Integration of Internet of Things, Cloud Computing: Review

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Abstract: As the Network of Things has grown exponentially, the Internet of Things devices generate tremendous data. IoT provides virtualization with or without the presence of being with the services. Managing this vast volume of data becomes a very tedious task. So in diverse sectors, including such as healthcare, education, agriculture, smart cities, there are various IoT applications. Using different technologies, sensor data is acquired and data collection, data cleaning, data processing, and analysis are done with the help of cloud computing. We present a survey of the integration of the Internet of Things, cloud computing, and healthcare in this paper. The paper focuses on the different IoT Cloud computing platforms used with the Internet of Things and is an advantage of the healthcare domain’s usefulness.

Keywords: Internet of Things, Wireless Sensor Network, cloud computing

1. Introduction

The Internet of Things is a really powerful 21st century technology which has a significant impact on everyday life and provides populations, education, companies, and customers with many possibilities for the future. IoT is essentially a network of things containing various sensors and capturing sets of data to the central infrastructure. There are various IoT applications that can track devices using the sensor network cloud, it can also allow two-way communication, enabling actuation close to the thing that an IoT application gathers data points from various sources and then makes meaningful decisions using that sensor data.[1]

The new trend that provides flexible computing and storage services that are used to support a massive amount of data processing is cloud computing technology. Thus, the analysis of data produced by sensors and IoT devices can be applied to cloud computing. Platform-neutral technologies are needed to resolve key issues such as communication bottlenecks, data interchange formats, protection and interoperability [2] to maximize the market potential for the future.

For any technical services offered via the Internet, Cloud Computing is a general term. For multiple computing tools such as networks, systems, software, and facilities, cloud computing offers compliant and on-demand network access.[15]
IoT devices form a network of sensors known as the Wireless Sensor Network, which are distributed to provide virtualization and services around the world. A Wireless Sensor Network forms a network of distributed sensor nodes to track physical conditions, such as sound, pressure, heart rate, humidity, and blood pressure. A sensor network’s nodes generate a huge amount of contextual environmental data. The sensor network has numerous capabilities, such as observing and transmitting raw sensor readings, and sensor networks revolutionize sensing in a wide variety of application domains. They provide different services in various fields, such as process monitoring for home automation, healthcare research, weather forecasting, understanding of the military situation, and traffic control. [3]

Systemized paper remains as follows. Section 2. Introduces simple Cloud Infrastructure based on IoT. Section 3 Particularly focus on IoT-based cloud computing needs and implementations and applications. the literature review is summarized in section 4. The 5th section, describes the elements of IoT and various IoT cloud platforms. In section 6, the benefits of IoT Cloud computing integration are classified. In section 7 Proposed future work is explained. Section 8 The paper concludes.

2. Cloud Architecture based on IoT

In order to form an intelligent network of connected items such as sensor technology, gateways, RFID, and other smart technologies, various components are embedded [15]. Figure 2 Displays simple cloud infrastructure for IoT. The raw data is obtained in the perception layer from IoT devices and sensors worn by a human being. In the network layer, data is accessed from internet gateways. Data
preprocessing and cleaning is performed on the edge computing layer. Data analytics and prediction was further carried out using various machine learning algorithms on the cloud platform.

The main goal of the IoT is to enhance and make human life simpler, either by helping people make better choices and by helping people to live with less tension, less repetitive work, less human contact with IoT computing technology, the promoter of the IoT [15].

3. IoT based Cloud Computing Requirements and Implementations

There is a massive demand for smart network IoT applications in every sector today. Sectors such as agriculture, healthcare, education, smart cities, retail, and many more. IoT is used for crop harvesting in agriculture to minimize transport costs, predictability of prices on past data analytics [16]. In electricity conservation, IoT is often used to alert the consumer of electricity conservation [17]. With different models for IoT in healthcare and the prediction of different types of diseases using different methods, many types of research are being performed. IoT and cloud computing in the healthcare domain are very helpful for real-time patient health monitoring for which sensor technology is used, raw data is sent to the cloud for analysis purposes and warning messages are sent to the doctor and caretaker to interpret and forecast any illness or condition in the preliminary stage itself. Different machine learning algorithms and data mining techniques are used for analysis and prediction [18]

