A Multi-Layer Sensing as a Service Model Based on Internet of Things for Smart-Healthcare Applications

Ali Abdul-Jabbar Mohammed, M. A. Burhanuddin, Adel Abdul-Jabbar Alkhazraji, Ali Abdul-Hussian Hassan, Halizah Basiron

Abstract--- Smart healthcare services have been known for requiring huge concentricity of information resources and establishments. However, unprecedented attraction of offering new technologies has now become an overwhelming resource management issue for healthcare service providers. The tremendous demands toward effective smart healthcare administration seems to have prompted to develop various ICT technologies in finding advantageous solutions to positively solve the increasing problems. The Internet of Things (IoT) even offers considerable interest to deliver an efficient resource management in Smart healthcare services. Such tremendous smart IoT health devices that linked to the internet could very well provide various types of service solutions and generate a big amount of data and information. However, most applications that may have interaction with smart IoT health devices just like sensors come with particular requirements to allow real time processing for different data types. In this paper, we introduce a multi-layer Sensing as a Service model as well as, clarifying how it end up being addressed by the concept of IoT. Our target is definitely to investigate the IoT technologies towards the delivery of Sensing as a Service with regard to the technical perspective and recognize the key available problems. We also illustrate the proposed multi-layer sensing as a service model byemploying the scenario of smart healthcare application. Finally, discussion has been delivered for providing the major advantages and benefits of our proposed model.

Index terms---Sensing As A Service,Sensors Management, E-Health Gateways, Internet Of Things (Iot), Smart Healthcare.

I. INTRODUCTION

Smart healthcare is originated to solve the problems in the modern healthcare services and applications. As a result of the abundant in availableservices and applications towards smart healthcare, managing and monitoring the sensing data streamshave become a significant challenge to both the patients and to the healthcare service providers[1].Thus, the Internet of Things (IoT) has been presented to incorporate massive amounts of health devices and sensors which usually have the ability to sense, compute, communicate as well as , perhaps actuate with their unique virtual representations in the web-based configuration[2][3].Likewise, the cloud computing is also presented as being an approach intended for on-demand access to a shared pool among different configurable data and information resources (e.g. software, services, applications, storage, networks, and servers) which usually store, manage, and process data[4], [5].Due to the advancement inmany technology areas such as; smart sensors and devices, cloudcomputing,andthe latest communication capabilities, the growth of Sensing as a Service deployments has been increased recently in many smart applications. As shown in Figure 1 below, IoT and cloud computing are actually shifting toward one another and effectively interacting to perform a common goal for the purpose of delivering Sensing as a Service. It is believed the fact that the sensing as a service execution is located in the middle of these two concepts complete with various technological and industry models. By the definition of smart healthcare, it is primarily driven by technological advances, application requirements, and user needs. In contrast, the smart healthcare is believed to deal with these types of difficulties in efficient and effective manner by using the information and communication technologies (ICT).

Data streams that received from IoT health devices and sensors will certainly challenge the typical and traditional methods for data administration and management in order to really contribute for the promising paradigm of smart healthcare. This is required more developments in the intelligence of the solutions that may utilize the huge quantity of data produced by way of the IoT health networks[2][7]and then process this kind of data into valuable information to allow real-time decision making .

Nevertheless, at this point, limited support has recently been delivered for the advancement of automated environmental monitoring system and modeling approaches[8][9]. Particularly, the environmental dynamism causes it to be complicated to deliver computational resources that will be enough to handle and manage the changing environmental circumstances. Figure 1 describes the technologies which usually evolved just like IoT, wireless sensor networking and cloud computing that may complete one another in a wide range of smart applications.

Revised Manuscript Received on December 22, 2018.

Ali Abdul-Jabbar Mohammed, M. A. Burhanuddin,Adel Abdul-Jabbar Alkhazraji,Ali Abdul-Hussian Hassan,Halizah Basiron

