Context Aware Quick Sensor Service (CQSS) to Remote Patients

Sushama Rani Dutta, Sujoy Datta, Monideepa Roy

Abstract: ***Using sensors in healthcare can greatly improve the quality of life, especially for elderly patients. The data from the sensors of the patients is constantly monitored for abnormalities at a server. Whenever this data crosses a threshold value, the information is notified to the corresponding doctor. The doctor can then take the necessary action. However an inspection of historical data has shown that some conditions of patients have cyclic patterns and the medications are often repeated. The proposed system is designed to assist the doctor in diagnosis by retrieving those patterns. We have compared the times taken for receiving responses from the two different systems and a significant amount of improvement was noticed. We have introduced a Dynamic Context Aware Technique (DCAT) which can improve the quality of 24 hour monitoring patient. This paper presents the design and implementation of a system based on DCAT using SAMSUNG GEAR S (Heart rate monitor sensor.The backend remote centralized computation and data storage can decreases the workload of the remote health care provider by avoiding of sending the identical and similar cases data to the doctors. This improves the processing speed and also gives solutions in case of the unavailability of doctors in some cases. Experimental results based on real datasets show that our system is highly efficient and scalable to a long time monitoring patients.***

Index Terms: Context aware; Machine learning Technique; Continuous monitoring; DCAT; CQSS middleware

I. INTRODUCTION

The different health sensors and various intelligent services reduce the need of indoor and outdoor care taker for the elderly person. For example after heart surgery of an elderly person who is living alone can be reported to remote health care taker by using different sensors. These intelligent services include different new techniques to provide early health services. Ambient assisted living (AAL) technology [9, 13] help the elderly people to keep in touch and communicate with their family members. Even though several applications have already been developed, still many new problems arise which suggesting new development of applications. We give emphasize in this system to increase the functional efficiency as well as to reduce time, cost and energy of the remote continuous monitoring architecture [1, 2]. In the case of continuous monitoring of a patient for 24 hours through the health sensor, we found many identical and similar cases. These cases may happen in different time within a day, week or month but it can be handled by previous same medications without reaching out to the doctors. Sometime it gives solutions to the unavailability of doctors. This type of cases can be handled in backend server by maintaining some security issue (correct identification). To significantly reduce time of service in case of identical and similar type of sensor data (critical case but identical or similar cases as previous), we propose a technique called Dynamic Context Aware Technique (DCAT). In which the backend server dynamically process, store and manipulate the health sensor data and medication data by using machine learning techniques. Our technique works only on those conditions when the sensor data crossed the limitation of the expected pattern (normal condition value) and comparing with the previous unexpected pattern (crossed threshold value). To determine the Dynamic Context Aware technique, we have implemented the Context aware Quick Sensor Service (CQSS) middleware on the backend server. CQSS machine learning engine runs on the server which manipulates receiving sensor data streams and medication from the doctors using machine rules, which is required for the current context. Using the CQSS middleware, we have collected the heart rate using SAMSUNG GEAR S (Heart rate monitor sensor) of a user with their context changed. We observed the time variations for different identical cases services. This system can be used and experimented by taking any health sensor data. This experiment concludes that using DCAT technique, context-aware matching can reduce the time of response in remote health services.

II. BACKGROUND WORK

In [1,2] architecture, the available personal digital assistance device (smart phone or PDA) is placed in between the wearable body sensors and the remote cloud server. The device (Smart phone) connects to the wearable sensors by a Body Area Network (BAN), short-distance technology like ZigBee or Bluetooth, and uses a Network interface like GPRS or 802.11 for sending the collected sensor data to the backend server and the backend server process data and connects to the remote doctor for medication. Many techniques used to compress the health sensor data for better communication [3].Remote health monitoring of energy efficient communication already described by xiaohui liang [4]. Disease selection is a technique from health sensor streaming data by data analysis and care monitoring [6, and 7].

