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Social Internet of Vehicles: Complexity, Adaptivity, Issues and Beyond

AYESHA SIDDIQA[1], MUNAM ALI SHAH[1], HASAN ALI KHATTAK[1], ADNAN AKHUNZADA[1,2], IHSAN ALI[3], ZAIDI BIN RAZAK[3], AND ABDULLAH GANI[4], (Senior Member, IEEE)

[1]Computer Science Department, COMSATS University Islamabad, Islamabad 44500, Pakistan
[2]RISE SICS Swedish ICT Västerås AB, 722 12 Västerås, Sweden
[3]Department of Computer System and Technology, Faculty of Computer Science and Information Technology, University of Malaya, Kuala Lumpur 50603, Malaysia
[4]School of Computing and Information Technology, Taylor's University, Subang Jaya 47500, Malaysia

Corresponding authors: Hasan Ali Khattak (hasan.alikhattak@comsats.edu.pk), Ihsan Ali (ihsanalichd@siswa.um.edu.my), and Abdullah Gani (abdullah.gani@taylors.edu.my)

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ABSTRACT Social Internet of Things (SIoT) is a specialized form of adaptive networks, where any change in one node can affect other nodes in the network. Millions of devices, including vehicles, buildings, healthcare, industries, and several other types of devices, share and exchange sensitive data among each other. Interconnection of these devices changes the paradigms of the world around us and puts a great effect on the overall society. The number of nodes, types of devices, layout of the overall network, and sensitivity of the data adds more and more complexity in the domain of SIoT. In this paper, our contribution is twofold, first, we provide a brief and comprehensive overview of the social aspects of the IoT by selecting the most recent papers to investigate the complexity, adaptivity, and other social aspects of the IoT and their implications. The main aim of this paper is to analyze the benefits of IoT to the society, social acceptance of IoTs, and social connectivity of different age groups. Second, we forecast the future trends and predict the world in the year 2020. We provide a detailed analysis by using several different data tables to present the future trends of different aspects of SIoT. With this survey, we aim to provide an easy and concise view of different challenges in implementing SIoT and how it will affect the future smart cities and overall impact on the society.

INDEX TERMS Smart cities, vehicular networks, Internet of Things, social Internet of Things.

I. INTRODUCTION

The complex setup of the components in a system and the complications of the communication amongst agents lead towards the formation of a Complex Adaptive Networks (CAN). These systems are established by combining many entities which interact with each other in a distributed manner [1]. In a CAN, the agents/nodes are connected to each other and can accept changes in their environment for its survival. These agents are interconnected and any change in the behavior of an agent can lead to the changes in the whole network. In a CAN, the interlinked nodes have some characteristics of interrelationship, cooperativeness and competitiveness [2]–[4].

The management of CAN like complex systems is carried out through algorithms and efficient computational models [1]. Social networks, communication network and hyperlinks are some of the examples of CAN. Figure 1 shows the example of the CAN network where a change in one node due to environment effects the whole network. Nodes in a CAN are dynamic, interacting and autonomous in nature. These nodes are functional and operational under the influence of each other.

The technological advancements in information communication technology have changed lifestyle of the individuals in society i.e., the interpersonal interactions of the individuals, their interaction to information, devices and services [5]. One of the most emerging area of influence is Internet of Things (IoT). IoT is a broader concept that refers to connect different devices from virtual networks to physically connected devices in real world. IoT is an interconnectivity of

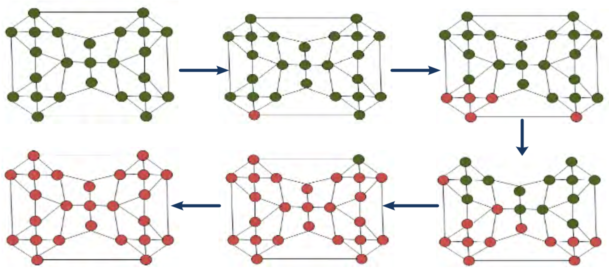

FIGURE 1. Complex adaptive network, where nodes are acting as intelligent agents in a social internet of things.

different physical objects in real world using RFID (Radio Frequency Identification), NFC (Near Field Communication), WSN (Wireless sensor Networks), IPv6 addresses and M2M-communication. IoT is a network that connects smart objects such as vehicles, machines, home appliances, and business storage etc., to exchange the information through compatible protocols. A market survey has estimated that by 2020, more than 50 billion smart devices will be deployed and connected to the Internet, and can provide services anywhere anytime [6], [7]. Accessibility and awareness towards the IoT boosted the industry and facilitated the users in adopting and using modern technology [8].

As the connection time of a device with the network increases, the battery consumption and computational overload also increases. In wireless sensor networks (WSN) all the devices are wirelessly connected to WSN. The challenge of the sensor network is to maintain energy consumption and lifetime of connectivity of a node [9], [10]. The energy consumption of a device during the data transmission is usually high [11], to reduce it non clustered head nodes are used. The complexity of the system increases as the number of nodes increase, because of increased device interactions and transfer of data and services.

As complex adaptive systems are intelligent networks [12] in which the complexity increases as the time and space sensitivity increases at different component levels. Such intelligent networks adapt to their environment and closely observe the links to all related systems. Those intelligent networks provide distribution control, connectivity, can change connecting systems at the time of connectivity, dependency of initial conditions and dynamic combination of order and disorder of a system. As the number of devices grow in the intelligent network, the security, privacy and trust become the main concerns to IoT [13], [14]. The concept of trust is different from that of the security [15], efficiency, accuracy and reliability are some characteristics of the trust in IoT.

IoT provides the control and automated environment. IoT is based upon the concept of anywhere any time connectivity to the devices to make smart world. Digital communication is probably the most influential development that changed the notion of connectivity, our digital devices and other Internet connected objects can transfer information anywhere. Sensors for example, enables more sophisticated traffic management by monitoring and transmitting the precise speed and location of every vehicle on the road, through near real-time terminals for analysis [16], [17]. SageCell has been proposed by Zhou *et al.* [18] which is a flexible, programmable and most importantly scalable architectural framework to integrate different resources for solving dynamic traffic demands with network capacity in efficient way. The interconnection of devices for information exchange shows a limited perspective of IoT because the applications of the IoT are not limited to device to device communications but device to human communication factor is also prevalent. For example, Kranz *et al.* [19] demonstrated the device to human communication by utilizing the social networks and deice networks. Kranz and his colleagues also state that besides human to human relationships, humans have relations to the things too and that leads to consider IoT as socio-technical IoT [19]. Besides, motivated by the human social networks Atzori *et al.* [20] highlights the prominent studies which establish that in IoT coexistence of human and device interactions is social in nature and could evolve as social internet of things for example a person can share services and capabilities of things he owns to his friend. Moreover, the nodes joining in IoT and communicate can evolve social relationships among them as highlighted by An *et al.* [21].

Atzori and colleagues establish that to attain actual social interaction of intelligent objects to establish social internet of things (SIoT) depends upon defining: social interaction among objects, reference architectural model based on pre-coded inter-object relationships and the understanding of social network that emerge from the interaction of objects based on defined social relationships [20]. Thus, the convergence of IoT and knowledge about the social networks is the basis for SIoT. The interconnectivity of things, their characteristics, the social connections among them and continuous information and resource sharing brings in issues like accessibility, reliability and data protection that are significant challenges to IoT and SIoT.

One of the large scale adoption of IoT is in the Smart cities where the complexity of a distributed network could increase if the number of objects or things increase in the network [12]. In smart cities, the concept of time sensitivity also increases the complexity of the system. Another form in which things can be connected is dynamic network that is an adaptive network whose state changes frequently [22]. In such networks agents use message passing to communicate with each other, first message is generated when a computer wants to take some action and the second message is a control message with some control action [23].

