Sensors Data Collection Architecture in the Internet of Mobile Things as a Service (IoMTaaS) Platform

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***Abstract*—Smart object interconnected between each other and producing a large volume of information in Internet of Mobile Things (IoMT) is a huge challenge. The things that we expect to connect to the Internet will consist of sensors, actuators with information processing and communication capabilities that will make themselves intelligent. Sensors are collecting continuously environmental data (e.g. body area network, smart city, cars, smartphones, etc.). We used Arduino, XBee, Raspberry Pi 3 and open source software for framework design. This architecture process real-time data and maximize the delivery of raw data to the cloud for post processing. It also ensure efficient event-driven data collection given the buffer space and communication bandwidth limitations of each sensor. An intelligent IoMT gateway and middleware used to support different message format of sensor data and efficient decision-making system. We also propose an Android data collection system where data collectors are smartphones. This paper defines a data collection architecture supporting the physical dimension of sensors to the storage of data in a cloud-based service. This class of architecture must tackle several challenges, e.g., buffer management, sensor message ordering, data alignment for multiple temporal data streams, data storage, sensor heterogeneity, high throughput and avoiding processing bottlenecks. For the issues of an extended advancement cycle, poor transportability and high-chance in the improvement procedure of ZigBee remote system, presents the Unified Modeling Language (UML) to institutionalize the advancement procedure, enhancing improvement productivity and guaranteeing item quality.**

keywords: Architecture, Cloud, Data collection, Distributed computing, Sensors, UML.

I. Introduction

The smart objects are considered as the building blocks of IoT. Different type of objects where sensors are embedded, generate and share a large amount of data. This real-time streaming data gathered using sensors [1], [2]. This data is used for real-time decision making and offline data analytic. A class of applications that generate data that have value even if the processing does not occur in real time. This unprocessed raw data needed machine learning or signal processing algorithm that fuses data from different smart objects. Also assume that we desire to execute analytics algorithm that fuses the data from wireless sensors to the processing center located in the cloud. Heterogeneous sensor data provide some services to the human-being. We have sensors on a fleet of the truck of our customer and collect customer acoustic data from the engines. Any impending problem will cause the sound input change, when you can get a preventive maintenance done. This is an example of Internet of Mobile Things as a service (IoMTaaS) platform where running as a service. So, heterogeneous mobile sensors data collection is one of the most important research challenges.

In the current era, cloud computing is gaining lots of interest in several domains by processing big data [3], [4]. Where data are collected from several sources such as sensor networks, social networks, and vehicles [6], [7]. There is still scope to address security concern of data collected from above sources to cloud data center. There is need a common architecture to support the data collection of data from sensors to cloud [20]. Network protocols are the backbone of any communication system which follows certain Quality of Service (QoS) for each communication application. With the quick improvement of installed innovation, remote system framework becomes progressively capable, with its topological structure and correspondence turning out to be more unpredictable. As another remote innovation, ZigBee arrange has the comparative issue to the others. It is a remote innovation, which is a hardware of minimal effort remote system.

It is a remote system convention created by the ZigBee Alliance in light of IEEE 802.15.4 Standard. In the advancement procedure of ZigBee remote system, ZigBee in view of ZStack convention assumes a part of the skeleton, and its segments and various leveled structure give a great establishment to the

improvement of an effective application framework. In any case, customary advancement strategy has not been meeting the prerequisites, so it is trusted that an appropriate remote system improvement technique in light of implanted framework can abbreviate the framework improvement cycle, as well as decrease the improvement expenses and increment framework quality. Unified Modeling Language(UML) is a well-known modeling methodology. We are analyzing and describe IoMT protocol using UML.
Designing a good data collection system requires extensive knowledge in sensor selection, energy management, sensing application implementation, and privacy management. On the other hand, if data collection of mobile things is done properly and effectively, it provides the fundamental building block for the success of IoMT.

II. System Model

A. IoMT Sensor Model

Wireless Sensor Network (WSN) is the backbone of IoMT. Fig. 1 shows the system model of IoMT. Heterogeneous mobile sensor data provide some services to the human-being. We have sensors on a fleet of a truck of our customer and collect customer acoustic data from the engines. Any impending problem will cause the sound input change, when you can get a preventive maintenance done. This is an example of Internet of Mobile Things as a service (IoMTaaS) platform where running as a service. So, heterogeneous sensors data collection is one of the most important research challenges. There is need a common architecture to support the data collection of data from sensors to cloud server.

