A Compressive Review on Internet of Things in Healthcare: Opportunity, Application and Challenges

Pankaj Dadheech[1], Sanwta Ram Dogiwal[1], Ankit Kumar[2(✉)], Linesh Raja[3], Neeraj Varshney[2], and Neha Janu[1]

[1] Swami Keshvanand Institute of Technology, Management and Gramothan, Jaipur, Rajasthan, India

[2] GLA University, Mathura, UP, India
kumar.ankit@gla.ac.in

[3] Manipal University Jaipur, Jaipur, Rajasthan, India

Abstract. This article presents a review of the Internet of Things in the health area, focusing on the solutions that currently exist in home-oriented health. A very promising future is predicted with the appearance of portable smart devices, using protocols such as 6LoWPAN, which will allow the development of many applications for solving every-day problems in the health sector and the rapid implementation of the home-centered health model. In the various works and solutions consulted, the use of wireless technologies pre-dominates, such as: WPAN, WBAN, MBAN, Wi-Fi, WiMAX, ZigBee, Bluetooth, ANT, ultrawideband, ingestible sensors, and epidermal electronics, smart bandages, smartphone applications, RFID, RTLS and IPS. These technologies are widely used for biomedical census systems. This reflects a broad advance at the level of technologies and network architecture based on IoT, which provide specific solutions to problems in the health sector, especially in scenarios focused on home-centered health, which allows the maximum use of technology IoT in this area, very commonly called IoT Health. The above sounds promising for the health sector and ICT industry in general because it allows personalizing the health service, and accelerating its evolution.

Keywords: e-Health · Internet of Things · Telemedicine · Healthcare

1 Introduction

Internet of Things (IoT) is about connecting devices and objects of everyday life over the Internet [1]. IoT allows sensors and devices to be integrated with objects that are connected to the Internet through fixed and wireless networks [2–4]. It should be noted that the objects that will make up the network are varied: household appliances, industrial machinery, vehicles, among others. In IoT each object would have its own address of its Internet provider. This indicates that if we have objects such as car parts and cameras connected to the Internet, it will be easier to locate and identify them, it would be easier to carry out inventories, to know if the object is on or off at any moment. The Internet

V. E. Balas et al. (Eds.): ICETCE 2022, CCIS 1591, pp. 226–235, 2022.
https://doi.org/10.1007/978-3-031-07012-9_20

of things will allow a better quality of life, since it has the ability to collect and analyze such data that together can be converted into important information and knowledge.

1.1 The Internet in Health

The Internet of things applied in the health area will allow many people, regardless of their social class, to use the services that could be offered through the IoT and that are already being offered in many countries. It will serve to constantly monitor our health, taking into account that there are many diseases in which symptoms are silent and that an early diagnosis would allow prevention and possible solutions to diseases that can be fatal. All of the above sounds very convenient, considering that the global health system tends to change, focusing on home care. Figure 2 presents different applications of IoT in health.

