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Review Article

An Integration of IoT, IoC, and IoE towards Building a Green Society

Sultan Ahmad[1], **Sudan Jha**[2], **Hikmat A. M. Abdeljaber**[3], **Mohammad Khalid Imam Rahmani**[4], **Mohammad Maqbool Waris**[5], **Ajit Singh**[6] and **Muhammad Yaseen**[7]

[1]*Department of Computer Science, College of Computer Engineering and Sciences, Prince Sattam Bin Abdulaziz University, Alkharj 11942, Saudi Arabia*
[2]*Department of Computer Science and Engineering, School of Engineering, Kathmandu University, Banepa, Kathmandu, Nepal*
[3]*Department of Computer Science, Faculty of Information Technology, Applied Science Private University, Amman, Jordan*
[4]*College of Computing and Informatics, Saudi Electronic University, Riyadh 11673, Saudi Arabia*
[5]*Department of Mechanical Engineering, Adama Science and Technology University, Adama, Ethiopia*
[6]*Patna Women's College, Patna University, Patna, India*
[7]*Faculty of Information Technology, University of Central Punjab, Lahore, Pakistan*

Correspondence should be addressed to Mohammad Maqbool Waris; mohammad.waris@astu.edu.et

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Energy waste altogether adds to expanded expenses in the car fabricating industry, which is liable to energy use limitations and tax assessment from national and global strategy creators and confinements and charges from national energy suppliers. This checking is essential for energy sparing since it empowers organizations to roll out operational improvements to diminish energy utilization and expenses. The primary test to energy observation is the need to incorporate assembling and energy checking and control gadgets that help diverse correspondence conventions and are generally dispersed over a wide region. One of the most significant challenges in the advancement of the Internet of Things (IoT) has been the powering of billions of connected devices. Evaluation of digital services considering an energy impression of the Internet normally requires models of the energy intensity of the Internet. A typical way to deal with the display of the energy intensity is to consolidate assessments of market studies of introduced gadgets on a national or worldwide scale and their related power utilization with the aggregate information volume transported at a similar scale. Energy sources are a fundamental part of society development, and a steady power supply is essential for today's progress. End-use energy is transferred to various consumers via power transmission and circulation networks after being transformed to optional energy as electricity by various power facilities. The power grid serves as the physical stage for both wide-area electric power sharing and display exchanges, and it is at the heart of auxiliary energy sources. In this manner, it attempts to connect the part of a center point between essential energy and end-use energy. With the bidirectional power stream given by the Energy Internet, different techniques are elevated to enhance and increase the energy usage between Energy Internet and Main-Grid. Energy proficiency and, in addition, quick information transmission are fundamental to green correspondences-based applications for IoT. Here, we are trying to provide a state-of-the-art survey over various Internet of Energy techniques along with IoT.

1. Introduction

The Internet of Computer (IoC) has been widely used since 1991, which is utilized for people's interaction for a long time. New energy advancements for co-created warmth and power and expanded utilization of renewable ones, for example, biomass, sun-powered energy, and wind power, should be incorporated in a clever, data-based worldwide energy framework. In that sense, we have a worldview change from existing aloof and data-poor systems to

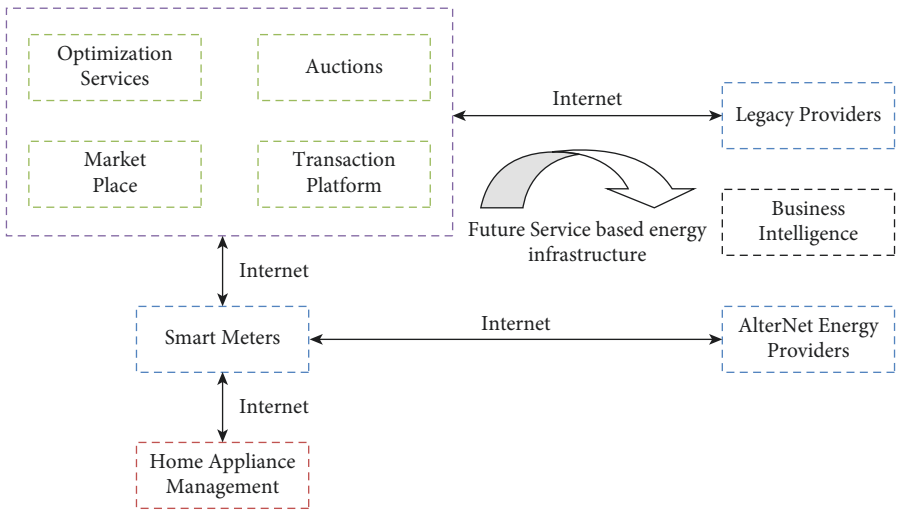

Figure 1: Internet of Energy.

dynamic data-rich energy systems, which alters the course of one-path stream since the power systems were started. The integration of little much conveyed energy creation sources and their coupling with cutting edge data-driven administrations will offer ascent to another foundation that we allude to as Internet of Energy as shown in Figures 1 and 2.