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But the above architectures are geared towards low-efficient, time consuming service and draining unnecessary energy of the doctor's mobile device. As the above systems do not manage and manipulate the identical and similar cases of sensor data. Above systems directly handling all sensor data in a similar fashion, which can be managed and manipulated by our proposed system for getting quick services. The author [10] described about the data stream in clustering technique. It has two phases, one phase divides data stream into buckets. Within the bucket again it finds clusters and cluster centre. According to cluster centre it selected the data pattern and discards any other. It has low time and space and this cannot be applied to evaluate data pattern which are identical and similar patterns. The quantitative evaluation of complexity health data is described by Hongpu Hu , Yanli Wan , Quan Chen [11] which provides the data quality management of health data. In remote health monitoring system ,a big issue is to store, retrieve, analyze and compare the health sensor data is already described by Li Guo , Chao Wu , Chun-Hsiang Lee ,Yike Guo [12] . But they did not handle the identical sensor data cases. In this paper, we are going to handle the identical data pattern and also the similar kind of data pattern from the received health sensor data. This will provide quick service to the remote patients.

III. PROPOSED FRAMEWORK

In case of health sensor environments, a large number of streaming data collected and conforms to *expected* patterns, and data should be transmitted only *unexpected* events to the doctor for medication [8]. The filtration of sensor streaming data (only unexpected data) reduces the volume of data for communication. From this system, we observed many cases that are identical and similar cases also communicating to the doctors for medication but the medications are same as earlier cases (carefully handling with same patient). But the issue is the patient is in critical condition and the system takes uncertain time (may be network problem) for sending data to the doctor for medication. There are many types of problems like doctor may be busy at that particular time to attend the patient request or there may be the network problem due to which the server unable to send the notification to the doctor or due to the network problem doctor's medication may not reach to the patient. But the time factor is a big issue for an emergency patient with critical condition and waiting for medication. In order to solve this problem we have designed a system called CQSS middleware which used the Dynamic Context Aware technique, which can solve the above problems and can provide an efficient service to the emergency patient at an early possible time. Figure 1(a), shows the health sensor which is sending the body signal or health related data to the patient mobile device through blue tooth which is available in every health sensors. The sensor is sending data periodically to the mobile device which is further sending to the remote server [11] through the Wi-Fi or using 3G connectivity (p1). The server matches the threshold value and if the value is more than the threshold value then the server will be sending a notification to the doctor (p3) through the messaging server (p2). The doctor sends medication to the patient through p4, p5, p6.

We proposed a system shown in figure 1(b), this can avoid the p2, p3, p4 processes in the repetitive and similar cases with different context. Within 24 hours monitoring cases, repetition may occur in the same day during the observation period with the same type of condition. In that cases if the patient is in emergency condition and the system will take uncertain time to provide medication (P4) by following the mentioned procedure, which may cause critical condition to the patient. In order to avoid this condition we are going to store all the sensor data in the server database D1 (periodic sensor database) and it will always match with the given threshold value with the given circumstantial condition. When the condition crossing the threshold value it will send the message to the doctor. The corresponding medication from the doctor will be stored along with the unexpected sensor data in the database D2 (medication database) in the server database before sending to the patient.D2 only stores medication with first time sensor data, not the identical cases nor the similar cases medication. So the further matching and comparison will be accurate and easy to identify the appropriate medication. Further when the patient is in any condition (sensor data with patient activity) same or nearer to the earlier condition that is any repetition case as before occurred. Then it will immediately check with the D2 database and search for the corresponding medication from the database D2 with the help of knowledge database. If proper matching (identical and similar case) found from the database then the server will directly follow the process p5 and p6 to send the medication to the patient, which will reduce the response time from a doctor. We are applying the sensor data pattern analysis model shown below in Figure 2, to analyze the sensor data with the threshold rule type and the knowledge database to extract the proper medication for the particular condition and time.

