A Survey on Sensor-Cloud: Architecture, Applications and Approaches

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Abstract

Many organizations desired to operate their businesses, works and services in a mobile (i.e. just in time and anywhere), dynamic, and knowledge-oriented fashion. Activities like e-learning, environmental learning, remote inspection, health-care, home security and safety mechanisms etc. requires a special infrastructure that might provide continuous, secured, reliable and mobile data with proper information/ knowledge management system in context to their confined environment and its users. An indefinite number of sensor networks for numerous healthcare applications has been designed and implemented but they all lacking extensibility, fault-tolerance, mobility, reliability and openness. Thus, an open, flexible and rearrangeable infrastructure is proposed for healthcare monitoring applications. Where physical sensors are virtualized as virtual sensors on cloud computing by this infrastructure and virtual sensors are provisioned automatically to end users whenever they required. In this paper we reviewed some approaches to hasten the service creations in field of healthcare and other applications with Cloud-Sensor architecture. This architecture provides services to end users without being worried about its implementation details. The architecture allows the service requesters to use the virtual sensors by themselves or they may create other new services by extending virtual sensors.

Key Words: Cloud Computing; XML Parser; Wireless Sensor Network (WSN); Virtualization; IT Resources

1. Introduction

Sensors are capable of sensing the several appearances and can be utilized in several areas like healthcare, defense, government services, environmental services etc. These sensors may provide various useful data but are closely attached to each of their relevant applications and services directly, causing several other services to be unused. Hence large number of our meaningful, expensive resources may become waste. But if anyhow we can integrate these sensors by sharing each other's valuable data through the number of unlimited services, it would accelerate the service creation. To realize this sensor cloud

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[1]infrastructure [1] has been proposed which is the extended form of cloud computing to manage our valuable sensors scattered around the network (sensor). This infrastructure would provide the service instances (virtual sensors) automatically to users as and when requested in same way as these virtual sensors are part of IT resources (like disk storage, CPU, memory etc.) to the end users. These service instances and its appropriate sensor data can be used via a user interface through the web crawlers as described in Figure 1. Before generating the service instances; the IT resources (like CPU, Storage devices etc.), sensor capable devices, service templates (that has to be used to create virtual sensors) should be prepared first.

Users request for service instances according to their needs by selecting an appropriate service template which will then provide the service instances freely and automatically because of cloud computing services integration. Once service instances became useless, it can be deleted quickly by users to avoid the utilization charges for these resources. Sensor service provider will manage the service templates and can add or delete the new service template as and when the requirement for template is needed by applications and services [1]. Automation of services played a vital role in provisioning of cloud computing services and automation can cause the delivery time of services to be better [2]. Before the emergence of cloud computing, services were provided by human influence and the performance metrics like efficiency, flexibility, delivery time etc. would have experienced an adverse effect on the system. But the cloud computing service model has reduced the cost expenses, delivery time and has also improved the efficiency and flexibility because the service providers need not to worry about preparing the IT resources and its infrastructure.

Cloud-Sensors can be used for deploying the health related applications like chronic patients with heart problems, blood sugar, sleep activity pattern monitoring, respiratory conditions, diabetics, cardio-vascular disease etc. Earlier the trials of individual's data like level of blood sugar, weight, heart rate, pulse rate etc. are reported everyday through some telemedicine interface [3]. The patient's trial information sends to a dedicated server and is stored there for doctors or helpers to analyze it sometime later. This system has some level of adversity when the patient move on from its current location i.e., when patient is "on the go". Thus there needed a more progressive, rapid, and mobile approach where our data can be processed in pipelined and parallel fashion, thereby making the system easier to scale and cost effective in terms of the resources available. The pipeline processing of data sets or instructions enables the overlapped operations into a conceptual pipe with all the stages of pipes processing simultaneously but handling of sensor data stream is not that straight forward and will be dependent on the nature of algorithm [4].

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This paper presents a comprehensive survey on Cloud-Sensor. Section 2 of this paper provides a brief overview of Cloud-Sensor including its definition, architecture and its processing life cycle. Section 3 of this paper discusses the layered approach of cloud-sensor architecture. Section 4 of this paper provides the Cloud-Sensor service creation and renovation capabilities. Section 5 presents the XML parsing of the sensor documents which enables to parse the sensor documents for various applications over various platforms. Section 6 and section 7 of this paper discusses the use of Cloud-Sensor in healthcare and cloud-sensor's pros and cons. Next, section presents several issues that may arise in cloud-sensor and some approaches to address these issues. Finally, we summarize and conclude the survey in last section 8.

2. Overview and Related works

The concept of sensor-cloud is a new paradigm for cloud computing that uses the physical sensors to accumulate its data and transmit all sensor data into a cloud computing infrastructure. Sensor-Cloud handle sensor data efficiently and then used for monitoring several applications.

A. What is a Sensor-Cloud?

According to IntelliSys sensor cloud can be defined as:

"An infrastructure that allows truly pervasive computation using sensors as interface between physical and cyber worlds, the data-compute clusters as the cyber backbone and the internet as the communication medium [32][34]."

According to MicroStrains's sensor cloud definition "It is a unique sensor data storage, visualization and remote management platform that leverages powerful cloud computing technologies to provide excellent data scalability, rapid visualization, and user programmable analysis. Originally designed to support long-term deployments of MicroStrain wireless sensors, Sensor-Cloud now supports any web-connected third party device, sensor, or sensor network through a simple OpenData API [33]. "

A sensor cloud collects and processes information from several sensor networks enables information sharing on big-scale and collaborate the applications on cloud among users. It integrates several networks with number of sensing applications and cloud computing platform by allowing applications to be cross-disciplinary that may spanned over organizational ranges [34]. Sensor cloud enables users to easily gather, access, processing, visualizing and analyzing, storing, sharing and searching large number of sensor data from several types of applications. These vast amount of data are stored, processed, analyzed and then visualized by using the computational IT and storage resources of the cloud.

Sensors are utilized by its specific application for a special purpose and this application handles both the sensor data and the sensor itself such that other applications can't use this. This makes wastage of our valuable sensor resources which could be effectively utilized when integrating with other application's infrastructure. To realize this scenario, a sensor cloud infrastructure is proposed that can make the sensors to be utilized on an IT infrastructure by virtualize the physical sensor on cloud computing. These virtualized sensors on a cloud computing platform are dynamic in nature and hence facilitate

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automatic provisioning of its services as and when required by users [2]. Also, users need not to worry about the physical locations of multiple physical sensors and the gapping between physical sensors; instead they can supervise these virtual sensors using some standard functions [1].

