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Cloud-based Smart Health-care Platform to tackle Chronic Disease

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Abstract: *The objective of the current work was to design and develop a cloud-based smart health data analysis platform for real-time patient-specific health monitoring and analysis with long-term surveillance to support learning based information processing system benefiting from cloud and mobile technologies. A DevOps approach to cloud-based applications development was used to create a platform for remote health data recording, surveillance and clinical reporting. IBM Bluemix as a platform, Gravitant for decision analysis for hybrid cloud, Urban Code for build deploy, and IBM Cloud Orchestrator to manage solutions in health care was utilized as infrastructure of the platform presentation layer where remote sensing of patient-specific vital physiological signals (Heart rate, Blood Oxygen level SpO2, Body temperature) are locally performed at the patient site via a designed embedded system equipped with Raspberry Pi. The embedded system is transmitting data to the cloud where the health care provider can control and analyze health data in real time. The proposed smart health data analysis platform on the cloud offered real-time remote health monitoring solution, which provides rapid and secure deployments of the best patient specific treatment strategy available for remote patients.*

Keywords: *Cloud; DevOps; health-care; platform; real time, real-time, software engineering, industrial systems engineering.*

1. INTRODUCTION

One in four Americans is diagnosed with multiple chronic conditions, the leading causes of death and disability, according to the recent released statistics by Centers for Disease Control and Prevention (CDC) [1]. Prevalence of chronic illnesses in the U.S. have been projected to reach 171 million cases by 2030 [2]. Medicare standard analytic file reported that two-thirds of Medicare spending is for beneficiaries with five or more chronic conditions. Same report reveals the exponential correlation among poor care coordination and unnecessary hospitalizations. Treatment of chronic health conditions demands more than eighty six percent of nation's total health-care cost. However, "Serious Chronic Illness" survey conducted by Gallup organization highlighted unsatisfactory level of received treatment among patients with serious chronic conditions which brings a big question mark of what is missing to provide the patients with the highest quality of care and yet relieving the financial burden.

The necessity of reviewing the current health monitoring techniques and care providing protocols is not only seconded by the above-mentioned facts but also looks like an undoubted trend when remote patient care and/ or real-time long-term monitoring is recommended. Accessing the timely fashioned care and monitoring for adults with Alzheimer's disease, a progressive neuro-degenerative disorder [3], or pediatric with epilepsy [4], shall not be considered as an option but a mustdo. Dynamic treatment regime (DTR), sustained health factors monitoring and smart multi-stages treatment adoption, is an emerging recommended strategy by medical community to enhance treat chronic diseases. Sustainable medical data collection, smart surveillance, resilient data analysis and decision makings are revolutionizing the ergonomics in health care and in particular DTR yet remained as top challenges lacking a proper platform.

Here, we contributed to design and develop a cloud-based smart health responsive smart and responsive health data analysis platform for real-time patient-specific health monitoring and analysis with long-term surveillance to support a learning based information processing system benefiting from cloud and mobile technologies. Cloud based systems cited as the innovation of the current century in Networked Control Systems (NCS), facilitates configuration, monitoring and controlling devices through cloud worldwide [5].

2. SYSTEM ARCHITECTURE

System architecture includes two interconnected units: Local Unit (LU) and Cloud Unit (CU). In Cloud Unit (CU), A DevOps approach to cloud-based applications development was used to create the smart health care platform for remote health data recording, surveillance and clinical reporting. IBM Bluemix as a platform,

Gravitant for decision analysis to hybrid cloud, Urban Code for build deploy, and IBM Cloud Orchestrator to manage solutions in health care was utilized as infrastructure of the platform presentation layer, where remote sensing of patient-specific vital physiological signals (e.g. Heart rate, Blood Oxygen level and Body temperature) are locally performed at the patient site via a designed embedded system in Local Unit (LU). LU is transmitting data to the CU where health care providers can control and analyze data for further decision makings in real-time. Fig. 1. presents the suggested full utilization of the "Smart Health Care Platform on the Cloud".

A. Local Unit (LU)

Fig. 2. Shows the Local Unit (LU) hardware of the proposed smart health care platform. For the initial prototype, two sensors (joint pulse and SpO2 sensor, body temperature sensor)

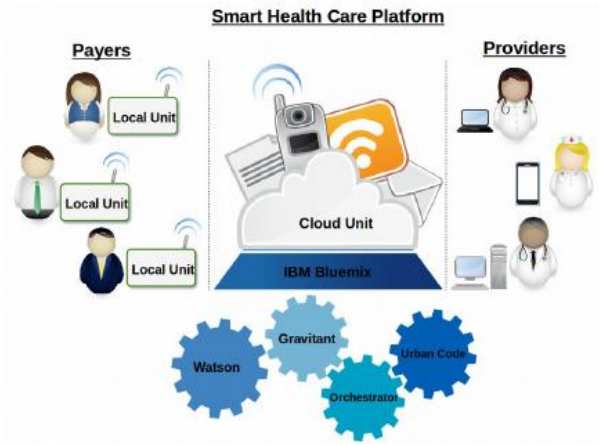

Fig 1: *"Smart Health Care Platform on the Cloud" in action.*

were utilized, enabling real-time monitoring of three vital physiological signals, Heart rate in the units of beats per minute (bpm), Blood oxygen level (SpO2) in the units of percent and the body temperature in the units of degree Centigrade.