3.1 IoT applications

There is a huge demand for IoT-enabled systems for easy living in each sector. A couple of the fields Listed below are

3.1.1 Smart cities:- To make the community a smart city to interact with the data exhaust produced from your neighborhood and city. It involves monitoring of the availability of parking spaces in the area, calculation of the energy radiated by cellular stations and Wi-Fi routers, vehicle and pedestrian level monitoring to improve driving and walking paths, Intelligent Highways with climate-specific warning notices and diversions, and unforeseen events such as accidents or jams.

3.1.2 Smart Security:- Involves identification and monitoring of people in unauthorized and restricted areas, liquid identification in data centers, sensitive building sites and warehouses for the prevention of breakdowns and corrosion, detection of gas leaks and levels in manufacturing settings, chemical plant settings and in mines.

3.1.3 Smart Medical field:- Which includes assistance for elderly or disabled people living, tracking and monitoring of conditions in freezers that store antibiotics, vaccines and organic components, monitoring of patient conditions in hospitals and in the home of elderly people

3.1.4 Intelligent agriculture:- Involves monitoring of soil moisture and vineyard trunk diameter to regulate the amount of sugar in grapes and grapevine health, regulate of micro-climate conditions to improve fruit and vegetable production and quality, research of field weather conditions to predict changes in ice formation, rainfall, drought, snow or wind.

3.1.5 Smart Industrial Control:- Involves auto-diagnosis of the problem and control of the system, oxygen and toxic gas monitoring inside chemical plants to ensure protection for employees and products, temperature monitoring within the industry[24]

3.1.6 Smart Entertainment and Media:- transferring data from one location to another via the cloud, IoT offers good connectivity between individuals by transferring the media to each other[25]

3.1.7 Smart Legal System:- With IoT, the Smart Court system is made possible by introducing
advanced analytics, better facts, and streamlined procedures to court systems that boost strategies, remove immoderate procedures, handle corruption, minimize costs, and enhance pride[26]

4. Literature Review (discussion and comparison)

The below Table 1. shows the brief Literature Review including Author’s contribution and techniques they have used

| Sr. No | Authors                  | Contribution                                                                 | Techniques                                      |
|--------|--------------------------|------------------------------------------------------------------------------|-------------------------------------------------|
| 1.     | M.Jacem et al [6]        | Feature allows monitoring of the state of the cloud infrastructure of the patient sensor. | sensor cloud architecture                        |
| 2.     | A. Abatal et.al [7]      | The system will share the medical history of patients with specialists and doctors at anytime, anywhere. | Cloud platform from Amazon, Mobile application, Ionic system |
| 3.     | Q.Zou et.al[8]           | Huge remote sensing data analysis and rapid drought monitoring model for knowledge extraction | Cloud computing platform for high throughput, a web-based platform that uses XML |
| 4.     | I.Ari et.al[9]           | Pearson-Product Moment Correlation for analytics and stream mining algorithms for Apriori & FP Development | Esper                                           |
| 5.     | R. K. Dwivedi et.al[10]  | Wireless Sensor Network and Cloud integration                               | Virtualization, Cloud platform                  |
| 6.     | Mohammad et.al[4]        | Medical Sensors and Cloud Security Integration                              | Integration Medical Sensors, Cloud Network, Techniques for Data Mining, AES Algorithm |
| 7.     | Emeakaroha et.al[10]     | Standardized architecture for a data monitoring, collection, and processing framework for a cloud-based sensor and IoT system. | RabbitMQ protocol. Advanced Message Queuing Protocol OpenStack Sahara with Spark Thyme leaf HTML template engine |
| 8.     | R.Dinakar et.al[12]      | Managing heterogeneous sensor data in a real-time and distributed environment | Using machine learning algorithms, Big Data Map-Reduce, Cloud Platform |
| 9.     | C.Zhu et.al[13]          | integration of WSN and Cloud Computing                                       | WSN-MCC integration                              |
| 10.    | Singh et.al[14]          | A model for elderly people especially for Alzheimer patients.                | Body Sensor Network, Cloud platform              |
5. Components of IoT and Cloud Platform