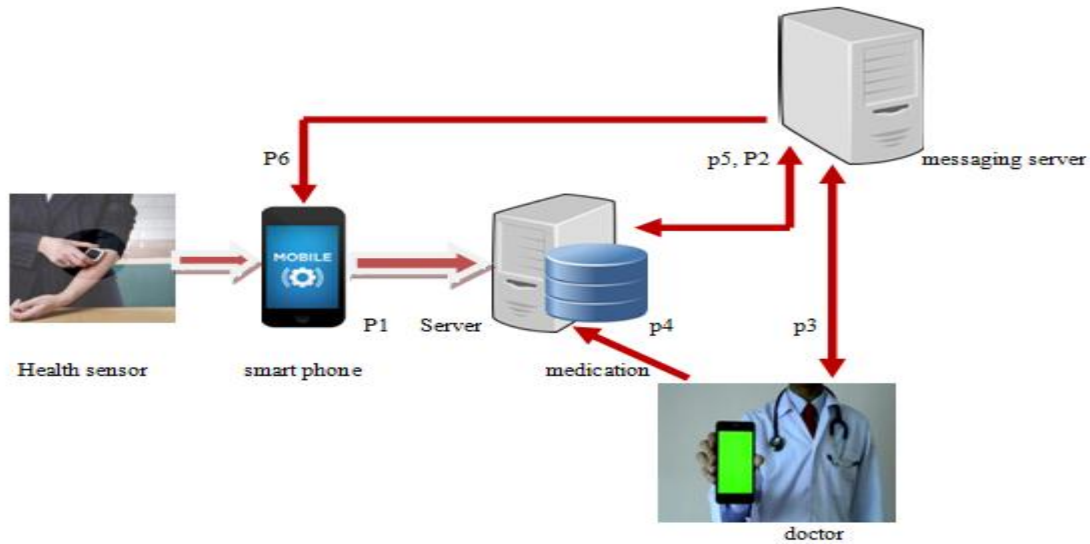

Fig. 1(a) Architecture of the existing system with problem statement of Identical and Similar unexpected event

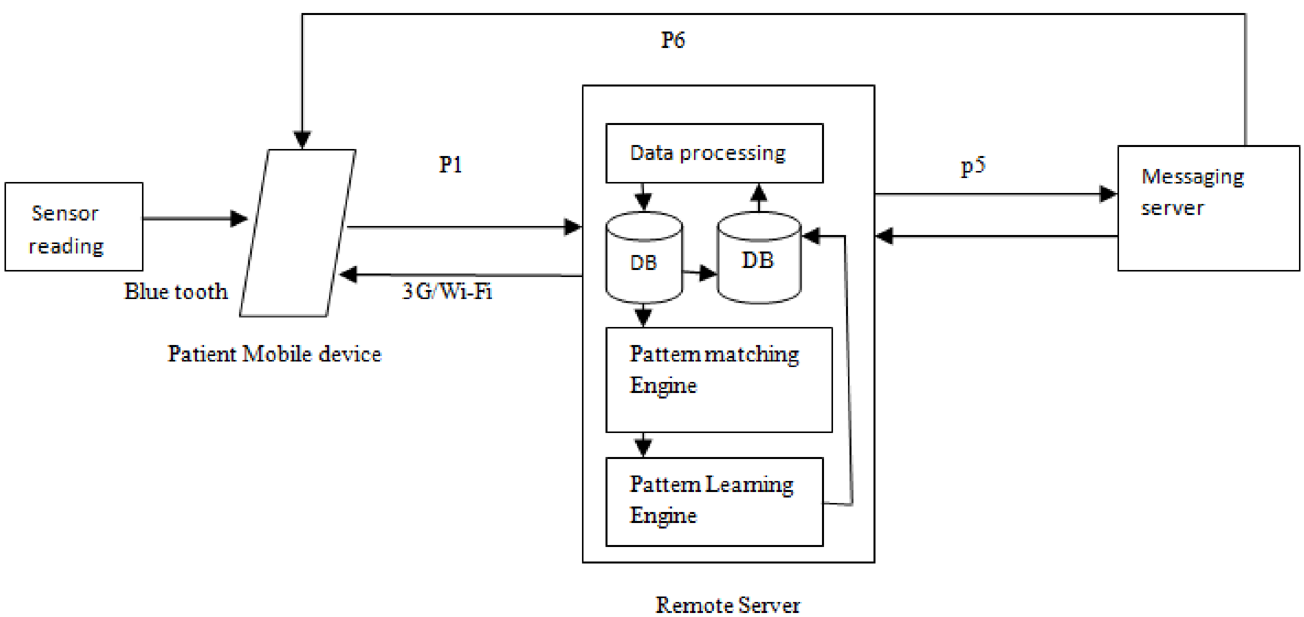

Fig. 1(b) Architecture of the proposed CQSS system in Identical and Similar unexpected event

