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Research Article

ElectricVehicles And Internet Of Things Enabled In Smart Cities: A Review

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Abstract:

This review paper examines the integration of Electric Vehicles (EVs) and the Internet of Things (IoT) in the context of smart cities. The coalescence of these technologies holds immense promise for sustainable urban development, energy efficiency, and enhanced quality of life. Through an exhaustive analysis of existing literature, case studies, and technological advancements, this review aims to provide a holistic overview of the current state, challenges, and future prospects of deploying EVs and IoT in smart city environments.

Keywords: IoT,Electrical Vehicles(EVs), Vehicle-to-Grid (V2G) Integration, Traffic Management and Air Quality Monitoring.

1. Introduction:

In the relentless pursuit of sustainable urban development and enhanced quality of life, the convergence of Electric Vehicles (EVs) and the Internet of Things (IoT) has emerged as a paradigm-shifting force in the realm of smart cities. As cities grapple with the challenges posed by rapid urbanization, climate change, and the need for efficient and eco-friendly transportation, the integration of EVs and IoT technologies presents a compelling solution to revolutionize urban mobility and infrastructure.

Electric Vehicles, propelled by advancements in battery technology and a growing global commitment to reduce carbon emissions, have transcended from niche alternatives to mainstream transportation options. The allure of zero-emission vehicles has spurred a monumental shift towards the electrification of transportation fleets, promising to alleviate environmental concerns and reduce reliance on traditional fossil fuels.

Simultaneously, the Internet of Things, characterized by interconnected devices and sensors facilitating seamless data exchange, has permeated various aspects of our lives. In the context of smart cities, IoT acts as the nervous system, interlinking diverse elements such as transportation, energy, and public services to create an intelligent and responsive urban environment. The amalgamation of EVs and IoT not only addresses the pressing issues of energy efficiency and environmental sustainability but also lays the foundation for the creation of truly smart and interconnected urban spaces.

This synergistic integration holds the potential to transform the urban landscape in several key areas:

Smart Charging Infrastructure: IoT-enabled charging stations can dynamically manage energy loads, optimize charging schedules, and integrate renewable energy sources, contributing to a more

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sustainable and efficient EV charging ecosystem.

Vehicle-to-Grid (V2G) Communication: The bidirectional communication facilitated by IoT empowers EVs to not only draw energy from the grid but also feed excess energy back, contributing to grid stability and supporting the integration of renewable energy.

Fleet Management and Optimization: Real-time data from IoT sensors in EVs enable predictive maintenance, route optimization, and efficient fleet management, enhancing operational efficiency and reducing costs.

Traffic Management and Air Quality Monitoring: Through IoT, EVs become integral components of a dynamic traffic management system, providing real-time data on traffic conditions. Additionally, IoT sensors in EVs contribute to air quality monitoring, aiding in the pursuit of cleaner urban air.

User Experience and Convenience: IoT technologies enhance the overall user experience for EV owners by providing seamless connectivity, enabling remote monitoring, and offering personalized services through mobile applications.

However, this integration also brings forth challenges, including cybersecurity concerns, data privacy issues, and the need for robust standards. This paper seeks to delve into the intricate web of opportunities and challenges presented by the integration of Electric Vehicles and the Internet of Things in smart cities, providing a comprehensive understanding of the transformative potential that lies ahead. Through a critical examination of existing literature, case studies, and technological advancements, we aim to pave the way for a sustainable and interconnected urban future.

Because of the rapid rise of the population density inside urban environments, substructures and services have been needed to supply the requirements of the citizens. Accordingly, there has been a remarkable growth of digital devices, such as sensors, actuators, smartphones and smart appliances which drive to vast commercial objectives of the Internet of Things (IoT), because it is possible to interconnect all devices and create communications between them through the Internet [1]. In the past, it was difficult or even impossible to combine these digital devices. Likewise, gathering their information for day-to-day management of activities and long-term development planning in the city is essential. For example, some public transport information, e.g., real-time location and utilization, occupancy of parking spaces, traffic jams, and other data like weather conditions, air and noise pollution status, water contamination, energy consumption, etc. should be gathered continuously. To this end, different technologies have been applied to address the specific features of each application. The required technologies cover a wide range and layer from the physical level to the data and application layers. One of these technologies, proposed in [2], considered a two-way relay network with an orthogonal frequency division multiple accesses to achieve higher efficiency in smart grid communications.

