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A Brand-New Framework for The Surveillance of Elderly Aged Patients

Durgaprasad Gangodkar[1], Vrince Vimal[2]

[1]Department of Computer Science & Engineering,Graphic Era Deemed to be University, Dehradun, Uttarakhand India, 248002
[2]Department of Computer Science & Engineering,Graphic Era Hill University, Dehradun, Uttarakhand India, 248002

ABSTRACT

As the number of people over 65 continues to grow at an astounding rate, it is crucial that new technologies be developed to meet the needs of this group and allow them to maintain their independence despite the challenges they face as a result of ageing. Patients with life-threatening diseases are another another population that may benefit from preventative medical surveillance. We present a cloud-based health monitoring system that makes use of physiological and environmental inputs to provide context in terms of activities of daily life; this system, called Fog IoT, is introduced in this study. Using our system, clinicians may track the health and behaviour of their elderly or homebound patients and react accordingly to any changes. In addition, our system enables medical professionals to monitor their patients' recovery and rehabilitation developments in real time. Our Fog-IoT infrastructure consists mostly of a wireless sensor network, a local gateway for data saved locally and immediately, and a Lambda cloud architecture for data processing and storage. Our novel approach rests in the graphical monitoring of recent and up-to-date patient data at the level of the regional smart gateway. The data may be easily accessed by medical staff, and abnormalities can be validated in a fully automated manner with the help of this examination. The gateway keeps on collecting data and analysing it, even if there is a telematic disturbance, which brings us to the final point. Throughout the course of follow-up care, medical practitioners may access anonymised data stored in the cloud and uploaded via smart gateways on a frequent basis.

Keywords:

INTRODUCTION

The UN Population Fund estimates that by 2050, the number of people aged 60 and up will have doubled to 4 billion (UNFPA). Significant societal changes will be necessary, particularly in health care and the medical care of the elderly, as the number of people over 60 years old doubles by 2050. The decline in physical and mental capacity that comes with age is a fact of life, but that doesn't stop many elderly people from wanting to age in place. Alzheimer's disease, dementia, breathing difficulties, diabetes, cardiovascular issues, osteoarthritis, stroke, chronic diseases, etc. are only few of the age-related disorders that many seniors face.

The ever-increasing demand for healthcare follow-up has made health monitoring systems (HMS) and health smart homes (HSH) viable solutions for providing e-health services to an ageing population. Thanks to these developments, patients can receive the same level of medical attention formerly only available in institutional settings like hospitals, in the convenience of their own homes. Personal health data, collected and interpreted by wearable sensors, is crucial to these kinds of care. This raw data is insufficient for providing e-health services because of HMS's interpretation errors. The observed patient and their ADLs require a greater grasp of the matter at hand, which can be obtained by further investigation (ADL). Putting sensor data in its right context is made easier by the use of context data, which is the result of applying raw data consistency checking or metadata enrichment.

However, there are many challenges associated with putting these devices into operation, such as remote monitoring of the environment, communication technologies, the existence of cognitive processing systems, and the provision of context-aware services. Current practise dictates that a personal sensors network's configuration—including the number of sensors, data rate, mobility, latency, communication, and transmission—be determined by the specifics of the application and the needs of the subject. Further, there are still major challenges related with the power requirements and lifespan of sensor network devices. As for multimedia gadgets, the only real issues are data privacy and processing time. Big data issues are further complicated by the need for massive-scale real-time monitoring.

HSH and HMS can make use of either a centralised or decentralised design. In a centralised system, all the data collected by the sensors is transferred to a central location for analysis and further processing by a collection of algorithms. The majority of existing monitoring systems have a centralised design. A significant drawback of such designs is their unreliability in the face of a centralised server failure, network outage, or network congestion.

In a distributed design, each node performs independently while still being able to talk to the others across the network. These architectures allow for greater system reliability, availability, application performance, and component integration. However, such systems' design and constituent elements are notoriously challenging to comprehend.

In this paper, we present a novel Fog-IoT-Cloud based architecture tailored to the needs of tracking in-hospital patients and the elderly who choose to recover in their own homes.