Transport, Home appliances, Medical and Smart Cities are now IoT based smart systems [24]–[26]. IoT puts benchmarks on different fields like health care, where social media tools now allow patients to access and communicate any time to the doctor and professional and in response doctors and professionals can also share data with the patients. Smart cities improve the quality of living through constantly monitoring various activities in cities, like traffic congestions,

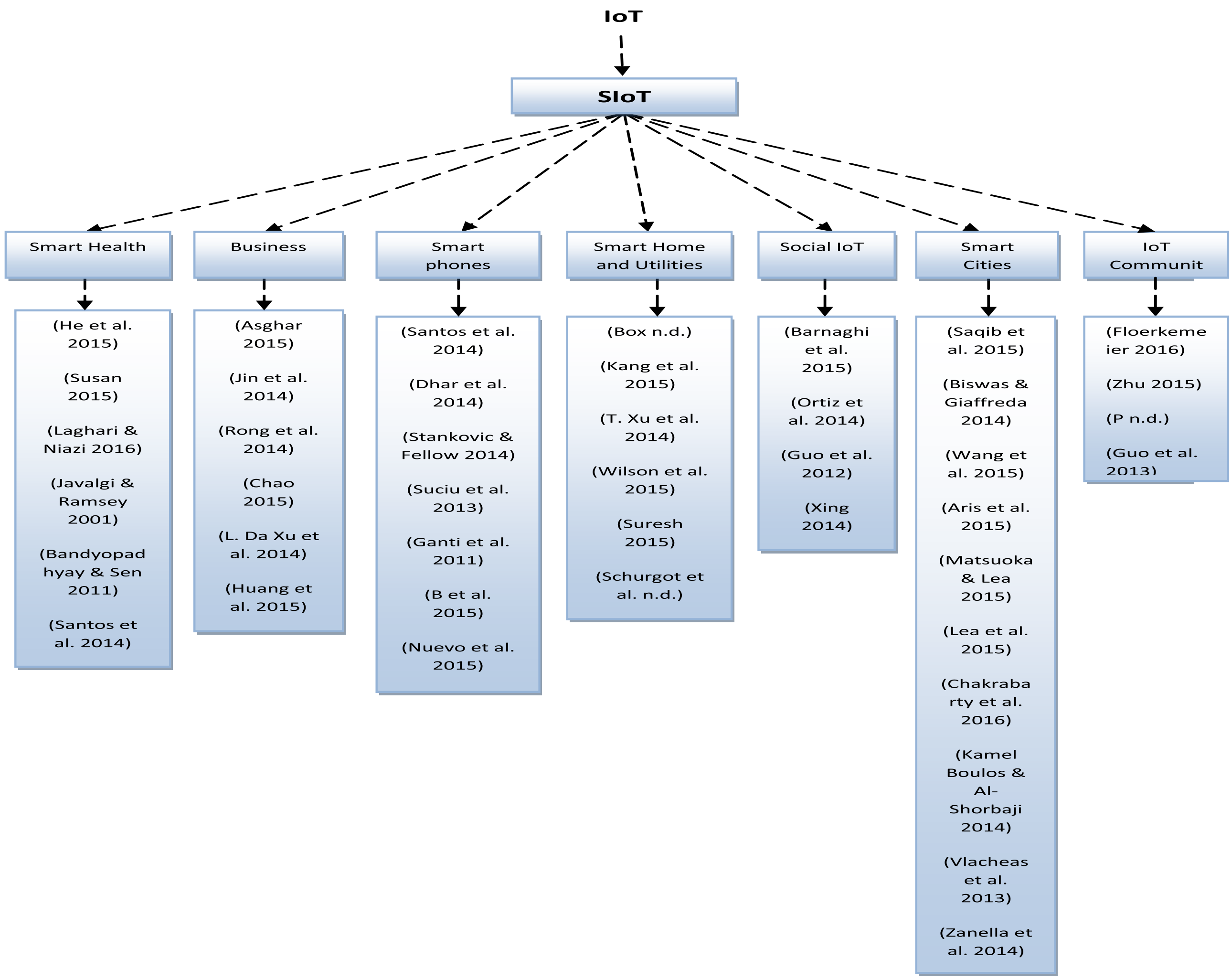

FIGURE 2. Taxonomy of social aspects of IoT.

transportation management, electricity and environment data collection and management. Most of the applications that are used as a subset of the IoT are cloud based because hosting and management of such applications is expensive and require technical support [27], [28]. The research about social effectiveness of IoT specially focuses on people's behavior in specific environments.

The IoT applications such as home automation can save lives from disaster or fire and help to monitor temperature and weather to avoid inconvenience of any kind. IoT saves time, money and effort through monitoring and measuring various systems, social and environmental parameters from remote locations [12]. For example, there are different devices available that uses Bluetooth to transmit patients' data to the health care service's database where health care manager can have access to the database for keeping track of the patients' health conditions and to analyze such data for further analysis and interpretation [29].

This research illustrates the social aspects of the IoT. We especially estimated the future trends of IoT in health, business and other sectors. We attempted to provide an image of the world in year 2020 and beyond. We also gathered and highlighted various views about the IoT, SIoT that will affect the life of individuals in coming future. We attempted to analyze the issues of IoT and their impact on society and the individual behavior in IoT environments. This paper also provides social aspects of IoT and critically evaluates the issues and challenges. Section II contains the most recent contributions in the domain of SIoT, that are published in year 2011-2017. Section III explains the expected growth of IoT and SIoT in various fields. In section IV, we discuss open issues of SIoT. We conclude the paper in Section V and discuss the future research areas.

II. RELATED WORK

IoT provides the concept of connecting various (things) to communicate and deliver the data to and forth on the network. Interconnectivity of such devices in gathering and analyzing data about different entities, processes, systems or components of the systems for management, decision making and future planning. For example, a sensor network helps in collecting the information from many machines in the surroundings and uploads it on some webpage from where the customer or a user can access that data.

In following subsections, we highlight different applications of IoT and discuss how it facilitates users.

A. HEALTH CARE

By using RFC (Remote Function Call) and NFC (Near Field Communication) we can track person's health condition. These sensors and technology can be used to measure the body temperature, heart beat and blood pressure, in case of emergency the data collected through the sensors can be sent to the doctors [30]. Doctor can respond immediately to the uncertainty and can quickly access the patient data, including medical history [31]. Automatic designs help to build a system where a new patient could be quickly diagnosed, corresponding help strategy can soon be worked out, and associated medical properties can be distributed in a short time. Sensor technology can be used in emergency response, and health monitoring applications as discussed in [23] and [32].

Stefanie and Christoph [33], discuss the IoT concept in terms of its applications and how it changes the life in eight difference perspectives. For smart health, efficient machine to machine communication is achieved and various health care devices are discussed in Natarajan [34] that becomes possible because of the invention of IoT.

Healthcare system is a set of interconnected devices [35], [36] that create an IoT network dedicated to healthcare assessment, automatically detecting situations and monitoring patients where medical assessment is required. However, IoT based rehabilitation applications face two key challenges i.e., i) quick and timely diagnosis of patients; and ii) rehabilitation procedure initiation and resource provision based on the diagnosis.

Bandyopadhyay and Sen [36] proposed an ontology-based design methodology for automation of smart medicine and physical health system (based on IoT), to provide efficient and effective information sharing method. The two important features of that approach are the quick system restoration and the easy allotment of domain knowledge, which makes the system admirable and distinctive. Moreover, for controlled large clinic studies in future, design methodology for feasible and convenient smart ehabilitation systems, featured with artificial intelligence is also highlighted in [36].

Consider a scenario in which a diabetic patient requires constant observation of sugar level through wireless insulin monitor. A smart phone with insulin monitoring app and the device can assist in monitoring the insulin level. Santos *et al.* [37] highlight more applications and implementations of IoT based solutions, but the authors do not provide any insights about the future of IoT.

Augusto and Nugent [38] proposed a community health service through health cloud platform, where the proposed approach relied on cloud subsystem for services, application and health data management. System development of such service consisted of six parts, i.e., *front-end data*, *front-end data acquisitioning module*, *message middleware*, *storage center*, *data mining center, medical graphics image processing center* and *presentation layer*. Health-Cloud platform has two functions, real-time medical care and personalized health services. Successful deployment of Health-Cloud can assist other applications and presents itself as cloud computing technology development. It provides the distributed data collection, heterogeneous data sharing and addresses storage problem in data processing on network.

Luo and Ren [39] combined health monitoring and managing in RMCPHI (remote monitoring cloud platform for healthcare information) architecture. Their simulations of the model show that in such approach efficiency increases by 50% through proposed PSOSAA algorithm.

Various applications, challenges and device constraints in cloud based IoT are highlighted in [40]. According to the authors cloud remarkably improves routine activities, makes smart cities more efficient and provides better health care facilities. In this study the open issues and challenges of IoT are identified by comparing different projects. Smart tracking devices help to track and monitor the movement of the patient to provide instant help in case of emergency [41].

Virtual-Radio for monitoring the breathing and heart beat though wireless sensors without the body contact is introduced in He *et al.* [32]. The surrounding environment affects are ignored and the sensor by the chest movement during breathing can sense the breath patters. It provides 99% accuracy even if user is 8 meter away from the sensor, it can handle multiple people virtual signs simultaneously, and it helps the inhabitant of smart home in monitoring their wellbeing. The limitations of Virtual-Radio are minimum distance between users, monitoring range, non-Human motion and Quasi-Static Requirements.

B. BUSINESS

IoT provides the platform to analyze the data to make decisions and devise new strategies. As growing trends of IoT applications in business sector, businesses are turned into e-commerce portals from which customer can virtually access the product anywhere [42].

The Internet of Things affects the business models and modifies them completely to an efficient industry to make new strategies to get success in digital environment. Jin *et al.* [43] Analyze the need of business model that can accommodate in IoT environment, and presents empirically tested model for both strategic management and information system research.