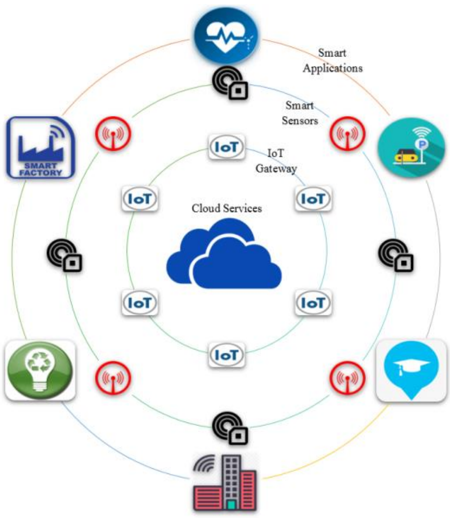

Figure 1. Evolving technologies for delivering Sensing as a Service concept

The Sensing as a Serviceconception brings new data gathering opportunities by a shared configurable sensing resources (e.g., medical sensors) that can be easily monitoring patients to offer real-time processed and analyzed data. Sensing as a Service can provide a meditative platform that aggregates the information resources to get maximum productive resource employment and delivery service by way of either on-demand or perhaps by way of data stream[10], [11]. Accordingly, it will allow the system software program for being configured as desired for the purpose of providing optimized monitoring environment by analyzing data based on the individual application requirements, even while preserving energy levels and minimizing the functional costs. Even so, come across varied issues of Sensing as a Service on demand just like the overall performance and as well , collaborative work environments[11]–[13].

In the health sensing streams, patients monitoring and related analytics can make a very large digital personal information associated with patients[14], once analyzed results in typical insights in the environmental And also genetic causes of the medical conditions, which usually leads to positively improvement in the medical diagnosis solutions. The effective mining of the obtained data can help the monitoring simulators to actually estimate any impact of the environmental and genetic causes on the patients. The real-time processing and analyzing of sensor data in such environments results the necessity of special requirements[15], [16], [17]. The investigation of the IoT technologies towards the delivery of Sensing as a Service is needed as a promising and cost-effective choice which can connect, track and manage the IoT health sensors.

The remainder of this paper is certainly organized as the following sections: In Section 2, the proposed multi-layer Sensing as a Service model which based on the concept of IoT is presented and we briefly review each layer in proposed model. Consequently, we clarify a case for the multi-layer Sensing as a Service model with the help of using a cutting-edge scenario of the smart healthcare in Section 3. In this section, we discuss the using of smart healthcare case scenario that can highlight a variety of aspects for delivering Sensing as a Service model by the proposed model. Afterwards, in the Section 4, we point out and make a discussing intended for the main available challenges and issues that associated with the IoT and Sensing as a Service. These open challenges and issues are actually outlined within three essential category groups, which are: technological advances, application requirements, and user needs. Finally, we tend to present the concluding statements in Section 5.

II. THE PROPOSED MULTI-LAYERSENSING AS A SERVICE MODEL

In this section, we are introducing a multi-layer model for delivering Sensing as a Service as a best approach predicated to do with IoT applications. This gets the capacity to deal with the difficulties found in smart healthcare applications. Due to obtaining more than 50 billion objects joined the web by way of 2020 [16], it is going to likely be a great number of sensors available which can be used. To this day, a great number of day-to-day items happen to be embedded complete with the sensors even though the usage is fixed to the things by themselves. As depicted in Figure 2, the IoT model for delivering Sensing as a Service includes four primary layers: 1) sensors communication layer, 2) sensor management layer, 3) local IoT gateway layer, and finally 4) service integration layer. Therefore, we describe the multi-layer Sensing as a Service model with regard to a common conceptual style. Over the following Section, we will show the scenario of smart healthcare applications based on the proposed model. The situation of the conceptual model can provide a practical understanding in smart healthcare applications.