LITERATURE SURVEY

By utilising data from the past and the SMAF evaluation model for human activities developed by ***Mshali et al.,*** an individual's ideal time allocation to each daily activity can be determined. By performing optimal and context-aware sensing, updating the sensing frequency on the fly, etc., a personalised prediction of the subject's behaviour can be derived and used. ***Pham et al***. present CoSHE, a cloud-based Smart Home Environment, which is built on a smart house setup, a wearable device, a private cloud infrastructure, and a home service robot. The house gateway analyses data about the home's surroundings, the health of its residents, and the people who live there. As a following step in building a SaaS company, moving the contextualised raw data to a private cloud running on Openstack Jena is necessary. CoSHE uses a hybrid data store, which mixes MySQL for structured data with MongoDB for storing sensor data, because of the necessity for fast access for real-time applications. ***Narendra et al***. developed a system for continuous health monitoring and notifications using Bluetooth low energy (BLE), general system mobile radio (GSM), and wireless fidelity (Wi-Fi). This concept solves the sensitivity problem of single-channel solutions by multiplexing the information across three communication channels.

Using a Fog Assisted model with three layers, ***Verma et al. (2018***) conducted data collecting in the last layer. With the data processed and validated by the Fog layer, a Bayesian Belief Network can decide whether an event is typical or out of the ordinary (BBN). Information gathered from fog layers can be analysed with the help of cloud computing to provide guidance on next steps. Data from fog nodes has been compiled and stored for posterity. To address the challenges of energy and network optimization, ***Mahmoud et al.*** propose an energy-aware application allocation that combines an improved round robin (RR) with dynamic voltage and frequency scaling (DVFS). ***Rahmani et al***. provide a smart e-health gateway as the foundation of a unified strategy for inpatient and outpatient treatment. In addition to mediating communications between radio and Internet networks, the gateway also performs data filtering, compression, merging, and analysis and ensures the data's adaptability. Cloud-level analysis is the usual, but low-resolution approaches can be used to view ECG and EMG data in a pinch..

PROPOSED ARCHITECTURE

We have previously worked on problems with similar characteristics, such as the need to respond quickly and continuously to a large volume of data.

With a sensor network and a local smart gateway as its foundation, our cloud-based architecture is well-suited to collecting, storing, and analysing data (SG). There are a few different sensors that make up a sensor network: a heart rate sensor (BPM), an LED light sensor, and an environmental sensor (a Bosch Sensortec BME 680) that measures things like temperature, pressure, and humidity. Built on Hardkernel's Cloud Shell 2, the Smart Gateway is driven by a single Odroid XU4Q, an HMP solution and two terabytes of WD Gold hard drives in RAID 1 configuration. When compared to the most recent Raspberry Pi 31, the popular Odroid device is seven times faster; furthermore, it is more powerful, consumes less power, and has greater energy efficiency. The wireless protocols supported by our Smart Gateway include Zigbee, Xbee, Wi-Fi, Bluetooth, and Ethernet. The smart gateway's electrical connection is safeguarded by a UPS.

Fig. 1 depicts the core components of our architecture, which include a uniform sensor network, a centralised gateway, a cloud-based data gathering, storage, and processing system, and a cloud-based processing engine. Measurement Devices for the Human Body Readings from other sensors, both those worn by the patient and those placed in the environment, supplement the data collected by the network (BSN). InfluxDB utilises a local database to store all of its data. Chronograf displays alarms and sensor thresholds defined in Kapacitor. A Node.js web service processes data, which is then periodically transferred to the cloud. All data streams from Apache Kafka are picked up by Apache Druid and then sent to the Hadoop File System for long-term storage (HDFS). Apache Druid is the information consumer, whereas Apache Kylin is the data processor. Finally, Apache

Ambari monitors the effectiveness of the cluster.