The IoT archetype is in the power of smart and self-configuring devices which are well linked together by global grid infrastructures. IoT can be typically defined as a real object, largely dispersed, with low storage capabilities and processing capacities, while aiming at enhancing reliability, performance and security of the smart cities as well as their infrastructure [3]. On this basis, in the present paper, a survey of the IoT-based smart cities information from related reports is conducted.

The IoT consists of three layers, including the perception layer, the network layer, and the application layer, as shown in Figure 1. The perception layer includes a group of Internet-enabled devices that are able to perceive, detect objects, gather information, and exchange information with other devices through the Internet communication networks. Radio Frequency Identification

Devices (RFID), cameras, sensors, Global Positioning Systems (GPS) are some examples of perception layer devices. Forwarding data from the perception layer to the application layer under the constraints of devices' capabilities, network limitation and the applications' constraints is the task of the network layer. IoT systems use a combination of short-range networks communication technologies such as Bluetooth and ZigBee which are used to carry the information from perception devices to a nearby gateway based on the capabilities of the communicating parties [4]. Internet technologies such as WiFi, 2G, 3G, 4G, and Power Line Communication (PLC) carry the information over long distances based on the application. Since applications aim to create smart homes, smart cities, power system monitoring, demand-side energy management, coordination of distributed power storage, and integration of renewable energy generators, the last layer which is the application layer, is where the information is received and processed. Accordingly, we are able to design better power distribution and management strategies [5].

2. EXISTING LITERATURE

Motivations

The smart city is becoming smarter than in the past as a result of the current expansion of digital technologies. Smart cities consist of various kinds of electronic equipment applied by some applications, such as cameras in a monitoring system, sensors in a transportation system, and so on. Furthermore, utilization of individual mobile equipment can be spread. Hence, with taking the heterogeneous environment into account, various terms, like characteristic of objects, participants, motivations and security policies would be studied [6]. Reference [7] presented some of the key features of potential smart cities in 2020. Smart citizens, smart energy, smart buildings, smart mobility, smart technology, smart healthcare, smart infrastructure, smart governance and education and finally smart security are the aspects of smart cities. The features of a smart city are shown in
As of my last knowledge update in January 2022, I can provide you with an overview of the general topics and areas covered in existing literature on the integration of Electric Vehicles (EVs) and the Internet of Things (IoT) in smart cities. Keep in mind that the field of EVs, IoT, and smart cities is dynamic, and new research may have been published since then. In an IoT environment, devices can be aggregated according to their geographical position and also assessed by applying analyzing systems. Sensor services for gathering specific data are utilized with some ongoing projects regarding the monitoring of each cyclist, vehicle, parking lot and so forth. There have been a lot of service domain applications which utilize an IoT substructure to simplify operations in air and noise pollution control, the movement of cars, as well as surveillance and supervision systems.

The developments on the Internet provide a substructure that enables a lot of persons to interlink with each other. The following development on the Internet may make it more applicable to arrange proper interlinks between objects. In 2011, the number of interconnected things was far higher than the amount of population [8]. Figure 3 shows the interconnection among the various objects based on the IoT [8]. Consequently, providing IoT improves cities and affects the different features of humans' life by creating cost-effective municipal services, enhancing public transformation, reducing traffic congestion, keeping citizens safe and healthier. Moreover, it plays a vital role in the national level associated with policy making (e.g., energy conservation and pollution reduction), monitoring systems, and needed infrastructures. Thus, it helps to supply a system with more efficiency, lower cost and more secure operation through energy conservation rules, economic attention as well as reliability level

