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Technical Constraints in the IoT, Enabling Technologies and Solutions

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Abstract: Presently, the Internet is being used by around 2 billion individuals around the globe and they utilize it for searching, sending and getting messages, getting to media contents and administrations, playing games and numerous different things. The Internet of Things is an innovative model and a new technology that targets connecting the gap between the physical world and its illustration inside the digital world. The concept behind the internet of things idea is to assimilate the state of the things that form the world into software applications, to provide benefits and ease from the world's context information. In this article, the study of innovations applications and two major technical constraints for the Internet of Things have been addressed. The issues in the field of Wireless Sensor Networks (WSNs) and Radio Frequency Identification (RFID) and IoT Technologies have been compared.

Keywords: IoT, Challenges, Development, Constraints, WSN, RFID,

1. Introduction

Internet of Things (IoT) involves various viewpoints identified with the allowance of the web and internet [1]. IoT depends on this vision by method for which different devices can be interconnected with each other [2]. IoT predicts future in which physical elements and the computerized gadgets can be connected and coordinate with each other. The last few years have seen a tremendous increase in the number of hands held devices and the other technologies stay on the rise promising more powerful and compact devices. The early years of this century witnessed the replacement of traditional desktop machines by notebook computers which themselves are being replaced by handheld mobile devices and so on. Wireless network field is fast emerging and the universal existence around us consists of a variety of objects, things like sensors, smartphones, etc. [3]. IoT provides us a platform to interact with each other with their unique addressing schemes and cooperate to achieve the mutual objective as illustrated in Figure 1. This phenomenon is known as IoT, Interconnection of the internet with the physical devices makes possible to take control of the gadgets which are around us and the information will be gathered from different resources [4]. IoT Concept IoT future can be seen as numerous physical devices where objects can be interlinked. The IoT technology is developing very rapidly and many applications have been

constructed recently. But there are still many challenges and issues are in the fields or other areas of IoT including Wireless sensor networks (WSN's), Radio-frequency identification (RFID), data processing, and security [5].

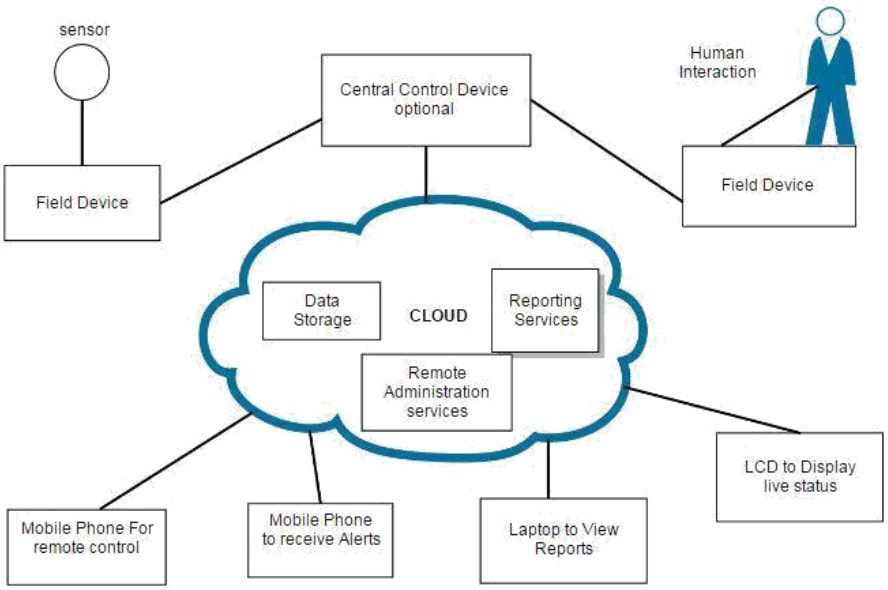

Figure 1. IoT Concept

This article studies and identifies technical constraints for IoT, new technologies which utilized and more important. Internet Engineering Task Force (IETF) are developed in various protocols and open standards to achieve the IoT concept by using wireless resource networks [6]. However, complex features and deployment of such systems have many challenges remain and need to be addressed. Therefore, it is very important to study the changes can be made and how the improvements can be made in this area to contribute to the IoT field [7]. Furthermore, database management is also a major challenge in the IoT. When we talk about database issues and challenges we consider the areas of querying, indexing, processing and modeling [8]. The IoT provides the smoothness to the internet by interconnecting each and every object through embedded systems and leads to a high and powerful distributed network system. Thanks to rapid advances in core technologies, IoT provides opportunities for a large variety of applications and provide ease to human beings [9]. This paper main objectives are as follows:

- To address the concept and advancements in IoT.
- To address the technical constraints of IoT.