In this way, the Internet-based foundation will be firmly combined with the energy area and is used to help the improvement of new components for exchange in view of free market activity in the power advertise. New data subordinate astute energy administration systems will be required for a framework equipped for supporting the deregulated energy advertise. In such an intricate and dynamic system, it is normal that disseminated energy makers and devouring substances will be much interconnected likewise by means of data streams. The expectation is to build up a free and focused market for energy generation and circulation by separating the esteemed chain creation, exchange, and appropriation of electrical power. ICT will make it feasible for future dispersed energy systems to act naturally and automatically in more better ways and will empower dynamic revamping and coordination of administration markets. Diverse models and situations for an exceptionally dispersed data-based energy framework will be developed [1].

IoE utilizes the bidirectional stream of energy and information inside the smart grid to increase profound bits of knowledge on power use and predicts future activities to build energy effectiveness and low general cost [2]. The combination of WSNs, actuators, smart meters, and different parts of the power grid together with information and communication technology (ICT) is alluded to as the Internet of Energy (IoE) [3, 4]. As of now, the utilization of renewable energy (counting hydroelectric energy) in the United States is just 6.8% of the aggregate energy expended, which is a level much lower than other created countries, where petroleum product costs are generally higher than the United States [5]. Therefore, to empower across the board usage of long haul, secure, feasible, and naturally benevolent

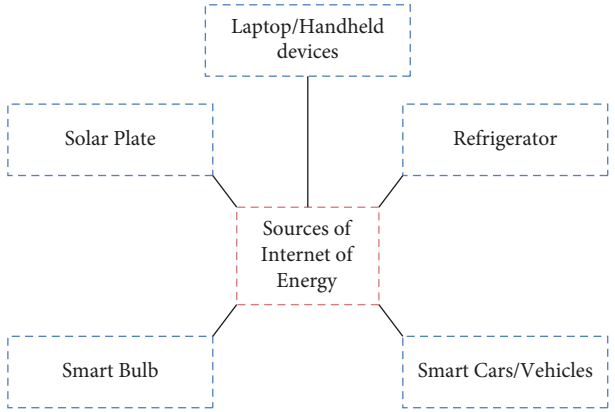

Figure 2: Source of Internet of Energy.

energy, the future electric distribution grid must address the issues of capacity and complex control.

According to the US Energy Information Administration, the US consumed more than 27 trillion kilowatt hours (kWh) in 2007, with electric energy accounting for about 11 trillion kWh and transportation accounting for 8.4 trillion kWh. The capacity to properly harness these assets must be evaluated in preparation for the United States' advancement to a greater level of renewable energy consumption. Renewable energy assets must be implemented in two ways to achieve this goal: large-scale centralized setups (such as wind or solar-based farms) and large-scale DRERs [6].

As nations around the globe put more efforts in green energy and renewable resources, the wasteful aspects of existing power frameworks around the globe are regularly neglected. This implies renewable energy cannot be given at its ideal level of proficiency on the grounds that the grid cannot completely bolster it. For instance, China is one of the world's biggest makers of renewable energy; however, despite everything, it encounters deficiencies and energy emergencies since it cannot convey that energy at a level that can support its populace [7]. This outcome results in power blackouts and holes. The energy exists yet the framework

Table 1: Comparative analysis of previous works [9].

S. No.	Authors	Advantages of the work	Limitations of work
1	Kumar and Sukumar (2018) [10]	Proposed a novel scalar point multiplication	ECC method cannot handle the DoS assaults
2	Yau et al. (2018) [11]	Provided a review of smart devices in heterogeneous environments and analysed the energy consumption of IoT devices	It did not address the major challenging issues
3	Wang et al. (2017) [12]	Analysed the development from smart grid to EI	It did not address the security of electrical systems and correspondence systems
4	Zhou et al. (2016) [13]	Analysed IoE (Internet of Energy) with the business perspective	It did not address various aspects like behavioural, security, and administrative issues
5	Kamalinejad et al. (2015) [14]	Reviewed on productive WEH and life-time of WEH-empowered IoT gadgets	It only outlined how to empower WEH for IoT frameworks but no proposed solutions were given
6	Kaur and Sood (2015) [15]	Defined three layers Detecting and control Data handling and presentation	Calculation of accelerating the calculation time is not enough for energy design
7	Moness et al. (2015) [16]	A review for cutting edge layers was exhibited	It did not address the social impact
8	Tao et al. (2014) [17]	A new ESER assessment was analysed	Lack of design, development, and use of ESER
9	Nieminen et al. (2014) [18]	Technique to connect bluetooth LE devices with the IoT	It did not focus on smart devices administration and their improvement
10	Shrouf et al. (2014) [19]	Focused on energy administration; in addition to this, it also addressed how to enhance energy	It does not focus on recovery of information
11	Cao and Yang (2013) [20]	Focuses on energy "web" issues	It does not address the upcoming problems like energy production, consumption, and sharing
12	Krenge et al. (2013) [21]	Introduced energy name service (ENS) inside the IoE	But it did not address how ENS prohibits security issues and how the objects are recognized
13	Kelly et al. (2013) [22]	Proposed techniques to check easiness universal detecting framework	It does not focus on the next network technologies including IPv6

does not. Correspondingly, the nation delivers an enormous number of electric vehicles; however, it does not have adequate charging stations, so the vehicles cannot work. In 2014, China's energy misfortune because of wasteful aspects of foundations was greater than the energy utilized every year by numerous nations around the globe.