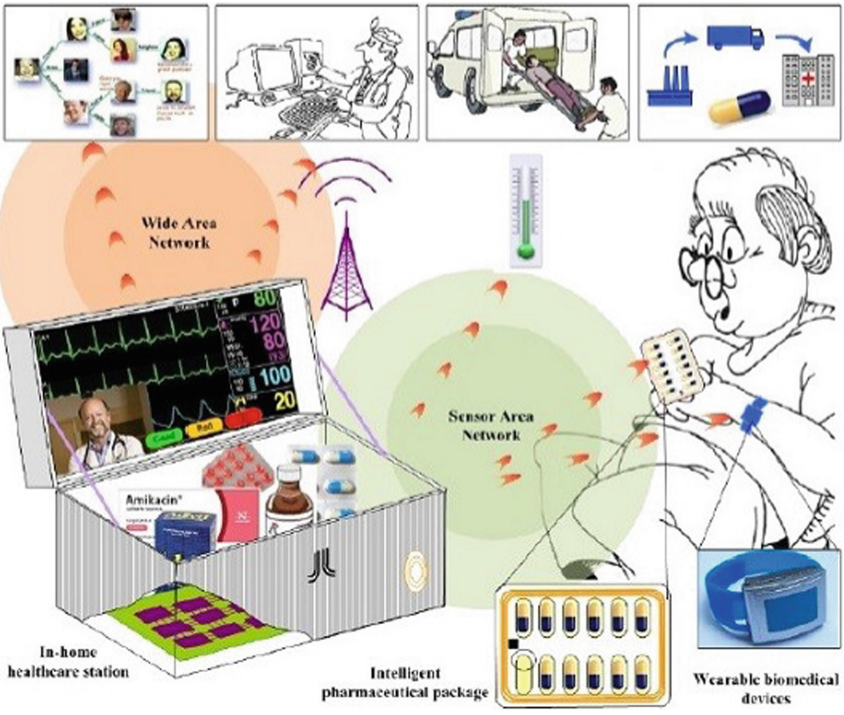

Fig. 1. Application of IoT in health

The different solutions/applications of the IoT in health can be sectorized in the services of Telemedicine, Emergency, Medication, Social networks for health, home health, smart pharmaceutical packages, biomedical devices, as shown in Fig. 1 [6].

1.2 IoT Technologies in Health

Among the fundamental characteristics offered by the Internet of Things is the increase in nodes connected to each other, which at the same time becomes a great challenge for the development of new communication protocols and updating of topologies. Sensor networks (WSN, Wireless Sensor Network) [7, 8] meet many of the requirements proposed by the technological solution of the Internet of Things. WSNs are made up of a set of nodes scattered in a given area, communicated in an ad-hoc manner [9] and can work cooperatively, this allows their applicability to be increased in almost all fields of the industry.

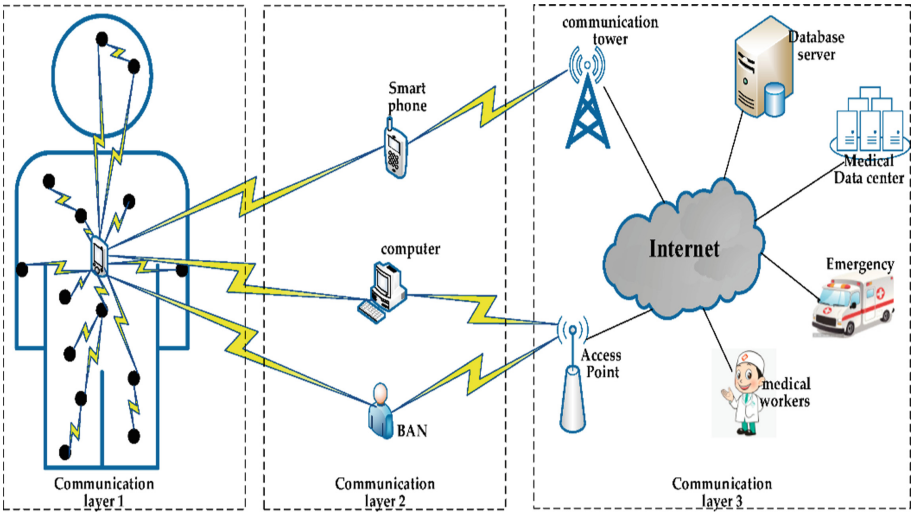

Fig. 2. Architecture of bio wireless network [14]

RFID is a technology that serves for automatic identification, in which it is used [10, 11] to capture data by means of electronic devices. This technology makes it possible to identify and locate objects, since this is a reader that reads labels, which internally carry data, which in turn are consulted in the database and thus serve to identify an object that contains it.

These tags have a built-in microchip, which stores the information, this information is unique, which is why it has an ID identification, and then it is stored in the RFID memory; these labels are of different size according to the system. Then the RFID is incorporated into the object to be identified and located. This is why in the health area it would be of great interest, because what is wanted is that a patient or worker be monitored and controlled to have better care.

2 Common IoT Application Architectures in Healthcare

The IoT makes good use of wireless technologies. In [12] an architecture is presented that serves as a test bed for applications on body area networks (BAN) (see Fig. 3) or body

area sensor networks (WSAN), it is a network designed with devices (sensors) of low power incorporated in the body, through which its movements and its vital parameters are controlled, and in turn these will be connected to a wireless network to be able to transmit the data to a base station, and that data is sent on time real to hospital and clinics. As said, this architecture is used to implement test applications; many solutions worldwide that are based on BAN use architectures similar to this.

After all the above, it is not difficult to realize that the ubiquity of the IoT almost requires us that most of the everyday objects can be accessible through the famous IP (Internet Protocol) addresses. IPV6 (IP version 6) over 6LoWPAN [13] personal area sensor networks (IPv6 over Low power Wireless Personal Area Networks) is a protocol that provides IPv6 compatibility with sensor networks. In [14] an architecture that integrates hardware and software is presented, based on heterogeneous 6LoWPAN networks. It is motivated by the need for the fusion of a body area network and an environment control network, for health monitoring applications. Internet connectivity was added through the use of an edge router.