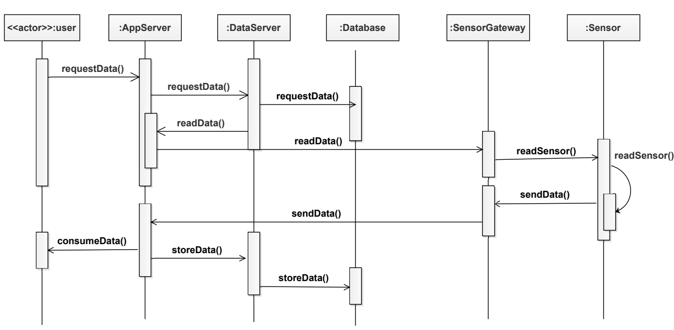

Fig. 1. IoMT Sensor Model

Fig. 2 represent the data collection system model of IoMT. The architecture is comprehensive as it addresses the complete spectrum of elements involved in such a context.

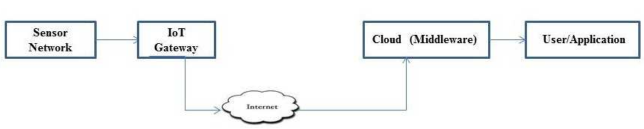

Fig. 2. Data collection system model for IoMT

B. Sensors Network

Heterogeneous sensors and sensor boards are the part of the sensors network [10]. Sensors were transforming a physical quantity into a measurement. Sensor board aggregates several sensors physically connected to it. Fig. 3 depicts an overview of the sensors network.

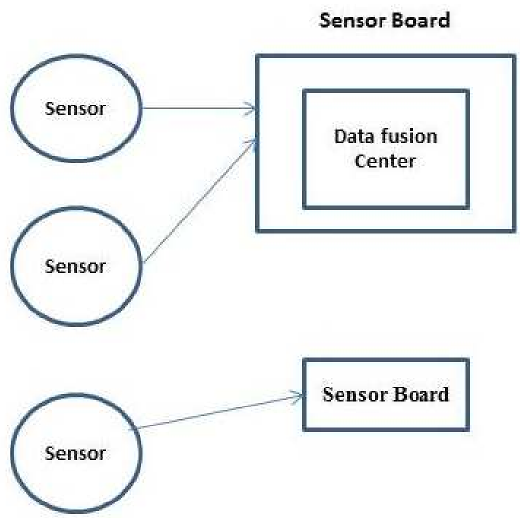

Fig. 3. Sensor Network

1) Sensor Node: Our architecture maximize the delivery of raw data to the cloud for post processing given the buffer space and communication bandwidth limitations of each sensors. Multiple sensors are connected in a star topology with the sensor board [11]. Each sensor node acquire a subset of the collected samples for locally compressing/summarizing from the random signal x with an average rate of λ samples/second , when the buffer to store data of the sensor and the sampling rate of the data exceeds the rate of the communication link (Fig. 4).

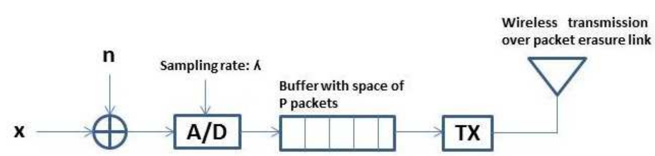

Fig. 4. Data collection in sensor

The communication channel shared by all the sensors with individual packet erasure some probability. Therefore, samples are lost if the buffer is in the sensor is full when a new sample arrives, and when there is a packet erasure. IoMT gateway received the data and forwarded to the cloud for the estimation of the random signal. The different type of sensors and qualities makes it numerous troublesome cases to translate the data accurately, for both locally on a senor node and remotely on PC framework. Object modeling approach helps to design data processing algorithm on sensor nodes as shown in Fig 5.

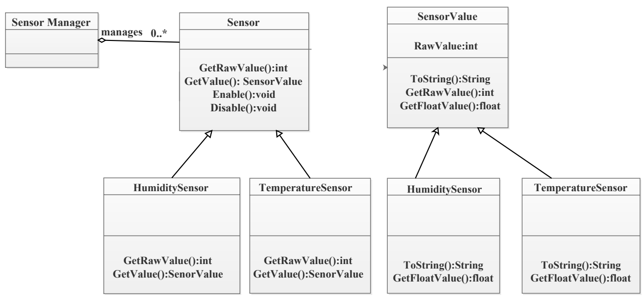

Fig. 5. Sensor Interfaces

2) Sensor Board: Sensor board is usually implemented by micro-controller(eg.Arduino). Sensors and actuators are connected to a micro-controller where predefined instruction set execute fro acquiring the data. It is a self-contained, deployable unit that captures the sensors data and sends it to the associated gateway. The most important requirement is systematic data collection where sensing data forwarded to the gateway through a number of hops for further processing. A data fusion center is embedded in the sensor board which uses co-operative game theory or Fuzzy logic to ensure efficient event-driven data collection. This reduces the minimal use of communication resource and payload which lead to packet fragmentation. This scheme is very much used in Body Area Sensor Network (BASN) for detecting the changing parameter of the body. The critical task for sensor board is to identify various occurrence of events and collect data in a reliable and timely manner. Some rules are set in collecting event-driven data. Sensor nodes collect environmental data and send it to a fusion center. The fusion center makes the decision and propagates to the sensor nodes. The sensor board sends valuable data to the fusion center.