To obtain QoS the virtual sensors are monitored regularly so users can destroy their virtual sensors when it becomes meaningless [12]. A user interface is provisioned by this sensor cloud infrastructure for administering i.e. to control or monitor the virtual sensors, provisioning and destroying virtual sensors, registering and deleting of physical sensors, and for admitting the deleting users. For health monitoring, patient may use a wearable computing system (that may include wearable accelerometer sensors, proximity sensors, temperature sensors etc.) like Life Shirt [13], Smart Shirt [14] or may use a handheld device loaded with sensors. But out of these computing systems the active continuous monitoring is most demanding and it involves the patient wearing monitoring devices to obtain pervasive coverage without being inputted or intervened [15]. However, the diverse monitoring scheme defers in their QoS requirements and they can be as follows:

(1) *Patient-Centric Healthcare-QoS*: Refers to monitoring delay and reliability of message delivery.

(2) *Network-Centric Healthcare-QoS*: Refers to number of patients supported and message throughput.

(3) *Healthcare professional-centric Healthcare-QoS*: Refers to cognitive load of healthcare professionals and number of correct medical decisions.

Sensor modeling language (SML) [16] can be used to represent any physical sensor's metadata like their type, accuracy and its physical location etc. It also uses XML encoding for the measurement and description processes of physical sensors. This XML encoding for physical sensors enabled these to be implemented across several different hardware, platforms (OS), applications etc. with relatively less human intervention. To transliterate the commands coming from users to virtual sensors and in turn to the commands for their pertinent physical sensors, a mapping is done between the physical and virtual sensors.

B. Architecture of Sensor-Cloud

Cloud computing service framework is used to deliver the services of shared network in which the users are aimed to be benefited by the services and they are not concerned with the implementation detail of the services provided to them. When a user requests, the service instances (e.g. virtual sensors) generated by cloud computing services are automatically provisioned to them [1] [2].

(a) Service Life Cycle Model of Sensor-Cloud:
The system operation can be divided into three phases. Before creating the service instances preparation phase is needed i.e., it's necessary to prepare the followings:

(1) Prepare the IT resources (Processors, storage, disk, memory etc.)
(2) Prepare the physical sensor devices.
(3) Prepare the service templates.

Users can select the appropriate service template and request for the required service instances. These service instances are provided automatically and freely to the users which can then be deleted quickly when it becomes useless. From a single service template multiple numbers of service instances can be created. Service provider regulates the service templates and can add new service templates as and when required by different number of users.
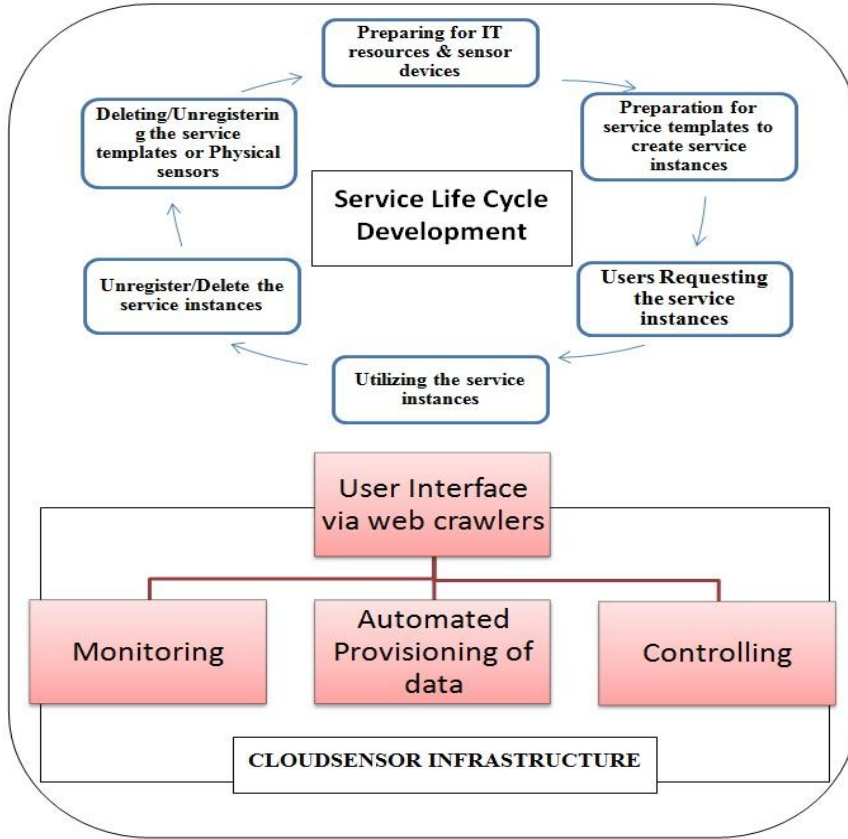

Figure 1: Demonstration of Cloud-Sensor Life Cycle Development Phases.

Some previous studies on physical sensors focused routing [5], clock synchronization [6], data processing [7], power management [8], OS [9], localization [10] and programming [11]. But few studies concentrate on physical sensor management because these physical sensors are bound closely to their specific application as well to its tangible users directly but users other than their relevant sensor services can't use these physical sensors directly when needed. Therefore, these physical sensors should be supervised by some special sensor-management schemes. The sensor-cloud infrastructure would subsidize the sensor system management which is when, if used with existing sensor data management usability of resources would be fairly improved.

There exist no application that can make use every kind of physical sensors all time; instead each application required pertinent physical sensors for its fulfillment. To realize this concept publish/subscription [17] mechanism is being employed for choosing the appropriate physical sensor [18]. In multiple sensor networks, every sensor network publishes its sensor data and metadata. The metadata comprises of the type, locations etc., for the physical sensors. Application either subscribes to one or may be to more sensor networks to retrieve real time data from their physical sensors by allowing each application to opt for the appropriate physical sensors type. The cloud sensor infrastructure procreates virtual sensors from multiple physical sensors which can then be utilized by users. But prior to avail the virtual sensor facilities users should probe first for the physical sensors availability and might also inspect the physical sensors faults to maintain the data quality emerging from these physical sensors.

The physical sensors are ranked on basis of their sensor readings as well on their actual distance from an event. FIND [19] proposed a technique to locate physical sensors having data faults by assuming a mismatch between the distance rank and sensor data rank. However, the study led by FIND aims on the assessment of physical sensors faults, there is a close relation among the virtual and physical sensors and hence a virtual sensor will provide incorrect results if their relevant physical sensors are faulty. It concludes that the virtual and physical sensors cooperate while delivering the sensor data report to its applications and to maintain the best report both the virtual and physical sensors should be faultless.