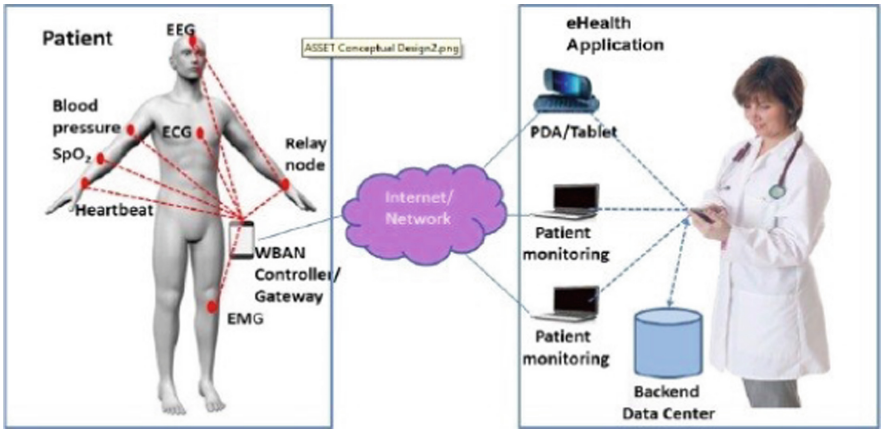

Fig. 3. Human network in eHealth [32]

3 Typical Scenarios of Application of the Internet of Things in Health Smart Emergency Service

Emergency services (ES) are also joining the evolution and new paradigm of patient-centered medical service from home. The SE is extremely important, since many lives depend on its good and timely management [15–17]. Many times, the responsibility falls on the prehospital service and the quality of the emergency medical service. So far, there are several solutions that help in the timely management of the pre-hospital service, through wireless technologies and the use of IoT as a basis. In [18, 19], time is described as a purpose to improve communication between the ambulance, the dispatch control center and the hospital emergency service (Fig. 4).

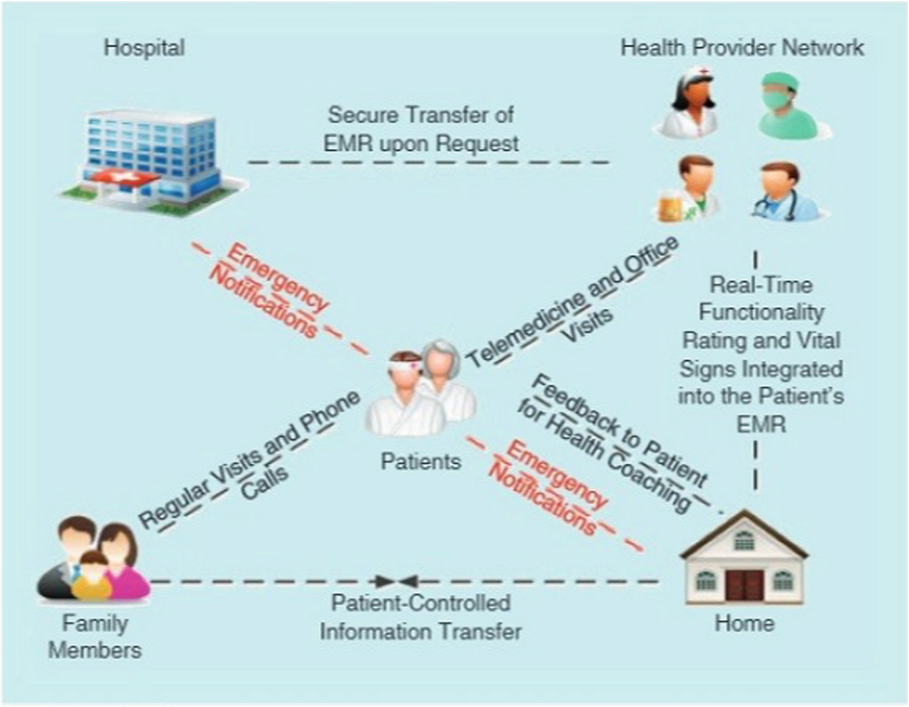

Fig. 4. Home-centered health

- **Smart Medication Service**

  Success in treating any disease is highly dependent on compliance with taking the prescribed medicine at the right time. Factors associated with the patient can lead to non-compliance in taking medicine, either due to psychological factors associated with anxiety, motivation for recovery, attitude towards the disease, or forgetting the schedule in the elderly [20–23].