III. IoMT GATEWAY

The sensor board does not have enough processing power, memory to deal with data locally. So, for further processing, it sends the data to the IoT gateway by the low-energy communication links like ZigBee, Bluetooth Low Energy (BLE) or Power over Ethernet (PoE). The hub that acts as an aggregator of multiple raw datasets generated by the sensor nodes is called an IoMT gateway (Fig. 6).

IoMT gateway is an edge device. Collecting and processing data at the edge and reduce the amount of data that need to exchanged in the cloud. Sending data back to the cloud or remote data center is slower than processing at the edge. It also reduces the data processing and management cost. This cost can be reduced by applying some optimal consolidation of resource and task in the cloud environment [15], [16], [17],

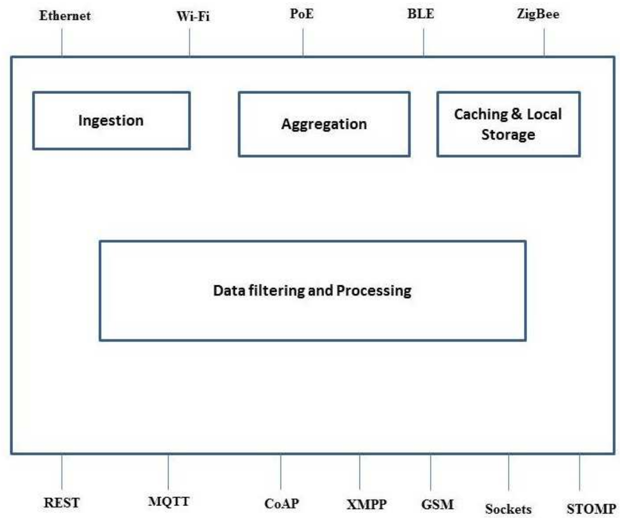

Fig. 6. IoMT gateway architecture

[18]. Data processing is distributed among edge devices, so if one device is faulty, then other devices work properly. IoMT gateway is intelligent because it puts the decision making close to where the action performed. The gateway acquires heterogeneous sensor data and converts them to a standard format. There are various outbound low-power communication protocol like MQTT, COAP, REST, etc. supported by IoMT gateway. Complex processing, smart alert system, smart decision making perform in-depth. We use Raspberry Pi 3 as an IoMT gateway and Arduino as the sensor node (Fig. 7). XBee modules use to create wireless point to point or mesh network.

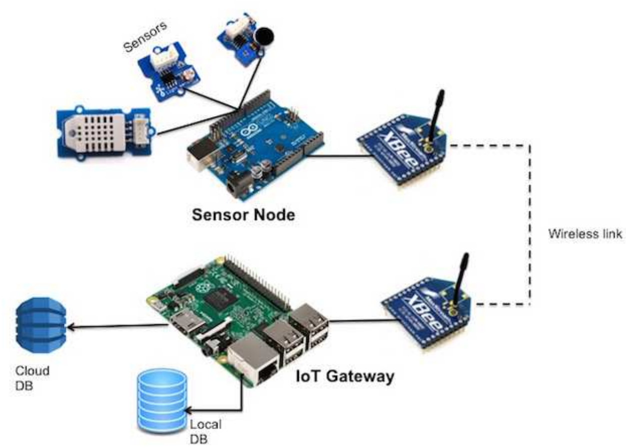

Fig. 7. IoMT gateway

We design an IoMT gateway based on the Android operating system. It is a mobile data collector which can interact many communication interfaces for data collection. As illustrated in Fig. 8, the data collection system can be configured either manually by the user (human) or automatically by an another smart object.