Customers differentiate among products through various characteristics like reliability, accessibility and security. It is the responsibility of the business to provide secure protocol for transaction, deliver quality product to the customers to establish confidence level [33]. Customers just have to select the required product and provide some details and can get product anyplace, anytime [39].

The main issues are how to achieve full interoperability between connected devices, and how to provide them with a high degree of security by enabling their adaptive and autonomous behavior, while guaranteeing security, privacy, trust, and accessibility of their data to the users [38], [44]. In the context of user privacy, the specific challenges are to provide user the data and location privacy and making and implementing specified protection rules and standard methods to provide interconnectivity between user and devices [37].

Cultural issues like language, traditions and value system are barrier in information sharing. Javalgi and Ramsey [31] analyze such issues and present state of IoT and potential applications, challenges and future research areas. The authors also address academic and industry perspective on IoT environments, Networking and communication research and highlighted some challenges in industry and academia in future.

E-commerce is defined in social and cultural aspects in which the user must be familiar with the technology and have language understating, and the products (s)he is presented must be of his concern and interest. Online survey conducted by IDC suggests that more than 76% of Chinese people prefer to browse in Chinese not in English [31].

Rong *et al.* [45] presents the IoT business eco-system within 6C framework; it is much more complex network with different stakeholders to contribute in evaluating business eco-system. The 6C framework is a benchmark system for the business eco-system; it is not easy to generalize the 6C eco-system with other systems. To confirm and realize the actual potential of the 6C framework more data and efforts are needed in future.

As the growing trend of IoT [46], objects are more connected and socialized; IoT put a direct impact on the business. Users from different geographical locations access objects of deferent range, Community need to define common communication language for easy interoperability. More automation and semantic technologies are needed to be used to facilitate the user to discover services.

Rapid progress in smart phone technology, the mobile carrier can now offer and help the client to make the payments, but the cloud provides the efficient way for making payments. Huang *et al.* [47] proposed an efficient payment and authentication service framework for OIoT (Operational Internet of Things). Proposed system provides low cost communication and non-repudiation and prevents all known attacks. But the proposed system does not provide the Time-Stamps for authentication of devices [47]. In their paper Da Xu *et al.* [48] summarize the industrial progress in IoT. Through development in field of IoT industry is interested in deploying IoT devices in automation, maintenance, control and monitoring the environment.

C. SMART PHONES

Define abbreviations and acronyms the first time they are used in the text, even after they have already been defined in the abstract. Abbreviations such as IEEE, SI, ac, and dc do not have to be defined. Abbreviations that incorporate periods should not have spaces: write "C.N.R.S.," not "C. N. R. S." Do not use abbreviations in the title unless they are unavoidable (for example, "IEEE" in the title of this article).

Different applications are available for smartphones in health care field, such as IHM as a new virtual manager for each user. IHM runs in a smart phone, creates a flexible solution so it can as assist health managers on different locations. There are two approaches for Bluetooth health devices, Health Device Profile (HDP) or for Bluetooth 4.0 Low Energy mode. HDP profile transfer Health Information over Bluetooth links. Due to wide use of smart phones, patients can share health information anytime and anywhere. Health information can be shared from multiple sources like PHDs (Personal Health Devices), by manual input in smart phones or even your CE (Consumer Electronic) device in your living room [37].

Data collected from large mobile sensing devices termed as MCS [49], several MCS applications CarTel, Nericell, BikeNet, ParkNet and DietSense are used to collect data about cars, traffic, detect parking spots and utilize the parking spaces, location of bike, quality and share your diet with others through mobiles. Provide environment for providing and sensing data from different sensors to make analysis. Xu and Zhu [50] proposed the efficient networking structure to meet user experience, efficiency and 5G mobile communication from different aspects. Cloud services and applications are on the top level of the network structure.

IoT extents the Opportunistic network concept by using handheld devices [51]. Suciu *et al.* present the software infrastructure of OIoT which helps to develop and manage OIoT communities for smart devices. Results from OIoT shows that it is useful infrastructure to manage and share data across OIoT communities. IoT and cloud computing are the most important ICT (Information and Communication Technology) paradigms. Benefits of IoT and distributed nature of Cloud computing. Paper parents the platform for the data coming from distributed, heterogeneous and decentralized real or virtual environment. For future work more experiments with open sensor platform on other application see [28].

D. SMART HOMES AND UTILITIES

Smart Homes are usually equipped with embedded devices that enhance the functionality of conventional demotic appliances. Smart homes enhance the comfort and security of living [52] but also provide the ecological stability. The research by Augusto and Nugent [38] replace the less systematic approach currently employed and benefit system from well-established domains of research of AI. User centric building management [53] provide the smart environment to control and monitor the things. Smart homes provide the intelligent connectivity between objects [54].

The vision of IoT is to enhance the connectivity from *"any-time, any-place"* for *"any-one"* into *"any-time, any-place"* for *"any-thing"*. Stefanie and Christoph [33] proposed a controlled environment in which the appliances are connected to each other, through which sensor data processed by single board computer and deliver to the mobile application using wireless connections [33]. Bandyopadhyay and Sen [36] proposed a prototype for small scale systems which is able to extended to large scale system. This helps in building databases for sensor environments and user custom appliances and operations, this system becomes a source of the Big Data of IoT [55]. The main challenge in the said approach is the user security and privacy.

Kang *et al.* [56] suggest a model for an IoT-based monitoring system for context aware services in smart homes using a tri-level context. In home comfort systems, air conditioning, heating, lighting, and ventilation, doors and windows all can be automated and controlled by remote control. In the future, IoT imposes more effect on life and new technologies will be implemented. Therefore, more analysis will be required in knowledge area, along with processing data from different sensors and visualizing data and information. Sensors and actuators are the major components of the IoT [57] but they can impose the threat of actuation events and integrity of the physical signals.

Suresh [58] it is discussed how user uses parking service using ID and password provided by the airport security, the user checks vehicles in parking through log in the website, efficient car parking service is implemented. It will display user detail, user can examine the parking details through cloud server, provides security to the vehicles. But the cyber security risks involved in cloud computing in real-time implementation. Schurgot *et al.* [59] analyze the security and privacy risks in home automation system, and resolve security and privacy issues through the cryptography and information manipulation system to protect user information to improve security and privacy. In future network characterization techniques will be used for IoT, also analysis technique will be extended to perform protocol reverse engineering analysis of IoT architecture using captured binary traffic. Smart homes vision is growing domain in engineering and technology [60]. Different objects are connected to each other and exchange large amount of data between them. In near future, privacy and security in data exchange will be a limitation of big data analysis [61].

E. SOCIAL INTERNET OF THINGS

Today almost every person in the world is connected to the virtual network to exchange data and can communicate around the world. The need is, that the data efficiency and real time access to the devices should be efficient enough to respond in real time, although there is some security, privacy and trust issues in the network connection [62]. Combining heterogeneous data and services and integrated data by providing the control to respond in real time to the user's various needs and requirements. Automation approach and semantic technology helps network to reduce the cognitive load, filtering and selecting appropriate information to build smart PCS (Personal Computer Software) [55]. SN (social network) along with IoT provides the connectivity of nodes in physical world through sensing [63].

Through Dynamic Social Structure of things, a Contextual Approach focus on adaptive frame work in which heterogeneity is hidden in the infrastructure and support seamless service visibility integration among cyber and social world. Matching over Linked Data Streams in the Internet of Things focus on the important problem of disseminating data to relevant data consumers efficiently, [62] proposed a system that can disseminate Linked Data at the speed of 1 million triples per second with 100,000 registered user queries, which is faster than existing techniques. Humans play a critical role in Smart Systems in which each agent's cognitive abilities are finite in terms of constrained by model of system control and computational resources [64].

Much focus of IoT is to connect, communicate and manage the things. The paper [65] analyzes the human centric perspective of IoT by analyzing tight couple relationship between human and Opportunistic IoT of smart system. Author characterized the bi-directional effect between OIoT and human, presents innovative application areas and analyzes challenges. The focused challenges are data dissemination protocols, heterogeneous social network, security and privacy, Incentive Mechanisms and generic infrastructure. Author believes that by convergence of pervasive sensing technique and social science will play role in IoT development in new stage of Social IoT.

The authors in [66] analyze IoT service, the public food quality and tractability plat form, its social impact. They have proposed the architecture to use hand held devices to use as a technology to share information in industry chain.