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

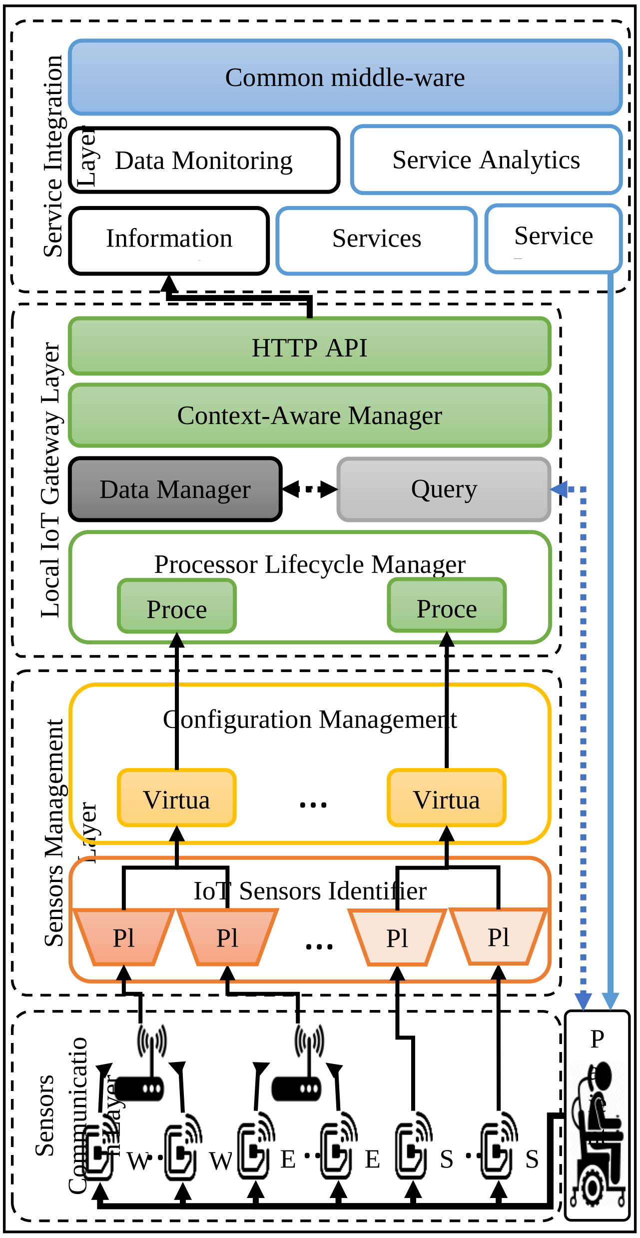

Figure 2. The Multi-layer Model for delivering Sensing as a Service based on IoT

A. *Sensors Communication Layer:*

This layer involves of the health-related sensors and its communications. A sensor is an object that detector measures a physical event for example blood glucose sensors, blood oxygen sensors, ECG sensors, etc. [18]. Numerous sensors can be distributed separately orinvolvedinside the smart device[19]. For example, the patient monitoring system may have sensors(e.g. Wearable Sensors (WS),Environmental Detection Sensors (EDS), Smart Device Sensors (SDS), etc.) that can be used to detect several events. This kind of information can be utilized to comprehend user behavior and user preferences more accurately. Today, vast types of different sensors are around for health monitoring. These can handle calculating in an extensive selection of personal healthcare and human-activity monitoring [20]. Above and beyond the sensor management communications, the sensors have the connectionof a specific sensors with the IoT gateway at a given time.Further, they are capable to send health monitoring data to the cloud and service providers.At the same time of sensing data, related context information also offers a significant value [13], [21].

The local IoT gateway effect the final decision on whether to transmit the data tothe cloud or not. However, an individual sensor only transmits data to the sensor management via a single sensor port (to conserve energy). Data will end up being shared within the local IoT gateway if required, based on consumer requirements. Despite the fact that all sensor classes perform the identical job (i.e. sensordistribution anddeployment), the making decisions process could be very diverse specifically in term of approval processes, personal privacy and policy concerns.

B. Sensor Management Layer:

The sensors management layer involves of the IoT sensors identifier sand sensors configuration management, which are termed in this paper as sensor managers. In this layer of our proposed model, a plugin based IoT sensors identifiers are presented to allow collecting and processing the sensors data without programming efforts. The plugging can be installed separately by the sensor owners to extend the capability of sensors management in an IoT manner. Moreover, the plug-in based IoT sensor identifiers supports distributed and scalable sensing, which can handle multiple user requests at the same time. Further more, the IoT sensor identifiers are connected to virtual sensors, which are the key element in the sensor's management layer. The virtual sensor may represent any type of data extractor, such as; health sensors, cell phone, linked camera, or any combination of virtual sensors. In most cases, one of the virtual sensors can easily possess multiple source data channels but then however, have actually just one single output data stream, which is the output of the sensor's management layer in our proposed model.

The primary responsibility of the sensor management layer is to identify the available and existing sensors, communicating and get permission from the sensor owners for publishing the sensors data. Sensor managers are individual business entities. Whenever a sensor owner registers a particular sensor, the service agency gathers information regarding the sensor availability, owner personal preferences and expected return, etc. All of this information must be released in the cloud. After the registration is performed, the service agency waits until a sensor end user makes a request. Once the service agency receives such a request, it transfers every detail including the offer to the related sensor owner(s) to simply accept or reject.