The paper is organized as follows: Section 2 briefly discusses the related work of IoT, vision and concept, IoT new trend challenges, the current state of IoT, storage, and development. Section 3 discusses the technical constraints of IoT. In section 4, a summary of network technologies discuss. At the end of the paper discussion and open issues presents. The last section concludes the paper with future direction.

2. Related Work

2.1 Vision and Concept

In the last few years, people have witnessed the hardware trend, but with the passage of time hardware became much smaller and cheaper than previous and also powerful in performance. With the vision and perspective of IoT, most of the devices soon interact with each other and it will be more powerful and most importantly it will interact with the environment to provide an ease to the people. It facilitates and overcome the minimal service overhead and registration efforts [10]. Basic idea behind the concept of IoT is to transferring everyday real objects into smaller objects that can interact and understand the environment. Some points are more important to discuss that how the functionality of all objects and their balance link with each other and how it relates with infrastructure, what would be the model and which representation will be used for the smart objects and how people will interact with the physical objects [11].

2.2 New Trend and Challenges

Now a days Internet is being used by 2 billion people around the world and they use it for browsing, sending and receiving emails, accessing multimedia content and many other things. Developers main focus is on align the IoT concepts and its applications. IoT is one of the arising concepts which shapes the development of technologies in the area of Information and Communication Technologies (ICT) [12]. Miorandi, et al. [1] presented the three Pillars of IoT as, it should be identifiable (anything which can describe the communication by itself), it should communicate with other objects (anything which communicates with each other) and it should interact either among themselves. In relation to research, author briefly discussed the relevance and potential impact of the existing IoT research [13].

2.3 Current state of IoT

The main strength of IoT is its impact on everyday life and user behavior. Its effect can be observed in daily life and domestic areas as well. However, there are many challenges and issues still need to be address before its being widely accepted. Authors in [14], highlighted the proposed algorithms and the protocols which have been done, and what needs to be addressed, furthermore they highlighted what could be the risk factors and its weaknesses. It gives us a picture of the current state of the IoT and provides the different visions of the IoT. Authors also review the emerging technologies and demonstrate the benefits of IoT and gives us an analysis of the major issues. Huge benefits which are provided by the IoT technologies are in the health care domain, augmented maps, tracking, identification and authentication and in data collections, etc. New concept and technologies initiate the idea of IoT possible but a lot of efforts and research still needs to be done, and the most important issues and things which needs to be researched and addressed are mainly the requirements of IoT, data communication and interconnection issues, networking issues related to privacy and security [14].

2.4 IoT and Storage

Besides offering various benefits, emerging technologies and near future of IoT, efficient and effective database management is a significant issue. IoT uses different models and storage schemes so it produces an enormous amount of data. Due to the collection of unreliable data from different resources, IoT should collect the data from reliable sources and should perform some processing efficiently to enhance the data accuracy. Many of the smart objects reported the data on the real-time, therefore, it is important to analyze and enable the function of real-time canalization of time. IoT data grows very fast where the designed models must be fast enough to organize the data quickly and able to meet all requirements. The designed model should be able to overcome all existing limitations and facilitate to track the objects, processes, and events management, monitoring and control management. IoT contains enormous amounts of data both in structured and in the unstructured form [15].