2. Future of IoE

One potential answer to the issue of energy inefficiency is ultra-high voltage transmission (UHV), a framework that enables very fast energy transmission over long distances with minimal power loss. Adoption has been relatively slow over the years after all the benefits of UHV. China initially actualized UHV in 2009, yet its advancement is continually extending to take care of demand. China is attempting to computerize appropriation and add more resources to take care of demand, including all the more charging stations for electric autos. It is likewise building stockpiling destinations, especially in those urban areas that utilize the most energy, keeping in mind the end goal to store extra energy productively and near where it will be required. This will have included financial advantages for the organizations providing renewable energy, for example, sun powered and twists, because of the way that more energy will be held and sold, notwithstanding moderately low stockpiling costs.

In the future as the world moves in the direction of dependence on and reaping of renewable energy sources, the utilization of nonrenewable resources relied can fall, which will decrease the requirement for obsolete foundations that handle resources, for example, coal and oil. The IoE is the consequence of the execution of IoT innovation with distributed energy systems. Its motivation is to upgrade the productivity of the age, transmission, and usage of electricity. IoT innovation empowers the IoE by making networks of sensors that have various smart grid applications. These incorporate power observation, request side energy administration, distributed capacity, and renewable energy combination among others. The IoT is estimated to add $14 trillion to the worldwide economy by 2030, and the market for computerized gadgets that empower the IoE is probably going to develop to $89.4 billion by 2030. Smart sensor networks are generally cheap so they can be comprehensively sent at scale bringing about a huge measure of information which can be examined to uncover approaches to upgrade grid proficiency [8].

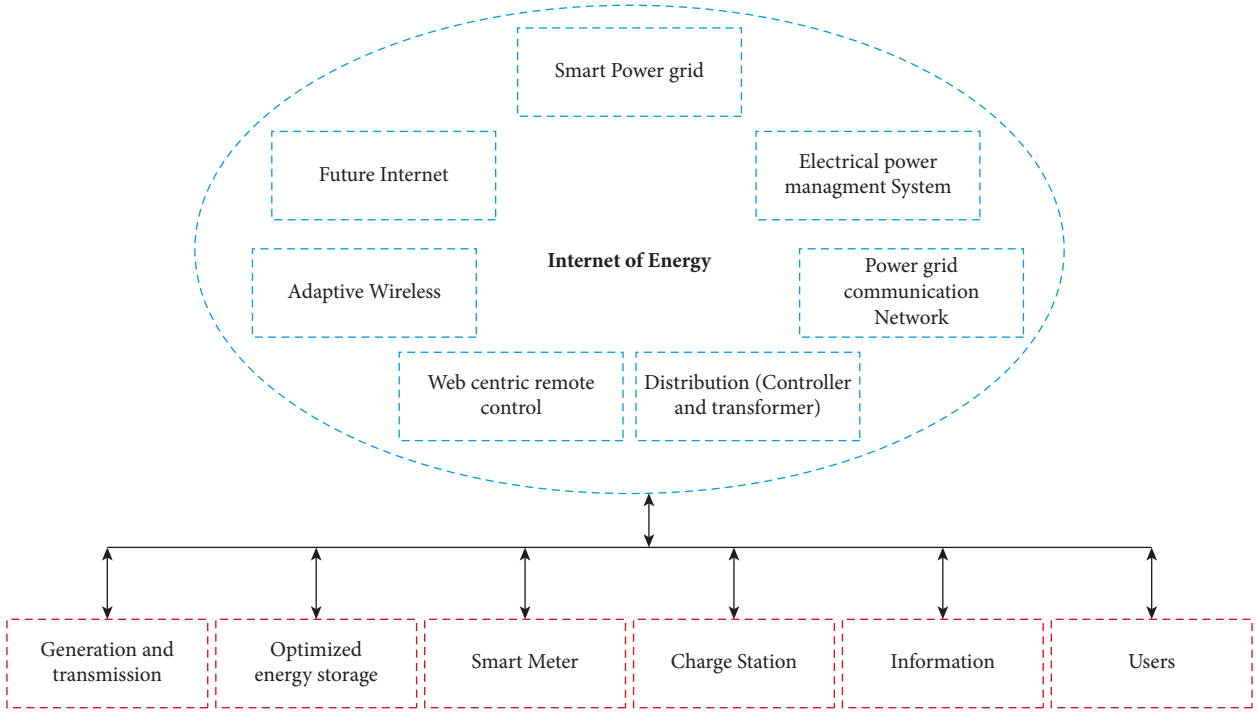

Figure 3: Concepts of Internet of Energy.