Biomedical Devices

The research and development of wearable smart devices (SWDs) for personalized services (health being one such example) has motivated governments and research agencies around the world in recent years. Europe, the United States and Asia have put a notable interest in funding research projects in which topics such as E-Health and ICT are the main ones. An example of the numerous projects developed in the United States is the "Oregon Center for Aging and Technology", a project focused on the development and deployment of sensor technology to monitor older adults at home.

A network architecture based on 3G, GSM, Internet infrastructure and wireless body area sensor networks (WBASN) is proposed, called Community Physicians Networks, CMN for its acronym in English. (Community Medical Network). The architecture proposed by is divided into 5 main parts: WBASN, mobile devices, mobile communication networks, backbone and servers in local hospitals. Regarding the implementation of the

proposed system, WBASN is responsible for both monitoring the health status of patients and the acquisition of medical information; this management plays an important role in the CMN. According to its authors, CMN does not need large costs for its deployment, it is not altered by the mobility of patients, a device called AMI (Active Monitoring Insole) is proposed for monitoring lower limb loads. According to its authors, the AMI formulated system is trained to be used by a doctor or a therapist in order to analyze the progress of patients and take the necessary corrective measures for their recovery.

On the other hand, MuSa (MUlti Sensor Assistant) is proposed by Bianchi et al. MuSa is a portable multisensory device, trained in detecting drops in heart rate and respiration rates.

- **Social Media Service focused on Health**

  With the appearance of the World Wide Web, the Internet has been the protagonist of numerous advances in society, even with the explosion of the so-called Web 2.0, the phenomenon of social networks began. Social media sites (social networks), such as Facebook, Twitter, YouTube, among others, have become powerful tools through the Internet, content generation applications, blogs, wikis, have largely strengthened the way of do business on the Internet, being the source of income for many companies and families worldwide.

Currently with the IoT, communities on the Internet are growing even more, as for example, in a community of social support for weight loss is described, which is shared through an Internet social network. These people can share their motivations and experiences. Support for these people is as personalized as if they were face-to-face with the doctor, but offers unique aspects of comfort, anonymity, and non-judgmental interaction. Within the methodology used, they conduct surveys to analyze information.

It is proposed that social support within Internet communities for weight loss deserves more attention and better evaluations; these communities can improve, a study is also carried out in young adults between 18 and 29 years old with the purpose of controlling their weight loss. The purpose was to offer guidance regarding their eating habits and analyze their weight management behavior. The work yielded good results and contributed to the understanding of the strengths and limitations of the use of Facebook in research and health promotion in general presents a not very common statistical study, in which social networks are used for medical use and research related to control, trust and intimacy. This study uses data from Europe, which contains information on behavior and perceptions on social issues such as the media, privacy and social networks. The results show that there is some evidence of a digital divide due to age, while income does not significantly affect access to social networks in the health area. Perceptions of privacy appear to be a deterrent, while trust in health care providers is not an important factor for social development and network use.

The area of radiology has also benefited claim that social networking services on the Internet have changed the way we communicate as a society and offer opportunities to improve the way radiology is practiced today. This study proposes some areas where radiologists can benefit from the new tools provided by IoT and concludes with several steps they can take to become more involved with social networks through the Internet.

According to, the accelerated change in health technology is rooted in trends. In their work they review the activities in the training of consumers and technology, and found that social trends are visible in the integration of information and communication technologies in the health area, both in search and exchange of information on the Internet, in the use of social media to create new types of interactions with family, providers and colleagues, and in the e-patient, which integrates these new functions and new technologies.

Another important example is found, where social media and file-sharing websites have brought together MS patients from all over the world and facilitated the sharing of personal experiences and information derived from medical research and its relationship with CCSVI (chronic cerebrospinal venous insufficiency). This paper carefully reviews the resources available on the Internet for MS patients seeking information on CCSVI, and the responsibilities of clinicians as they participate in these online discussions. As a result, there has been an accelerated growth in the number of patients seeking treatment for this syndrome, contemplating the possibility of improving their current condition.