Since the cloud computing enables the physical sensors to be virtualized the users of the sensor cloud infrastructure need not to worry about the status of their connected physical sensors (i.e., whether fault free or not), but they should concern only with the status of their virtual sensors. In a cloud sensor architecture sensors owners are free to register or unregister their physical sensors and can join this infrastructure. These IT resources (Physical sensors, Database Servers, Processors etc.) and sensor devices are then prepared to become operational. After that templates are created for generating the service instances (virtual sensors) and its groups(virtual sensors), once templates are prepared then these virtual sensors are able to share the related and contiguous physical sensors to receive quality sensor data. Users then request these virtual sensors by choosing the appropriate service templates, use their service instances (virtual sensors) after being provisioned and discharge them when became useless [1].
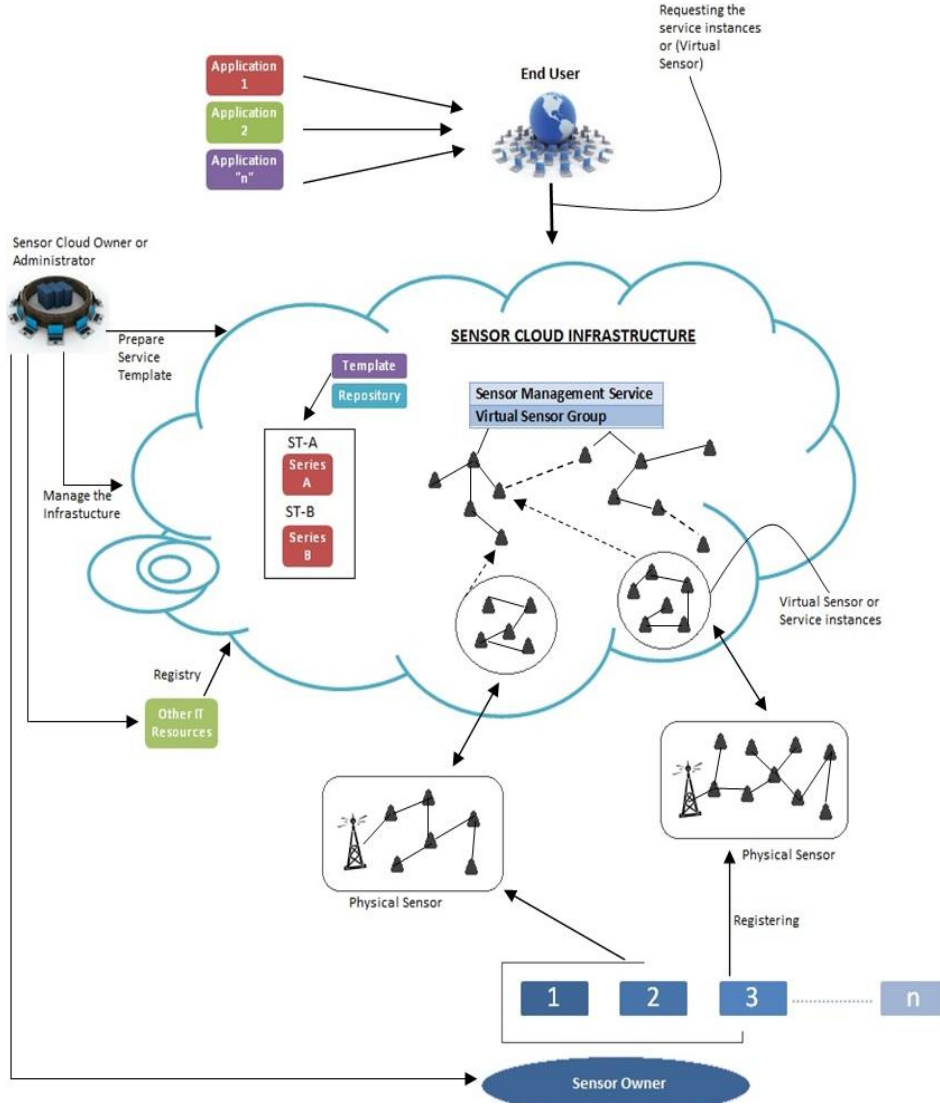
Figure 2: Brief Overview of Cloud-Sensor Infrastructure

C. Advantages of Sensor-Cloud

Cloud computing is very encouraging solution for sensor-cloud infrastructure due to several reasons like the agility, reliability, portability, real-time, flexibility etc. Structural health and environment based monitoring contains highly sensitive data and applications of these type can't be handled by normal data tools available in terms of data scalability, performance, programmability or accessibility. So we need a better infrastructure that contains tools to cope with these highly sensitive applications in real time. Now, we describe the several advantages and benefits of sensor-cloud infrastructure that may be the cause of its glory and these are as follows:

(1) *Analyze:* The integration of huge accumulated sensor data from several sensor networks and the cloud computing model makes it attractive for various kinds of analysis required to users by provisioning the scalability of processing power [42].

(2) *Scalability:* Sensor-Cloud enables the earlier sensor networks to scale on very large size because of the large routing architecture of cloud [32]. It means that as the need for resources increases, organizations can scaled or add the extra services from cloud computing vendors without having to extra money for this additional hardware resources [40].

(3) *Collaboration:* Sensor-Cloud enables the huge sensor data to be shared by different groups of consumers through collaboration of various physical sensor networks [32]. It eases the collaboration among several users and applications for huge data sharing on the cloud.

(4) *Visualization:* Sensor-Cloud platform provide a visualization API to be used for representing the diagrams with the stored and retrieved sensor data from several device assets. Through the visualization tools, users can predict the possible future trends that have to be incurred [48].

(5) *Free provisioning of increased data storage and processing power:* it provides free data storage and organizations may put their data rather than putting onto private computer systems without being hassled. It provides enormous processing facility and storage resources to handle data of large-scale applications [35] [32].

(6) *Dynamic provisioning of services:* Users of sensor-cloud can access their relevant information from wherever they wish and whenever they needed rather having to stick remain at their desks [35].

(7) *Multi-tenancy:* Number of services from several service providers can be integrated easily through cloud and Internet for numerous service innovations to meet user's demand [34]. Sensor-Cloud allows the accessibility to several number of data centre placed anywhere on the network world [40].