**Sensors:** Different sensors are used for the diagnosis, monitoring and treatment of different diseases in Healthcare. Examples of sensors are given in Table 2. below [19][22][23]

Table 2. Sensors and Their Purpose.

| Sr.No | Sensor Name                        | Purpose                                                                                                                                 |
|-------|------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------|
| 1.    | Temperature Sensor                 | This sensor is used for calculating the temperature of the body.                                                                      |
| 2.    | Force sensors                      | used in kidney dialysis machines.                                                                                                |
| 3.    | Airflow sensors.                   | Its primary application is in anesthesia delivery systems.                                                                             |
| 4.    | Pressure sensors.                  | Mainly used in infusion pumps and sleep apnea devices.                                                                                 |
| 5.    | Implantable pacemaker              | To maintain an efficient cardiac rhythm, this sensor provides a coordinated rhythmic electrical signal to the heart muscle.          |
| 6.    | Oximeter                           | Measures the fraction of oxygen saturated with hemoglobin.                                                                               |
| 7.    | Glucometer                         | Estimated blood glucose concentration tests                                                                                              |
| 8.    | Electrocardiogram sensor           | Is used to measure the electrical activity of the heart.                                                                                 |
| 9.    | Heart rate sensor                  | Used to measure the number of heart contractions per minute.                                                                             |
| 10.   | Electroencephalogram sensor        | In order to calculate the electrical activity of the brain                                                                               |
| 11.   | Respiration rate sensor            | This counts how many times in a minute the chest rises                                                                               |
| 12.   | Proximity Sensors                  | A proximity sensor is a sensor of a non-contact type that recognizes an object’s presence.                                               |
| 13.   | Infrared Sensor (IR Sensor)        | Used for object detection                                                                                                               |
| 14.   | Ultrasonic Sensor                  | This is a device of the non-contact kind that can be used to measure the distance and velocity of an object                             |
| 15.   | Piezoelectric sensor               | To measure changes in friction, acceleration, temperature, strain of force, Piezoelectric sensor plates are used [23]               |
IoT Cloud Platforms:

For the collection, aggregation, processing and analysis of sensor data for prediction, various IoT platforms are available. The table 3. below shows the IoT Cloud Platforms Comparison [20]

Table 3. IoT Cloud Platforms and Their Features.

| Sr.No | IoT Cloud Platforms | Features |
|-------|---------------------|----------|
| 1.    | Salesforce IoT Cloud| IoT Cloud Deals with enormous data from computers, sensors, websites, clients, applications, and Cloud-connected partners. |
| 2.    | AWS IoT Core & Analytics| With the help of different industry-standard devices and sensors with support of protocols like HTTP, MQTT and Network Sockets protocols, for example. AWS IoT Analytics performs data preprocessing, such as cleaning and filtering of sensor data. |
| 3.    | Oracle IoT Asset Management Cloud| Asset Management Cloud offers information on asset health and usability in real-time, notifies and predicts asset failure. Oracle Stream Analytics is used to conduct computational manipulation on a continuous flux of massive data. |
| 4.    | Particle IoT| It manages a large amount of data and maintain safe device communication. This framework can be combined with any other platform that supports the REST API, such as Microsoft Azure, Google Cloud, and IoT. |
| 5.    | Predix| Is a platform for the production, implementation and maintenance of industrial machinery applications. This platform securely links devices, collects information, analyzes the information and provides users with feedback. |
| 6.    | SQL stream| SQLstream provides simple integration and analysis for Kafka, Kinesis, and other stream users and analyses data in real-time. It provides continuous ML in real-time. |
| 7.    | Ubidots| Ubidots IoT platform provides tools for data collection, analysis, and visualization. This framework supports a system that allows Microsoft Azure-compatible REST APIs. |
| 8.    | Azure Stream Analytics| Is a Microsoft product offering real-time device data analytics and real-time analytical intelligence. Analytics from Azure processes data from sensors and devices show and display data. With the assistance of Power Business Intelligence, |
| 9.    | Ayla Insights| This framework for IoT is an Ayla Network product. It is used to incorporate business intelligence and analytics |
| 10.   | Watson IOT Platform| The key strength of the platform is cognitive computing, which gives its users deep insights into their data. This enables users to receive data safely from Cloud-connected devices and sensors. |
| 11.   | Cisco IoT Cloud| This is a Cisco-owned network. The Cisco cloud platform focuses primarily on development, Power, transport, smart cities, government, for business |


purposes, and healthcare. The Cisco cloud collects raw sensor data, stores it on the cloud, and conducts complicated data analytics.