2.5 IoT Development

The development of the IoT is still in progress where services and composition of IoT still discoverable. Atzori, et al. [16] proposed a possible ways to solve these kind of issues. They presented the new idea of Social Internet of Things (SIoT). As name indicates, it considers the social aspects and architecture of the objects and a starter predominantly architecture for the implementation of SIoT. It gives the capacity to people and gadgets to decide and utilize these articles with their administrations in the IoT. Another kind of relationship is characterized for the genuine items which are claimed by the same clients and they named it proprietorship relationship. The last relationship is made or we can say set up when consistently they related their relations among the proprietors for instance gadgets or sensors which has a place with companions and so forth [13]. In this section, two major technical constraints of IoT have discussed including Wireless Sensor Networks (WSNs) and Radio Frequency Identification (RFID) technology.

2. Constraints of IoT

In this section, two major technical constraints of IoT have discussed including Wireless Sensor Networks (WSNs) and Radio Frequency Identification (RFID) technology.

3.1 Radio Frequency Identification (RFID)

The early vision of IoT was about the connection of physical objects with the other devices, tagged and are uniquely identified by RFID technique [17]. Now the concept has emerged into several other scopes. RFID and its applications looks simple and straightforward to implement and deploy but it's not that simple as it looks. RFID is a kind of technology which

requires the development of distinct other systems, networks, and software with significant difficulty. It requires the designing of the antenna, analysis of radio waves and low-cost circuit and integrated production techniques as well. In 1948 [18], stockman stated that RFID required at least 60 years of development to end and its influence for other huge applications [19]. Radio communication is vital and important to the IoT. Firstly and the obvious thing is that, it supports ubiquity and mobility and its supports with flexibility which is impossible with wired communications. Devices can move and work together in a group. Furthermore, new devices can join existing group, it increases the power and the things that the group can do collectively [20]. The upcoming years of modern computing will be out of the box and different than traditional desktop machines.

3.2 RFID and IoT Model

Gubbi, et al. [21] recommended that the IoT model and numerous articles which are around us have some structure and they collaborate. Innovations like RFID and sensor systems will be developed to create new test cases so that they communicate with each other. In this model, it comprises of administrations and supplies that are conveyed in a way simply like conventional supplies. The term IoT was used by Kevin Ashton in 1998 and it was with regards to the production network and its administration. The following upheaval has interconnection of the physical articles to make their surroundings more feasible. The author presented the patterns in IoT which are supported by the applications and the need of the consolidating a few advancements and applications. The early visualized IoT that the physical items which are labeled are exceptionally distinguished by (RFID).

3.3 Use of DNS and ONS Heritage System

Weber [22] briefly defined the notion and technical background of IoT. The basic purpose of introducing the term IoT is to provide ease to information exchanges among devices. The term IoT was initially depicted in 1998 as specified before it was utilized to portray the effect of IoT and in fact, the design depended on specialized devices. They introduced another idea of Object Naming Service (ONS) and Domain Name System (DNS) legacy framework. ONS is a surely DNS with a various leveled tree where the pertinent data required for the articles. As explained earlier, we must keep in mind the end goal to utilize the DNS to discover the data firstly then we have to change over Electronic Product Code (EPC) into an appropriate organization so that DNS can comprehend. DNS and ONS have certain likenesses like in structure, they both utilize the same database structure and in engineering both utilize the same customer server model, and there are a few contrasts too like in institutionalization process and bodies. Standardization procedure is concocted by the web building Task Force (ETF). ONS utilizes the standard advancement model of EPC through DNS and uses Requests for remarks (RFC) arrangement. With regards to the naming plans, DNS utilizes two or more alpha-numeric parts (marks) and every name can contain up to 63 octets, yet the entire space ought not to surpass 255 octets. ONS likewise acquires the greater part of the DNS and shortcomings since ONS depends on DNS. The early vision of the IoT was about the physical articles which are labeled and are extraordinarily recognized by RFID.

3.4 Wireless Sensor Networks (WSNs)

Now the concept has been grown into several multiple scopes [23]. Emphasizing on the sensor networks which enables real-world intelligence in association with the smart objects. Authors specifically surveyed the current research techniques and methods in accordance with their availability, they also identified the research which has to be addressed and future directions. Designing such a system which can efficiently support a wide variety of applications as well as interconnection with other gadgets is a difficult task. WSNs research has provided various solutions to overcome problems and challenges. However, moving towards the WSNs, global infrastructure of IoT opens up new challenges and task which requires more efforts and capabilities. Authors discussed the key issues and challenges from WSNs to IoT. They motivated the requirements for future challenges and experimentation of IoT based technologies. Anwar, et al. [24] presented the method and talked about the hierarchical wireless, RFID architecture in association with field communication. Furthermore, about the other high frequency technologies to create a service just like smart home that facilitates the user with cost, energy consumption, and several other services [25].

