Big Data Edge on Consumer Devices for Precision Medicine

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IEEE International Conference on Consumer Electronics (ICCE) | DOI: 10.1109/ICCE53296.2022.9730484

***Abstract* - Consumer electronics like smartphones and wearable computers are furthering precision medicine significantly, through capturing/leveraging big data on the edge towards real-time, interactive healthcare applications. Here we propose a big data edge platform that can, not only capture/manage different biomedical dynamics, but also enable real-time visualization of big data. The big data can also be uploaded to cloud for long-term management. The system has been evaluated on the real-world biomechanical data-based application, and demonstrated its effectiveness on big data management and interactive visualization. This study is expected to greatly advance big data-driven precision medicine applications.**

***Index Terms*—Big Data Edge, Precision Medicine, Mobile Edge, Smart Health.**

I. INTRODUCTION

Big data is advancing many areas and industries, among which the healthcare field is attracting intensive interest. Consumer electronics like smartphones and wearable computers are furthering the precision medicine field significantly [1, 2]. The consumer devices facilitate the big data capturing and in the context of precision medicine, advance the long-term biomedical dynamics monitoring. Moreover, the consumer devices have the potential to provide real-time and interactive demonstration of the big data for the users.

Efforts have been made previously on advancing the usage of consumer devices for precision medicine. Wearable computers [3-5] have demonstrated the potential for health monitoring, through monitoring different biomedical or behavioral signals. For example, the physical activity sensor is used for oncology monitoring applications [6]. The wearable Electrocardiogram monitor [7] is used for heart disease monitoring. However, the management of big data from wearable computers needs further studies. Besides, smartphones [8, 9] have also been leveraged for health monitoring or analysis, leveraging its convenience and pervasiveness. Nevertheless, it is still necessary to co-consider the mobile edge and the cloud to enable effective big data management.

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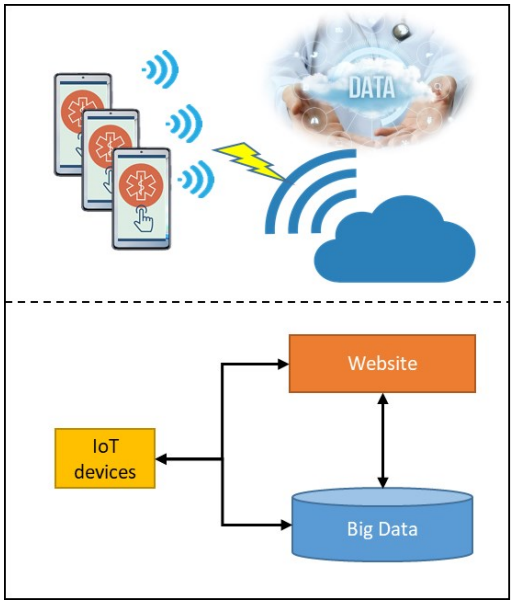

Fig. 1 Concept of mobile edge for big data interaction.

In this study, we propose a big data edge platform that can, not only capture or manage different biomedical dynamics, but also enable real-time visualization of the big data. Furthermore, the edge platform can also be used together with the cloud system to co-evaluate and/or co-visualize the big data. More specifically, out contributions include:

(1) A big data edge platform that enables management of data from consumer devices;

(2) The big data edge has comprehensive designs to support big data security and interaction;

(3) The big data edge can effectively coordinate with the cloud system for big data co-demonstration.

The system has been evaluated in real-world applications, in which the biomechanical dynamics are captured, streamed and visualized in real-time. This study will greatly advance the at-fingertip big data-driven precision medicine applications.

II. METHODS

A. System Overview

The purpose of the proposed big data edge platform is to provide a smart and secure interface for patients to get full access to their health data, receive real-time illustration of their

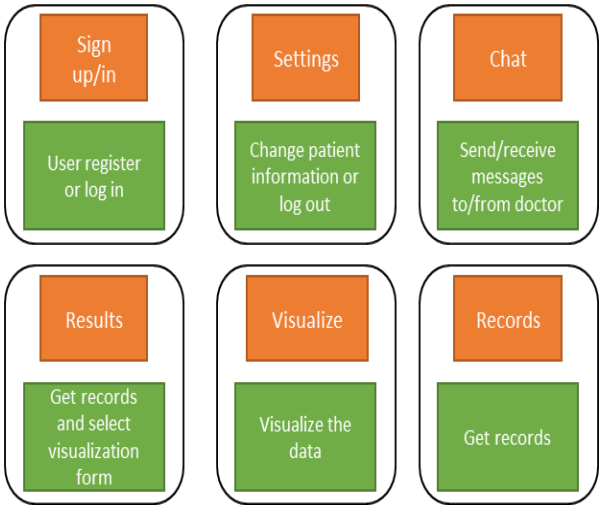

Fig. 2 System Overview of the proposed s²Edge system for smart and secure big data interaction on the mobile edge.

physical activities, and communicate with their doctors. The system diagram of this mobile edge system is given in Fig. 2.