Body temperature is amongst those vital signals with high importance due to its casual relationship with a number of diseases, as well as adopted way of following a course of treatments by physicians. On average, the core body temperature is being reported to be 98.6 °C with 0.9 °C variance during the day. Pulse oximetry is a non-invasive solution for indicating the arterial oxygen saturation level in blood hemoglobin. Pulse oximetry is a prompt technique to indicate the patient's need for supplemental oxygen when their SpO2 level is indicated out of the normal range of 95 to 99 percent [6].

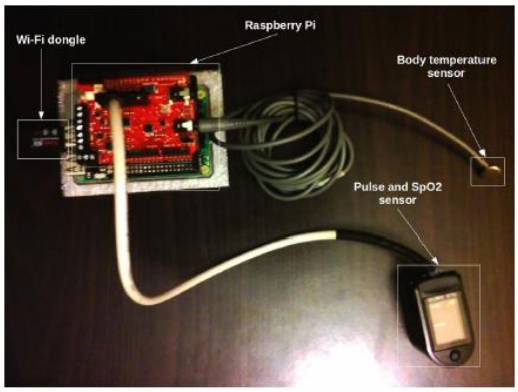

Fig 2: *"Smart Health Care Platform"'s Local Unit (LU).*

Raspberry Pi, as the core of the LU, controls the operation of the sensors and assures continuous recording of the vital signals. The LU core then transmits the data packet formatted as JNODE string to the CU. The communication between LU and CU is following MQTT protocol for communication [7]. Software codes for the LU are written in C++ programming language. Autonomous running of the LU minimizes user intervention as the full operation cycle (recording and communicating with the CU) happens automatically while power is supplied.

B. Cloud Unit (CU)

The CU of the smart health care platform, as shown in Fig. 1., covers by the umbrella of IBM Bluemix. Bluemix is the IBM cloud platform, enriched with tools and solutions for rapid and efficient prototyping of cloud-based applications [8] such as the smart health care platform discussed here. Main elements of the smart health care platform's CU is listed as follow with their unique utilization area.

IBM Watson IoT Platform is being utilized for device connectivity, information management, and risk management for safe and secured connection with the LU.

IBM Watson IoT Platform Analytics Real-Time Insights is being utilized to monitor and conceptualize data from the LU's, visualize what's happening in the operation of LU's, as well as respond through automated actions. Automated actions range from calling the associated individuals, sending text messages, and/ or activating an actuator in case of abnormality detection in health status send by LU.

IBM Gravitant is being employed for decision analysis for hybrid cloud as an extra optional layer being added to the prototype platform.

IBM Cloud Orchestrator is being utilized to accelerate the CU management by reducing the number of steps to

administer the public, private and hybrid cloud such as metering, usage, accounting, monitoring and capacity management in the smart health-care platform.

IBM UrbanCode is being utilized for building and deploying the applications such as worldwide web and mobile access to the platform and/ or clinical documentations.

3. SYSTEM SNAPSHOTS

Fig. 3. shows snapshots of the prototype platform while running. The embedded security layer of the platform, requiring API Authentication and key, guarantees privacy access of the data and reports to whom granted with the permission. As discussed previously, the architecture allows administration and different levels of access modes.

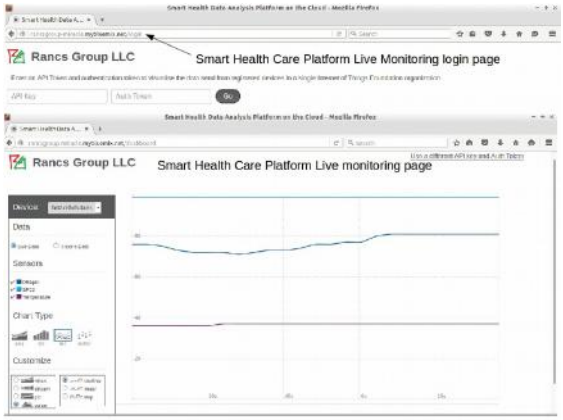

Fig 3: *"Smart Health Care Platform"'s Live Monitoring.*

4. CONCLUSION AND FUTURE WORKS

The proposed smart health care platform on the cloud offered real-time remote health monitoring solution, which provides rapid and secure deployments of the best patient specific treatment strategy available for remote patients. Furthermore, applying machine learning techniques such as abnormality detection, early detection of potential health risks could be applied in terms of modeling, parameter estimation on the model leading to the construction of an optimized treatment regime prescribed to each individual. Adding more specialized physiological signals related such as blood sugar, blood pressure, airflow, Electrocardiogram (ECG) and Electromyography (EMG) plus prediction capabilities to the platform are on the list of added capacities to the prototype.

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