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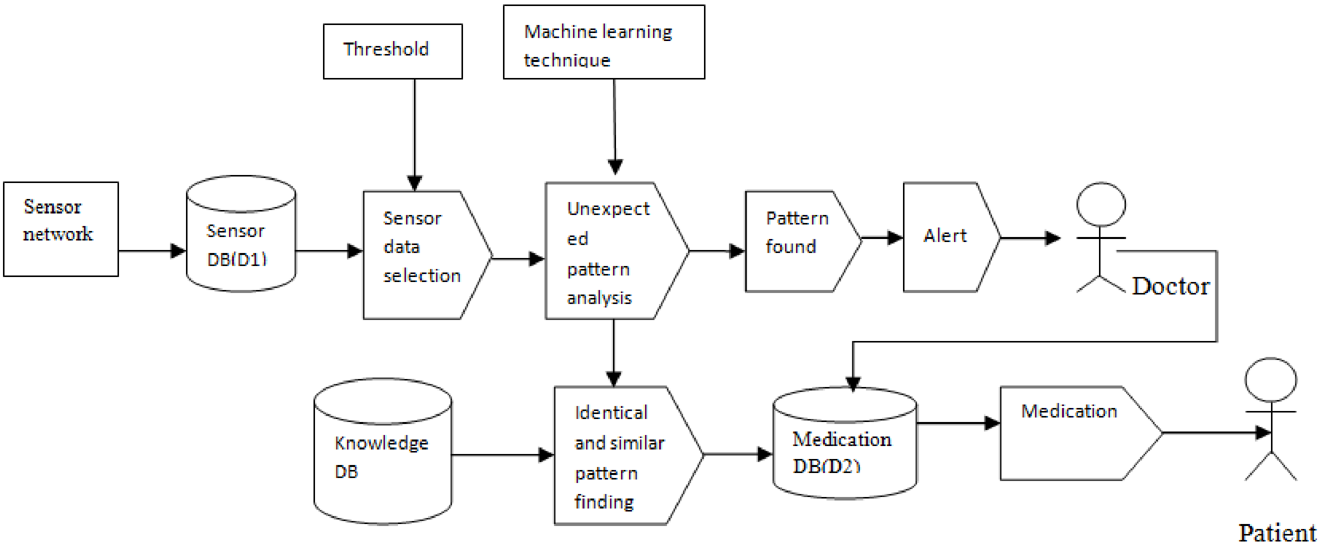

Fig. 2 Sensor data pattern analysis using Dynamic Context Aware Technique

IV. IMPLEMENTATION

We have experimented with a health sensor, SAMSUNG GEAR S (heart rate monitor), the Sensor Activity mode is set to walking mode, the person is walking and the heart rate values are noted (randomly within a day) shown in Figure 3.