3.5 WSNs Challenges

Emphasizing on the sensor networks which enables real-world intelligence in association with the smart objects. Tripathi, et al. [26] specifically surveyed the current research techniques and methods in accordance with their availability, it also identified the research which has to be addressed for future directions. Designing such a system requires a mixture of components and technologies. WSNs research has provided solutions to reduce problems and challenges. However, moving towards the WSNs global infrastructure of IoT opens up new challenges and task which requires more efforts and capabilities. Authors briefly highlighted and discussed the key issues and challenges from WSNs to IoT. They motivated the requirements for future challenges and experimentation of IoT based technologies. Now this concept is implementable

in Smart homes for using and creating own services [27]. WSN based systems recues the user cost and make them more convenient and easy to use services such as smart appliances, smart grids and security systems.

3.6 Problems in Sensor Actor coordination

Wireless Sensor and Actor Networks (WSANs) are capable of sensing the physical world and it can lead us to the new technology era, by making decisions performing suitable actions, etc. WSANs are the gateway for the IoT because through WSANs, physical objects intercommunicate with each other. Many algorithms and models have been proposed for the WSANs. These networks have certain unique characteristics, like Real-Time Requirement where we may need a rapid response to sensor input but it depends upon the application. For example in the case of emergency and alarming situations, the actions should be initiated as soon as possible depends upon the event area. The process of coordination performed in in these networks by the central entity, where it performs all the tasks of data collection. Wherever in WSANs, coordination process is performed through new network process called sensor-to-actor and actor-to-actor coordination, in sensor-to-actor coordination process, event transmission takes place and after receiving that event information actors need to collaborate with each other and need to perform suitable actions according to the event occurred as shows Figure 2. We can see the components of sensor actor coordination. Besides they have examined what could be the issues in sensor-on-screen character coordination. Various inquiries can be involved by psyche like (i) what will be the necessities of this correspondence (ii) which sensors will speak and which nodes performs as an artists and how the correspondence would be cured it out. Because of the principal, the significant prerequisite of sensor-performer correspondence is to expending the low vitality while in light of the second question.

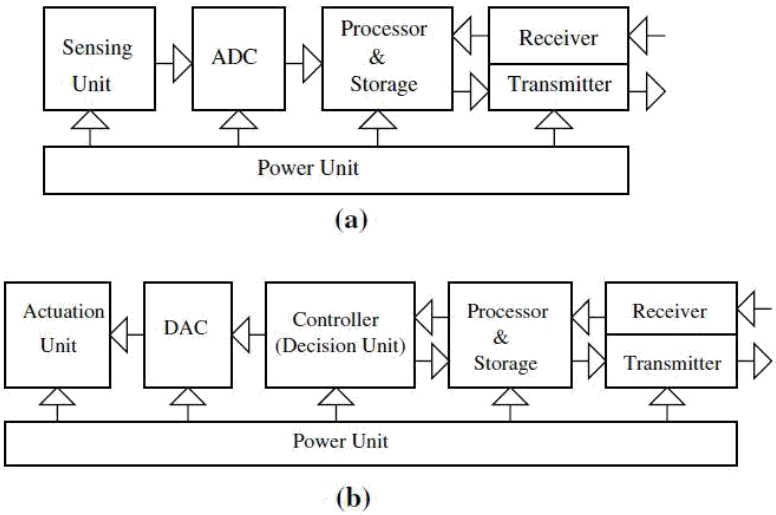

Figure 2. Components of Sensor Actor

For data transmission, there can be two sorts of single-jump or multi-bounce, however, single-bounce is not reasonable in because of the long separation amongst source and the sink node its inverse case. Multiple on-screen characters get the data from sensor nodes in WSANs and are signified by the case name as Multi-Actor. For this situation, each sensor hub can autonomously choose to performs the artist where they need to send their readings [28]. More gadgets are getting associated with the web, more applications are utilized nowadays [29].