F. SMART CITIES

Saqib *et al.* [67] deployed WSN nodes for constant monitoring of the moving public transport and the air pollution around the city. This methodology gives us the monitoring data from the stationary nodes deployed in the city to the mobile nodes on Public Transport buses and cars. The data of the air pollution particles is collected via sensors on the Public transport buses and the data is being analyzed when the vehicle reaches to the destination. Proposed architecture has efficient mesh network to gather data from WSN. It will have a lot of benefits for future concepts of smart cities that will have new technology of IoT. Using sensor nodes and sink nodes, we can collect data in much easier way. Mobile nodes are deployed on vehicles; they are clustered together to measure the data collected from dust particles and pollution and took appropriate action on the collected data if air pollution is in large concentration.

Biswas and Giaffreda [68] describe IoT centric cloud smart architecture deal with IoT and cloud computing challenges. It analysis various issues in IoT and cloud computing including virtualization, reliability, portability, interoperate ability and accountability. Through the Internet of things and LTE-M modules, efficient M2M communication can be achieved which is not expensive compared to what is defined by earlier technologies. With the help of mobile nodes connection and data collection through the public transport can save time and energy [69]. Bin Aris *et al.* [70] discuss impacts of IoT and big data on automotive industry. Energy efficient intelligent vehicles are made to overcome the energy (fuel) issues in the vehicles and contribute in achieving smart cities [71].

Specified workshop focuses on the complex relation among technology, citizen, data and how technologies meet their needs. Matsuoka *et al.* [72] analyzed the different infrastructure provided for the improvement and development of the Smart Cities. Matsuoka *et al.* [72] have focused on proposing an easy to use IoT infrastructure and System-of-System approach, through cloud-based hub integrating number of sub-systems, which collectively make smart cites software infrastructure. In smart street IoT-hub is used to collect data from schools' street, highways and airports. Data collected from highway to analyze the traffic flow, incidents that affect the traffic flow, and rain data using a smart Street Hub.

Park Quest (PQ) was developed in conjunction of city parks [73] and non-profit organization that engaged citizens to maintain and use parks. This application ran about one year and had 1000+ members, aware user about the park system thorough the different tasks and efficient use of the things provided in parks using mobiles. My Everyday Earth (MEE) is just like a PQ, which encourages adults to efficiently use resources like food and transport through heat and light, game fiction model was used to rely on points and reward. Using different techniques like energize etc. provided efficient way for community service thus signifies that a community driven eco systems are more self-sustaining and robust.

Jin *et al.* [43] presented framework for actuation of Smart Cities through the IoT, through the data management and cloud-based integration of respective system, forms a transformational part of cyber-physical system. This vision is mapped on the noise mapping case study to explain new method for existing operations that can adopt for the delivery of important city services. Jimanagemn *et al.* has provided the blue print of Smart city development using IoT, which has strongly motivated and demanded the provision of essential services and quality of life for city in habitants. Proposed [74] secure IoT smart city architecture includes trust, authentication, privacy, secure key management and id management.

Saqib *et al.* [67] analyzed the vision of application domain of IoT, and show capability Gaps between virtual and physical objects. Saqib *et al.* [67] argued that using the advance technique, different physical objects could be connected together to provide quality of life and utilization of services to the citizens. Data collected from different sensors can help to take appropriate decisions.

Boulos and Al-Shorbaji [75] analyzed the smart cities and Healthier cities, in which objects are connected through the sensors, control, collect and manage the data to take actions on it. For the secure environment, the citizen should be educated and aware about the importance and benefits associated with smart cities. However, the challenges of privacy and security should be overcome. In research paper [76] author proposed cognitive management framework for the smart cities deployment. It uses VO concept as the dynamic virtual representation of physical object. Similarly Muzammal *et al.* [77] have defined a framework for catering with the IoT device security in a conceivable way.

Zanella *et al.* [78] illustrated the relationship between the smart city and digital city, analyzing the importance of application system and difficulties of the smart city construction. Zanella *et al.* [78] has focused on the urban smart city vision using IoT, which is most advanced communication technology for the city and citizens. A comprehensive survey for the enabling protocols is also provided. Furthermore, the authors also gave the guideline for best practice for the Padova Smart City, Italy in assistance of municipality. Smart cities are second third largest area of the IoT [40].

G. IoT COMMUNITIES

The IoT community focuses on HCI issues [79] and persuasive computing focus on connection of devices. Improvement in personal devises and internet, has developed the IoT environment that provides the control surroundings and improves human life [80]. Safe Community Awareness and Alerting Network (SCALE) have provided a platform to assist in public safety.

CarTel [81], [82] was delay-tolerant mobile computing that process and deliver data collected from the sensor installed on mobile units, for which car were used as instance. As for the reliability for IoT the privacy and security will be the issue for IoT community system, mobile technology and complex network topologies [67]. SND presents transparent flexible network to topologies for upper-level applications. MINA is a framework to manage the change caused by dynamics during deployment [83].

Nuevo *et al.* [51] presented a framework, Opportunistic IoT platform (OIoT) to create opportunistic communities for smart devices, which helped to create the opportunistic IoT communities between smart devices. Their results showed that OIoT platform presents that this platform is useful to share and manage the data across OIoT. Serrano *et al.* [84] analyzed the recent trends and opportunities on interoperability and support of data inter-operability between open service framework and information model. As a growing trend the data interoperate ability and linked data, challenge to manage the complex system operations in absence of interoperate ability.

Bao *et al.* [85], author designed a trust management protocol for community of dynamic interest based social IoT. Protocol is distributed, and nodes update other interested nodes in interaction events. Different nodes are arranged in the community in intra-CoI and Inter-CoI; results showed that Intra-CoI trust converges faster than the inter-CoI under same parameters. Trusted network protocol performance is also analyzed.

III. THE WORLD IN 2020 AND BEYOND

In this section, performance evaluation of different IoT applications is analyzed. Based on current results, we estimate the upcoming IoT influence on the life of user. The key word E shows the Expected year. As the growing trend of the IoT, interconnected devices will increase to billions. Through the analysis of different reports, we predict the number of connected devices in future. The statistical data obtained from [86] has been computed and presented in Table 1.

TABLE 1. Connected devices in billions.

Year	Devices connected in Billion
2013	8
2014	10
2015	13
2016	18
2017	23
2018E	28
2019E	33
2020E	38
2021E	43
2022E	48

It could be observed that if the number of connected devices continues to increase, more automated system will be in the different fields of life. IoT benefits different field, in business more appropriate strategic decisions will be taken to reach the competitive market benchmarks.

By taking average increment in the billions of devices per year we estimated that in 2022 there would be 48 Billion devices connected in the network. The Figure 3 explains Table 1 along with linear relationship. From 2013 to the 2022E shows devices connected with passage of time. As above give Table 1 predicts the connections up to 48 billion in 2022. The research gives us the expected value till 2016 by estimating the average increment of 5 billion per year we estimate 48 billion in 2022.

We analyze the latest trends of IoT through the latest blogs and highlight the public view about IoT in 2014-2015. As the fact and figures we depict the upcoming trends of society towards the IoT and its Social acceptance. Through different factors we conclude different results.

People start thinking about IoT [87], after some period of time its popularity will increase continuously. Table 2 shows the growing trend of IoT in society in accordance with some common aspects. Information mentions in Table 2 specify the awareness of people now and after some years, as per results shows that due to continue improvement in IoT environment the number of connections will increase.

According to the given data the increment in 2014-2015 is at different rates according to the awareness level. But some constant values depict the area where technology is far away to understand. The Line graph of Figure 4 shows the social behavior toward the IoT acceptance. Each line depicts year range from 2014-2022 and point shows the percentage value of the social awareness. As increase estimated awareness also increases the number of devices connected.

By estimating the results, we conclude that as the time pass and due to increase in benefits of IoT, society will increasingly accept it and soon everyone will be a part of smart world. The statistics shows that as per increase in the awareness of the IoT will increases and more and more people will be connected to each other. In the context of fact and figures, we estimate that as passage of time the connection of different business application will increase [88] and would provide continues growth in business. Result of the Table 3 shows the future trends of IoT in Business field. In Figure 5, we show the growth of business-to-business device connection in each year along with estimated values. In accordance with average increment of 0.7 during the year 2014-2015, authors already estimate the values till 2020. We estimated that in 2022 there would be 6.8 billion B2B connected devices. Automation in business turns the great profit and can easily address the customer around the world, but language compatibility in the system is necessary. Customers will be highly effected by the IoT services if it satisfied their needs [89], this shows that

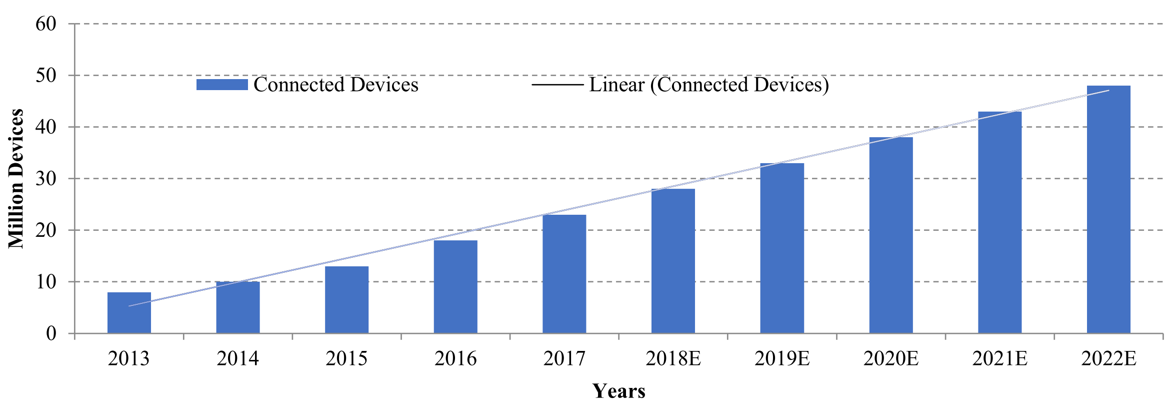

FIGURE 3. Annual increase in number of connected devices.