2.1 IoT Technologies for Smart Cities

The IoT is a broadband network which employs standard communication protocols [9,10], whereas the Internet would be its convergence point. The major notion of the IoT is the widespread existence of objects which are able to be measured and inferred, as well as it is able to modify the situation. Accordingly, IoT is empowered by the expansion of several things and communication equipment. Things in the IoT involve smart equipment such as mobile phones and other facilities including foodstuff, appliances and landmarks [11,12] that can collaborate to achieve a joint objective. The main characteristic of the IoT is its effect on consumers´ life [7]. In the concept of IoT, since the cabling cost for millions of sensors is expensive, the communication between sensors should be wireless. Low-power standard communication is suitable for interconnection among many devices. According to location and distance coverage, some networks are introduced as follows.

Home Area Networks (HAN) which use short-range standards like, ZigBee, Dash7, and Wi-Fi. All monitoring and control components in a home are connected by the HAN.

Wide Area Networks (WAN), provide communication between customers and distribution utilities which require much broader coverage than HAN and for implementation needs fiber cable or broadband wireless like 3G and LTE.

Field Area Networks, which are used for connection between customers and substations [5].

In IoT, two tasks, including sensing and processing the data, are performed, but they are not unified from a wireless sensor network (WSN) viewpoint. The unified solutions are Speakthing and iOBridge. Speakthing is an analytics IoT platform for gathering, visualizing and analyzing the live data in the cloud and you are able to analyze the data by MATLAB coding. In contrast, iOBridge has its own hardware modules that are connected to the cloud which can be accessed by web interfaces and collected data can be aggregated to other web services. It is noteworthy that cloud is very important in smart cities for data storage and processing. The IoT-related technology is explained in this section.

2.2. Radio-Frequency Identification (RFID)

RFID including readers and tags has a vital task in the framework of the IoT. Employing the technologies on each related thing, accomplishing their automatic identification and dedicating the single digital identity to any of the things will be possible, to include the network associated with the digital information and services [13]. RFID provides some applications in smart grids, including tracking and localization of objects, healthcare applications, parking lots and asset management. Each tag can be as a sensor because they have not only data which is written manually but also capture data like environmental information.

2.3. Near Field Communication (NFC)

Near Field Communication (NFC) is used for bidirectional short distance communication, especially in smart-phones. This range usually involves a centimeter range. The application of NFC in smartphones enables us to use it in smart cities, as well. One of its applications includes using smartphones with NFC as a wallet which enables us to use smartphones as our personal cards such as bank card, identification card, public transportation card, access control cards. Moreover, since NFC is bi-directional, it can be used to share data between devices, multimedia, and documents [5]. By placing NFC at a strategic position at the house and providing an interface with the central controller, it is possible to change the status of objects by checking the location for example switch on the Wi-Fi when the user comes home.

2.4. Low Rate Wireless Personal Area Network (LWPAN)

LWPAN is amongst short-range radio technology, that covers large distances of up to 10–15 km. The energy consumption of this technology is extremely low and battery lifetime is about 10 years [2]. According to the IEEE 802.15.4 standard, it provides low cost and low-rate communication for sensor networks. It has the lowest two layers of protocols including physical and medium access level, besides upper layers protocols including 6LoWPAN and ZigBee [14].

2.4.1. ZigBee

In the sensor nodes, ZigBee is applied as a low-power and low-cost wireless communication technology [5]. It is based on the IEEE 802.15.4 standard and is suitable for creating wireless personal area networks (WPAN) such as home automation, medical device collection and other low-power, low-bandwidth. Some of its applications include wireless light switches, electrical meters, and traffic management systems. ZigBee is suitable for limited ranges, coverage of city region and supporting billions of devices. With the ZigBee-based network, a mechanism for transmission of IPv6 packets is specified. To apply ZigBee, additional equipment usually is required involving a coordinator, router and ZigBee end-devices.