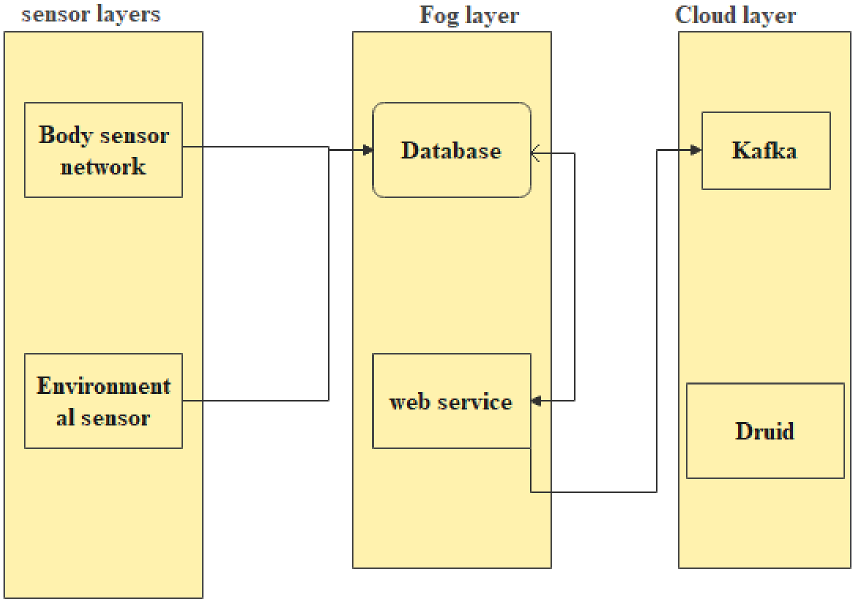

Fig 1: Proposed architecture

Physiological sensors and environmental sensors (which provide additional context for the physiological data) are all part of a Body Sensor Network (BSN) (e.g.: temperature, humidity, air quality, noise level, etc). Because of privacy considerations, multimedia sensors are rarely used. Once the data has been delivered wirelessly from the sensors, it is received by a TCP/IP-based Smart Gateway, where it is processed. Temperature and humidity readings were taken with the help of the BME680 Bosh Sensortech. For the electrocardiogram, we use Maxim Integrated's MAX30102, a high-sensitivity pulse oximeter and heart-rate sensor. Additionally, the MPU-9250's accelerometer, gyroscope, and magnetometer are used to analyse the patient's mobility while simultaneously acquiring their heart rate and oxygen saturation. Melexis Technologies NV's MLX90614ESF infrared sensor is capable of sensing a human body's temperature without coming into physical contact with the subject.

It is important to evaluate the individual dependency profile of each elderly person or patient in order to establish a baseline against which unusual behaviours can be judged. This profile is used to determine how long it will take to perform a number of common, day-to-day activities. These intervals must be modified according to the subject's pathology and previous data in order to prevent false positives and change the frequency with which sensing data is taken**.**

RESULTS AND PERFORMANCE EVALUATION

An in-home use case was successfully tested, and it involved a bedridden patient. Our platform's performance will be evaluated in this area, with particular attention paid to the "Fog" layer's quality processing, data transmission, and data volume.

Since we've established that 7.5Mbits /s is the typical rate at which packets are transferred between an Arduino Mega running FreeRTOS and our Smart Gateway, we can move on to the next issue. A physiological parameter (heart rate) and environmental measures (temperature, humidity, pressure, and air quality index) are transmitted to the Smart Gateway in an average of 7 ms. This method is superior to the state-of-the-art, which produces a value of 21 ms under the same conditions. This variation might be explained by the LAN environment. Possible causes of the lag include the size of the data being communicated, the Wi-Fi card installed in the Arduino, and the smart Gateway's network connectivity (in our case, for each metric record, we have 3 fields: Time, Local Identifier, Measure). Processing data from multiple sensors simultaneously requires a local server with sufficient performance. We used InfluxDB, a time-series database we developed in-house, to keep tabs on things like disc, RAM, and CPU utilisation to reach this goal. These results suggest that, on average, the time base "influxDB" uses 7.86% of the Gateway's CPU. However, the Raspberry shown in the article is substantially weaker than the one in our intelligent Gateway.

While collecting data for our experiments in the cloud, we kept an eye on how well the underlying technology was holding up. According to the schedule, data is uploaded to the Druid system every 20 minutes. Any time data left Smart Gateway, it was transferred. After ingesting from Apache Kafka, Druid's memory and CPU usage increased by 2 GB and 73%, respectively.