12. Google Cloud IoT

In order to collect data from smartphones, Google uses Cloud IoT Center. This information will be processed on the Cloud Pub/Sub. BigQuery from Google enables fast queries and insights. Cloud machine learning engines are used to run advanced analytics as well as machine learning algorithms. Google Data Studio publishes the results on its rich dashboard. This platform provides better Android performance, and it also supports Intel and Microchip devices.

13. Autodesk Fusion Connect

Connects is an Autodesk IoT solution. Enterprise business is the primary target.

14. SAP Analytics Cloud

SAP HANA uses in-memory technology. To make forecasts and future developments, it incorporates machine learning.

It is clear from above table that every IoT cloud platform can be used by users according to their needs.

6. Advantages of IoT and Cloud computing Integration

The combination of cloud and IoT systems has various advantages. Several advantages are described as follows.

6.1 Analysis—Vast volumes of unstructured sensor data are collected on the cloud platform and aggregated sensor networks are collected via the prototype of cloud computing. This integration offers the study of this knowledge.

6.2 Scalability—The organization uses any additional cloud merchant services with no expense if it needs to increase resources. This is called the scalability of a cloud of sensors.

6.3 Visualization—The cloud infrastructure of the sensor offers a forum for creativity to collect and retrieve sensor data from various sources.

6.4 The Collaboration—Sensor cloud enables many categories of retailers to exchange sensor data, thus uniting several physical sensor networks.

6.5 Improving data storage and processing—Allocating data storage and unnecessary processing facilities and also offering an application to handle a vast volume of data.

6.6 Dynamic Service Processing—Sensor clouds access their data from anywhere, anywhere, anytime they like to access sensor data.

6.7 Flexibility—It allows the user the extensibility of the previous computing method. It helps us to store and share sensor data in an environment for versatile use.

6.8 Fast response time—Wireless sensor network (WSN) concatenation and cloud computing provide the user with a rapid response time. Therefore, it is considered an application in real-time.

6.9 Automation—Automation plays a significant role in cloud computing for sensors. It also increases the transmission time for essential modifications.
6.10 Multitenancy-It is a feature that distributes services to many users and shares cloud resources for sensors. It also enables sensor data access to be available anywhere and everywhere.[9]

7. Proposed Future work

In the future, we have planned a proposed model focused on IoT, Cloud Computing and Healthcare domain integration. We have planned to build a system for patient monitoring suffering from different diseases in this model using biosensors for data generation and capture, Raspberry Pi microcontroller for data processing and Thingspeak cloud for analysis and visualization and sending alert messages to healthcare providers via mobile apps.

8. Conclusion

The summary of the integration of IoT, Cloud Computing and its implementations is discussed in this paper. In healthcare, specifically. With the help of virtualization and the cloud, users can use the sensors of various wireless sensor networks for different applications. Virtualization makes it easier to build virtual sensor networks from different physical sensors that allow the cloud to provide its end users with sensor-as-a-service. This integration helps to maximize the utility of the sensor networks as well as the cloud, it concludes. The Sensor Cloud is very useful for real-time monitoring in the healthcare domain and enables improved medical services for users. This integration is, therefore, the need of the century. The key future guidelines of this technology are the use of different IoT cloud platforms and medical sensors for energy efficiency, protection, QoS, user-friendliness, real-time updates, data processing, and visuals or alerts.