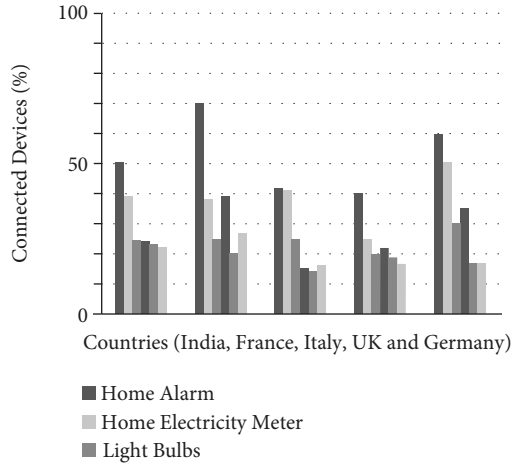

Figure 4: Devices that consumers want to connect.

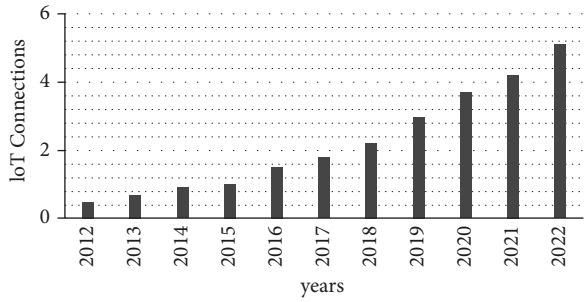

Figure 5: IoT connections.

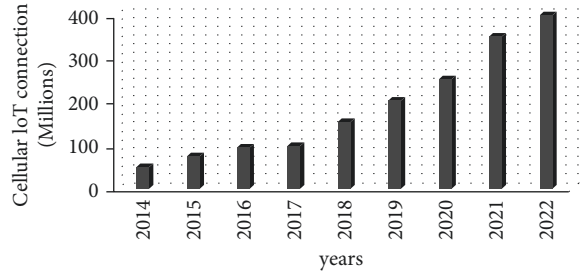

Figure 6: IoT consumer perspective.

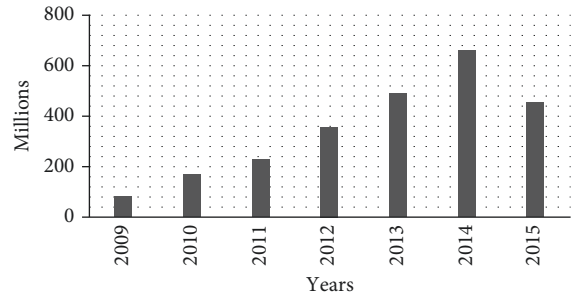

Figure 7: Statistic of I3 connect platform.

3. Related Work

In the last decade, there are many potential works have been done on green society and Internet of Energy. These works have their own advantages and limitations. Biswaranjan et al.

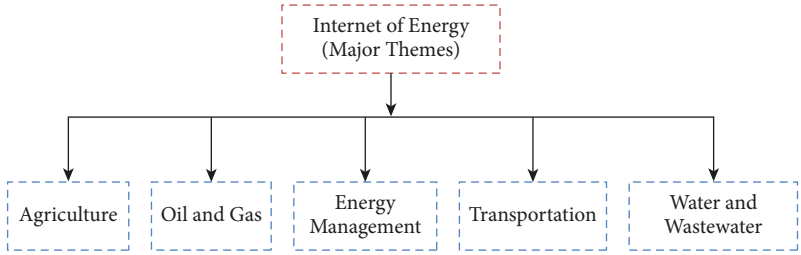

Figure 8: i3Connect platform.

