Application of IoT and Cloud Computing towards Ubiquitous Healthcare: A Review

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Abstract:
Pervasive healthcare applications utilizing body sensor networks generate a vast amount of data that need to be managed and stored for processing and future usage. Cloud computing along with the internet of things (IoT) concept is a new trend for efficient managing and processing of sensor data on line. This paper gives a platform based on Cloud Computing for management of mobile and we arable healthcare sensors, demonstrating this way the IoT paradigm applied on pervasive healthcare.

Keywords*:* Internet of Things (IoT), Cloud Computing, Patient Monitoring, Wearable Sensors.

1. Introduction

The introduction of the pervasive healthcare paradigm has enabled the attention toward the independent residing of elderly people and the need for regular clinical supervision of continual patients or habitants at remote, isolated or underserved locations. In this context, advanced electronic healthcare services are required to be made available through a network anytime, wherever and to anybody. A medical assistive environment however concerns the utilization of pervasive and ubiquitous technologies for delivering the above services. Wireless technologies enable the real time transmission of data about a patient's circumstance to caregivers. numerous portable devices are available that can detect certain clinical conditions—pulse rate, blood pressure, breath alcohol level, and so on—from a user's stomach.

But this improvement and deployment of health information management through mobile devices introduces several challenges: data storage and management (e.g., physical storage issues, availability and maintenance), interoperability and availability of heterogeneous resources, safety and privacy (e.g., permission control, data anonymity, etc.), unified and ubiquitous access are a few to mention. One potential solution for addressing all aforementioned issues is the introduction of Cloud Computing concept in digital healthcare systems. Cloud Computing provides the facility to access shared resources and common infrastructure in a ubiquitous and transparent manner, offering services on-demand, over the network, and performing operations that meet changing desires. Similarly, the advance of machine to-machine communication (M2M) permits the direct interaction of pervasive healthcare sensors with the internet and by extension with Cloud Computing systems. This communication with the internet has been recently introduced because the 'internet of things' (IoT).

IoT utilizes specific protocols for inter-device and Internet communication, provides real time access to device information and permits the remote control of the devices. It also features web applications that are scalable, accessible globally and provide communication interfaces to external applications. In the case of healthcare monitoring the IoT has already been proposed as an infrastructure for medical sensor communication ([11] - [12]).

2. Related Work And Background Information

There is an incredible range of research works on pervasive healthcare sensors. Most of them deal with data management on the devices (e.g., using storage method like SD cards) or utilize intermediate nodes (e.g., mobile phones) or store the data directly on computer nodes. Only few works exist however that deal with the issue of data storage and management directly on the Cloud. Authors in [2] present a sensor-oriented cloud infrastructure. The provided platform is proprietary and the initial evaluation results do not include actual devices, but they are based on simulated sensors. On the other hand a number of Cloud-based services dedicated for storing sensor-based data are in recent times available. Pachuca be [1], Nimbi's [4], Thing Speak [2] and digit [3] are a few that could be mentioned.

Patchable has been one of the first database service providers that allow developers to connect sensor data to the Web. It is a real-time data Cloud-based infrastructure platform, which supports the internet of things (IoT) paradigm. More specifically it could be described as scalable infrastructure that permits users to build IoT products and services, and store, share and discover real-time sensor, energy and environment data from objects, devices &homes around the world. The main capabilities of the platform are: managing real time sensor and environment data, graphing and monitoring and controlling remote environments. Similarly there is a remarkable quantity of interfaces available for building sensor or mobile-based applications for managing the data on the Cloud infrastructure. One of the essential capabilities of Patchable that have facilitated its penetration as a IoT cloud service is that the primary usage if free, it is based on an open and easy accessible API and has a very interactive web site for managing sensor data [13].

Nimbits is a data processing service for recording and sharing sensor data on the Cloud. It is a free, social and open source platform for the internet of things. Within Nimbits sensor data are saved as data points using textual, JSON or XML values. Data points can also be configured to perform calculations, generate signals, relay data to social networks and can be connected to SVG process control diagrams, spreadsheets and web sites. Nimbits provides a data compression mechanism, an alert management mechanism, and data calculation on the received sensor data using simple mathematic formulation. Thing Speak is also an open source "internet of things" utility that provides developers with APIs to store and retrieve data from sensors and devices using HTTP over the Internet. With Thing Speak, users can create sensor-logging applications, location-tracking applications, and a social network of things with reputation updates. in addition to storing and retrieving numeric and alphanumeric data, the Thing Speak API allows for numeric data processing such as time scaling, averaging, median, summing, and rounding. Each Thing Speak Channel supports data entries of up to 8data fields, latitude, longitude, elevation, and standing. The channel feeds support JSON, XML, and CSV formats for integration into applications. The Thing Speak application also features time zone management, read/write API key management and JavaScript-based charts [13].

