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IoT-Cloud based framework for patient's data collection in smart healthcare system using Raspberry-pi

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***Abstract*—The Internet of things(IoT) has brought the vision of the smarter world into reality and including healthcare it has a many application domains. The convergence of IOT-cloud can play a significant role in the smart healthcare by offering better insight of healthcare content to support affordable and quality patient care. In this paper, we proposed a model that allows the sensor to monitor the patient's symptom. The collected monitored data transmitted to the gateway via Bluetooth and then to the cloud server through docker container using the internet. Thus enabling the physician to diagnose and monitor health problems wherever the patient is. Also, we address the several challenges related to health monitoring and management using IoT.**

***Index Terms*—Internet of things, healthcare, symptom, patient care , Bluetooth, cloud server, docker container.**

I. Introduction

With the proliferation of smart mobile devices and cloud computing technologies, Internet of Things (IoT) has come up as a new computing paradigm for building the next generation health care applications. The basic concept behind the IoT is the presence of different objects around us. The IoT involves radio frequency identification (RFID) tags, sensors, actuators, and mobile phones. These objects will collaborate with each other to achieve a common objective [1]. They cooperate with RFID systems and sense the physical phenomenon occurring around them. Sensor passed the information to the network then it is transmitted to actuator where an action is taken according to the sensed data. The integration of healthcare with the Internet and mobile technologies has led to increased accessibility to healthcare providers, more efficient processes and higher quality of healthcare services[2], [3], [4].

Several studies have demonstrated that the limited access to patient-related information during decision-making and the ineffective communication among patient care team members are proximal causes of medical errors in healthcare ([5], [6]).

We emphasis on the issues of patients vital data gathering, delivery, and processing. We propose that current manual note based solutions are time-consuming. Moreover, it imposes a problem to real-time data access that barrier the ability of clinical diagnostics and monitoring. And furthermore we have present a solution to automate this process from bedside data collection to information dissemination and remote access by the caregiver using raspberry pi and docker container. Raspberry pi act as the gateway for processing the data captured from the sensors .Sensors are connected to the existing medical equipment. Then these medical equipment are interconnected to exchange services. The information becomes available in the cloud, from where expert systems can process it or distribute to the caregiver for analysis.[7]

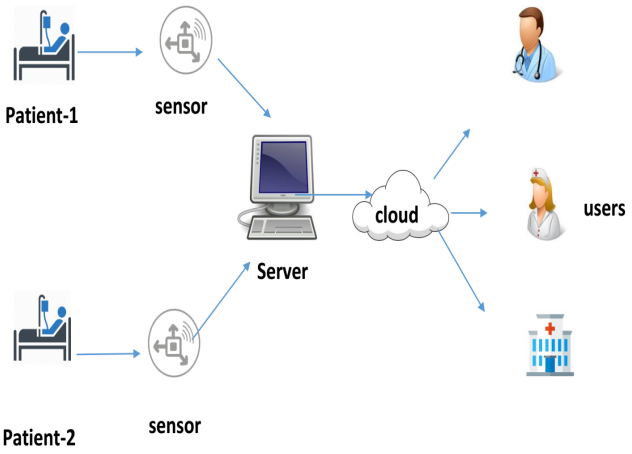

Fig. 1: Concept Design

Fig-1 depicts the concept design of IoT based healthcare. At the patient's side, we have sensor nodes to monitor the patient's symptom. These sensors capture the data and sends it to a server. Then the server will further process the collected monitor data and provide it to different users like cloud, doctors, nurses, and hospital to diagnose and monitor health problems. From the literature survey on IoT for healthcare, we found that many authors focused on designing and implementing various IoT based healthcare service frame work and solving various technological and architectural problems [8]. In this paper we propose a frame work for IoT cloud based healthcare sytem to address the challenges and issues related to healthcare monitoring using IoT which are unexplored.

The rest of the paper is organised as follows: The next Section

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II outlines the issues and challenges of IoT-cloud platform in healthcare domain. Section III shows our proposal and describes the proof-of-concept design. Section IV shows the conclusions and future works.

II. Issues and Challenges

The internet of things has the potential to provide physicians with valuable data that can improve patient health, but there are several barriers to IoT adoption in healthcare:

Confidentiality and data security

Confidentiality ensures the inaccessibility of medical information for unapproved clients. With the lack of common security standards and practices, many health IT experts have concerns about the risks associated with IoT device tampering and information leakage.

Scalability

IoT has to serve efficiently the requirements of the application for which we have deployed. And it has to be scalable since large no. of things are involved with IoT, scalability is important issue that has to be addressed even if the no. of sensors or sensing devices are going to increase the overall network performance should not be compromised.