3.7 Tight Resource Constraints

Tight resource constraints mean an embedded system with very little resources. The IoT devices depend on low data transfer capacity, limited channels for collaboration between little hubs, limited processing of CPU, limited memory, and vitality spending plans. These attributes straightforwardly act the dangers and leads to security conventions [27]. To begin with, the utilization IEEE 802.15.4 standard which has estimated 127-byte bundles at the physical layer, may bring huge security problems. These constraints may open new issues like Denial of service (DoS). Also, the discontinuity issues usually minimizes the general framework execution because of section misfortunes and the requirement for data retransmissions. Particularly, destiny sharing of parcels is tight, as executed by DTLS, which disturbs the subsequent execution misfortune. Rare CPU and memory assets are connected to the utilization of asset requesting cipher primitives, for example, open key cryptography as utilized as a part of most Internet security guidelines. This is particularly valid, if the fundamental cipher techniques should be utilized or if the applications with basic requests have a low-level packet. For the improvement in the IoT area, we need to overcome the cryptographic expense of the required key which trades and marks with the Electronic Communications Committee (ECC) [18, 30-32]. In addition, the conventions and assaults have

been revised in the most recent years to empower the cryptography. Host Intrusion Prevention Computing (HIP) could decrease the cryptographic burden and beyond by concentrating on cryptographic primitives that are required and empowered in equipment. For example, in IEEE 802.15.4 consistent gadgets. However, HIP does not require cryptographic hash works but rather utilizes a Cerebellar Model Articulation Controller (CMAC) technique in which we can easily utilize the AES equipment, and we see these protocols and requirements as illustrated in Table 1 [33].

Table 1. Tight Resources Constraints and Protocols

	Bootstrapping Phase	**Operational Phase**
Requirements	Incremental Development identify and key establishment Privacy aware-identification Group creation.	End-to-end security Mobility support group membership management.
Protocols	IKEv2, TLS/DTLS, Diet-HIP, PANA/EAP	IKEv2/MOBIKE, TLS/DTLS, HIP/Diet-HIP

Table 2. Summary of Network Technologies

Technology	**Objective**	**Implementation**	**Hardware Trends**	**Limitations**	**Applications**
IOT	Interconnections of different devices.	Sensors, devices, human beings, internet, network systems.	Cheaper and small sensors.	Data processing storage, Security Complex features, deployment and requirements of IoT.	Health care domain, Augmented maps, tracking, identification & authentication, data collection.
RFID	Tags attached to objects are identified automatically.	Requires development of distinct other systems, networks and software, Designing of antenna, analysis of radio waves and circuit integrated production techniques.	Integrated circuits, Readers, Antennas.	Large amount of data, successful reading of tags and frequencies domain.	Tracking of objects, people and assets for different purposes.
WSNs	Transmission of data wirelessly using sensors.	No. of nodes connected to one or more sensors. Wired and wireless devices are connected.	Sensors, antenna, microcontroller, battery.	Security, Performance and availability issues in critical environments.	Health care area, industrial and environment monitoring.
WSANs	Sensing physical world using sensors and actors linked by some wireless medium.	No. of actors and sensors. Distributed local coordination mechanism among sensors and actors for sensing.	Sensors, actors, power unit, controller.	Unstructured or structured data that may have incompleteness, heterogeneity, redundancy, privacy and delay sensitivity concerns.	Group of mobile robots for perceiving environment, parking system heating, ventilating, and air conditioning system

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The inquiry remains if different methodologies can be connected to lessen the expense of understanding the private key in these complicated environments. A further key need to be included to allude to the restricted vitality spending plan accessible to IoT hubs. Cautious convention design and utilization are required to diminish the vitality utilization amid typical operation, as well as under DoS attacks. Since the vitality utilization of IoT gadgets differs from other gadget classes, judgments on the vitality utilization of a special convention can't be made without tailor-made IoT executions.