TABLE 2. Social acceptance of internet of things.

Social Aspect	2014	2015	2016	2017	2018E	2019E	2020E	2021E	2022E
Less Familiar to IoT	30%	14%	7%	3%	2%	2%	2%	2%	2%
Less Availability of IoT	23%	16%	9%	2%	2%	2%	2%	2%	2%
Currently Analyzing Benefits	20%	25%	30%	35%	40%	45%	50%	55%	60%
Will be Interested within year	8%	17%	26%	35%	44%	53%	62%	71%	80%
Current Implementation	7%	11%	15%	19%	23%	27%	31%	35%	39%
Interest in IoT	3%	5%	7%	9%	11%	13%	15%	17%	19%

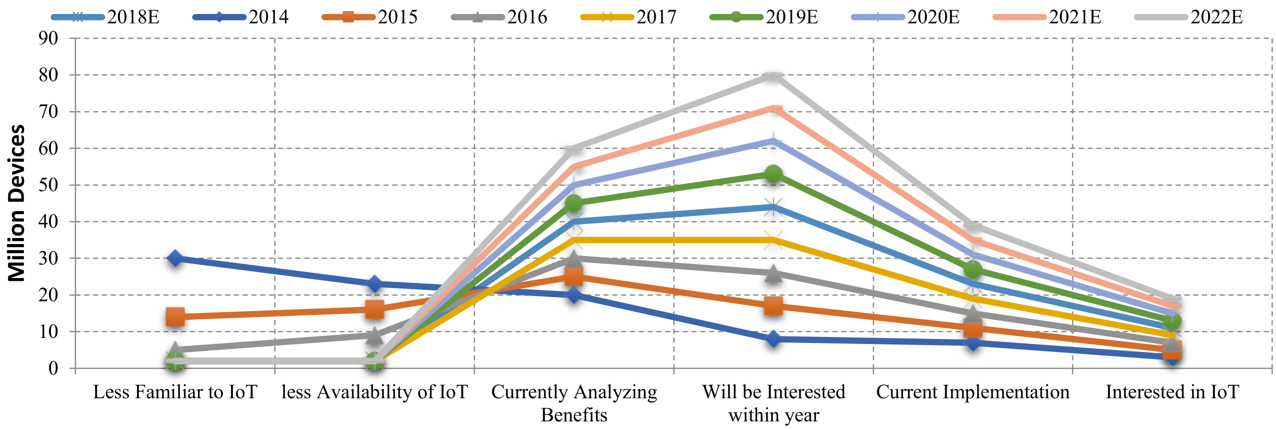

FIGURE 4. Important factors in social growth of IoT.

TABLE 3. Facebook trend.

Years	Social Networking Site	%
2012	Facebook	67
2013		71
2014		71
2015		72
2015		73
2016		75
2017		77
2018E		79
2019E		81
2020E		83
2021E		85
2022E		87

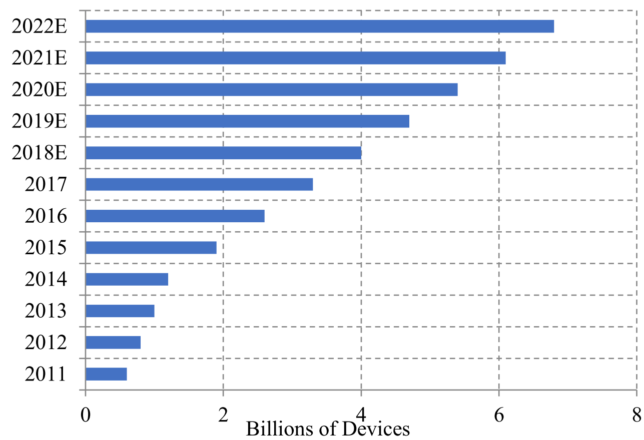

FIGURE 5. B2B increment trend.

customer will adopt the IoT services if enough information is given to them.

The statistical data obtained from [88] has been presented in Table 3 and Figure 5. It could be inferred that more automation will be achieved in 2022 and more than 6.8 billion devices will be connected. The automation in business will increase the accessibility of the product around the world. By analyzing the data, we can achieve the better strategic planning for the business progress and improved competitive analysis.

IoT not only influence the business field but also enhance the social connectivity of the people. The report [90] analyzes the results of half year so we use 2015mid as half year result and 2015end represent complete result of year. The latest research based on how more people are connected to one another. In near future, we can predict that more than 80% people will be connected [90].

By analyzing different social sites and their awareness in public, we plotted the figures, tables and estimated the future trends. Table 4 shows the half year estimated growth of face book user data of 2015; we can estimate that at the end

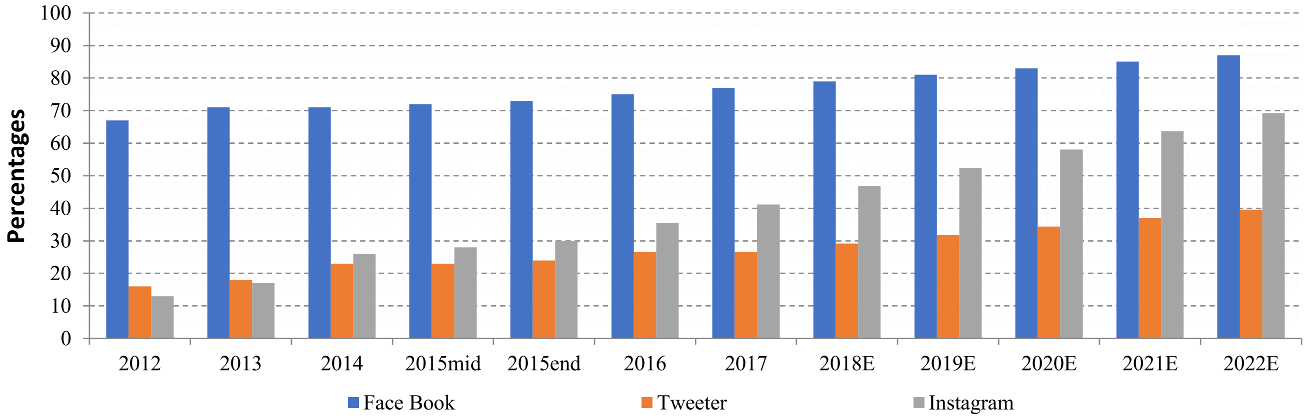

FIGURE 6. SIoT future trends in percentage.

TABLE 4. Twitter social trend.

Year	Social Networking Site	%
2012		16
2013		18
2014		23
2015		23
2016		24
2017	Twitter	26.6
2018E		29.2
2019E		31.8
2020E		34.4
2021E		37
2022E		39.6

of 2015 the growth will be 2%, by taking average increment value 2% from year 2013 to 2015end. We estimate the Face book user growth will be 2% per year, so according to this we can say that in 2022 the estimated usage will be 87% (as per estimations).

Instagram is also a famous social connection trend in society; people use it to share their media files. As per its current trend, almost 28% of the Internet users access it and use it. Table 4 shows the results of half year of 2015; the increment is 2%. We can estimate that at the end of the year it will reach till 4%. Then we take average growth rate of 2013-2015end, we estimate that average increase per year is 5.6%. So, we estimate that if increment level remains the same as 5.6% then in 2022 there will be 69.2% users, who use the Twitter as SIoT as a social connection.

Another revolutionary trend of social networking is Twitter, which is growing its popularity after the continue average. Table 6 shows the half year results of 2015. As the end of 2015 we can assume that it will grow to %. By taking average results of 2013 to 2015end, we estimate that its popularity is increasing at the average of 2.6%, so in 2022 it will cover almost 39.6% market of social connections. It could be concluded from the comparison provided in Table 4, 5 and 6 that in near future, the SIoT trend plotted in Figure 6.

TABLE 5. Instagram social use.