B. Big Data Management

The big dada management is enabled by secure design and important management settings. Each screen on the APP has a specific functionality that helps carry out the purpose stated above in Fig. 2. First and foremost, data security is an important aspect of the system. In order to keep patient data safe, AWS [10] Cognito is used to store and verify user credentials. Every patient must have login credentials to access their data, so that no unauthorized person can access their data. Data is not shared and there is no way to access another patient's data without accessing their account or being their doctor. Each patient has a doctor that they work with. In order to maintain and improve the health of their patients, doctors will create health records to track a specific aspect of a patient's health. These records and their associated analysis are made readily available via the Records and Results screens. These screens list out the health records associated with the patient. The Results screen will allow patients to view the associated activity data.

C. Big Data Interaction

Real-time analysis is conducted by retrieving phone sensor data and sending it to the cloud system. Upon starting up the real-time analysis feature, a direct connection is made to the AWS cloud system and data is captured from the phone's sensors and sent to the cloud system. This feature is only activated when the patient turns on a sensor in the Visualize Screen. The patient always has the option to turn off phone sensor data capture. Not all sensors available on the phone will be captured. Only the necessary sensors that are listed by the doctor are used. The Visualize Screen will show time-series graph of each sensor output that is being used. Besides, a Chat feature allows the patient to directly send messages to their doctor. This gives patients direct access to their doctors. The Settings screen is for patients to view and update their information. Patients can change their information they would like (e.g. name, height, weight, account login, etc.) as well as sign out of the mobile application.

III. RESULTS

A. Experimental Setup

To evaluate the system, we have conducted a real-world experiment: biomechanical dynamics-based physical activity monitoring. We have demonstrated that the biomechanical data can be successfully streamed and managed by the big data edge, toward precision medicine practices [11-13].

B. Big Data Co-visualization on Edge-Cloud

In order to test the real-time functionality, the Visualize screen was selected and the correct sensor graphs were displayed and that the data was flowing through the AWS cloud system. The data was also viewable on the doctor's account on the cloud in real-time. When testing this aspect of the system, both the mobile application and website were pulled up. As shown on the left side of the Fig. 3, the mobile application visualizes the sensor data on a time-series graph. Different channel axis values are being captured from the sensors and graphed. All of the data is sent in real-time to the cloud system. The mobile application makes a direct connection to the cloud system and is able to capture and send data directly to the cloud.

Fig. 3 Big Data Co-visualization on Edge-Cloud, indicating the effectiveness of the proposed s²Edge system and how it works together with the cloud.

The doctor who uses the website portal on the right, can subscribe to the data that the patient is sending and view it in real-time. Notice in the figure, the doctor's graph and the patient's graph are very close to in-sync. This means that the doctor gets almost instantaneous updates of what the patient is currently doing and is able to get an in-depth analysis of the data. The graphs only show a certain interval of time, so as more data comes in, the graphs will shift so that new data can come in. Notice also that each graph is equipped with controls that allow the patient and doctors to look at only certain axes or increase/decrease the view size. This enables both the doctor and patient to get a close look at the data they want. This is a significant result because it makes it easy for patients to be monitored with a touch of a button. These results are also significant because it allows doctors to better monitor and analyze their patients. Doctors can now get real-time information on their patients so they are better able to analyze and improve their healthcare.

IV. CONCLUSION

In this study, we have proposed, developed, and demonstrated the effectiveness of a big data edge platform. This new platform can stream and manage the big data from consumer devices like wearable computer and smartphones. Furthermore, this system can effectively manage the big data in coordination with the cloud system. We have implemented the system on AWS and shown its potential on the biomechanical data streaming and management. This study will greatly advance big data edge on consumer devices for precision medicine.

V. ACKNOWLEDGEMENT

This material is based upon work in part supported by the NSF CAREER Award 2047849. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the NSF. The authors (qxzhang@purdue.edu) are with Purdue School of Engineering, Indiana, USA.

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