We put our system through its paces for a whole day, gathering data from the BME680 environmental sensors and the Arduino Puls/Heartbeat Rate BPM sensor to track heart rate and other biometrics. Our calculations from these figures provide the following results:

The results show that our experimental latency at the fog computing level (between the sensors and the SM) is lower than that reported by earlier methods. Our CPU utilisation is also lower than the state-of-the-art. Under table 1, we compare and contrast our results with those of the literature.

	Proposed method	**Existing method**
Fog CPU usage (in %)	8	15
Fog latency (in ms)	7	21

Table 1: performance evaluation of proposed method

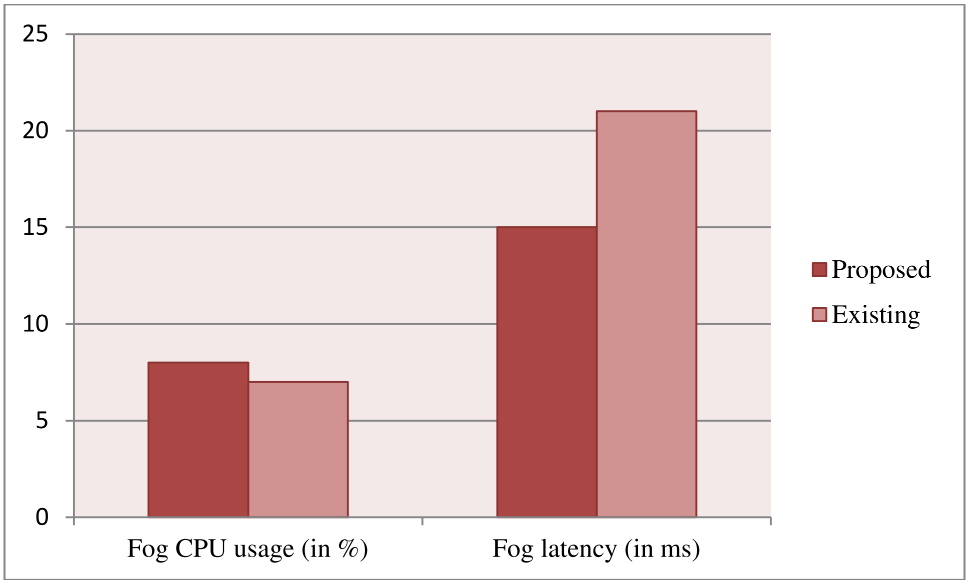

Fig 2: Existing method compared with proposed method

We compared as shown in fig 2 our experimental findings to those presented in published literature on the topic of deploying Fog architecture in the realm of IoT for healthcare. The testing results were inconsistent in terms of data transmission and material performance due to the disparity in the resources utilized. However, if this issue is taken care of, our design may be superior to current practices.

CONCLUSIONS

In this paper, we offer a General Data Protection Regulation (GDPR) compliant Fog-Cloud-IoT architecture, focusing on the importance of local verification of collected personal data. Patient information is kept private and anonymous even as it is transmitted between the sensor, Fog, and Cloud levels. Cross-data-set (patient measurements and identification) sharing outside of the cloud in a hospital context raises the question of how to further protect patient privacy.

At its core, our system is a smart gateway running on the Samsung Exynos5422, which uses Heterogeneous Multi-Processing in the form of a pair of CortexTM-A15 Quad Core 2Ghz processors, a CortexTM-A7 Quad Core 1.4Ghz processor, and a Mali- T628 MP6 graphics processing unit to achieve impressive energy efficiency. The SMAF profile is regularly updated to reflect the patient's current health condition and chronic disorders, and our smart gateway uses this information to adjust how often samples are collected.

To further improve the Smart Gateway's data filtering, aberrant value identification, sensor drift, and anomalous behaviour detection using machine learning, we aim to include an Nvidia Jetson Nano in the near future. Presently, data can be exported from the system in a format compatible with FHIR. Humans may be able to read this format, but it will still be tough to understand for the typical reader. You can choose to work with meta-data-free plain text, Excel, or CSV files. Full data traceability must be applied once again in the future when caring for patients.

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