The IoT through social media has also had an impact on mental health. In a study with this purpose is presented, in which the development and current uses of social networks on mental health are reviewed, ethical and legal dilemmas, as well as practical guidelines for mental health practitioners interested in developing a social networking site to support their professional practice. In conclusion, the ethical implications that clinicians should consider when using personal social networking sites are discussed.

- **Telemedicine Service**

  There is more than a one analyst who thinks that the IoT has the potential to revolutionize civilization and also increase the standard of living and increase industry performance of the economy on a lot more than the internet and IT can. Expanding the advantages of IoT [24–26] system-level qualities including scalability, dependability, inclusiveness, and general protection combine to generate a real opportunity for designers to develop efficient, highly successful and resilient IoT infrastructures. The paper shows the current state of the field of functionality in relation to academic institutions and researchers as well as its implementations which make things like the principles of cloud-based, operational, and safe all at the same time-integrated pillars in the coming. This paper gives an overview of the design of IoT, discussing the current state of the architecture of IoT architecture. Furthermore, highlighted to be ready for future IoT implementation are the IoT system-related problems that will allow for more real-time applications to be developed. There are millions of devices connected to the network and various protocols are required for the interconnection to be deemed relevant. This paper reveals the existing state of the communication requirements and implementation protocols for IoT as well as well as a systematic review of their actual and possible future use. Various service capabilities including data offloading, resource and system management are present in the computing paradigms including Cloud, Fog, Cloudlet, and Edge computing that help IoT move forward [27–29]. The main theme of this report is the search for better ways to make use IT to link devices and systems and operate things at the edge of an organization. As more and more people begin to use IoT, there may be problems of privacy and protection. This paper stresses how the protection concerns, risks, security strategies,

and traditional mitigating tactics are on top of this subject [30, 31]. The additional scope that this address is presenting is concerning privacy. Scheduling is enabled by Real-Time Operating Systems (RTOS) [32, 33] simplifies the use of time-critical IoT applications because of their reduced memory footprints, and in-time execution, which is why it is an advantage for those working on them. To see the latest features and networking infrastructure specifications of the review also gives an overview of the RTOS's abilities with respect to IoT and networking. In the final section, it addresses open research problems in IoT device production.

4 Conclusion and Future Work

One of the widely used applications of telemedicine is the electrocardiogram (ECG); there are several published works. For example, in (60) the design of a portable cardiology system is presented that allows the electrocardiographic signal to be transmitted in real time via mobile telephony. A similar but more applied solution is presented in a study carried out in Bangladesh (South Asia), where the majority live in rural areas that lack specialized care, the need for Internet-based telemedicine systems is much greater, which would allow a large number of doctors and hospitals to collectively provide health services to entire populations. A scalable architecture is proposed, based on the Internet for telemedicine (ECG), which integrates multiple hospitals; is a distributed information system based on mobile telemedicine that allows connecting patients in rural locations with specialist doctors. Regarding connectivity, the solution indicates that the portable ECG equipment communicates through the mobile device to a server (robust computer equipped with sophisticated software and conditioned for the solution) located in the rural medical center. This, in turn, communicates through the network with a specialist who can verify and process the information to diagnose through their mobile device or a compute. The solution indicates that the portable ECG equipment communicates through the mobile device to a server (robust computer equipped with sophisticated software and conditioned for the solution) located in the rural medical center. This, in turn, communicates through the network with a specialist who can verify and process the information to diagnose through their mobile device or a computer. The solution indicates that the portable ECG equipment communicates through the mobile device to a server (robust computer equipped with sophisticated software and conditioned for the solution) located in the rural medical center. This, in turn, communicates through the network with a specialist who can verify and process the information to diagnose through their mobile device or a computer.

References

1. Swamy, S.N., Kota, S.R.: An empirical study on system level aspects of Internet of Things (IoT). IEEE Access **8**, 188082–188134 (2020). https://doi.org/10.1109/ACCESS.2020.3029847
2. Neshenko, N., Bou-Harb, E., Crichigno, J., Kaddoum, G., Ghani, N.: Demystifying IoT security: an exhaustive survey on IoT vulnerabilities and a first empirical look on internet-scale IoT exploitations. IEEE Commun. Surv. Tutor. **21**(3), 2702–2733 (2019). https://doi.org/10.1109/COMST.2019.2910750