9. The References

[1] Chacko V and Bharati V 2017 *IEEE International Conference on IoT (iThings) and IEEE GreenCom and IEEE CPSCom and IEEE SmartData*. pp. 906–909
[2] Vincent A, Gupta A, LiRShaw C and Akhya1ni S 2019 *Proceedings of the 13th EAI International Conference on Pervasive Computing Technologies for Healthcare - PervasiveHealth’19* Trento Italy pp. 320–326
[3] Fortino G, Pathan M and Di Fatta G 2012 *4th IEEE International Conference on Cloud Computing Technology and Science Proceedings* Taipei Taiwan pp 851–856
[4] Jassas M S, Qasem A and Mahmoud O H 2015 *IEEE 28th Canadian Conference on Electrical and Computer Engineering (CCECE)*, Halifax NS Canada pp 712–716
[5] Dwivedi R K, Singh S and Kumar R 2019 *9th International Conference on Cloud Computing, Data Science & Engineering (Confluence)* Noida India pp 114–119
[6] Guezguez M J, Rekhis S and Boudriga N 2016 *31st Annual ACM Symposium on Applied Computing - SAC ’16* Pisa Italy pp. 612–617
[7] Abatal A, Khallouki H and Bahaj M 2018 *the International Conference LOPAL* Rabat Morocco pp 1–5
[8] Zou Quan 2017 *IEEE International Conference (ICCCBDA)*, Chengdu , China pp. 29–33
[9] Ari I, Olmezogullari E and Celebi O F 2012 *IEEE International Conference on Cloud Computing Technology and Science* Taipei Taiwan, pp. 857–862
[10] Emeakaroha V C, Cafferkey N, Healy P and Morrison J P 2015 *3rd International Conference on Future Internet of Things and Cloud*, Rome, Italy, pp. 50–57
[11] Maria A R, Sever P and Carlos V 2015 Conference Grid Cloud & High-Performance Computing in Science (ROLCG), Cluj-Napoca, Romania pp. 1–4

[12] Dinakar J R and Vagdevi S Dec 2017 Int. Conference on Electrical, Electronics, Communication, Computer, and Optimization Techniques (ICEECCOT), Mysuru , pp. 342–345

[13] Zhu Chunsheng, LiXiJi Hong and Victor. M. Leung 2015 IEEE 7th Int. Conference on Cloud Computing Technology and Science

[14] Singh R ,Gaonkar M V, Sharma S, Grover P and Khatri A 2019 IEEE international conference on machine learning, Big Data, cloud and parallel computing, India

[15] Chen S, Xu HuihanzhiLiu D , Hu B and Wang H 2014 IEEE INTERNET OF THINGS JOURNAL, VOL. 1, NO. 4, AST 2014

[16] Shenoy J and Pingle Y 2016 INDIACom Int. Conference on "Computing for Sustainable Global Development ,New Delhi, INDIA

[17] Pingle Y, Chaudhari S R, Dalvi S N and Bhatkar P 2016 INDIACom International Conference on "Computing for Sustainable Global Development" New Delhi , INDIA

[18] Banka S, Madan I and Saranya S S 2018 Int. Journal of Applied Engineering Research ISSN 0973-4562 Volume 13, Number 15 (2018) pp. 11984-11989

[19] https://www.rfwireless-world.com/Articles/Medical-sensor-basics-and-medical-sensor-types.html

[20] Olaolu Akinnawonu-July 3, 2018https://www.loginworks.com/blogs/best-tools-for-iot-data-processing/

[21] https://www.researchgate.net/profile/Kostas_Psannis/publication/311065854/figure/fig3/A S:576491348033536@1514457656687/IoT-Cloud-Computing-integration.png

[22] https://www.electronicshub.org/different-types-sensors

[23] https://en.wikipedia.org/wiki/Piezoelectric_sensor

[24] Sharma V and Tiwari R 2016 International Journal of Science Engineering and Technology Research (IJSETR) Volume 5 Issue 2 pp 472-476

[25] Reddy M T and Mohan R K 2017 International Journal of Trend in Research and Development (IJTRD) pp 86-87

[26] Dawood M S, Margaret J and Devika R 2018 International Journal of Advanced Research in Computer Engineering & Technology (IJARCET) Volume 7 Issue 12 pp 841-845