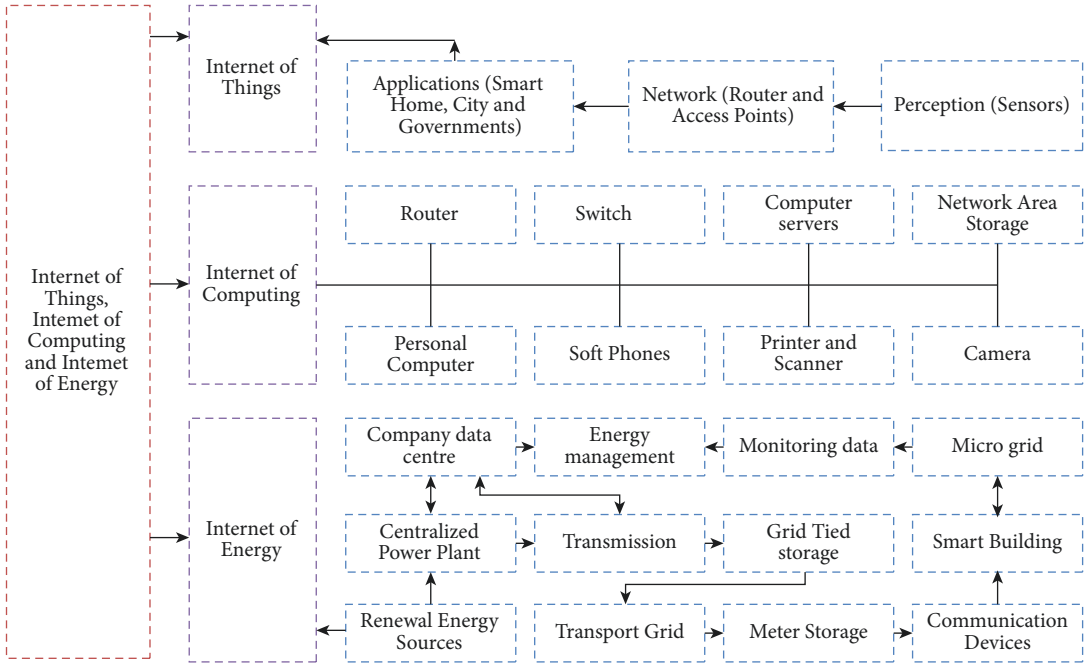

Figure 9: Taxonomy IoT, IoC, and IoE.

have done a very comprehensive comparative study and included cloud integration with Lora watermeter network in their paper [9] available as preprint on Research Square. In Table 1, the brief comparative analysis of these works is being referred.

4. Internet of Energy for Electric Mobility

The task will address reference plans and installed framework designs for exceptionally proficient, imaginative smart network frameworks with respect to prerequisites of similarity, organization, security, power, conclusion, support, coordinated asset administration, and self-association [23]. Figure 3 shows the concept of Internet of Energy in graphical form.

Productive, spotless, sheltered, and consistent portability: IoE proposes inventive answers for interfacing the Internet with the power grid with applications for electric versatility, making transport more maintainable, proficient, perfect, protected, and consistent [24, 25].

Finally, from the perspective of customers, IoT is beginning to expand beyond entertainment and communication devices. Phones, laptops, televisions, and game consoles are all connected to wearable devices [26]. For example, 8% of western Europeans possesses a smart watch, with additional 8% expecting to get one within the next year.

Figures 4 and 5 demonstrate a strong desire to connect additional household gadgets and appliances. As seen in Figure 6, this interest is closely related to the utility industry's growth around smart meters and consumer energy management. Georgina Penfold, Director of Spraga Ltd and winner of Energy Industry Expert of the Year at the 2016 Energy Live Consultancy Awards expressed the following: "A current survey of substantial vitality end-clients (£500 K per annum power spend or more noteworthy) affirmed that about 20% of vitality supervisors trust suspicion of the innovation among the chiefs will be a huge boundary to the appropriation of keen resources inside the business".

As the following outline represents, our i3Connect (Figure 7) stage has followed five years of consistent development of wander venture into IoE, finishing in $657 million put crosswise over 106 arrangements in 2014. We trust this could be a monstrous open door for financial esteem creation; however, the vitality business will require greater security and unwavering quality in contrast with what is satisfactory for buyer applications [27].

Table 2: List of different areas and the works.

Domain	Area	Work
Energy efficiency and Savings	Architectural flexibility	Integration of HVAC with service oriented architecture
	Optimization using big data	Big data and cloud
	Big data	New platform 'open Fridge' created to collect data.
	User satisfaction from services	Dynamic power allocation to optimize user satisfaction
Networking and security	Low power wide-area network	Wide coverage of network (low cost and adaptive data rate)
	Reduction in packet size	Used 6LoWPAN over IPv6 along with CoAP
	Developed security framework	The problem of multimedia heterogeneity is addressed and new framework proposed
	New system architecture	New architecture is proposed to handle large-scale data based on CoAP
	Introduction of Fog computing in IoT (indirectly leading to low latency and wide coverage)	Thought of Fog computing as a unifying platform for new services
Safety	Safe disposal of dam tailings	The tailings dam monitoring and prealarm system along with cloud for real-time monitoring and safe disposal
	Transportation	Smart-eye technology developed for real-time monitoring of vehicle data
	Healthcare	Real-time monitoring of patient data using CoAP and integration of different low-cost devices

Note that these numbers exclude consumer (and other) IoT applications to concentrate on Industrial IoE over various distinctive parts. For instance, organizations like WellAware and PetroFeed have brought up capital in 2014 to convey IoE to the oil and gas industry (Figure 8).