2.4.2. 6LoWPAN

The 6LoWPAN standard is specified to adapt IPv6 communication. Over the time, IPv4 which was the leading addressing technology supported by Internet hosts has been replaced by IPv6 due to the exhaustion of its address blocks and the inability to separately address billions of nodes which is a characteristic of IoT networks. IPv6 by providing 128-bit addresses solves the lack of enough nodes for IoT networks, but it creates another problem however, which is compatibility with constrained nodes. This problem is addressed by 6LoWPAN which is the compression format for IPv6 [15].

2.5. Wireless Sensor Networks (WSNs)

WSNs make diverse proper data available and might be applied in lots of uses like healthcare, as well as government and environmental services [12]. Moreover, WSNs can be aggregated with RFIDs to obtain several targets such as gaining data related to the position of people and objects, movement, temperatures, etc. A WSN consists of wireless sensor nodes which include a radio interface, an analog-to-digital converter (ADC), multiple sensors, memory and a power supply [5]. The different parts of a wireless sensor node are illustrated in Figure 4. According to the wireless sensor node framework, it includes various kinds of sensors which measure data in analog format which are converted to digital data through an ADC. Some procedures are processed on the data through a memory and microcontroller according to data requirements. Finally, data are transmitted by a radio interface. All of this equipment needs to be equipped with a power supply.

Energies 10 00421 g004 550Figure 4. The architecture of a wireless sensor node.

A completed WSN is an extremely tiny low-power, low-cost sensor node which can be applied in any environment and works continuously for a few years. In reality, this utopic WSN has not been realized. WSN has severe source constraints like reliance on battery life. With a large number of sensor nodes in smart cities, replacing or recharging their batteries is infeasible. Designing a protocol for sophisticated power management schemes like solar panels is essential for WSN power sources.

2.6. Dash7

Dash 7 is a promising standard for WSNs used in long distance and low power sensing applications such as building automation and logistics. This protocol is for kilometer-distance range and operates at 433 MHz which not only has better penetration through walls than 2.7 GHz but is also appealing for HANs. It is worth noticing that Dash is very attractive in military application especially substation construction. Some of its applications are hazardous material monitoring, manufacturing and warehouse optimizations and smart meter development [16].

2.8 3G and Long Term Evolution (LTE)

3G and LTE are standards for wireless communication for mobile phones and data terminals. Regarding the development and expansion of wireless communication infrastructures, LTE and 3G are available everywhere, even in third world countries. This technology is for broadband connectivity and was not designed for short range uses. Hence, it is applied for WANs which require longer distance ranges. Nevertheless, there are some barriers to their implementation that should be addressed. High data cost due to providing this service by the service providers, and inability to use them for communication among billion devices are some of the problems of these services.

2.9. Addressing

The Internet empowers a significant interconnection among persons, and similarly, the current tendency in the IoT creates an interconnection of things and stuff, for providing smart environments [8]. For this purpose, the ability of exclusively identifying devices and things is essential for desirable results of the IoT. The reason behind this is the fact that exclusively addressing the large-scale mixture of things is crucial to control them through the Internet. Besides the expressed exclusivity idea, reliability, scalability and strength indicate the main needs to establish an improved unique addressing structure [8].

2.10. Middleware

Due to several concerns regarding the heterogeneity of contributing objects, to the limited storage and processability, along with to the huge different kinds of application, the middleware has a vital task in the interconnection of the things to the applications' layers. The main target of the middleware is to briefly aggregate the functionality and communication abilities of all included devices.

2.9. Smart Cities Platforms and Standards

The relationship between the physical and IT infrastructure constructs a novel machine-to-machine (M2M) communication for smart cities which along with new features of network drives smart cities' communication platforms. These platforms help to cover the communication requirements between heterogenous access technologies and application suppliers. Moreover, these platforms help form the IoT with real world sensors and communication networks. One of these platforms which is being used widely is openMTC extracted from the latest ETSI standards for the smartM2M specification. The aim of the openMTC platform is to provide a compliant middleware platform for M2M applications and implementation of the smart city [17].