The iDigi system is a machine-to-machine (M2M) platform-as-a-service. iDigi platform lowers the obstacles to building secure, scalable, cost-effective solutions that seamlessly tie together organization applications and device assets. iDigi platform manages the communication between enterprise applications and remote device assets, regardless of vicinity or network. It makes connecting remote assets easy, providing all of the equipment to connect, manage, store and circulate information across the near and far reaches of the enterprise. The platform includes the device connector software (called iDigi Dia) that simplifies remote device connectivity and integration. It allows the control (configure, upgrade, monitor, alarm, analyse) of products including ZigBee nodes. The application messaging engine enables broadcast and receipt notification for application-to device interaction and confirmation. There is also cache and permanent storage options available for generation based storage and on-demand access to historical device samples. These services however, awareness mostly on the visualization of the data and usually lack of secure data access and provision of interfaces for linkage to mobile or external applications for further processing. the majority of the aforementioned available systems is based on proprietary architectures and communication schemes, which requires the deployment of specific software components. Moreover, these systems deal mostly with delivering data to healthcare applications and do not address problems of data management and interoperability issues introduced by the heterogeneous data assets found in modern digital healthcare systems. The introduction of Cloud Computing infrastructure can also provide data management and access capability overcoming the fore mentioned issues as discussed in previous lines. Cloud Computing is a model for enabling convenient, on-demand network access to a shared group of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimum control attempt or service provider interaction. Resources are available over the network and accessed through standard mechanisms that promote use by heterogeneous thin or thick client systems (e.g., smart phones). Examples of assets include storage, processing, memory, network bandwidth, and digital machines [13].

Given the characteristics of Cloud Computing and the flexibility of the services that can be developed, a major benefit is the agility that improves with users being capable of rapidly and inexpensively re-provisions technological infrastructure resources. Device and location independence enable users to access devices using a web browser, irrespective of their location or what device they are using (e.g., cell phones). Multi-tenancy enables sharing of resources and costs across a large pool of users, thus allowing for centralization of infrastructure in locations with lower costs. Reliability improves through the use of multiple redundant sites, which makes Cloud Computing suitable for business continuity and disaster healing. Security typically can be improved, due to centralization of data and increased availability of security-targeted resources. Sustainability comes about through improved resource utilization, resulting in more efficient systems. The concept of utilising Cloud Computing in the context of pervasive healthcare information management is rather new however is considered to have remarkable potential [3, 13].

A number of Cloud Computing platforms are already available for pervasive management of user data, both free (e.g., iCloud [6], ¬Oceans [8], Pathos [9] and Drop box [7]) or business (e.g., GoGrid [4], Amazon AWS [7] and Rack space [10]). Most of them, however, do not provide substantial developer support, to create custom applications and comprise Cloud Computing functionality, apart from Amazon AWS.

3. Materials and Methods

The main components of the proposed architecture are [13]:

- The wearable and mobile sensors that acquire patient bio signals, motion and contextual information.
- The sensor gateway that collects all the signals from the sensors and forwards them to the internet. It can be a mobile phone or a microcontroller platform capable of communicating with the internet. It also forwards information about the status of the sensors (e.g., proper operation, power supply levels, etc.).
- The communication APIs that are provided by the Cloud platform. The latter are light-weight interfaces (like rest web services) than can be used by the sensor gateways for sending sensor data and retrieving information. The API can also be utilized by external applications for data processing, alert management, billing, and many others.
- The managing application consists of a web-based application that is updated real time and provides visualization of the sensor data (in graphs, and many others.) and important information about the patient's context (like location, activity status, etc.).
- The Cloud infrastructure that hosts the interfaces and the managing application. It provides the essential assets (like CPU, storage and application servers) for deploying the web application and the interfaces that permit the communication with the sensors and the diverse external devices.

The essential capabilities of the proposed architecture are it scalability, interoperability and light-weight access. It is scalable because of the fact that it relies on a Cloud infrastructure that presents assets primarily based on utilization and demand. More users, sensors and different data resources can be added without affecting the functionality of the system or without the need for further protection or expansion. The web services based interfaces ensure the maximum interoperability with external applications. The Representational state transfer (rest) API is very lightweight and can be easily accessed and implemented by wireless sensor and mobile platforms. Rest has also been proposed as a communication mechanism for IoT applications ([5], [6]) and is the fundamental interfacing technology behind established IoT platforms like Patchable, Nimbits and Thing Speak [13].

4. Conclusions:

Pervasive healthcare applications generate a huge amount of sensor data that need to be controlled properly for further analysis and processing. Cloud computing through its elasticity and facility to access shared resources and common infrastructure in a ubiquitous and pervasive manner is a promising solution for efficient management of pervasive health care data.

5. References

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