3. Conclusion

IoT technology is developing very rapidly and many applications have been constructed recently. Ultra-large sensing devices access such as massive heterogeneous data processing in WSNs. To achieve the open acknowledgment would along these lines have various difficulties concerning protection, possession, Information trustworthiness, and application honesty and security. Benchmarks are irrefutably tended to categorize the major issues in the deployment of WSNs and addressing the challenges to set a benchmark of system quality comparison of two systems to check the reliability. There are still numerous challenges are in the fields of WSNs like radio-frequency identification distinguishing proof, information preparing, and security. The conclusion from all the above discussion, it is concluded that IoT is a leading advancement in the field of networks and communication. IoT takes account of things that form the world into software applications, to provide ease and access to different objects. The IoT is an imaginative model and we can say innovation that centers the hole between the physical world and its description inside the computerized world. But there are still numerous difficulties and issues in the field of remote sensor systems, radio-recurrence recognizable proof, information preparing, and insecurity are yet need to be addressed to utilize better IoT concept in future.

References

[1] D. Miorandi, S. Sicari, F. De Pellegrini, and I. Chlamtac, "Internet of things: Vision, applications and research challenges," *Ad hoc networks*, vol. 10, pp. 1497-1516, 2012.

[2] H. Kopetz, "Internet of things," in *Real-time systems*, ed: Springer, 2011, pp. 307-323.

[3] A. Iera, C. Floerkemeier, J. Mitsugi, and G. Morabito, "The internet of things [guest editorial]," *IEEE Wireless Communications*, vol. 17, pp. 8-9, 2010.

[4] K. N. Qureshi, F. Bashir, and A. H. Abdullah, "Distance and signal quality aware next hop selection routing protocol for vehicular ad hoc networks," *Neural Computing and Applications*, pp. 1-14, 2019.

[5] C. Srinivasan, B. Rajesh, P. Saikalyan, K. Premsagar, and E. S. Yadav, "A review on the different types of Internet of Things (IoT)," *Journal of Advanced Research in Dynamical and Control Systems*, vol. 11, pp. 154-158, 2019.

[6] Z. Sheng, S. Yang, Y. Yu, A. V. Vasilakos, J. A. McCann, and K. K. Leung, "A survey on the ietf protocol suite for the internet of things: Standards, challenges, and opportunities," *IEEE Wireless Communications*, vol. 20, pp. 91-98, 2013.

[7] P. P. Ray, "A survey on Internet of Things architectures," *Journal of King Saud University-Computer and Information Sciences*, vol. 30, pp. 291-319, 2018.

[8] J. Cooper and A. James, "Challenges for database management in the internet of things," *IETE Technical Review*, vol. 26, pp. 320-329, 2009.

[9] T. Qiu, N. Chen, K. Li, M. Atiquzzaman, and W. Zhao, "How can heterogeneous Internet of Things build our future: A survey," *IEEE Communications Surveys & Tutorials*, vol. 20, pp. 2011-2027, 2018.

[10] D. Guinard, V. Trifa, S. Karnouskos, P. Spiess, and D. Savio, "Interacting with the soa-based internet of things: Discovery, query, selection, and on-demand provisioning of web services," *IEEE transactions on Services Computing*, vol. 3, pp. 223-235, 2010.