Memory Limitations

Most IoT healthcare devices have low on-device memory (example BP sensor , temperature sensors have low on device memory).Since such devices are activated using an embedded operating system (OS), system software, and an application which consume lots of memory. So their memory may not be adequate to implement complex security related protocols.

Mobility

Building up a mobility-compliant security algorithm is a genuine challenge as medicinal devices are not static but rather mobile. Such devices require help of IoT service providers to connect to the Internet.

Data heterogeneity

Patients may use variety of health monitoring tools such as glucose meters, weight scales, blood pressure monitors or other wireless devices available in the market to monitor their health data.

Data mining challenge

The use of data mining tools becomes crucial as additional data are accessible for processing and analysis, Data not just comprise of traditional discrete data, yet in addition to streaming data generated from digital sensors in industrial equipment, automobiles, electrical meters, and dispatching crates.

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III. Proposal

Our proposal is based on automating the method of gathering patients data via sensors connected to medical devices and conveying this information to the medical centers cloud for the purpose of storage, processing, and dissemination using docker container and raspberry pi.

The Fig. 2 portrays the proposed model. The system involves four main components: sensors, raspberry pi, server, and users. At the patients side, we have sensor nodes that have the software to collect, encode, and transmit data over wireless communication channels. These sensors connected to raspberry pi which read data from the sensor and sends it to a server. The server comprised of docker container and the local database for further processing of collected monitor data and provide it to different users like the cloud, doctors, nurses, and hospital to diagnose and monitor health problem.

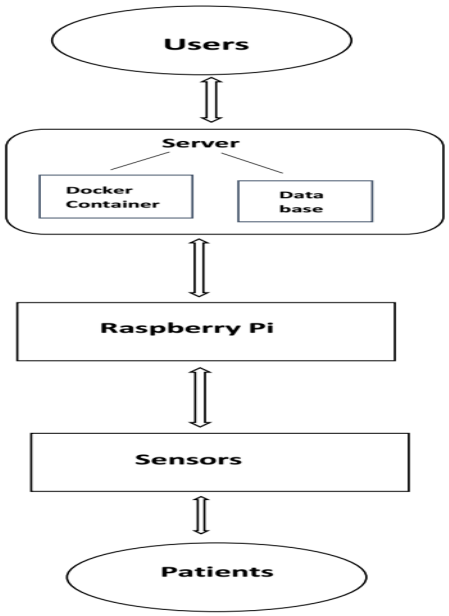

Fig. 2: The proposed model for IoT cloud in Healthcare scenario

The sensors are used to collect patient's vital data (e.x. body temperature, electrocardiography (ECG), blood pressure (BP), etc.) and contextual information.Through Bluetooth, the input monitored data are transmitted to the raspberry pi and then via internet transmitted to other users. The Raspberry Pi acts as sensor gateways. Raspberry Pi is a credit card sized computer with the support of 40 GPIO pins, enabling it to sample the sensor data at regular intervals. It has an on board processor powerful enough to collect and process data simultaneously.
Sensor offers powerful container resources such as the memory, CPU, and network bandwidth on demand for faster management of the data widely by a variety of interfaces such as personal computer, TV, and mobile phone.

Between the docker container-users and the rest of the components, all the communication is secure by applying proper authentication and data encryption mechanisms like blockchain method[9]. Many IoT services viz. storing, sharing, summarizing and searching for collected data as well as acquiring context-awareness to different users such as hospitals and other users of data or even patients are provided by the proposed integrated system. Following are the feature of the proposed model: (i) the long-term monitoring health status at any time and any place, (ii) it can facilitate to build an intelligent cost effective and scalable data-driven pervasive healthcare service platform. In many models of IoT-Cloud Healthcare system virtual machine is being used on the server, so we challenged their framework by using docker container instead of the traditional virtual machine. Following is the comparison of docker container and traditional virtual machine:

Comparing Containers and Virtual Machines: Both containers and virtual machines have similar resource isolation and allocation benefits but function differently as each virtual machine runs its own operating system whereas docker container uses the same kernel as that of hosts, so containers are more portable and efficient [10].