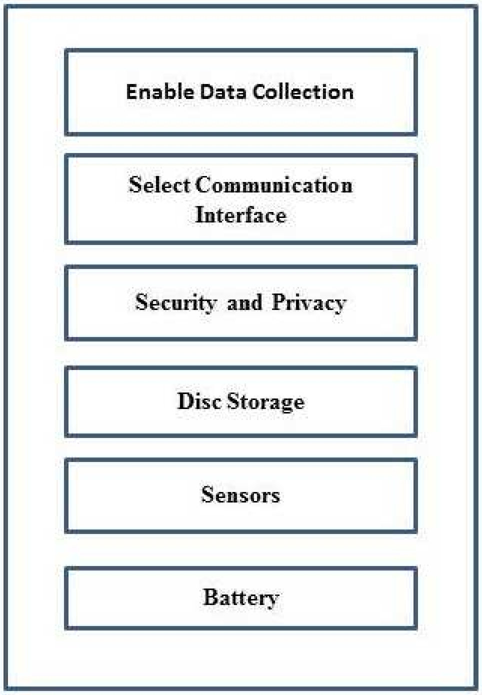

Fig. 8. Mobile data collection architecture based on Android app

The data collection controller (DCC) manages the data collection operation. The configuration is done by the data collection controller, which comprises:

1. The activation and deactivation time monitoring of the system.

2. The specification of the security mechanism for collected data protection.

3. The system is deactivated when the battery label is below the threshold value.

4. The selection of the communication interfaces that will be based in the data collection.

To evaluate the performance of the developed system, we perform set of experiments on the developed prototype and the GUI of DCC is represent in Fig 9.

IV. Cloud centric IoMT Middleware

The middleware defines three distinct APIs: (i)IoMT sensor board send data by the gathering API, (ii) a configuration API to support the set-up of measurement retrieval and (iii) a data API used to interact with the collected datasets. Middleware supports heterogeneous sensor configuration and the measured datasets. The cloud handles the scalability of the data collection. Fig. 10 represent Cloud Middleware architecture.

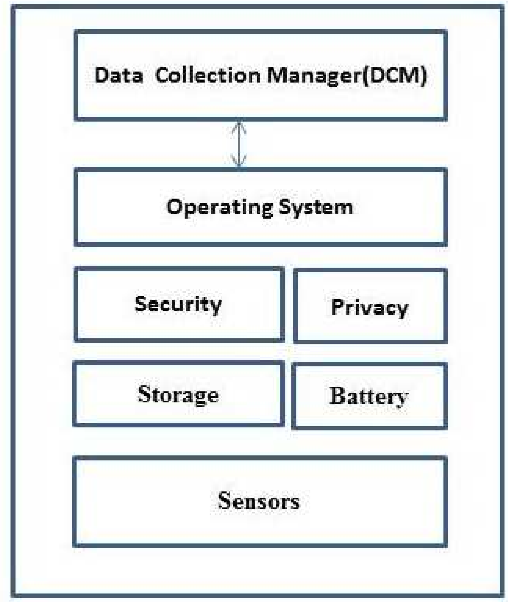

Fig. 9. A GUI of DCC in Android App

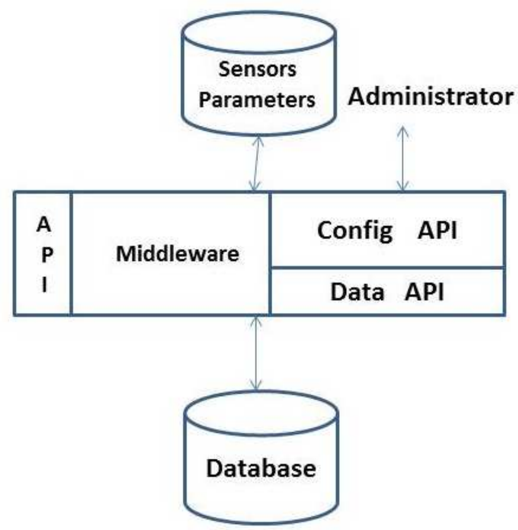

Fig. 10. Data collection architecture of Cloud Middleware

V. Conclusion

This architecture focus on IoMT data collection. The key point is to develop hardware and software data capturing technique. Fuzzy logic is used for detection of an event and identifying which data is required to be forwarded.Data collection, mobility of things such as phones and vehicles impacts several important relations: (a) relation between number of sensors used during data collection, energy usage, and storage usage, i.e., if number of sensors goes up in a mobile device, energy usage goes up and data collection requires more storage space; (b) relation between data collection, energy management and data analysis, i.e., if one collects more data, more energy is being spent, but also better data analysis can be done learning more detailed patterns such as mobility patterns, usage patterns, social context patterns, and other patterns of mobile devices; (c) relation between data collection and privacy; i.e., if one collects private data, one needs to provide privacy-preserving algorithms for mobile devices; (d) relation between data collection and data quality, i.e., since mobile data collection is opportunistic, how much data one collects (duration and frequency of data collection) impacts the data quality implicitly.

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