C. Local IoT Gateway Layer

Along with allocating and distributing the monitoring sensors for data streaming, the IoT gateway allows for the structure concerning high-level strategies to symbolize the exact property of the ecosystem and also to support level of privacy insurance.

Therefore, smart services, made up of reasoning guidelines or perhaps event triggers, could be sufficiently flexible that will help the healthcare practical application. The local IoT gateway layer can be a solution that may fill the semantic gaps in between the raw sensor data and the

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

information content which can be interested bythe service providers and high-level applications. It can be a universal interface between the sensors and Internet. The design of local IoT gateway is based on four basic principles: scalability, adaptively, light-weight implementation, and simplicity. The local IoT gateway layer can filter the sensors data streams based on users defined queries. Specifically, it delivers the ability to query, discover, filter, combine, and integrate sensor data over a declarative XML-based language and empowers sensor distribution and administration control. This is can be done with the help of IoT processing engine that include a context-aware data processor, as described in the following paragraphs.

The data manager is normally in control with the processing involved with the raw data which can be gathered by specific or maybe compound of sensors which usually distributed in targeted instance of an practical application ecosystem. Every sensor (for example, virtual sensor or source sensor) has got its definitely attached information structure and as well, there is always a slot intended for every different data collection command (for example, get status) established by the sensor. Thus, once any kind of new data confirmed via the data manager, they will be prepared for further context analysis.

The context manager can play major task in the entire operation concerning the local IoT gateway layer. The aim of the context manager is undoubtedly to sustain semantics information about environmental surroundings handled by way of the IoT gateway. This level of detail can be represented with regards to ontology and simply can be used successfully to solve any kind of recommendations to a particular query predicated on the sensor's properties just like effectiveness, destination, and the way in which they affected by environmental surroundings. The context manager is influenced by two modules. Firstly, the activity-aware module that's with the capacity of recognizing many detectable actions, such as moving, cycling, walking, running, not really moving, falling, and etc. For that reason, clients have the ability to incorporate these types of actions to produce various kinds of queries. Secondly, the location-aware module that is capable of recognizing when the sensors or user move into a specific location. These kinds of places are characterized by using latitude, longitude. Location-awareness may similarly be merged with several other sensing parameters.

D. Service Integration Layer:

The service integration layer consists of an extended cloud platform that aimed for delivering adaptable middleware to deal with the difficulties of the integrating collected sensor data, distributed query processing, and the service provided. It really is a general data stream processing generator. The service integration layer helps simplify the task of linking heterogeneous sensor solutions to different service applications. This important layer can be viewed as the utmost smart amongst all of the four layers which usually add the intelligence to positively the whole sensing as a service model. The integration provided by the service providers can be diverse and very depends from one service provider to another. To achieve the integration among different service providers, they have to provide value added services to the sensor service users [22]. Nevertheless, each service provider has got access (only) to sensors which can be authorized by it. Whenever a sensor data customer requires sensor data coming from perhaps many sensors when every single sensor has got licensed due to completely different service providers, the integration of providers can be utilized to obtain data easily.

The service integration middle-ware intercommunicates with diverse service providers with regards to different sensor data acquirement with respect to the sensor data owners. One of the valuable services is usually determining different sensor data based upon user's requirements[23]. Customers and prospects provide their expectations by high-level queries rather than selecting the sensors by them self. In return for this, the service integration and utilization middle-ware is going to select the appropriate sensors and then the suitable service provider. Each of the sensor data end users will have to sign-up themselves and acquire an accessible digital certificate by the authority to be able to use the sensors data. The users of sensor data that have not as much technological skills and experience may gain necessary sensor data by using the services integrating middle-ware wherever the majority of difficult duties just like merging sensor data coming from multi-sensor managers and choosing suitable sensors depending on the user criteria are actually addressed.

III. SCENARIO FOR DELIVERING SAAS IN SMART HEALTHCARE APPLICATIONS

In this section a scenario can be used to explain the multi-layer model for delivering Sensing as a Service based on IoT infrastructure. The scenario demonstrated in the following Figure 3 is based on Smart Healthcare domain which also plays a significant role in the IoT applications. In the scenario, the patient is the sensor owner. Therefore, he and his sensors represent the sensors communication layer. The hospitals and the medical service providers represent the service integration layer. The sensor management layer enables the communication and transactions between the patient and the medical service providers. The medical service providers retrieve the data from local IoT gateway layerdirectly and conduct the data analysis. The medical service providers collect the data and information via handling all the transaction and agreements with the sensor owners.