With the presentation of associated sensors and cloud-based information logical frameworks, customers and districts are currently ready to change conventional sprinkling frameworks into dynamic savvy watering structures to accomplish the most ideal water utilization [28]. Organizations like aWhere, CropX, and Granular are helping ranchers better comprehend climate information, water utilization, and vitality utilization. Organizations, for example, Enlighted, Blue Pillar, and Simple Energy, are helping undertakings to enhance lighting effectivenessand turn out as more vital. Zenodys, the Internet of Things platform, solution is based on the Zenodys visual IoT platform that handles most of the tasks without any programming: ZenoConnect provides connectivity of various smart energy vendors (houses, windmills, PV panels, batteries, etc.) and connects them to the microgrid.

The solution is fully independent and can run offline, but for demonstration purposes, we also enabled remote solution delivery and Docker-based service deployments. Zenobox physically connects all the equipment and services and provides a runtime environment.

The vision of OSI model is integration of all power systems and power grid apparatus. It contains procedures of generation, transport and conveyance, utility store network, buyers and customers' energy-utilizing contraptions, and machines or any systems that add to the creation or utilization of the electron. The request reaction will use the virtual power plant as far as oversaw stacks and oversaw supplies, for example, electric vehicle battery stockpiling, etc. With IoT-E, purchasers without bounds can turn into a virtual small-scale power plant, offering their overabundance energy, put-away energy, or sustainable age into the grid. Here are some fundamental intriguing ideas: "IoT-E permits the flip of a solitary light switch to put into impact a procedure that flags all procedures upstream to account, alter for and begin a chain response including all parts of the energy creation, conveyance, and upkeep and production network."

5. Taxonomy of Different Technologies

In general, IoT systems make use of a three-layered architecture consisting of the application, network, and perception layer [29]. The generation of data is solely handled by the perception layer [30]. It chiefly consists of sensors fitted onto various devices. Other sources of information such as computers, mobile devices, social media, forms, audio data, speech data, image data, and power generation data may also be part of this layer. The taxonomy of IoT, IoC, and IoE is shown in Figure 9.

This layer plays a crucial role in data transfer from sensors to the user applications because data are of crucial importance and this is the only medium of communication (wired or wireless) between a user and a device. The data generated from smart energy devices can be used to gain insights and predict outcomes that can be useful for optimization. This huge influx of data can overwhelm existing systems, and incorporation of cloud computing technology might be beneficial to address this issue [31]. Table 2 shows it in detail:

5.1. Combination of the Three Fields: A Prophecy. The integration of cloud computing and the architecture for heterogeneous devices can give a pathway to increased security and scalability in the context of smart grids. Pervasiveness of IoT-based devices and smart appliances has led to the problem of continuous authentication which may be addressed by the different security frameworks established. Seemingly enough, as mentioned before, there has been work done on the integration of real-time monitoring systems with existing ones in order to ensure optimized performance and

Table 3: List of related problems, possible solutions, and outcomes.

Area	Problem	Possible solution	Outcome
Smart grid	Scalability and mobility	Integration of new heterogeneous cloud architecture, different IoT devices, and the security framework (Perles et al. 2018).	Data security and ease of real-time monitoring; scalability achieved
User satisfaction	Companies not able to gain trust and bad user experience	Integration of CoAP with cloud with security architecture mentioned [12]	Low latency and high throughput achieved leading to better performance
Environment	Needless consumption of natural resources to generate energy	Integration of cloud and real-time monitoring systems (Wanyama 2018)	Optimized consumption of natural resources for energy production

Table 4: Comparison of different domains, related problems, and solutions.

Domain	Cloud	Enhanced network	Real-time monitoring	Sensors
Smart grid	Yes	Yes	Yes	Yes
User Satisfaction	Yes	Yes	Yes	Optional
Environment	Yes	Optional	Yes	Yes

reduce losses [32, 33]. These are listed in Table 3. This higher performance along with new security architectures are more robust and less prone to cyber-attacks, making people put their trust on such organizations [34, 35].

5.2. Parametric Comparison. Table 4 shows a parametric comparison of different domains of problem addressed in Table 4. The fields that are having 'YES' represent the availability of the required parameter for optimal performance and 'OPTIONAL' represent that the inclusion of the parameter is not of utmost importance. However, one's aim should be to include the integration of all the technologies into an application to achieve good cooperation among the three technologies.

6. Conclusion

IoT innovation is developed alongside the savvy power grid to make our day by day life more brilliant and less demanding. Energy supply, as well as monetary and natural security, is all interwoven and influences people's development. Far-reaching energy security, based on the security of power grids, should be emphasized in the electric power business. As a result, essential and end-use energy conversion is tightly linked, demanding a large-scale energy strategy. We have reviewed innovations and plans to empower IoE for IoT frameworks. The IoE worldview with its guarantee of more effective energy administration and appropriation speaks to the future for all on-screen characters in the energy advertise. Accordingly, a market incorporates energy providers, affiliates, and innovation suppliers and additionally clients of various types (residential, modern, business), and it is a principal need to construct the savvy grid idea with respect to institutionalized and interoperable apparatuses. Standard arrangements will build advertise infiltration: it is very simple for a client to utilize another innovation on the off chance that it is worked over (and available through) all around trying and generally utilizing apparatuses, for example, plain Web 2.0-empowered programs. for example, plain Web 2.0-empowered programs. In any case, the savvy grid will presumably be an exceptionally complex framework, made of various elements, likely passage-level expenses, however perhaps constrained abilities. It is thus key that empowering advances be standard, as well as adequately lightweight to take a shot at these gadgets. We have attempted to give a short outline of IoE over IoT stage. In future, we will try to implement something to work into this huge IoE and IoT field.