[11] G. Kortuem, F. Kawsar, V. Sundramoorthy, and D. Fitton, "Smart objects as building blocks for the internet of things," *IEEE Internet Computing,* vol. 14, pp. 44-51, 2009.
[12] Y. Huang and G. Li, "Descriptive models for Internet of Things," in *2010 International Conference on Intelligent Control and Information Processing*, 2010, pp. 483-486.
[13] A. Whitmore, A. Agarwal, and L. Da Xu, "The Internet of Things—A survey of topics and trends," *Information Systems Frontiers,* vol. 17, pp. 261-274, 2015.
[14] L. Atziori, A. Iera, and G. Morabito, "The Internet of Things: A SurveyCOMPUTER NETWORKS," ed: doi, 2010.
[15] L. Chen, M. Tseng, and X. Lian, "Development of foundation models for Internet of Things," *Frontiers of Computer Science in China,* vol. 4, pp. 376-385, 2010.
[16] L. Atzori, A. Iera, and G. Morabito, "Siot: Giving a social structure to the internet of things," *IEEE communications letters,* vol. 15, pp. 1193-1195, 2011.
[17] R. Singh, E. Singh, and H. S. Nalwa, "Inkjet printed nanomaterial based flexible radio frequency identification (RFID) tag sensors for the internet of nano things," *RSC Advances,* vol. 7, pp. 48597-48630, 2017.
[18] S. Madakam, R. Ramaswamy, and S. Tripathi, "Internet of Things (IoT): A literature review," *Journal of Computer and Communications,* vol. 3, p. 164, 2015.
[19] G. Szabó, E. Wirth, and A. Czinkoczky, "Monitoring Urban Roadspace Usage with Radio Frequency Identification Tags and Internet-of-Things," *Journal of Digital Landscape Architecture,* pp. 319-326, 2018.
[20] J. Zhang, S. Rajendran, Z. Sun, R. Woods, and L. Hanzo, "Physical Layer Security for the Internet of Things: Authentication and Key Generation," *IEEE Wireless Communications,* 2019.
[21] J. Gubbi, R. Buyya, S. Marusic, and M. Palaniswami, "Internet of Things (IoT): A vision, architectural elements, and future directions," *Future generation computer systems,* vol. 29, pp. 1645-1660, 2013.
[22] R. H. Weber, "Internet of things–Need for a new legal environment?," *Computer law & security review,* vol. 25, pp. 522-527, 2009.
[23] A. Al-Fuqaha, M. Guizani, M. Mohammadi, M. Aledhari, and M. Ayyash, "Internet of things: A survey on enabling technologies, protocols, and applications," *IEEE Communications Surveys & Tutorials,* vol. 17, pp. 2347-2376, 2015.
[24] M. Anwar, A. Abdullah, A. Altameem, K. Qureshi, F. Masud, M. Faheem, *et al.*, "Green Communication for Wireless Body Area Networks: Energy Aware Link Efficient Routing Approach," *Sensors,* vol. 18, p. 3237, 2018.
[25] K. N. Qureshi and A. H. Abdullah, "Adaptation of wireless sensor network in industries and their architecture, standards and applications," *World Applied Sciences Journal,* vol. 30, pp. 1218-1223, 2014.
[26] A. Tripathi, H. P. Gupta, T. Dutta, R. Mishra, K. Shukla, and S. Jit, "Coverage and connectivity in WSNs: A survey, research issues and challenges," *IEEE Access,* vol. 6, pp. 26971-26992, 2018.
[27] K. Sha, W. Wei, T. A. Yang, Z. Wang, and W. Shi, "On security challenges and open issues in Internet of Things," *Future Generation Computer Systems,* vol. 83, pp. 326-337, 2018.
[28] I. Lee and K. Lee, "The Internet of Things (IoT): Applications, investments, and challenges for enterprises," *Business Horizons,* vol. 58, pp. 431-440, 2015.
[29] J. Lin, W. Yu, N. Zhang, X. Yang, H. Zhang, and W. Zhao, "A survey on internet of things: Architecture, enabling technologies, security and privacy, and applications," *IEEE Internet of Things Journal,* vol. 4, pp. 1125-1142, 2017.
[30] A. Sebastian, S. Sivagurunathan, and V. M. Ganeshan, "IoT Challenges in Data and Citizen-centric Smart City Governance," in *Smart Cities*, ed: Springer, 2018, pp. 127-151.
[31] D. Bandyopadhyay and J. Sen, "Internet of things: Applications and challenges in technology and standardization," *Wireless Personal Communications,* vol. 58, pp. 49-69, 2011.
[32] F. Wortmann and K. Flüchter, "Internet of things," *Business & Information Systems Engineering,* vol. 57, pp. 221-224, 2015.
[33] O. Elijah, T. A. Rahman, I. Orikumhi, C. Y. Leow, and M. N. Hindia, "An overview of Internet of Things (IoT) and data analytics in agriculture: Benefits and challenges," *IEEE Internet of Things Journal,* vol. 5, pp. 3758-3773, 2018.