Year	Social Networking Site	%
2012		13
2013		17
2014		26
2015		28
2015		30
2016		35.6
2017	Instagram	41.2
2018E		46.8
2019E		52.4
2020E		58
2021E		63.6
2022E		69.2

TABLE 6. Current trends of IoT.

FIELDS	Current Trends (percent)
Business	29
Smart Homes	54
Connected Cars	11
Smart Cities	61
Smart health	4

In Smart Health, an automation system allows constant monitoring and instant medical aid in any critical situation. By using different apps in the Smart phones, it can help to prevent from the issues of health and monitoring devices can send updates to doctor through constantly observation of the patient's condition. But there must be mechanism, which ensure the patient's private information hidden from other and sometimes consistent observation and calculation and wearable devices disturbs the personal life of the effected person, and cause the mental disturbance and irritating behavior can arise.

As suggested in [91], author estimated values from 2015 till 2017E by assuming average increment in connected smart Health devices we estimated that in 2022 65.4 million devices will be connected. In Figure 7 the graph shows the continuous increasing trend of Smart health. In Smart Health system estimated average increment between 2016 and 2017 is 8.4 per year. We made assumptions on the basis of 2016-2017 that it is quite possible that growth rate will be the same for all predicted years. The authors in [91] estimate the growth till 2017.

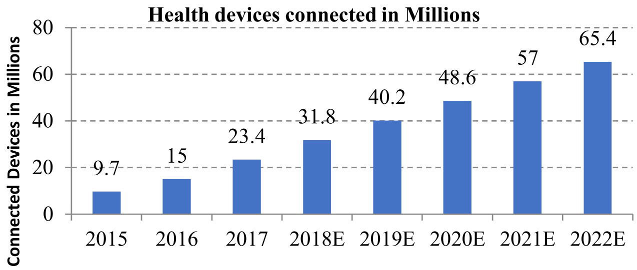

FIGURE 7. Health devices connected in billion.

In Smart Cities and Smart Communities, all the utilities and different kind of machines will be interconnected. For their incessant monitoring and controlling there must be proper and secure network, so that correct and real-time alert can be deliver in any case of emergency. But in other perspective some people objects the level of information sharing, because sometimes it may contain their personal or sensitive information, which they do not want to share. On the other hand too much ease in life can affect your mind capabilities and it can lead towards the different mental and physical sickness [92]. According to business point of view large scale user based and mature eco mobile system [93] has been established to facilitate the elder age health care system.

In Social Networking area, recent reports show that more or less 49% people of elderly age of 60+ are using different social sites to interact around the world. Low rates, better service, and many services providers create the addiction of smart phone use and social connectivity. This extreme connectivity leads towards the different crimes and different social tribulations.

Children at the age of 13-17 [94], [95] are using different social sites, which may contain the material which is not suitable for them, this kind of activities creates high level of depression and distraction them from their goals. According to the surveys some of the children took IoT as better tutor for themselves, from which they can learn about the world. We show the results in Figure 8 by using the data of Ref. [95], this survey includes 55.3% male participants and 44.7% female participants.

There should be check and balance imposed by the parents on the usage of social links and the activities of their children. These activities not only affect their mental health,

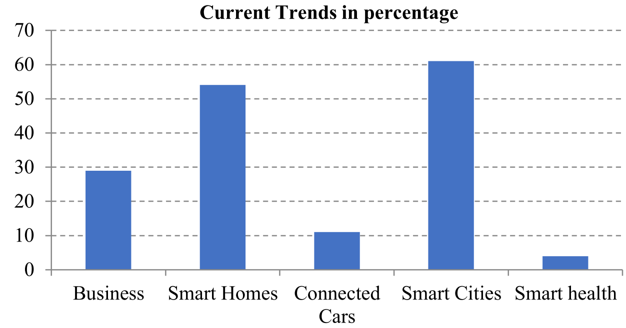

FIGURE 8. Current trends of IoT growth.

but they can also harm to others. We take data from different [94], [96], [97] surveys and provide an estimate percentage users in Figure 8 showing the SIoT influence in different age groups. All the data is already estimated by the authors.

Experts are predicting that in near future market will target IoT based smart devices that deliver efficient control and management of information. Information would be delivered to the user and device can be controlled through the remote locations. Market will launch smart hand-held devices and cool gadgets will attract the people.

According to the Figure 9 [98], [99], we estimate that the interconnected devices in year by taking average estimation from pre-define value. If device connection increases at same rate in 2020, there will be more the 9 Billion connections. The facilitation and new technology of controlling the utilities from remote locations will grab great market of appliances.

The developers are expecting to target the great market of the IoT by addressing the current hurdles and facilitating the user. As much the facilitation to the user the way and increment in real time but secure access to the user information will increase the market value of the products. By new technology IoT is expected to connect about 38 Billion devices, for facilitation of the user.

According to current trends [82] and technology huge market share is occupied by the huge share of the market. It enables user facilitation and accessibility to the smart world. Table 6 shows the social acceptance of IoT based applications and reliability on interconnection. Because of its reliability and ease in maintenance will attract more users to adopt this technology.

The increased awareness in the IoT, different companies are launching social apps [74], [81], [100], [101] as well as the apps that will help to configure the Smart automation system. The statistical data obtained from [81] has been estimated and plotted in Figure 10.

According to Figure 9, we explore that society is aware of IoT based automated system in different fields. Business applications provide better strategic polices, Smart homes provides automated environment. Connected smart cars, Variety of apps are available to control and maintain the information exchange between different devices. These devices are used to configure and control the smart environment and

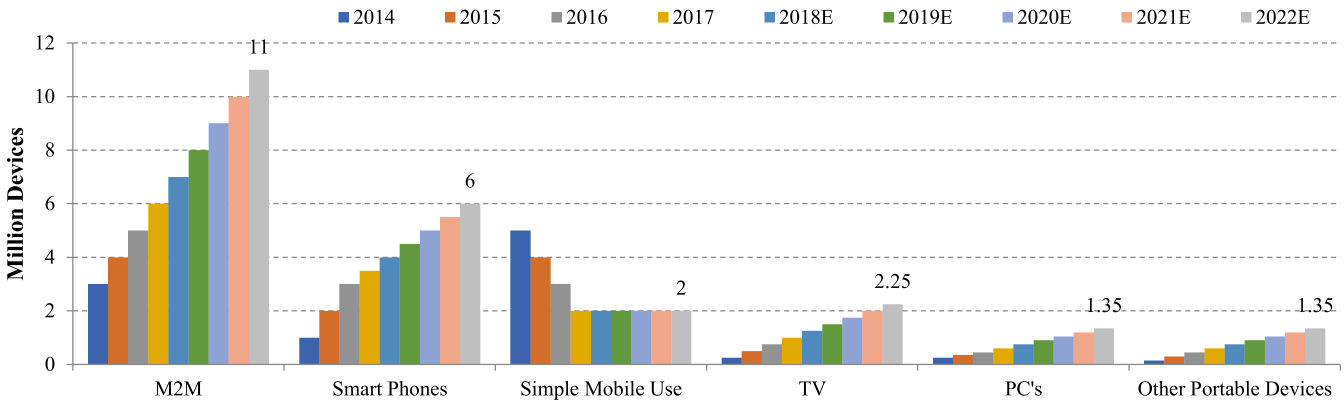

FIGURE 9. Different devices connection in billions.

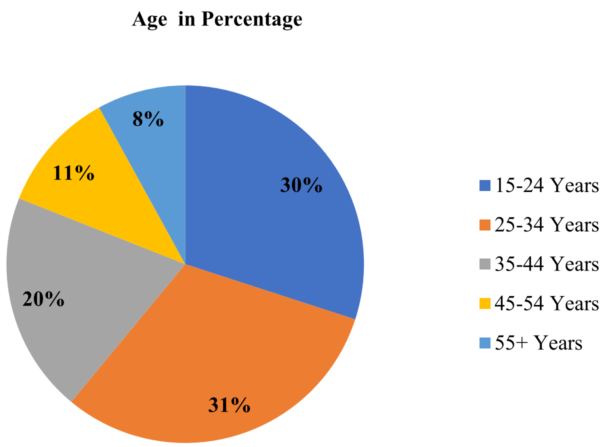

FIGURE 10. SIoT trends in different age groups.

applications facilitate this surrounding cities and smart health provides real time automation that uses the information and take appropriate action. As mention above Table 1 provides connected devices in environment, Table 3 provides precise social awareness rate increment and Table 3 provides the B2B connections according to years. Table 4, Table 5 and Table 6 presents the most popular social sites popularity rate in different years.

Due to SIoT, connectivity enhances the social connections and increment in connected devices will increase the social sites usage. According to Figure 8, we analyze the different age groups and provide the comprehensive calculations of their SIoT, using different parameters to estimates Social needs and how extensive use can cause high rate of social faults in the system. Figure 7 presents the health devices prediction and Figure 9 presents different device connections. The Table 7 and Figure 10 show the current five IoT application trends in percentage.