As introduced earlier, the main standard for smart cities is IEEE 802.15 which is for wireless personal area networks. This standard consists of different parts including: 1—Bluetooth, 2—coexistence, 3—high rate WPAN, 4—low rate WPAN, 5—mesh networking, 6—body area networks, 7—visible light communication, 8—peer aware communication, 9—key management protocol, 10—layer 2 routing, 11—wireless next generation standing committee [18].

Smart Charging Infrastructure:

Research often explores the design and implementation of intelligent charging infrastructure for EVs within smart cities.

Topics include dynamic pricing mechanisms, load balancing, and the integration of renewable energy sources into the charging grid.

Vehicle-to-Grid (V2G) Integration:

Literature discusses the bidirectional communication between EVs and the power grid, exploring the potential of V2G for grid stability, energy balancing, and demand response.

Studies often evaluate the economic and environmental implications of V2G integration.

Fleet Management and Optimization:

Existing literature delves into the use of IoT for real-time monitoring of EV fleets, predictive maintenance, and route optimization.

Case studies may focus on the operational benefits and cost savings achieved through effective fleet management.

Traffic Management and Air Quality Monitoring:

Research explores how IoT sensors in EVs and throughout the urban environment contribute to

real-time traffic management and air quality monitoring.
Studies may assess the impact on congestion reduction, efficient traffic flow, and improvements in air quality.

User Experience and Convenience:

Literature often discusses the role of IoT in enhancing the user experience for EV owners, including mobile applications for remote monitoring, scheduling charging sessions, and accessing real-time data.

Security and Privacy Concerns:

Research addresses the potential risks associated with the widespread deployment of IoT in EVs, focusing on cybersecurity, data privacy, and strategies for mitigating vulnerabilities.
Policy and Regulatory Frameworks:
Some literature examines the role of government policies and regulations in fostering the integration of EVs and IoT in smart cities. This includes incentives, standards development, and regulatory frameworks to support the transition.
Case Studies and Implementation Strategies:
Existing literature often includes case studies of cities or regions that have successfully implemented EV and IoT integration into their urban infrastructure. These studies provide insights into best practices, challenges faced, and lessons learned. Fig1: IoT potential for the smart cities

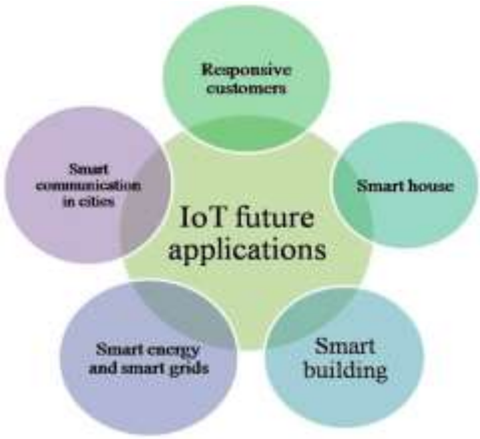

Fig1: IoT potential for the smart cities

3.Challenges

This section presents the current challenges for the implementation of IoT-based smart cities. Different IoT challenges for smart grids are demonstrated in **Fig** 2 and the expression of each one is as follows:

Figure 2. IoT challenges for smart cities.

3.1. Security and Privacy

When all the information is gathered and evaluated in the same IoT platform, the system may confront numerous attacks such as cross-site scripting, and side-channels. Moreover, the system can be subjected to significant vulnerabilities. In addition, its multi-tenancy may lead to the security problems as well and result in data leakage [3]. Therefore, cities must adopt serious measures to ensure the privacy and security of citizen data. Without this guarantee, citizens cannot trust to government, and the colection of the information will be difficult. All systems should be resistant against cyber-attacks, particularly the critical infrastructure like smart meters. As a result, for successful implementation of IoT, cities should place privacy and security as a top priority. In Figure 3, some aspects of security in IoT including privacy, trust and data confidentiality as well as their solutions are presented.