(8) *Reduced cost and higher gains:* The integration of sensors with cloud enables to reduce the resource cost incrementally and achieve higher gains of services. With sensor-cloud both the small and mid-sized organizations can obtain the benefits of an enormous resource infrastructure without having to involve and administer it directly [40].

(9) *Automation:* Automation played a vital role in provisioning of sensor-cloud computing services. Automation of services improved the delivery time to a great extent [2].

(10) *Flexibility:* Sensor-Cloud provides more flexibility to its users than the past computing methods. It provides flexibility to use random applications any number of times and allows sharing of sensor resources under flexible usage environment [32].

(11) *Agility of services:* Sensor-Cloud provides agile services and the users are being able to be provisioned with the expensive technological infrastructure resources with less expenditure of cost [48]. The integration of wireless sensor networks with cloud allows the high speed processing of data using immense processing capability of cloud.

(12) *Resource optimization:* Sensor-Cloud infrastructure enables the resource optimization by allowing the sharing of resources for several numbers of applications [48].

(13)   *Quick Response Time:* The integration of WSN's with cloud provides a very quick response to the user i.e., in real-time due to the large routing architecture of Cloud [50]. The quick response time of data feeds from several sensor networks or devices allowed us to make critical decisions in real time.

3. Service Creation and Renovation Capability in Several Applications

Sensors are very limited and are specific to their applications/ services when linked very closely to them, and thus very few organizations can provide the sensor services. But, if we move these services of sensors onto the cloud, it is possible to use it into several numbers of different applications [20]. Number of services can be provided to the users which include different fields like it may be employed into health applications, environmental monitoring, and industrial task (e.g. refining), surveillance, senior residents monitoring etc. During earthquake the vibration in building's can be monitored efficiently. But these services are provided by different organizations and the services of these sensors are limited to each organization. Thus, these sensor services are exposed to cloud computing in order to enable it to be used by several numbers of different organizations without being interrupting the other one [1] [20]. It means that if these sensors and service templates are constructed as catalog menu service on the cloud computing service, the requesters can create new sensor services with the existing sensors in these service instances. For example, service requester can create a sensor service to analyze the impact of earthquake to each floor or room of the rehabilitation center or hospital also it can create sensor services to support the older residents with the same set of sensors (virtualized sensors) at the same time. This service will provide ease to helper in order to shifting the older adults one by one. Using the same sensor services for healthcare another service requester can create dissimilar sensor service to track the patient's medicine intake and then to analyze the effectiveness of pills through the use of some selected healthcare sensors. Thus the service requesters can be provided new services using the same set of sensors on cloud computing service platforms. This will result in reduced cost for the resource usage and have numerous elastic merits to it. In this section several typical applications are introduced and these are:

(1) Ubiquitous Healthcare:
    Sensors like heat sensors, bed sensors, stove sensor, camera and accelerometer sensors etc. can be used together in monitoring for very aged residents to prevent from any casualty without being harmed and interrupting them [21]. These sensor services can provide the perception to older residents in health services.

(2) Environmental Monitoring for emergency/disaster detection:
    In environmental applications it can be used to detect the earthquake and volcano explosion before its eruption by continuously monitoring them through the use of several numbers of different sensors like strain, temperature, light, image, sound, acceleration, barometer sensors etc through the use of wireless sensor networks [22].

(3) Telematics:

Sensor-Clouds can be used for telematics means to deploy the long distance transmission of our computerized or information to a system in continuum. It enables the smooth communication between system and devices without any intervention [34].

(4) ***Google Health:***

It is a centralization service of Google that provides personal health information [36] and serves as Cloud health data storages. Google users are allowed to monitor their health records by logging into their accounts at collaborated cloud health service providers into the Google health system.

(5) ***Microsoft Health-Vault:***

This cloud platform is developed by Microsoft to store and maintain health and fitness related information [37]. Health-Vault helps users to store, gathered and share their health relevant information and it's data can be acquired from several pharmacies, cloud providers, health employees, health labs, equipments and from the users itself.

(6) ***Agriculture and irrigation Control (Field server sensors):***

Sensor-Cloud can be used in the field of agriculture to monitor the crop fields in order to upkeep it. For this a field server is developed that comprises of a camera sensors, air sensor, temperature sensor, CO_2 concentration sensor, soil moisture and temperature sensors etc. These sensors continuously upload the field data via Wi-Fi access point to the field owner to track the health of their crops [38]. This can also be used for harvesting.

(7) ***Earth observation:***

A sensor grid is developed for data gathering from several GPS stations, to process, analyze, manage and visualize the GPS data [39]. This GPS data would then be uploaded onto the Cloud for efficient monitoring, early warning, and decision-making capability for critical situations like the volcanic eruptions, earthquakes, tsunamis, cyclones etc. to the users all around the world.

(8) ***Transportation and Vehicular Traffic Applications:***

Sensor-Cloud can be used to provide an efficient, stable, equilibrium and sustainable tracking system. Earlier existing technologies like GPS navigation can only track the status and current location of vehicle but when we implement this vehicle monitoring using cloud computing, centralized web service, GPS and GSM enabled devices, embedded device with sensors fitted into it [40] will enable-

-to identify the current name of the location

-to predict the time of arrival

-to find status of driver via alcohol breath sensor

-to find the total distance covered

-to track the level of fuel

All the data fetched are stored onto some centralized server that will be resided into the cloud. The vehicle owner can access this data on cloud via web portal and can retrieve all data on cloud in real time to visualize the vehicle information.

A. Other Existing Sensor-Cloud Applications:

There exists numbers of services based on cloud-sensor infrastructure to store the sensor-based information. Few of them are described briefly below:

(1) Nimbits:

Nimbit [44] is a free and social service that is used to record and share sensor data information on cloud. It is a cloud based data processing service and is an open source platform for the IoT (Internet of Things). We can feed the versatile numeric, text-based, JSON, GPS or XML values by creating a data points on the cloud. The data points can be connected to Scalable Vector Graphic (SVG) process control, spreadsheets, diagrams, websites and more. Data points can also be configured to generate alerts, data-relay to social networks and to perform calculations. Nimbits also provide an alert management mechanism, data compression mechanism, and data calculation on received sensor data by employing some simple mathematical formulas.

(2) Pachube platform:

Pachube [45] is one of the first online database service providers which allow us to connect our sensor data to the Web. It is a real time cloud based platform for IoT with a scalable infrastructure that enables us to configure IoT products and services, store, share and discover real time energy, environment, healthcare etc. sensor data from devices and buildings around us. Pachube has a very interactive website for managing the sensor data and an open easily accessible API. Pachube system provides free usage and has several numbers of interfaces for producing a sensor or mobile-based applications for managing the sensor data on a Cloud framework anytime.