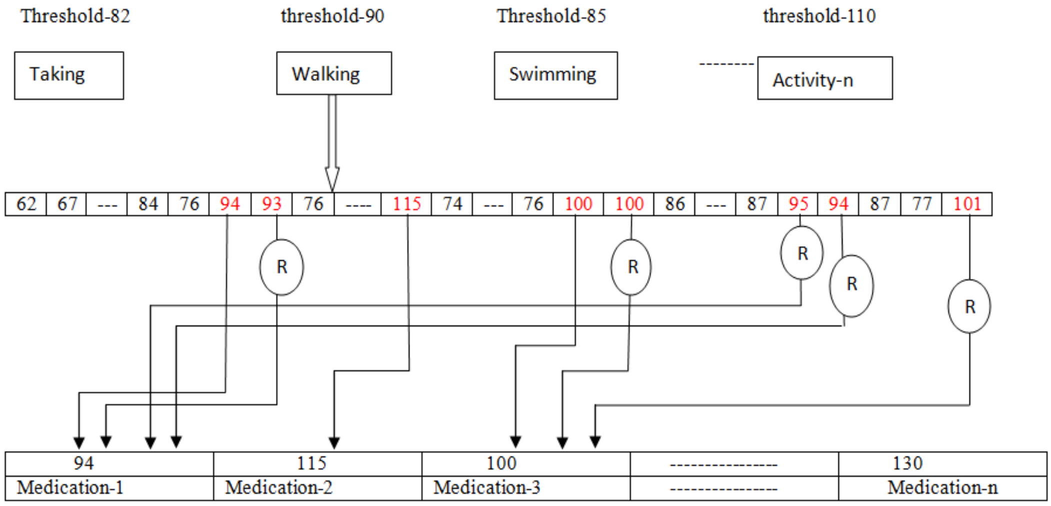

Fig. 3 Manipulation schema for repetitive and similar value of Sensor

Threshold value is different for different activity level. The red marked values (8 times) crossed the threshold value (90) for the particular activity. The existing system server needs to send the alert for **8 times** (without handling identical and similar cases), which can be reduced to **3 times** alerts to the doctor for medication by handling identical cases. To satisfy the condition our system filtering the sensor data only that is crossing the threshold value. Taking that value as 'n' and calculating 'n-i' and 'n+i' value (it may be varying to detect similar case) for identifying the nearest value that is very close to the sensor data. The similar value selection can be changed based on patient condition. Comparing these 'n', 'n-i' and 'n+i' with the existing values that are already crossed the threshold value (D2 database) earlier by applying proposed Contextual matching detection algorithm given below. For all the case 'n','n+i','n-i' have the same matching medication can be provided to the particular patient (based on domain expert).

Contextual Matching Detection Algorithm (CMDA)

Input A_n is Activity;

S_n is periodic Sensor data;

T_n is the Threshold for Activity 'n';

a[i] is cases (1st time deviated not similar cases) of deviation for medication;

Output: Matching Medication

Begin

1. A_n = Activity(n);
2. S_n =Periodic sensor data(i);
3. T_n =Threshold of Activity(n);
4. a[i] =array of medication case;
5. If $S_n > T_n$ and S_n = a[i] , (a[i] > T_n) Then
6. Set No Alert;
7. Write Medication of(a[i]);
8. else
9. If $S_n > T_n$ and (S_n-i) = a[i], (a[i] > T_n) Then
10. Set No Alert;
11. Write Medication (a[i]);
12. else
13. If $S_n > T_n$ and (S_n+i) = a[i], (a[i] > T_n) Then
14. Set No Alert;
15. Write Medication of(a[i]);
16. else
17. If $S_n > T_n$ Then
18. Set Alert;
19. Write Medication;
20. Update S_n;

In this section, we introduce a Contextual Matching Detection Algorithm (CMDA), which is used to solve the problem of identification of identical and similar data from a stream of health sensor data and match it with the corresponding medication from the previously stored medication database. Most of the available sensors for continuous health monitoring are activity based, so in our algorithm' A_n' is the type of activity, which is set as walking in our experiment in Samsung Gear S. The streaming data (periodic) which is taken as' S_n' and 'T_n' is the threshold value (different for different activity). 'a[i]' is the sensor value which has crossed the decided threshold value but this will not store the identical or any other similar pattern for which we are going to provide the same medications. This is because to avoid the continuous following the next and next value which may cause wrong matching medication for the patient. The corresponding medication to the sensor data a[i] will be stored in a database, which can be retrieved by following algorithm steps 7, 11, and 15.The similar cases medication cannot be further applied for next similar case to this previous similar cases, this may cause to identify all the sensors data as similar in long run. For this reason every time system should match with only first time entered value to a[i].

The matching case model for identical and similar type of data pattern is given below in Figure 4.

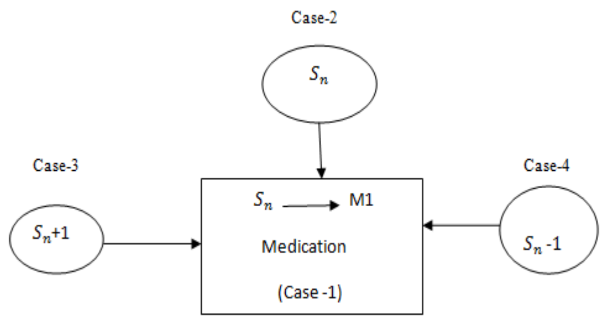

Fig. 4 Four cases have same medication (matching cases)

The matching case model describes how few data patterns given above (case-1, case-2, case-3, and case-4) are similar. The similar patterns are decided by the domain experts and it is also varying with different conditions of the patient. They can be allowed for same medication as referred in first time for case-1 and followed by other cases (period of following same medication based on domain expert).

V. RESULT & DISCUSSION

The observed Process time from the experiment (taken few instances randomly within a day) in system clock for medication in different Heart rates (collected by "Samsung Gear S" Heart rate sensor and using back end server) for both the existing system and proposed system is shown in below . The Figure 7,given below is our server system developed by using Programming Languages: Python 2.7, JavaScript and Java. Frameworks:Django,SDK:Android ,Platforms: Redhat OpenShift (PaaS). The server was developed in an MVC pattern and with Android Devices acting as clients to the server. The server was deployed on Open Shift, a Platform as a Service provider by RedHat. The experiment tested by using two smart phone, one as a patient smart phone and other is as doctor's smart phone. Because of applying our technique in the server ,we get immediate responses in identical cases without sending to the doctors.The activity of the patient is set as 'walking'and the threshold value is set to 110 bpm (according to domain expert).