Data Availability

No data were used to support this study.

Conflicts of Interest

The authors declare no conflicts of interest.

References

[1] G. Pepermans, D. H. Driesen, R. Belmans, and W. D. Haeseleer, "Distributed generation: definition, benefits and issues," *Energy Policy*, vol. 33, no. 6, pp. 85–94, 2005.

[2] S. Karnouskos and O. Terzidis, "Towards an information infrastructure for the future internet of energy," in *Proceedings of the 2007 ITG-GI Conference Communication in Distributed Systems (KiVS)*, pp. 1–6, VDE, Bern, Switzerland, 2007 February.

[3] X. Fang, S. Misra, G. Xue, and D. Yang, "Smart grid - the new and improved power grid: a survey," *IEEE Communications Surveys & Tutorials*, vol. 14, no. 4, pp. 944–980, 2012.

[4] J. Huang, B. Lv, Y. Wu, Y. Chen, and X. Shen, "Dynamic admission control and resource allocation for mobile edge computing enabled small cell network," *IEEE Transactions on Vehicular Technology*, vol. 71, no. 2, pp. 1964–1973, 2022.

[5] V. Gungor, B. Lu, and G. Hancke, "Opportunities and challenges of wireless sensor networks in smart grid," *IEEE*

Transactions on Industrial Electronics, vol. 57, no. 10, pp. 3557–3564, 2010.

[6] A. Q. Huang, M. L. Crow, G. T. Heydt, J. P. Zheng, and S. J. Dale, "The future renewable electric energy delivery and management (FREEDM) system: the energy internet," *Proceedings of the IEEE*, vol. 99, no. 1, pp. 133–148, 2011.

[7] Z. Xie, "Energy insecurity and renewable energy policy: comparison between the People's Republic of China and Japan," 2020, https://policycommons.net/artifacts/392394/energy-insecurity-and-renewable-energy-policy/1357112/.

[8] S. Karnouskos, "The cooperative internet of things enabled smart grid," in *Proceedings of the 14th IEEE international symposium on consumer electronics (ISCE2010)*, pp. 07–10, Braunschweig, Germany, June 2010.

[9] B. Bhola, R. Kumar, H. Long, I. Priyadarshini, and N. Son, "Cloud integrated with LoRa watermeter network: a water expense repository," 2021, https://assets.researchsquare.com/files/rs-835166/v1_covered.pdf?c=1635431660.

[10] K. S. Kumar and R. Sukumar, "Achieving energy efficiency using novel scalar multiplication based ECC for android devices in Internet of Things environments," *Cluster Computing*, vol. 22, pp. 1–8, 2018.

[11] Y. Yang, M. Zhong, H. Yao, F. Yu, X. Postolache, and O. Postolache, "Internet of things for smart ports: technologies and challenges," *IEEE Instrumentation and Measurement Magazine*, vol. 21, no. 1, pp. 34–43, 2018.

[12] K. Wang, X. Hu, Y. Sun, D.-J. Deng, A. Vinel, and Y. Zhang, "Wireless big data computing in smart grid," *IEEE Wireless Communications*, vol. 24, no. 2, pp. 58–64, 2017.

[13] C. Zhou, M. Zelinka, and S. Klein, "Impact of decadal cloud variations on the Earth's energy budget," *Nature Geoscience*, vol. 9, no. 12, pp. 871–874, 2016.

[14] P. Kamalinejad, C. Mahapatra, Z. Sheng, S. Mirabbasi, V. C. M. Guan, and Y. L. Guan, "Wireless energy harvesting for the internet of things," *IEEE Communications Magazine*, vol. 53, no. 6, pp. 102–108, 2015.

[15] N. Sood and S. K. Sood, "An energy-efficient architecture for the internet of things (IoT)," *IEEE Systems Journal*, vol. 11, no. 2, pp. 796–805, June 2017.

[16] M. Moustafa and A. M. Moustafa, "A survey of cyber-physical advances and challenges of wind energy conversion systems: prospects for internet of energy," *IEEE Internet of Things Journal*, vol. 3, no. 2, pp. 134–145, 2016.

[17] W. Kim, T. He, D. Wang, C. Liang, and S. Liang, "Assessment of long-term sensor radiometric degradation using time series analysis," *IEEE Transactions on Geoscience and Remote Sensing*, vol. 52, no. 5, pp. 2960–2976, 2014.