3. Meneghello, F., Calore, M., Zucchetto, D., Polese, M., Zanella, A.: IoT: Internet of Threats? A survey of practical security vulnerabilities in real IoT devices. IEEE Internet Things J. **6**(5), 8182–8201 (2019). https://doi.org/10.1109/JIOT.2019.2935189
4. Said, O., Al-Makhadmeh, Z., Tolba, A.: EMS: an energy management scheme for green IoT environments. IEEE Access **8**, 44983–44998 (2020). https://doi.org/10.1109/ACCESS.2020.2976641
5. Frustaci, M., Pace, P., Aloi, G., Fortino, G.: Evaluating critical security issues of the IoT world: present and future challenges. IEEE Internet Things J. **5**(4), 2483–2495 (2018). https://doi.org/10.1109/JIOT.2017.2767291
6. Hwang, J., Aziz, A., Sung, N., Ahmad, A., Le Gall, F., Song, J.: AUTOCON-IoT: automated and scalable online conformance testing for IoT applications. IEEE Access **8**, 43111–43121 (2020). https://doi.org/10.1109/ACCESS.2020.2976718
7. Gutiérrez-Madroñal, L., La Blunda, L., Wagner, M.F., Medina-Bulo, I.: Test event generation for a fall-detection IoT system. IEEE Internet Things J. **6**(4), 6642–6651 (2019). https://doi.org/10.1109/JIOT.2019.2909434
8. Said, O., Albagory, Y., Nofal, M., Al Raddady, F.: IoT-RTP and IoT-RTCP: adaptive protocols for multimedia transmission over internet of things environments. IEEE Access **5**, 16757–16773 (2017). https://doi.org/10.1109/ACCESS.2017.2726902
9. Samaila, M.G., Sequeiros, J.B.F., Simões, T., Freire, M.M., Inácio, P.R.M.: IoT-HarPSecA: a framework and roadmap for secure design and development of devices and applications in the IoT space. IEEE Access **8**, 16462–16494 (2020). https://doi.org/10.1109/ACCESS.2020.2965925
10. Zarca, A.M., Bernabe, J.B., Skarmeta, A., Alcaraz Calero, J.M.: Virtual IoT HoneyNets to mitigate cyberattacks in SDN/NFV-enabled IoT networks. IEEE J. Sel. Areas Commun. **38**(6), 1262–1277 (2020). https://doi.org/10.1109/JSAC.2020.2986621
11. Bhayo, J., Hameed, S., Shah, S.A.: An efficient counter-based DDoS attack detection framework leveraging software defined IoT (SD-IoT). IEEE Access **8**, 221612–221631 (2020). https://doi.org/10.1109/ACCESS.2020.3043082
12. Muñoz, R., et al.: Integration of IoT, transport SDN, and edge/cloud computing for dynamic distribution of IoT analytics and efficient use of network resources. J. Lightwave Technol. **36**(7), 1420–1428 (2018). https://doi.org/10.1109/JLT.2018.2800660
13. Alsaedi, A., Moustafa, N., Tari, Z., Mahmood, A., Anwar, A.: TON_IoT telemetry dataset: a new generation dataset of IoT and IIoT for data-driven intrusion detection systems. IEEE Access **8**, 165130–165150 (2020). https://doi.org/10.1109/ACCESS.2020.3022862
14. Jain, P., et al.: Impact analysis and detection method of malicious node misbehavior over mobile ad hoc networks. Int. J. Comput. Sci. Inf. Technol. (IJCSIT) **5**(6), 7467–7470 (2014)
15. Condry, M.W., Nelson, C.B.: Using smart edge IoT devices for safer, rapid response with industry IoT control operations. Proc. IEEE **104**(5), 938–946 (2016). https://doi.org/10.1109/JPROC.2015.2513672
16. Sathyadevan, S., Achuthan, K., Doss, R., Pan, L.: Protean authentication scheme – a time-bound dynamic KeyGen authentication technique for IoT edge nodes in outdoor deployments. IEEE Access **7**, 92419–92435 (2019). https://doi.org/10.1109/ACCESS.2019.2927818
17. Shafiq, M., Tian, Z., Bashir, A.K., Du, X., Guizani, M.: CorrAUC: a malicious bot-IoT traffic detection method in IoT network using machine-learning techniques. IEEE Internet of Things J. **8**(5), 3242–3254 (2021). https://doi.org/10.1109/JIOT.2020.3002255
18. Simiscuka, A.A., Markande, T.M., Muntean, G.-M.: Real-virtual world device synchronization in a cloud-enabled social virtual reality IoT network. IEEE Access **7**, 106588–106599 (2019). https://doi.org/10.1109/ACCESS.2019.2933014
19. An, J., et al.: Toward global IoT-enabled smart cities interworking using adaptive semantic adapter. IEEE Internet Things J. **6**(3), 5753–5765 (2019). https://doi.org/10.1109/JIOT.2019.2905275