Table 1. shows the time comparision between existing vs proposed system and the Figure 5, shows the Time Graph.

Table I Time comparision between existing vs proposed system

Sensor Value (Threshold-110 bpm)	**Time taken in sec (Traditional System)**	**Time taken in sec (Proposed System)**
120	230	220
121	230	55
180	210	210
179	210	46
119	240	40
187	230	232
188	230	45
129	240	200

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181	240	46
121	220	45
129	235	40

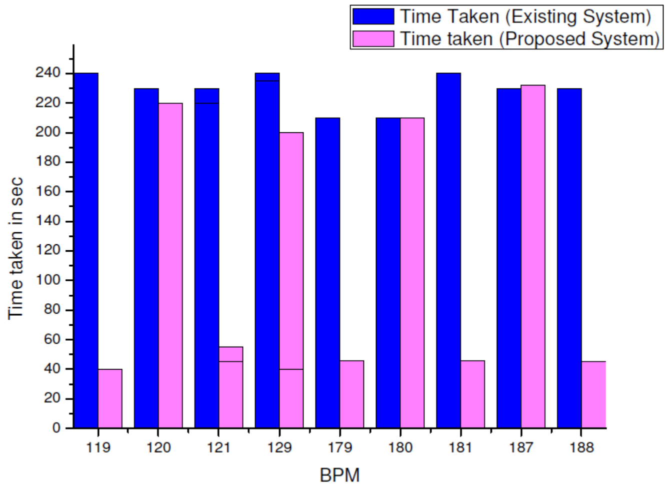


Fig. 5 Time Graph Existing vs proposed system

Following figures are tested for single event of identical sensor data (tested for 120bpm and121 bpm) .The time for different processes are noted in device clock according to the above given Figure 1(a), existing archtechture and Figure 1(b), proposed architechture are given in table 2. and the graph for this time comparision is given below in Figure 6, From this we can observe how much time can be saved in total if there is any identical or similar case to be handle.

Table II Process time comparison for single event

process	trditional time in sec	proposed time in sec
p1	10	10
p2	20	0
p3	10	0
p4	150	0
p5	10	25
p6	10	10
total	210	45

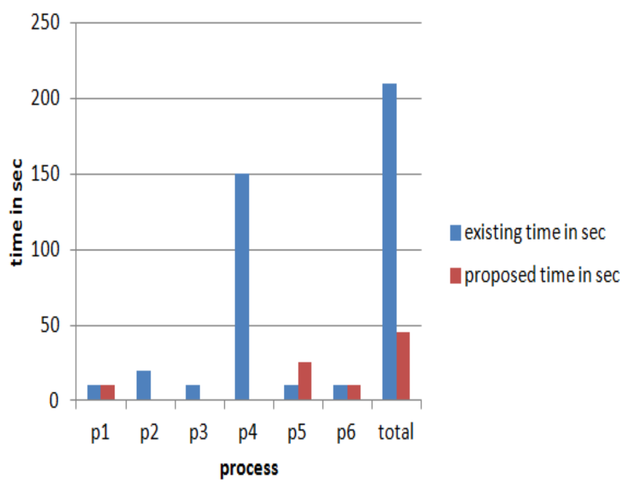


Fig. 6 time comparison Graph

While observing the real time testing, the following screenshot Figure 7, captured randomly which stored the sensor streaming data from the heart rate sensor "Samsung gear s".