(3) iDigi:

iDigi [46] is a machine 2 machine (M2M) platform as a service PaaS that minimize the barriers to build scalable, secure and cost effective solutions which can bind the enterprise applications and device assets together. iDigi ease the connectivity of remote assets devices, provide all the tools to manage, store, connect and moving the information across the enterprise irrespective of its reaches. To simplify the remote device connectivity and integration it uses connector software called iDigi Dia. Regardless of network location iDigi platform manages communication between remote device assets and enterprise applications.

(4) ThingSpeak:

ThingSpeak [47] is another open source IoT applications and have an open API to store and retrieve data from device assets or things via LAN or using HTTP over the Internet. With this platform, we can create location tracking applications, sensor logging applications, and social network of device assets with proper update of its status. ThingSpeak allows numeric data processing like averaging, time-scaling, rounding, median, summing etc. to store and retrieve the numeric and alphanumeric data. ThingSpeak application features a JavaScript based charts, read/write API key management and a time-zone management.

However, these above services are able to visualize the sensor data information but they are lacking secure access of data and interface availability for linking the external or mobile applications for further processing of sensor data. It means that most of these aforementioned projects do not address the issues of data management and interoperability issues caused by heterogeneous data resources found in present modern

environmental tracking or electronic healthcare systems. But introducing these aforementioned works with Cloud Computing infrastructure may overcome the issues regarding the access functionality and data management [48].

4. Cloud-Sensor as Layered Structured Approach
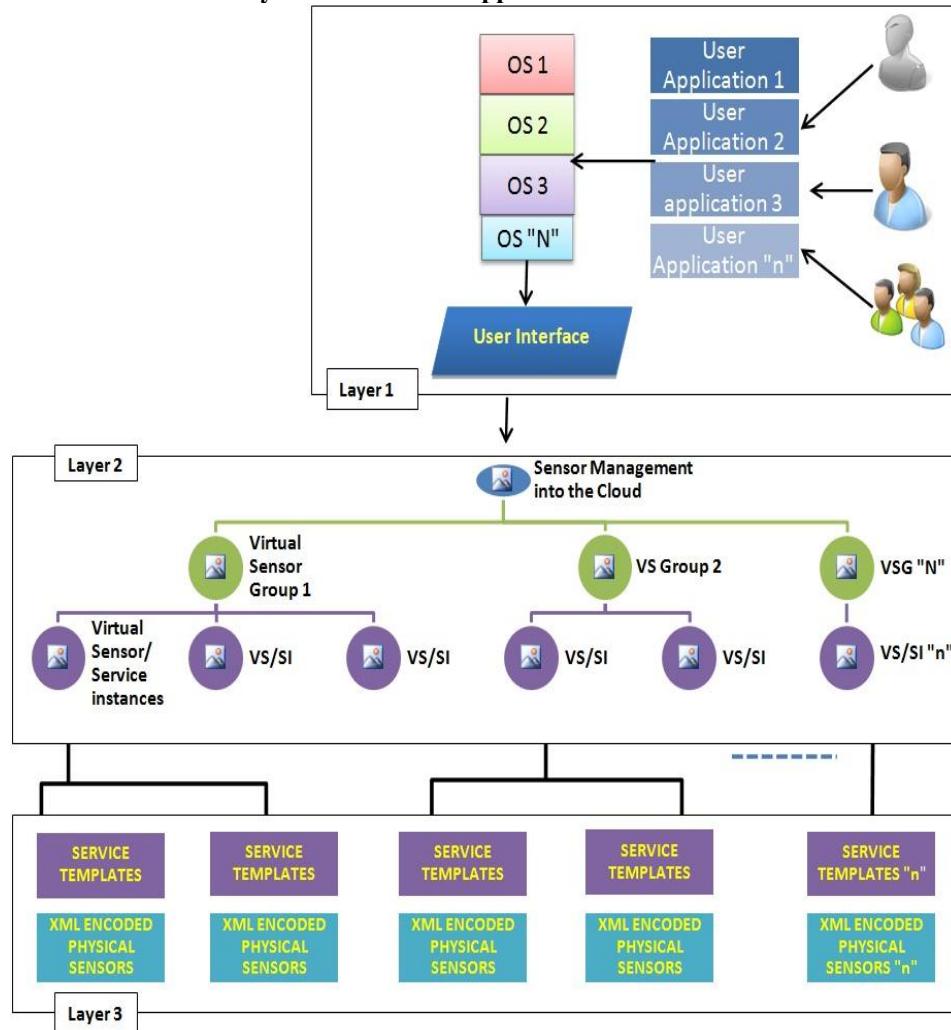
Figure 3: Layered Architecture of Cloud Sensor

The above diagram depicts the layered architecture of the Cloud-Sensor platform which divides it mainly into three phases:
  (1)   User and Application Phase.
  (2)   Sensor Cloud and Virtualization Phase.
  (3)   Template Creation and Tangible Sensors Phase.

There are numbers of physical sensors scattered around our environment which may left unused once used. These physical sensors are combined efficiently in order to create network of sensors which may include several number and different type of sensors. These networked sensors are then allowed to create service templates by classifying the different type of sensors in accordance to their readings provided. Service templates are created to generate service instances once they moved to the Cloud-Sensors platform means these physical sensors are going to be virtualized using the cloud computing scenario through the basis of service templates. The advantage of service templates is that the users need not to worry about the discovering of its appropriate virtual sensors for their applications, instead they are categorized in order to save the important time of users in searching for the suitable virtual sensors.

Layer1: This phase deals with the users and their relevant applications. Several users want to access the valuable sensor data from different number and types of OS platforms for their number of applications. Users may access this sensor data from different platforms like some access from their mobiles, some may access from Windows OS, Mac OS etc. This structure allows user of different platforms (be it from Windows, or from Macintosh and so on.) to access and utilize the sensor data without facing any problem because of cloud computing.

Layer2: This phase deals with virtualization of the physical sensors. Cloud computing enables us to virtualize the resources and physical sensors. This enables to provide services of sensors and other IT resources on cloud remotely to the end user without being worried about the sensors exact locations. The virtualized sensors are created by using the service templates automatically. Service templates are being prepared by the service providers which defined this as the service catalog menus, and these catalog menus enables to create the service instances automatically and is used to redundant the same specification's virtual sensors for multiple number of users [2][20].