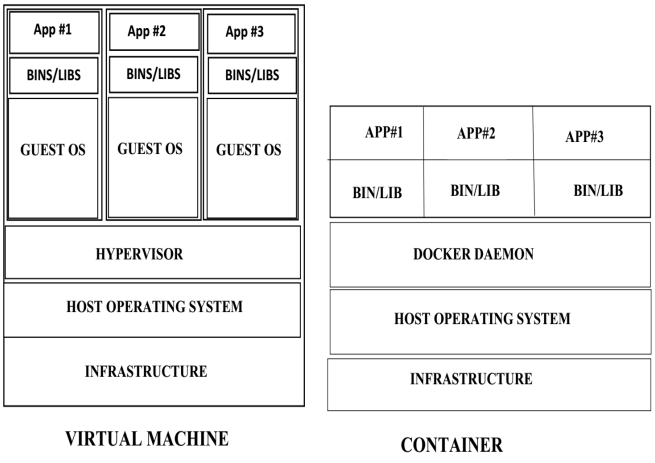

Fig. 3: comparing containers and virtual machines

- Containers The application layer provides another abstraction called container which consists of codes and dependencies.By sharing the kernel of OS with other containers, we can run multiple containers on the same physical system. These container run as an isolated process.Compare to VM containers consumes less space (typically container images are tens of MBs in size) and start instantly.
- Virtual machines
  The physical hardware provides an abstraction called virtual machines(VMs) that turns one server into many servers. On a single machine, multiple VMs can be run with the help of hypervisor. Each VM consist of the complete replica of an os, one or more apps, libraries and necessary binaries. Compare to containers VMs boot slowly and takes up tens of GBs size space.

proof of design

Fig: 4 illustrates the proposed solution. It is based on socket programming. The socket programming creates a 2 way connection between two nodes in a network. The nodes are termed as client and server, the server performs the task requested by the client.In our case, Raspberry Pi is loaded with docker container and server, where the container is a client that receives data from the sensors. We have many containers in the network that receive data and send it to the local docker server for processing. If there is an emergency, then the local server will send an alert message to local caregivers for immediate medical attention. simultaneously it sends data to a remote server for further processing of captured data and distribute it globally to the health experts to further examine and diagnose the health complications.

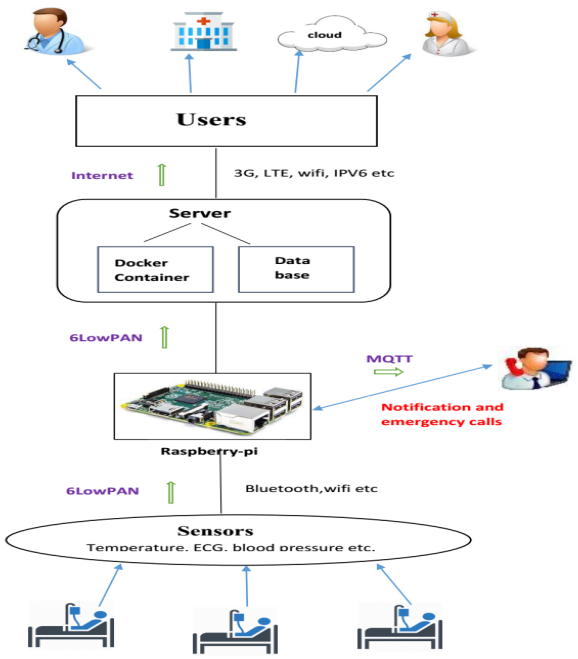

Fig. 4: Proof-of-concept design

From the sensor to local docker server the data transfer is done using a 6LowPAN protocol. These protocol also helps in creating a network of sensors via multisensor board, like ADXL346 digital three-axis accelerometer.Then from the local docker server to the local user MQTT protocol is used, similarly from local server to remote server internet protocols(3G, LTE, wifi, etc.) used for data transmission and communication.
6LowPAN stands for Lowpower Wireless Personal Area Networks over IPv6, which is used for the smallest devices with limited processing ability to transmit information wirelessly using an Internet protocol. And also it allows lowpower devices to connect to the Internet. And MQTT stands for Message Queue Telemetry Transpor, which is a publish-subscribe-based lightweight messaging protocol for use in conjunction with the

TCP/IP protocol.And also it is designed to provide connectivity (mostly embedded) between applications and middlewares on one side and networks and communications on the other side.

IV. Conclusion and futurework

The rise of the internet of things has potentially lifesaving application within the healthcare industry by collecting data from bedside devices , viewing patient information and diagnosing in real time. By using IoT technology in healthcare, it not only brings benefits to doctors and managers to access wide ranges of data sources but also challenges in accessing heterogeneous IoT data, especially in mobile environment of real-time IoT application systems.

Our proposed solution is based on how data is integrated with IoT based healthcare system using a raspberry pi and docker container. Raspberry Pi collects and stores the medical data through the sensors attached. The received data can be transferred to the user through mobile apps. The information provided through apps improves the health of the patients. Potential future work may include Location Aware Applications for mobile devices which exploit location information for patients, to provide personalized information or alerts regarding the patient

Potential future work may include Location Aware Applications for mobile devices which exploit location information for patients, to provide personalized information or alerts regarding the patient.

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