[18] J. Nieminen, C. Gomez, M. Isomaki et al., "Networking solutions for connecting bluetooth low energy enabled machines to the internet of things," *IEEE network*, vol. 28, no. 6, pp. 83–90, 2014.

[19] F. Shrouf, J. Ordieres, and G. Miragliotta, "Smart factories in Industry 4.0: a review of the concept and of energy management approached in production based on the Internet of Things paradigm," in *Proceedings of the 2014 IEEE International Conference onIndustrial Engineering and Engineering Management (IEEM)*, pp. 697–701, IEEE, Selangor Darul Ehsan, Malaysia, 2014 December.

[20] J. Cao and M. Yang, "Energy internet--towards smart grid 2.0," in *Proceedings of the 2013 4th International Conference onNetworking and Distributed Computing (ICNDC)*, pp. 105–110, IEEE, Los Angeles, CA, USA, 2013 December.

[21] J. Krenge, M. Scheibmayer, and M. Deindl, "Identification scheme and name service in the Internet of Energy," in *Proceedings of the 2013 IEEE PES Innovative Smart Grid Technologies (ISGT)*, pp. 1–6, IEEE, Washington DC, USA, 2013 February.

[22] S. D. T. Kelly, N. K. Suryadevara, and S. C. Mukhopadhyay, "Towards the implementation of IoT for environmental condition monitoring in homes," *IEEE Sensors Journal*, vol. 13, no. 10, pp. 3846–3853, 2013.

[23] J. Huang, C. Zhang, and J. Zhang, "A multi-queue approach of energy efficient task scheduling for sensor hubs," *Chinese Journal of Electronics*, vol. 29, no. 2, pp. 242–247, 2020.

[24] H. Shahinzadeh, J. Moradi, G. B. Gharehpetian, H. Abedi, and M. Abedi, "Internet of energy (IoE) in smart power systems," in *Proceedings of the 2019 5th Conference on Knowledge Based Engineering and Innovation (KBEI)*, pp. 627–636, Tehran, Iran, March 2019.

[25] S. Jha, S. Ahmad, D. Prashar et al., "A proposed waiting time algorithm for a prediction and prevention system of traffic accidents using smart sensors," *Electronics*, vol. 11, no. 11, p. 1765, 2022.

[26] Xu Zhang, H. Chen, Y. Zhao et al., "Improving cloud gaming experience through mobile edge computing," *IEEE Wireless Communications*, vol. 26, no. 4, pp. 178–183, 2019.

[27] S. Ahmad, M. M. Afzal, and A. Alharbi, "Big data analytics with fog computing in integrated cloud fog and IoT architecture for smart devices," *International Journal of Computer Science and Network Security (IJCSNS)*, vol. 06, pp. 171–177, 2020.

[28] Y. Chen, Z. Liu, Y. Zhang, Y. Wu, X. Chen, and L. Zhao, "Deep reinforcement learning-based dynamic resource management for mobile edge computing in industrial internet of things," *IEEE Transactions on Industrial Informatics*, vol. 17, no. 7, pp. 4925–4934, 2021.

[29] Xu Zhang, Z. Qi, G. Min, M. Miao, Q. Fan, and Ma Ma, "Cooperative edge caching based on temporal convolutional networks," *IEEE Transactions on Parallel and Distributed Systems*, vol. 33, no. 9, pp. 2093–2105, 2022.

[30] S. Ahmad, "A review on edge to cloud: paradigm shift from large data centers to small centers of data everywhere," in *Proceedings of the 2020 International Conference on Inventive Computation Technologies (ICICT)*, pp. 318–322, IEEE, Lalitpur, Nepal, February 2020.

[31] S. Ahmad, A. Alharbi, A. Zamani, and M. Yousufuddin, "Implementation of fusion and filtering techniques in IoT data processing: a case study of smart healthcare," *International Journal of Computer Science and Network Security (IJCSNS)*, vol. 20, no. 12, pp. 131–137, 2020.

[32] Y. Chen, W. Gu, and K. Li, "Dynamic task offloading for internet of things in mobile edge computing via deep reinforcement learning," *International Journal of Communication Systems*, 2022.

[33] Y. Chen, F. Zhao, Y. Lu, and X. Chen, "Dynamic task offloading for mobile edge computing with hybrid energy supply," *Tsinghua Science and Technology*.

[34] S. Ahmad and M. M. Afzal, "Deployment of fog and edge computing in IoT for cyber-physical infrastructures in the 5G era" in sustainable communication networks and application," in *Proceedings of the International Conference on Sustainable Communication Networks and Application (ICSCN 2019)*, vol. 39, Erode, India, July 2020.

[35] J. Huang, Z. Tong, and Z. Feng, "Geographical POI recommendation for internet of things: a federated learning approach using matrix factorization," *International Journal of Communication Systems*, 2022.