Layer3: This is the last phase which copes with the service template creation and service catalog definition phase in form of catalog menu. Physical sensors are XML encoded that enables the services provided through these sensors to be utilized on various platforms without being worried to convert it onto the several platforms.

Sensor-Cloud provides a web based aggregation platform for sensor data that is flexible enough to help in developing user-based applications. It allows users quick development and deployment of data processing applications and give programming language flexibility in accordance to their needs [33].

5. Multi-Service Provisioning on Multiple Platforms

Layer 3 deals with the XML [16] encoded physical sensors. The XML encoding defines some set of rules for these physical sensors such that it will be both human readable and machine readable with less intervention and enable these to be implemented on several numbers of different platforms. XML enable documents to give physical sensor's metadata i.e., type of the physical sensors, its specifications, the accuracy or intensity of

these physical sensors, the exact location etc. This whole scenario can be depicted by the figure below:
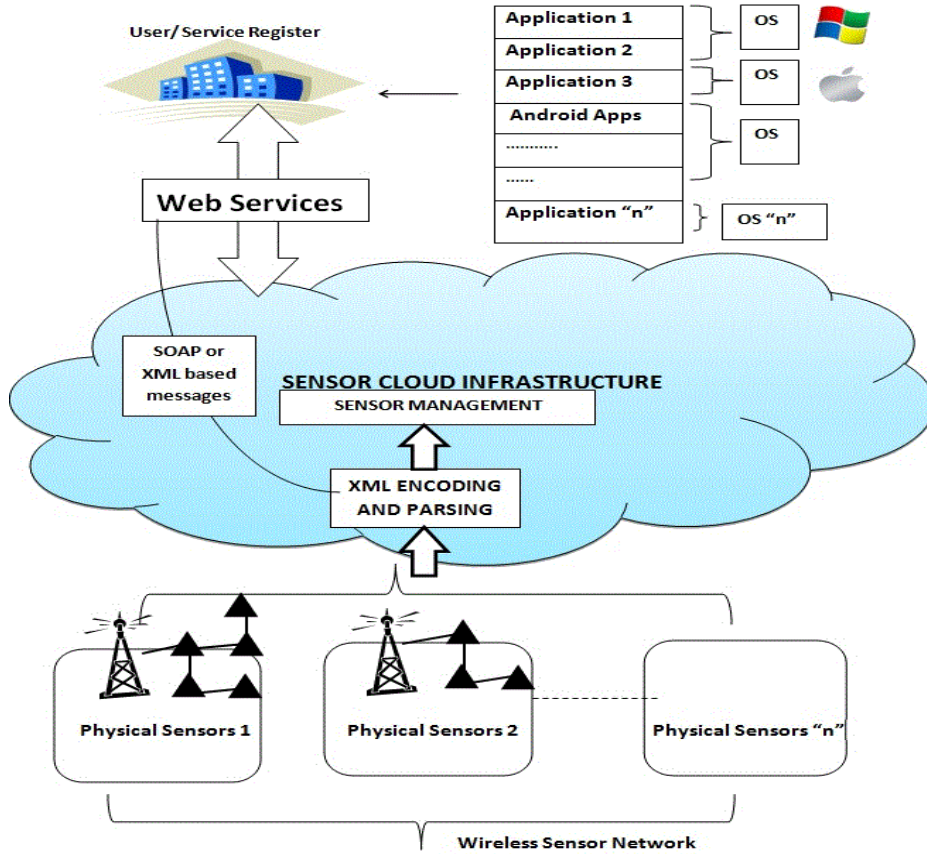
Figure 4: XML encoded physical sensors into the Cloud-Sensor

The author [41] has proposed to access the sensor information by using the Web Service Description Language (WSDL) and structure data, so that the multiple applications may access sensor information. But the key issue in using the web services on sensor nodes is energy and bandwidth overhead of structured data formats used in the web services [42]. In heterogeneous sensor networks, integration is a complex task because there is an absence of standardized data exchange format between the heterogeneous systems and networks. XML has evolved then to overcome this insufficiency by providing a standard data exchange format between heterogeneous network and systems. Because of the limited hardware resources within sensor networks, XML usage was not fully introduced earlier. But now XML usage in sensor networks is made applicable by introducing the XML template objects in an optimized manner [43]. XML is basically a key feature towards the service-oriented sensor networks and a proper medium to support complex data management and heterogeneous sensor networks.

To enable the applications to communicate with each other and to provide remote access to the services offered by Sensor-Cloud platform, Web Services are introduced [48]. Web

Services mainly refers to accessing the services over Internet connection. It has WSDL (Web Service Description Language) definitions which describes what the web service can do, how web service can be used by client applications and where the web service is located. SOAP messages are used to communicate with Web Services and these SOAP messages are XML based that are transported over Internet protocols like SMTP, FTP, and HTTP etc.