In Table 7 precisely analysis different researches and their proposed models/ methods. And protection, depression, mental sickness, backbone problem, nerve problems, weight problem and more problems like that. In results and discussion section IV, we summarize our findings that are defined in this section. We provide the over view of some of the predictions according to the year in Table. In Table 7, we describe different impacts of methods still proposed along with the challenges. If we overcome the most of issues and challenges IoT connectivity will be more reliable and results in more trust building factor. It will invite most users to get connected.

IV. RESULTS AND DISCUSSION

We estimated that as the number of devices increase, the social acceptance of IoT based systems also increase. And the increased use of its different application increases the reliability of the system and provides better SIoT for the user to get connected to the system any time anywhere.

By using Eight Tables of different fields, we analyzed the different aspects of IoT on social values and social behavior. We consider various parameters and values to prove our assumptions. Identifying different applications of IoT, we estimated its future trends and current social acceptance. In Table 1 and Figure 3, we predicted that the devices connected in the IoT will increase up to 48 billion devices in 2022. In business field, we identified that the number of connected business devices will increase in linear co-relation. Table 2 and Figure 5 show the linear increment in connections in the different years. There will be approx. 6.8 billion B2B devices which will be connected in 2022E. The more automated system will provide better strategic solutions and better business performance in current environment. IoT will increase the competition level in the market and help customer to access the product any, where anytime. But on other perspective, more revenue will be required to maintain and protect sensitive information from unauthorized access will be more critical [102]. If there comes a fault in the system, competitors can illegally access customer data base and can misuse it.

In home automation system, the devices are smartly connected to each other, and controlled through the central units. Currently more than 50% devices are connected to the system. In Figure 9, different daily used devices are

TABLE 7. Evaluation of IoT approaches.

Ref.	Methodology/Benefits	Challenges	Social Impact
[17]	Using proposed ontology-based system, quick construction of restoration system and the easy allotment of domain knowledge, which makes the system, perform admirable	For controlled large clinic studies, design methodology for feasible and convenient smart rehabilitation system, which will be featured with artificial intelligence.	Proposed an ontology-based automating design methodology for smart medicine and physical health system, to provide efficient and effective information sharing.
[56]	The paper suggests model for an IoT-based monitoring system for context aware services in smart homes using a tri-level context.	In the future IoT create more effect on life and new technologies will be implemented.	In home comfort systems, air conditioning, heating, lighting, and ventilation, doors and windows are automated and controlled by remote locations
[43]	The paper presents framework actuation of Smart Cities through the IoT, through the data management and cloud-based integration of respective system, forms a transformational part of cyber-physical system	Provides the blue print of Smart city development using IoT, it strongly motivates and demanded the provision of essential services and quality of life for city in habitants.	Smart city implementation will change the life of user and facilitate the daily activities.
[66]	The paper proposed the architecture to use hand held devices to use as a technology to share information in industry chain.	Still there need to have more specialized system and analysis.	Quality of food can easily be identified and supplied to the user. Increases the health awareness and opportunities to avoid unhealthy substance.
[36]	The paper gives us idea of IoT and its applications.	Did not analyse its possibilities and effects on life of user	Describe the applications of IoT and various directions. Social Acceptance of IoT.
[38]	The research replaces the less systematic approach OF SMART HOMES currently employed and benefit system from well-established domains of research of AI.	Trust and security is still an issue to resolve.	Smart homes provide many advantages to its inhabitants and satisfy user's extraordinary needs.
[45]	The paper presents the IoT business eco-system within 6C framework, it is much more complex network with different composed stakeholders to contribute in evaluating business eco-system	To confirm 6C framework more data and efforts are needed in future	6C framework is a benchmark system for the business eco system It helps to increase reliability.
[73]	PQ was developed in conjunction of city parks and non-profit organization that engaged citizens to maintain and use parks.	Trusted system, significant, critical Community engagement is needed and efficient improvement of infrastructure.	Increases the awareness in the people to utilize the resources efficiently.
[58]	In The paper user uses parking service using Id and password provided by the airport security, users check vehicles in parking through log in the website, efficient car parking service is implemented.	Barrios of Cyber security risks involved in cloud computing in real-time implementation.	User can examine the parking detail through cloud server, provides security to the vehicles.
[59]	In The paper, analyses the security and privacy risks in home automation system, and resolve through the cryptography and information manipulation system to protect user information to improve security and privacy.	In future network characterization techniques used for IoT, proposed analysis technique extends to perform protocol reverse engineering analysis of IoT architecture using captured binary traffic.	More secure system of home automation increases the reliability of the devices and information.
[69]	Research paper proposed a controlled environment in which the appliances are connected to each other, through which sensor data processed by single board computer and deliver to the mobile applications using wireless connections.	User security and privacy is issue in proposed prototype Proposed prototype is for small scale system.	Control appliances for real-time environment information sharing and analysis facilitate user.
[65]	The paper analyse the human centric perspective of IoT by analysing tight couple relationship between human and Opportunistic IoT of smart system.	Using pervasive sensing technique and social science will play role in IoT development in new stage of Social IoT.	Presents Social and Community Intelligent system.
[75]	The paper analyse the smart cities and Healthier cities, in which objects are connected through the sensors, control, collect and manage the data take actions on it.	Challenges of privacy and security should be overcome.	For the secure environment, the citizens should be educated and aware about the importance and benefits associated with smart cities.

connected to the IoT network. We explicitly predicted that there will be more than 11 billion devices connected to the network in 2022E. If there is problem is single device, it can affect other devices that are interconnected with it. Also, the automation cost and energy consumption will be increased tremendously, if we add more devices in the inter-connected network. It should be noted that IoT facilitate user and help to avoid any emergency situations such as fire or theft etc., but users should spend more money on it and need specialized environment to implement.

TABLE 8. IoT social acceptance.

Year	Social Aspects (Percent)						No. of Devices (Billions)	Social Networking Survey (Percent)			Health care Devices in (Billions)
	Less Familiarity	*Availability of IoT*	*Current Benefit Analysis*	*Will be Interested within year*	*Current Implementation*	*Interested in IoT*		*Faceb ook*	*Twitter*	*Instagram*	
2014	30	23	20	8	7	3	8	71	23	26	NA
2015	14	16	25	17	11	5	10	73	24	30	9.7
2016	7	9	30	26	15	7	13	75	26.6	35.6	15
2017	3	2	35	35	19	9	18	77	26.6	41.2	23.4
2018E	2	2	40	44	23	11	23	79	29.2	46.8	31.8
2019E	2	2	45	53	27	13	28	81	31.8	52.4	40.2
2020E	2	2	50	62	31	15	33	83	34.4	58	48.6
2021E	2	2	55	71	35	17	38	85	37	63.6	57
2022E	2	2	60	80	39	19	43	87	39.6	69.2	65.4

Smart cities and IoT communities provides better interconnected sensor system in which data is collected in real time environment. Figure 10 shows the current trend of IoT and facilitation in smart surroundings. In smart cities, IoT plays its role and after analyzing the data, appropriate actions are taken to track the accidents and offer help and recovery. Data deliver to the terminals on which action has been taken, but some people don't want to share their private information to others [103]. There may be chances that someone misuse data collected from a vehicle transmission unit of a car in a smart city [104].

Smart IoT Health system provides the doctor 24/7 monitoring and automated checkup details through smart medical devices. According to our estimations in Figure 7, 65.4 million devices will be connected in 2022. But in case of emergency IoT applications must respond instantly to the patient [92], and doctor should be able to access the patient history with no time delay. The emergency messages should be sent to the ambulance and to the hospital efficiently, so that patient could get medical help as soon as possible. Privacy and security issues of the patient's history is also a big question and smart devices also cost money.

IoT and smart phones, the most revolutionary application of IoT provides instant connectivity to the world. People from different ages use this facility to keep track of things; different apps help to control and monitor smart homes and facilitate mobile-heath and electronic-health through constant observation. By plotting Figure 8, we analyzed the current trends of SIoT in different age groups. Due to current trends of interconnectivity of devices, smart phone causes addiction of use in almost every age group. It not only costs our time but also leads society towards crimes and mental sickness. We summarized our contribution in Table 8 from year 2014-2022; the information before 2014 is available in Section III. The current trends of device connectivity about 13 billion to the average increment rate of 4 billion per year, we estimated that in 2022, more than 48 billion devices will be connected. Social acceptance of smart health will be increased and will reach up to 65.4 billion in 2022. As increment in connected environment, there is also social awareness increment and acceptance in the society and estimated Smart health devices.