20. Cheng, Y., Xu, Y., Zhong, H., Liu, Y.: Leveraging semisupervised hierarchical stacking temporal convolutional network for anomaly detection in IoT communication. IEEE Internet of Things J. **8**(1), 144–155 (2021). https://doi.org/10.1109/JIOT.2020.3000771
21. Ngu, A.H., Gutierrez, M., Metsis, V., Nepal, S., Sheng, Q.Z.: IoT middleware: a survey on issues and enabling technologies. IEEE Internet Things J. **4**(1), 1–20 (2017). https://doi.org/10.1109/JIOT.2016.2615180
22. Chen, S., Xu, H., Liu, D., Hu, B., Wang, H.: A vision of IoT: applications, challenges, and opportunities with China perspective. IEEE Internet Things J. **1**(4), 349–359 (2014). https://doi.org/10.1109/JIOT.2014.2337336
23. Xu, D., Zhu, H.: Secure transmission for SWIPT IoT systems with full-duplex IoT devices. IEEE Internet Things J. **6**(6), 10915–10933 (2019). https://doi.org/10.1109/JIOT.2019.2943377
24. Azari, A., Stefanović, Č., Popovski, P., Cavdar, C.: On the latency-energy performance of NB-IoT systems in providing wide-area IoT connectivity. IEEE Trans. Green Commun. Netw. **4**(1), 57–68 (2020). https://doi.org/10.1109/TGCN.2019.2948591
25. Petrov, V., et al.: Vehicle-based relay assistance for opportunistic crowdsensing over narrowband IoT (NB-IoT). IEEE Internet Things J. **5**(5), 3710–3723 (2018). https://doi.org/10.1109/JIOT.2017.2670363
26. Hafeez, I., Antikainen, M., Ding, A.Y., Tarkoma, S.: IoT-KEEPER: detecting malicious IoT network activity using online traffic analysis at the edge. IEEE Trans. Netw. Serv. Manag. **17**(1), 45–59 (2020). https://doi.org/10.1109/TNSM.2020.2966951
27. Metzger, F., Hoßfeld, T., Bauer, A., Kounev, S., Heegaard, P.E.: Modeling of aggregated IoT traffic and its application to an IoT cloud. Proc. IEEE **107**(4), 679–694 (2019). https://doi.org/10.1109/JPROC.2019.2901578
28. Wang, J., et al.: IoT-praetor: undesired behaviors detection for IoT devices. IEEE Internet of Things J. **8**(2), 927–940 (2021). https://doi.org/10.1109/JIOT.2020.3010023
29. Meena, G., Sharma, D., Mahrishi, M.: Traffic prediction for intelligent transportation system using machine learning. In: 2020 3rd International Conference on Emerging Technologies in Computer Engineering: Machine Learning and Internet of Things (ICETCE), Jaipur, India, pp. 145–148 (2020). https://doi.org/10.1109/ICETCE48199.2020.9091758
30. Sultania, A.K., Mahfoudhi, F., Famaey, J.: Real-time demand response using NB-IoT. IEEE Internet Things J. **7**(12), 11863–11872 (2020). https://doi.org/10.1109/JIOT.2020.3004390
31. Fernández-Caramés, T.M.: From pre-quantum to post-quantum IoT security: a survey on quantum-resistant cryptosystems for the Internet of Things. IEEE Internet Things J. **7**(7), 6457–6480 (2020). https://doi.org/10.1109/JIOT.2019.2958788
32. Xu, L., Yin, W., Zhang, X., Yang, Y.: Fairness-aware throughput maximization over cognitive heterogeneous NOMA networks for industrial cognitive IoT. IEEE Trans. Commun. **68**(8), 4723–4733 (2020). https://doi.org/10.1109/TCOMM.2020.2992720
33. Chettri, L., Bera, R.: A comprehensive survey on Internet of Things (IoT) toward 5G wireless systems. IEEE Internet Things J. **7**(1), 16–32 (2020). https://doi.org/10.1109/JIOT.2019.2948888