6. Cloud-Sensor for Health Monitoring Applications

Cloud-Sensors can be used for health monitoring by using number of easily available and most often wearable sensors like accelerometer sensors, proximity, ambient light and temperature sensors etc to collect patient's health relevant data for tracking his sleep activity pattern, blood sugar, body temperature and other respiratory condition data. These wearable sensor devices must have support BWI (Bluetooth wireless interface), UWB (Ultra wideband) etc. interface for streaming of data and are connected wirelessly to any smartphone through this interface. These smartphone devices pretend to function like a gateway between the remote server and sensor through the Internet; maybe GPRS/ Wi-Fi, or other sort of gateways. To transform this system into services based structure, Web Services based interface are used by smartphone device to connect to the server [23]. The system prototype should have made to be robust, mobile and scalable. Robust in sense that it should recover itself from circumstances which may lack connectivity issues due to power (i.e., battery) failure or gateway cutoff to patient's wearable devices [24]. Mobile in sense that it should be capable of tracking signals into heterogeneous environments i.e.it must catch the signals irrespective ofwhether the patient go outside or still resided into the hospital/ building. It should be scalable means it can be deployed easily for several numbers of users concurrently without affecting the performance metrics. And finally, it should be re-targetable and extensible in nature. Re-targetable refers that it can handle various displays with distinct form factors and screen resolution. It means that the same health applications or other applications can be displayed to any smartphone display like PDA (Personal Digital Assistant) or to a bigger console device in hospital where doctors, helpers, nurse staff etc. may track the acquired data information from distance. Extensible in the sense that if any newer sensing devices are introduced into the system for acquiring the patient's health based information, system should function efficiently and conveniently without affecting backend server of the services [25]. Context-awareness can direct us to derive a better level of emergency services to patient [12]. The information regarding recent operational laboratories, missing doses of pills, number of handicaps and other situations would be helpful in health monitoring. The system should not adhere to any changes made into the operating system or intermediate components of sensing devices and is designed in such a way that it would cause minimal disturbance to services provided to existing end users of the system [4].
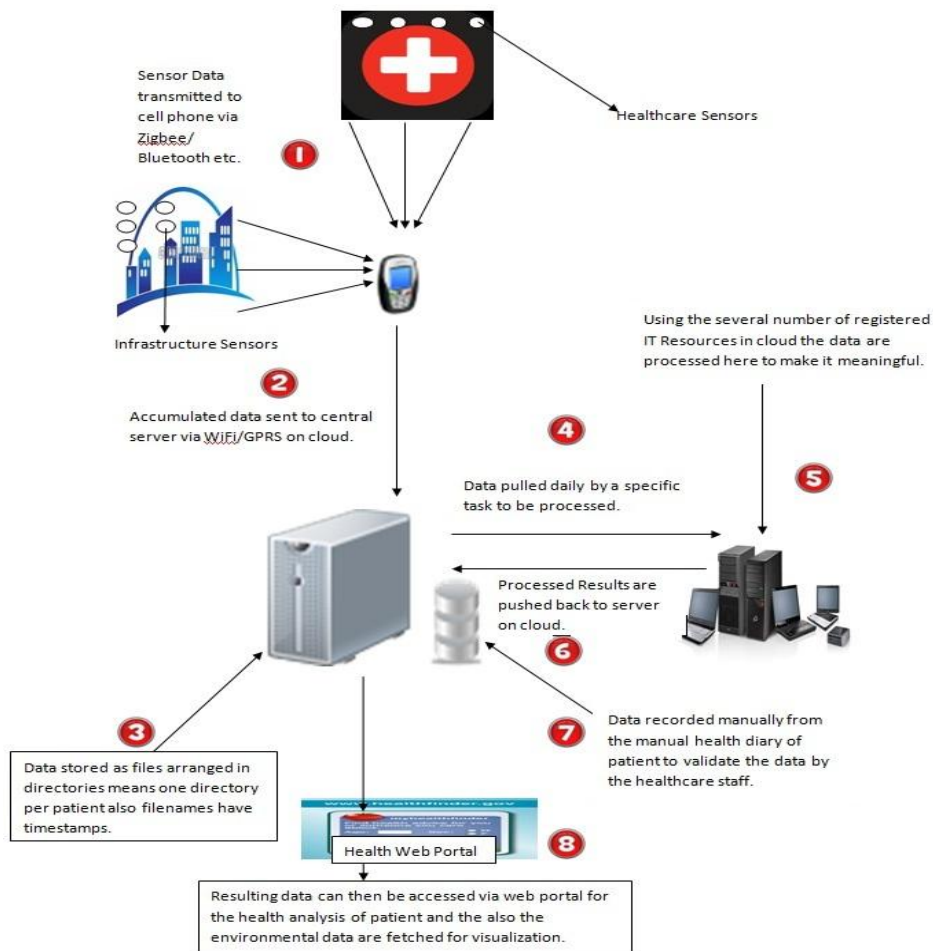
Numbers of sensors pick up the patient data and these accumulated data are uploaded to server on cloud. If found any noise data then they are filtered using some filtering mechanism on server. The doctors/health employees, nurses etc. can then access to the patient's data on cloud through a web service portal after being authenticated /permitted by the patient.

7. Advantages and Disadvantages of Cloud-Sensor Architecture

Serial Number	Advantages	Disadvantages
(a)	Service requesters and users can control the service instances freely.	The IT Resources and physical sensors should have to be prepared prior to operation of the Cloud-Sensor Infrastructure.
(b)	End users can inspect the status	The service templates for creation of

	of their relevant virtual sensors.	virtual sensors have to be prepared by the Cloud-Sensor administrators.
(c)	The client users need not to worry about the exact locations and detailed description of their sensors [23].	This infrastructure will not provide much accurate data as in case of direct sharing of physical sensors data.
(d)	The service instances are automatically provisioned whenever a request is made [2].	The services provided are not fast enough as compared to services provided by direct sharing of physical sensors to our applications.
(e)	The IT Resources and sensors are released as and when the required job is over, means users can delete them when become un useful.	The Cloud-Sensor requires a very broad management system in order to track the end users, IT resources, Virtual Sensors, Physical Sensors etc.
(f)	Usage of physical sensors can be tracked by the sensor owner.	Cloud-Sensor infrastructure is vulnerable and more prone to sophisticated distributed intrusion attacks like DDOS (Distribute Denial of Service) and XSS (Cross Site Scripting) [26].
(g)	For securing the data in Cloud-Sensor, Network IDS (NIDS) is proposed [26].	There needed a continuous data connectivity between end users and Cloud-Sensor server [4].
(h)	The Cloud-Sensor architecture provides an extensible, open and interoperable and intelligent sensor network for service provisioning in health care [27].	
(i)	The cost of IT Resources and WSN Infrastructure reduced when integrating with Internet/ Cloud [28].	

8. Issues and challenges while Designing Cloud-Sensor Infrastructure in HealthCare and other Applications

There are several issues like designing issues, engineering issues, reliable connection, continuous data flow, power issues etc. that should have to be handled while proposing such an infrastructure for health care and other related applications [29]. Some of the main issues are as:

(1) There are several issues while designing the system in real scenario like nursing home, health care, hospitals etc. to be tracked, and these are *fault-tolerant, reliable continuous transfer of data* from sensor devices to the server. For example: In a

private health care the patient may be out of coverage area from the smart-phone gateway most often because of patient come in and out frequently. This scenario would be more prone to connection failure between the server and smart-phone (or any other display device like PDA etc.) thus this scenario must have to be considered while designing such system in order to avoid accumulation of errors. [4][31]

(2) Some *engineering issues* like *storage of data at server side, transferring data from phone to server* must have to be considered. To tackle from this timestamps are sent with each data packet to assist in reconstruction of data on the server side. Most of the data processing is done at server end so the system must be designed to avoid the bursty processing due to multiple users connected simultaneously to the system. The system must be designed to accommodate multiple users to connect at same time. [4]

(3) A web based user interface is used for doctors, patients, helpers, care-givers etc. to inspect and analyze the patient's health relevant results remotely, so the system should have to offer different *authorization roles* for different types of users and authenticated via this web interface. This will enable the *privacy* to some extent by allowing the care-givers to restrict them to just one patient that he/she will take care of.