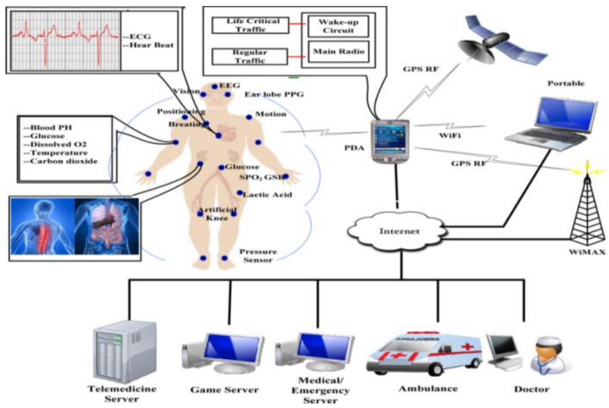

Figure 3. A Smart Healthcare scenario that explains the interactions in sensing as a service [24].

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

Smart healthcare is among the most challenging problems which usually ultra-modern smart cities suffer from. The smart healthcare includes several procedures which include gathering, transfer, controlling, processing, and monitoring patient's data and resources. These kinds of processes expenses heavy amount of cash, precious time, and labor. Enhancing smart healthcare managing procedures make it possible for saving expenses which usually can be utilized to handle a variety of other problems that may smart healthcare will have to work with. Towards today's smart health care, there are many parties who are considering patient's data as well as, resources administration (such as private treatment centers, hospitals, and health care respective authorities. Rather than deploying sensors and collecting data independent of each other, the sensing as a service model makes it possible for all of the interested communities to share the system and then bare applicable costs together. The most crucial element of this kind of a collaboration may be the cost elimination that each grouping have to dedicate actually. All of the interested groups could very well access and so practice the sensor data instantly to be able to accomplish their individual target. The cost is dependent on the information necessity belonging to the interest party.

IV. DISCUSSION

In this section, a discussion has been delivered on the major advantages and benefits of the proposed multi-layer model for delivering Sensing as a Service, which are summarized in the following below:

• Built-in cloud computing: the structure can be modeled in and around cloud computing. For that reason, it inherits all of the features of the essential cloud computing versions such as for example PaaS, IaaS, and SaaS. Scalable and highly available processing and storage space resources can be found to assist in sensing as a service application system.

• Participatory sensing: The overall workload can be distributed within many various layers in the model design. This allows fast deployment of sensors throughout more varied geographical places that capture different phenomena.

• Sharing and reusing: In ordinary solutions, each group or individual who would like to gather sensor data must go to the field of operation and release the sensors manually independently. Furthermore, there is absolutely no standard strategy to share sensor data gathered by one party with others. Sensing as a service is definitely a model which usually stimulates by idea of sharing. The purpose of IoT is to permit different devices to intercommunicate with one another. Generally, such an objective pushes next generation gadget to end up being embedded with wealthy sensing and communication features. As a result, the determination is made available to the suppliers likely by the perspective of IoT.

• Decrease of data acquisition cost: Because of the shared and collaborative character, data acquisition cost will probably be reduced considerably. This kind of a sustainable business design stimulates a growing number of sensor deployments. More deeply, technological advancements and higher needs allow to provide sensors in mass volumes by using low-cost components with reducing the value per unit. Furthermore, this can help to gather data coming from sensors that was not possible previously.

• Gather data recently not available: This model enables to gather sensor data which in turn is usually extremely hard to gather by using traditional non-collaborative strategies. This business design encourages and stimulates the sensor deployments by businesses at industrial level. In the multi-layer Sensing as a Service model, all of the data is direct from the sensor without end user intervention. This also really helps to eliminate the expense of data acquisition. For the reasons of privacy worries, it is very necessary to anonymize all the sensor data gathered.

• Innovations: For the reasons to decrease sensor data acquisition cost, much bigger percentage of interest communities can admission to these products. Additionally, the accessibility to sensor data that was not obtainable previously may also considerably stimulate innovation.