Figure 8 represents the social activities of different age groups. We also analyzed, use of smart phones in socializing in different age groups. The pie graph shows the growing trend of social awareness among different age groups. We estimated all these factors according to the ages in one graph. Table 7, consist of different references to the studies along with their social impacts that helps the users to analyze the trends of work in IoT range from 2011-2015. We also conclude the proposed solutions' effect on society and its benefits to the market. Social impacts also imply the improvement criteria in different aspects.

In this paper, we analyzed the research papers which has been published in 2011-2015. We explored IoT trends in different years. Few blogs and web links are also used to compute graphical data. We have estimated the future trends in business, connected devices, smart health, connected smart devices and social networking up to the year 2022. We also analyzed the cost paid for the smart-homes and its future directions. Through smart phones and social analysis, we also predicted some negatives social impacts on the society. We believe this paper contributes in the current research estimations. It also clearly defines social aspects of IoT and evaluates its issues and analyzes future challenges. This research helps researchers to overcome the negative effects of smart world. We summarize the different models provided for IoT which will help in future improvements in the Smart Systems.

V. CONCLUSION

In a CAN, the nodes are dynamically connected and adopt changes from the environment. This change in one node affects the whole network in which agents are interconnected. In this paper, we initially explored the design constraint of the CAN and provided different examples of the CAN. IoT is one of the specialized forms of a CAN where the number of devices, variations in the nature of the agents and sensitivity of the data adds more complexity to its existing structure. IoT applications are capable of handling various objects and their occurrence of things to achieve common goals. Devices obtain desired information through known interfaces such as connected networks. It puts great effect on the social connectivity and management of things.

There are numerous benefits that the IoT will bring to the society. Many improvements in health, medical, automobiles and housing sectors are expected. However, it should be noted that connecting everything with every other thing can also place some negative impacts in the lives, for example, being very much dependent on the technology can move humans away from each other. There must be check and balance of the contents being visited by the different age groups. IoT needs time and place sensitive traffic so it needs continuous signaling between devices, needs authorization and encryption of data for secure communication [105]. The sensors also need to record state and power consumption of the devices. If most of the communications are going to be performed by things, what will humans do? We analyzed and explained the previous research in the IoT in the last five years. We provided a vision of the world in the years 2022 and beyond. Specifically, we discussed positive and negative effects on the society. 24-hour IoT connectivity can cause mental sickness and leads toward evil social behavior. This needs a clear planning and understanding of implications of IoT. We specify different area of improvement in Table VIII; they can be use as the future work. In future, we plan to develop the more secure model for IoT based connected Home devices.

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AYESHA SIDDIQA received the B.Sc. and M.Sc. degrees in computer science from COMSATS University Islamabad, Pakistan, in 2015 and 2017, respectively. Her M. Sc. dissertation topic is based on social aspects and acceptance of Internet of Things. Her research interests include security risks and threats in smart devices, ethical hacking, information security, Internet of Things, and machine learning.

MUNAM ALI SHAH received the B.Sc. and M.Sc. degrees in computer science from the University of Peshawar, Pakistan, in 2001 and 2003, respectively, the M.S. degree in security technologies and applications from the University of Surrey, U.K., in 2010, and the Ph.D. degree from the University of Bedfordshire, U.K., in 2013. Since 2004, he has been a Lecturer, Department of Computer Science, COMSATS Institute of Information Technology, Islamabad, Pakistan. His research interests include MAC protocol design, QoS, and security issues in wireless communication systems. He received the Best Paper Award of the International Conference on Automation and Computing in 2012. He is the author of over 50 research articles published in international conferences and journals.

HASAN ALI KHATTAK received the B.Sc. degree in computer science from the University of Peshawar, Peshawar, Pakistan, in 2006, the master's degree in information engineering from the Politecnico di Torino, Turin, Italy, in 2011, and the Ph.D. degree in electrical and computer engineering degree from the Politecnico di Bari, Bari, Italy, in 2015. He has been serving as an Assistant Professor of computer science since 2016. His current research interests focus on distributed system, Web of Things and vehicular ad hoc networks, and data and social engineering for smart cities. He is involved in a number of funded research projects in Internet of Things, semantic Web, and fog computing while exploring ontologies, Web technologies using Contiki OS, NS 2/3, and Omnet++ frameworks.

ADNAN AKHUNZADA is currently an Assistant Professor and Incharge Program (software engineering and telecommunication networks) with COMSATS University, Islamabad, Pakistan. He got a great experience of teaching international modules and a renowned member of several research communities. He has published several high impact research journals, IEEE TRANSACTIONS, highly reputable magazines, book chapter, and conference papers. His current research interests include secure dependable software-defined networks, light weight cryptography, man-at-the-end attacks, human attacker attribution profiling, remote data auditing, and modeling secure software-defined smart cities.

IHSAN ALI received the M.Sc. degree from Hazara University Manshera, Pakistan, in 2005, and the M.S. degree in computer system engineering from the GIK Institute in 2008. He is currently pursuing the Ph.D. degree with the Faculty of Computer Science and Information Technology, University of Malaya. He has over five years teaching and research experience in different countries, including Saudi Arabia, USA, Pakistan, and Malaysia. His research interests include wireless sensor networks, underwater sensor network, sensor cloud, fog computing, and IOT. He has served as a Technical Program Committee Member for the IWCMC 2017, AINIS 2017, and Future 5V 2017, and also an Organizer of the special session on fog computing in Future 5V 2017. He has published over 10 articles in international journals and conference proceedings. He is also a Reviewer of *Computers & Electrical Engineering*, the *KSII Transactions on Internet and Information Systems, Mobile Networks and Applications*, the *International Journal of Distributed Sensor Networks*, the IEEE TRANSACTIONS ON INTELLIGENT TRANSPORTATION SYSTEMS, *Computer Networks*, the IEEE ACCESS, and the *IEEE Communication Magazine*.

ZAIDI BIN RAZAK received the bachelor's degree in computer science, the master's degree, and the Ph.D. degree in image processing particularly in Jawi character recognition from the University of Malaya in 1997, 2000, and 2006, respectively. In the University of Malaya, he taught a wide range of Computer Science subjects, ranging from the basics of programming to advanced computer architectures at master level. Besides, he also supervised a number of master's and Ph.D. students as part of his obligation as a Lecturer. In 2017, he joined the Sarawak State Government (seconded) and was tasked to plan, manage, and monitor the needs of IT resources state wide. He was the Chief of the Secretariat to the Sarawak's Digital Economy Initiative and simultaneously and was also tasked with the establishment of the Sarawak Multimedia Authority. He currently serves as the General Manager of the Sarawak Multimedia Authority which oversees Sarawak's digital economy initiatives.

ABDULLAH GANI (SM'00) received the Teaching Certificate from the Kinta Teaching College, Ipoh, the Diploma degree in computer science from ITM, the B.Phil. degree from the University of Hull, U.K., and the M.Sc. degree in information management and the Ph.D. degree in computer science from The University of Sheffield, U.K. He is currently a Professor with the Department of Computer System and Technology, Faculty of Computer Science and Information Technology, University of Malaya, Malaysia. He has vast teaching experience due to having worked in a number of educational institutions locally and abroad schools, the Malay Women Teaching College, Melaka, Ministry of Education, the Rotterham College of Technology and Art, Rotterham, U.K., The University of Sheffield. Internationally, he serves as a Visiting Professor with the King Saud University, Saudi Arabia, an Adjunct Professor with the COMSATS Institute of Information Technology, Islamabad, Pakistan. Locally, he was a Visiting Professor with University Malaysia Sabah, Kota Kinabalu, Sabah, Malaysia, from 2015 to 2017. He served as the Chairman of Industry Advisory Panel for the Research Degree Program at UNITEN, Malaysia, from 2015 to 2017. His interest in research kicked off in 1983 when he was chosen to attend the three-month scientific research course in RECSAM by the Ministry of Education, Malaysia. Since then, over 150 academic papers have been published in proceedings and respectable journals internationally within top 10 percent ranking. He received a very good number of citation in Web of Science as well as Scopus databases. He actively supervises numerous students at all level of study bachelor, master, and Ph.D. His areas of interest are in research includes self-organized systems, machine learning, reinforcement learning, and wireless related networks. He is currently working on mobile cloud computing with the high impact research grant of USD 800 000 (RM2.5) for the period of 2011–2016. He is also the Principal Investigator of the research Al-Quran and Hadith Authentication Systems with the grant of RM650,000. He has received several grants of over RM350,000. He is currently the Director of the Centre for Mobile Cloud Computing Research, which focuses on high impact research. The Centre has published over 60 papers in Tier 1 and Tier 2 ISI-indexed journals in the last five years. He currently serves as a Reviewer to several high-quality journals, and the Chief-in-Editor of the *Malaysian Journal of Computer Science*, ISI-indexed journal. He was elected as a fellow Academy of Sciences Malaysia for engineering and computer science discipline.