(4) While using smart phone as a gateway, *power (battery)* is the main issue that has to be taken care of because the continuous processing and wireless transmission would drained out the mobile battery within few hours or days. Thus, it is required to plug the phones directly from mains or the program running inside smart phone should control on proper power management functions. [23]

(5) *Event processing and Management*: Sensor-Cloud has to cope with very complex event processing and management means [34] [32]:

- How the events have to be synchronized that may come from different source in different time because of delays in network?

-How the event processing rules have to change without affecting the system?

-How the messages and events of varying type supported?

- How to support the enormous numbers of events and its conditions in an optimal way?

- How can we recognize the context (i.e., spatial, temporal, semantic) to its relevant situation detection?

(6) *Service Level Agreement (SLA) Violation:* Consumers dependency on cloud providers for their applications in computing needs (like their processing, storage, analysis of enormous sensor data and user generated data) on demand, may require a specific Quality of Service to be maintained for user's applications sustainability and to meet their goals. But, if cloud providers unable to provide these quality services on user's demand may be in case of processing huge sensor data in critical environmental situations, it would result in SLA violation and provider must be responsible. So, we need a reliable dynamic collaboration among the cloud providers. But opting for best combination of cloud providers in dynamic

collaboration is big challenge in terms of cost, time, discrepancy between providers and QoS [35].

(7) *Need for efficient information dissemination:* In sensor-cloud we need an efficient information dissemination mechanism that can match the published events or sensor data to appropriate user's applications. But there may be some issues like maintaining flexibility in providing a powerful subscription schema which may capture information about events, guaranteeing the scalability with respect to number of subscribers and published events or sensor data etc. [35]. Since the data sets and their relevant access services are distributed geographically, the allocation of data storage and dissemination becomes critical challenges.

(8) *Security and privacy support issues:* There are fewer standards available to ensure the integrity of the data in response to change due to authorized transactions. The consumers need to know whether his/her data at cloud center is well encrypted or who supervise the encryption/decryption keys (i.e., the cloud vendor/ customer itself). Private health data may become public due to fallacy or inaccuracy i.e., consumer's privacy may lost into cloud and sensor data or information uploaded into clouds may not be supervised correctly by user. The U.S., WellPoint disclosed that 130000 records of its consumers had leaked out and become available publicly over Internet. So, better privacy policies are the demand of time that can offer the services themselves while maintaining the privacy [35] [48].

(9) *Real time multimedia content processing and massive scaling:* Usage of large amount of information in real time and its mining is a big challenge in the integration of heterogeneous and massive data sources with cloud. To classify this real time multimedia information and contents such that it may trigger to the relevant services and assist the user to his current location is also a big challenge to be handled [32].

(10) *Collective Intelligence Harvesting:* The heterogeneous real-time sensor data feed enhances the decision-making capability by using the appropriate data and decision level fusion mechanisms. But maximization of intelligence developed from the massively collocated information in cloud is still a very big challenge [32].

(11) *Energy Efficiency issues:* The author of [48] has proposed a system for health monitoring using the textile sensors which works much better and gives more accurate results. These textile sensors can be easily sewed and even are washable. However the proposed system of textile sensors is performing well in majority of aspects but the battery can last only 24 hours after continuous monitoring and data transmitting regarding user's heartbeat rate, movement, respiratory conditions etc. The gathered accumulated data can then be visualized in charts using some web applications and the results are received at user end through an alert message remotely on his/her smartphone. But in order to extend system independency, energy efficiency of such systems (textile sensors and microcontroller based) is primary issue that has to be handled.

Data caching mechanism [49] can also be used to reuse our bygone sensor data for applications that are tolerant to time i.e. steady e.g., an application related to variant room temperature etc. If we use this bygone sensor data to satisfy the various requests for a common sensor data, the energy consumption will be reduced [53]. Still there are more work needed to overcome the energy consumption.

(12) ***Bandwidth Limitation:*** Bandwidth limitation is one of the current big challenge that has to handle in cloud-sensor infrastructure system because the number of sensor devices and its cloud users are increased dramatically high [49]. However there are numbers of optimal and efficient bandwidth allocation methods proposed but to manage the bandwidth allocation with such a gigantic infrastructure consisting of huge device assets and cloud users, the task of allocating bandwidth to every devices and users becomes almost difficult.

(13) ***Network Access Management:*** We have various and multiple number of networks to deal with in cloud-sensor architecture applications. So we need a proper and efficient access management schemes for these several numbers of networks because this will optimizes the bandwidth usage and links performance improved [52] .

(14) ***Pricing Issues:*** To access the services of Sensor-Cloud involves both the Sensor-Service Provider (SSPs) and Cloud-Service Provider (CSPs). However, both SSPs and CSPs have different customer's management, services management, mode and methods of payments and pricing. So, all this together will lead number of issues [51] like-
   - How to set the price
   - How the payment made to customers
   - How the price be distributed among different entities etc.

(15) ***Interface Standardization Issues:*** Web interfaces currently provide the interface among sensor-cloud users (may be Smartphone users) and cloud. But web interface may cause overhead because the Web interfaces are not specifically designed for smart phones or mobile devices. Also, there would be compatibility issues for web interface among devices and in this case signaling, standard protocol, and interface for interacting between sensor-cloud users and the Cloud would require seamless services for implementation. Thus, interoperability would be a big issue when the sensor-cloud users need to access the services with cloud [51].

9. Conclusion

In this paper we focused on the use of cloud-sensor architecture in context of pervasive healthcare applications apart from other applications. The cloud-sensor architecture enables the data to be categorized, stored and processed in such a way that it becomes cost effective, timely available and easily accessible. Earlier most of the WSN systems that are inclined to healthcare schemes were closed in nature, no interoperability or may be much lesser interoperability, specific-application oriented and non-extensible. But

integrating the existing sensors and may be by adding explicit sensors to the IT resources with cloud by using an intelligent mechanism would bestowed us an open, extensible, scalable, interoperable and easy to use, re-constructible network of sensors for healthcare monitoring applications. Several cloud-sensor frameworks have been proposed till date towards the achievement of an open, interoperable, extensible, scalable and intelligent utilization of WSN in pervasive healthcare applications. CHA (Continua Healthcare Alliance) has launched numbers of technological standards which envisioned the healthcare data collaboration from mobile devices and transferred data onto some backend server which also provides storage, processing, visualization, communication, and mobility [30]. Introducing the cloud computing services reduce delivery time effectively and improves the cost in maintaining the sensors and IT Resources.

10. Acknowledgment

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