, Telnet failed to connect. Since the system heavily relied on Telnet to work, the Ponder2 phase was left behind.

In the next step there was research done on alternative systems. Some systems that were found through online research were CIM Simplified Policy Language and AMUSE: Automatic Management of Ubiquitous e-Health Systems, but these systems faced the same problems Ponder2 had. There wasn't a team actively working on improving these systems and they were all systems developed at least a decade ago. Since the system includes smart phone integration, the development software must be updated. Since an effective alternative policy management software was not able to be found, the focus shifted from using a policy management platform to using a general platform combined with an android mediator program.

IFTTT was chosen to test the policy event responses. IFTTT (If This Then That) is a web based service that helps users write conditional statements and determine actions if those events are triggered. This software was utilized to create sample events and test how phone fast the phone responds. These tests will be further explained in the Results section.

III. RESULTS

The system proposed for the purpose of this research is shown in Figure 1. The users are divided into three groups: Low Privileged Users (Patients), Medium Privileged Users (Doctors and Nurses) and High Privileged Users (Hospital Administrators)

High Privileged Users are able to add and remove doctors and nurses. The administrators will also be able to access statistics about the hospital such as how many doctors, nurses and patients are in the hospital. High Privileged Users will not be able to access and edit patients' information. High Privileged Users, who will be hospital administrators will register to system through the system administrators.

Medium Privileged Users will be able add, edit and delete patients. While adding and editing patients they will be able to set different parameters for different sensors. They will also be able to write policies about different sensors that are being monitored. Currently there are no set differences between the methods for nurses and doctors, as these dynamics change from hospital to hospital. The system would be tailored according to special requests from the hospital administrators.

Low Privileged Users who are patients are guardians will be allowed to see their own vital signs, policies (if granted access by the doctor) and also have access to emergency contacts.

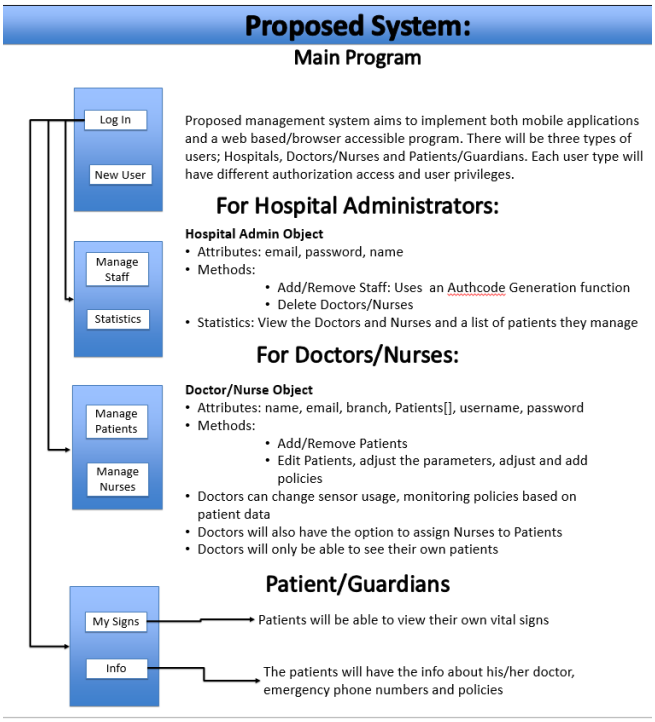

Figure 1: The proposed system

The sample programs from Ponder2 were modified. Figure 2 shows a sample Body Sensor Network (BSN) that includes various sensors and also an insulin pump which is activated when blood glucose is lower than the minimum amount set by the doctor.

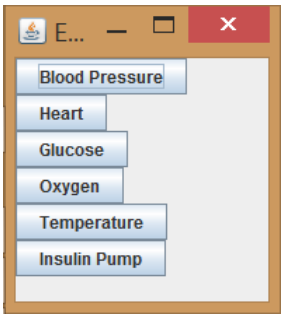

Figure 2: Sample Body Sensor Network from ponder2.com

Figure 3 shows one of the monitors from the BSN. The monitor is a virtual sensor. When a certain value is exceeded an alarm will show up on the screen according to the policies set by the user.

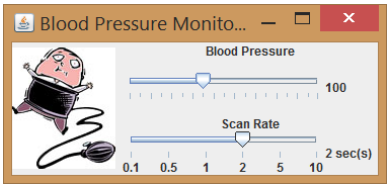

Figure 3: Blood Pressure Monitor

Due to the failure of Telnet, Ponder2 system had to be abandoned. The next phase of research focused on using IFTTT. Several tests were made for IFTTT to see its suitability for this project. One of the test recipes made was programmed so that it would turn the Bluetooth on a specified Samsung Galaxy S4 when a status update was made to Facebook by one of the researchers. This test worked successfully. It can be a groundwork to show that two seemingly unrelated things can be tied together with IFTTT. The only downsides about using IFTTT was the time it took the phone to receive the trigger from Facebook. When the response speed was timed, it averaged around 3-5 minutes. Since the system is proposed for emergency situations this can be a huge downside. Another disadvantage was the fact that IFTTT currently is closed source and only works with pre-registered. That defeats the universality purpose of the program.

IV. DISCUSSION

Another additional problem while carrying out this development process was setting Ponder2 on a computer running on Windows 8.1 operating system. Ponder2 and Ant were programs developed for older operating systems and many customizations to the system was needed to run these programs.

The alarms that were supposed to show up when heart rate monitor's value was adjusted didn't show up due the system not being able to access the Telnet server.

IFTTT is a great system that has a very simple User Interface but it is too restricting to use in a project like this. However, IFTTT can be utilized as an inspiration and an example to develop an Android application that is specialized for the purpose of this research.

So far the research has been mainly focused on policy writing and system management. The next steps for this project would be to finish the proposed system, adapt it to smartphones and working on calibrating body sensors with this system.

V. CONCLUSION

In summary, the design objectives of a policy based management system are:

- Dynamic management of policies: Injecting new policies into the system should be streamlined.
- Reconfigurability of policies: The policies should be able to adapt to the changing needs of the patient.
- Classification of policies: Policies will be classified according to patients' medical condition/history.
- Responsiveness: Policy software should introduce minimal processing latency, as some applications may require critical response times.
- Energy efficiency: Policies should minimize power consumption.

Ponder2 would be an ideal system to put these management goals in a health monitoring system. However there might be some problems due to Ponder2 losing active support from its development team. In addition to this, there might be problems transferring a program developed in Ponder2 to modern day smartphones.

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VII. REFERNCES

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