• Applications: Easy to access sensor data enables authorities, academia, research organizations, and businesses to handle different challenges towards Smart Cities, for example energy source, education, and health and wellbeing. For instance, accurate data on energy source usage with regard to smart city allows managing electrical grids effectively by analyzing and simply predicting energy usage behaviors, future tendencies, and needs.

• Real-time data intended for making decisions and policy planning: This kind of model allows getting involved in collecting sensor data in real-time, coming from a number of numerous domains, which usually creates an opportunity for the decision-making procedures. This kind of data is costly to collect and mostly not available for making decisions when it comes to traditional sensor implementing conditions.

One example, data gathered coming from sensors integrated in vehicles and roads permit the respective authorities to actually monitor and control targeted traffic when it comes to real-time. Additionally, sensor data gathered over a time period (archived) can be utilized to create policy decisions. For instance, traffic data over an interval on a particular city can certainly help a stateauthority make statement ideal decisions such as for example whether to get on a bus services almost everywhere in the city or not even.

• Level of privacy preservation: the following model delivers extensive control of the level of privacy most typically associated with sensor owners within their own side. The last decision concerning whether to publish most of their sensors or not is considered by way of the sensor owners. This will allow the sensor owners to manage and as well, secure their particular level of privacy. Besides that, the sensing as a service model is required to be protected via anonymization approaches. To be able to secure the level of privacy within the users, the anonymization approaches cope with the sensor owner, sensor customer and the sensor supplier. For that reason, data retrieves coming from sensors ought to be explicitly anonymized. This may protect against insider attackers which have more

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

privileged permission to access the sensors data when compared to outsider attackers [25].It is necessary to build up new security measures and algorithms which may anonymize and hide sensitive data and information (such as for example exact destination).

V. CONCLUSION

This paper presents an extensive summary of a multi-layer model for delivering Sensing as a Service and its particular applicability on the way to smart healthcare application due to the Internet of Things paradigm. We outlined the entire model with three distinctive perspectives which includes technological advances, application requirements, and user needs. Furthermore, A discussion is provided for how the way the sensing as a service could be a scalable, sustainable, and effective model. The sensing as a service model facilitates utilizing the information resources effectively which means that very little useful resource can be utilized to support many individuals. Additionally, this also produces a win for everybody circumstance for almost any parties involved. We recognized a considerable number of critical open problems and challenges that have to be resolved to be able to realize the vision of sensing as a service. Finally, this model will generate an unprecedented amount of possibilities to develop effective valuable possibilities which enables the making decisions practice reliable and practical when it comes to the IoT practice.

Acknowledgement

The authors would like to thank the Universiti Teknikal Malaysia Melaka, UTeM Zamalah Scheme for providing the facilities to conduct this research project and the Centre for Research and Innovation Management (CRIM) for the financial support in this project.