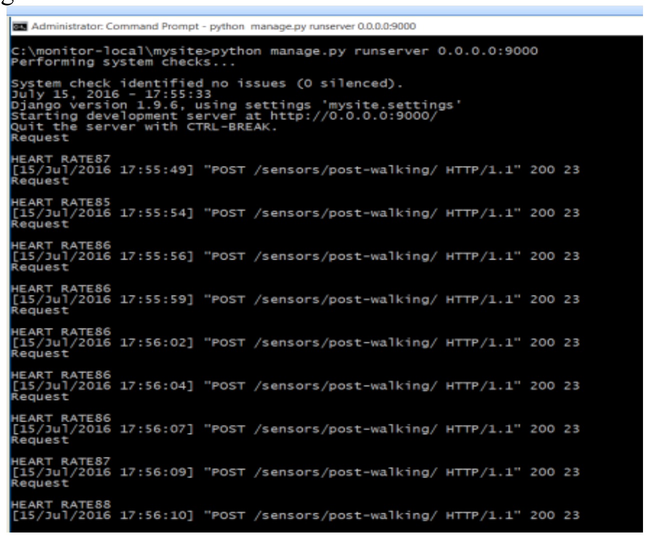
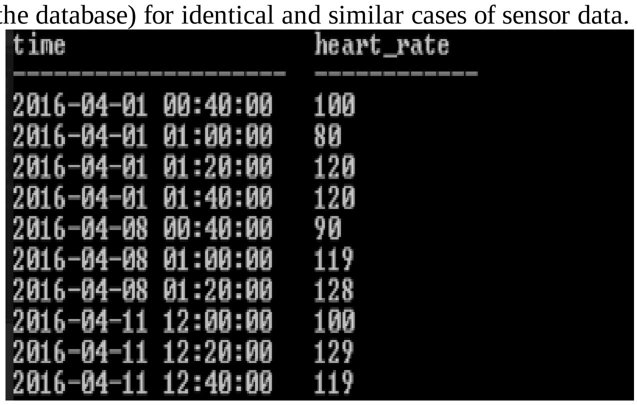


Fig. 7 Random heart rate SAMSUNG GEAR S data running in server

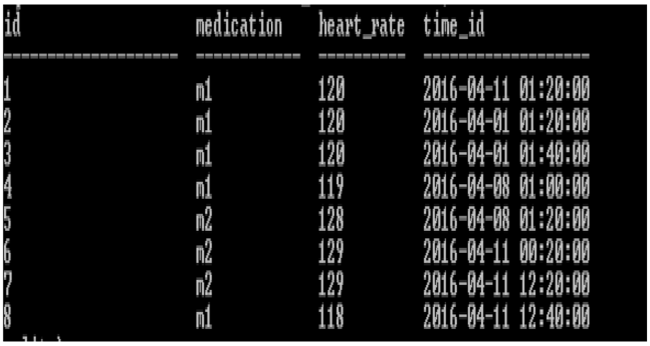
Figure 8, shows some of the cases which are exceeding the threshold value, which is fixed as 110 (according to domain expert)

Following Figure 9, shows the screenshot of the matching case medication (random collected data by putting query to the database) for identical and similar cases of sensor data.



time	heart_rate
2016-04-01 00:40:00	100
2016-04-01 01:00:00	80
2016-04-01 01:20:00	120
2016-04-01 01:40:00	120
2016-04-08 00:40:00	90
2016-04-08 01:00:00	119
2016-04-08 01:20:00	128
2016-04-11 12:00:00	100
2016-04-11 12:20:00	129
2016-04-11 12:40:00	119

Fig. 8 some cases with exceeding threshold value (110)



id	medication	heart_rate	time_id
1	m1	120	2016-04-11 01:20:00
2	m1	120	2016-04-01 01:20:00
3	m1	120	2016-04-01 01:40:00
4	m1	119	2016-04-08 01:00:00
5	m2	128	2016-04-08 01:20:00
6	m2	129	2016-04-11 00:20:00
7	m2	129	2016-04-11 12:20:00
8	m1	118	2016-04-11 12:40:00

Fig. 9 Database for Medication for identical conditions

VI. CONCLUSION

Traditional sensor streaming data-based on clinical decision support systems are designed to be used in a clinical environment and to query a central database for the relevant data. In this paper, we have present the architecture of a mobile CQSS middleware that is intended for use by the patient in a free-living setting and is tailored towards the telemedicine domain and the processing of streaming data such as from a body sensor. The design of our CQSS was inspired by existing stream data management systems. This system is handling the most identical and similar cases in order to save time of the remote patient and can avoid the problem of unavailability of doctor in this type of conditions. But this work can extended to account for the different types of activities involved in the full disease management process, namely Monitoring, Analysis, Decision and Effectuation.

VII. FUTURE WORK

In future we plan to take into consideration other context factors based on health sensor data. This may find any other matching event in order to find out any outcomes which will help the remote patients to get an early health services and preventions. And also to provide more efficient and accurate service matching results.

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