REFERENCES

1. W. Raghupathi and V. Raghupathi, "Big data analytics in healthcare: promise and potential," *Heal. Inf. Sci. Syst.*, 2014.
2. M. Hassanalieragh *et al.*, "Health Monitoring and Management Using Internet-of-Things (IoT) Sensing with Cloud-Based Processing: Opportunities and Challenges," in *Proceedings - 2015 IEEE International Conference on Services Computing, SCC 2015*, 2015.
3. S. T. Hasson and R. Y. Al-asadi, "Modeling the Patients Flow Behavior in Hilla Emergency Departments," *Int. J. Eng. Technol.*, vol. 1.5, no. 8, pp. 385–391, 2019.
4. B. B. P. Rao, P. Saluia, N. Sharma, A. Mittal, and S. V. Sharma, "Cloud computing for Internet of Things & sensing based applications," in *Proceedings of the International Conference on Sensing Technology, ICST*, 2012.
5. B. P. Rimal, E. Choi, and I. Lumb, "A taxonomy and survey of cloud computing systems," in *NCM 2009 - 5th International Joint Conference on INC, IMS, and IDC*, 2009.
6. R. S. H. Istepanian, S. Hu, N. Y. Philip, and A. Sungoor, "The potential of Internet of m-health Things m-IoT for non-invasive glucose level sensing," in *Proceedings of the Annual International Conference of the IEEE Engineering in Medicine and Biology Society, EMBS*, 2011, pp. 5264–5266.
7. M. S. Talib, A. Hassan, B. Hussin, Z. S. Talib, Z. Sabah, and M. Sammour, "Data Dissemination Based Clustering Techniques for VANETS : A Review," *Jour Adv Res. Dyn. Control Syst.*, vol. 10, no. 04, pp. 596–604, 2018.
8. A. El bekkali, M. Boulmalf, M. Essaaidi, and G. Mezzour, "Securing the Internet of Things (IoT)," in *Computing Community Consortium CCC*, 2019, pp. 1–6.
9. M. H. Albowarab, N. A. Zakaria, and Z. Z. Abidin, "Software Defined Network : Architecture and Programming Language Survey," *Int. J. Pure Appl. Math.*, vol. 119, no. 18, pp. 561–572, 2018.
10. S. Abdelwahab, B. Hamdaoui, M. Guizani, and T. Znati, "Cloud of Things for Sensing-As-A-Service: Architecture, Algorithms, and Use Case," *IEEE Internet Things J.*, 2016.
11. X. Sheng, J. Tang, X. Xiao, and G. Xue, "Sensing as a service: Challenges, solutions and future directions," *IEEE Sens. J.*, 2013.
12. B. Kantarci and H. T. Mouftah, "Sensing services in cloud-centric Internet of Things: A survey, taxonomy and challenges," in *2015 IEEE International Conference on Communication Workshop, ICCW 2015*, 2015, pp. 1865–1870.
13. C. Perera, A. Zaslavsky, P. Christen, and D. Georgakopoulos, "Sensing as a service model for smart cities supported by Internet of Things," *Trans. Emerg. Telecommun. Technol.*, 2014.
14. M. Srivathsan and A. K. Yogesh, "Health monitoring system by prognotive computing using big data analytics," in *Procedia Computer Science*, 2015.
15. P. Kakria, N. K. Tripathi, and P. Kitipawang, "A real-time health monitoring system for remote cardiac patients using smartphone and wearable sensors," *Int. J. Telemed. Appl.*, 2015.
16. A. A. Hassan, W. Shah, M. Iskandar, M. S. Talib, and A. A.-J. Mohammed, "K Nearest Neighbor Joins and Mapreduce Process Enforcement for the Cluster of Data Sets in Bigdata," *Jour Adv Res. Dyn. Control Syst.*, vol. 10, no. 04, pp. 690–696, 2018.
17. A. A. H. Hassan, W. M. Shah, M. F. Iskandar, M. N. Al-Mhiqani, and Z. K. Naseer, "Unequal clustering routing algorithms in wireless sensor networks: A comparative study," *J. Adv. Res. Dyn. Control Syst.*, vol. 10, no. 2 Special Issue, pp. 2142–2156, 2018.
18. P. Y. Chen, S. Yang, and J. A. McCann, "Distributed real-time anomaly detection in networked industrial sensing systems," *IEEE Trans. Ind. Electron.*, 2015.
19. M. Faeq Ali, N. Haryati Harum, and N. Azman Abu, "An Intelligent Radio Access Technology Selection For Vehicular Communications," 2017.
20. T. Q. Trung and N. E. Lee, "Flexible and Stretchable Physical Sensor Integrated Platforms for Wearable Human-Activity Monitoringand Personal Healthcare," *Adv. Mater.*, vol. 28, no. 22, pp. 4338–4372, 2016.
21. C. Perera, D. S. Talagala, C. H. Liu, and J. C. Estrella, "Energy-efficient location and activity-aware on-demand mobile distributed sensing platform for sensing as a service in iot clouds," *IEEE Trans. Comput. Soc. Syst.*, vol. 2, no. 4, pp. 171–181, 2015.
22. [J. Grenha Teixeira, L. Patrício, K. H. Huang, R. P. Fisk, L. Nóbrega, and L. Constantine, "The MINDS Method: Integrating Management and Interaction Design Perspectives for Service Design," *J. Serv. Res.*, 2017.
23. S. H. Chuang and H. N. Lin, "Performance implications of information-value offering in e-service systems: Examining the resource-based perspective and innovation strategy," *J. Strateg. Inf. Syst.*, 2017.
24. N. Ullah, P. Khan, and K. S. Kwak, "A very low power MAC (VLPM) protocol for wireless body area networks," *Sensors*, vol. 11, no. 4, pp. 3717–3737, 2011.
25. M. N. Al Mhiqani *et al.*, "A new taxonomy of insider threats: an initial step in understanding authorised attack," *Int. J. Inf. Syst. Manag.*, vol. 1, no. 4, p. 343, 2018.