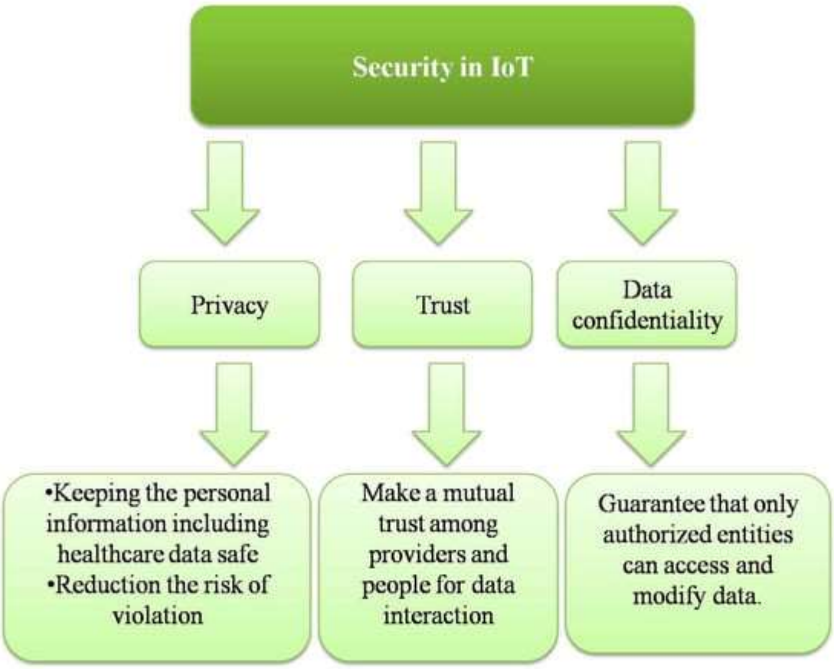

Figure 3. Security aspects in IoT.

3.2. Heterogeneity

IoT systems have usually developed with specific and notable solutions in which each element of the system is joined to the special application context. On this basis, the authorities have to examine their goal scenarios, define the needed hardware/software and afterward aggregate these heterogeneous subsystems. Providing such substructures and the procurement of a proper cooperating scheme among them is indeed a major challenging mission for IoT systems.

3.3. Reliability

IoT-based systems cause some reliability problems. For example, due to cars' mobility, the interconnection among them is not very reliable. Moreover, the participation of huge numbers of smart technologies would lead to some reliability challenges, particularly regarding their failure [74].

3.4. Large Scale

A number of defined scenarios need interactions among the enormous amount of distributed devices that are likely to be embedded in a wide area environment. The IoT system provides a proper platform which is able to analyze and aggregate information extracted from various devices [3,67,68,74,75,76,77,78]. However, this large-scale data needs proper storage and computational ability because it is gathered at high rates that lead to the usual challenges to be more difficult to cope with. In addition, the distribution of the IoT devices can influence the monitoring actions, since the devices have to deal with delays related to dynamics and connectivity.

3.5. Legal and Social Aspects

The IoT system likely is a service according to the user-provided data. For such terms, the service providers have to be based on various local and international rules. Likewise, the applicants are faced with sufficient incentives to attend a specified scenario and data gathering. It would be more comfortable if the opportunity were given to the applicants to choose and participate in the registration information that indicates an event [78]. Reference [79] handled the subject of systems that include people.

4.Conclusions, Remarks and Future Trends

The importance of considering how new concepts and technologies (especially the IoT) benefit smart cities is undeniable. The aim of this review article was to explore variant specifications and features of IoT systems, along with the efficient incentives for utilizing them. Because the accomplishment of the IoT substructures can enable a volume of opportunities for smart cities, first, the most important research motivations were expressed and afterward, several main and helpful applications explained. It was illustrated how daily activities could be extended and improved through employing them. Likewise, the challenges arising from implementing the IoT system were accordingly outlined. On this subject, the incorporation of the IoT platform into other independent and smart systems to provide an intelligent and widespread utilization is one of the most interesting future tendencies. Moreover, providing a methodology to cope with some important challenges, such as the privacy rights of the users/residents, is still an area of research interest. Some of the developments in the actual implementation of smart cities across the world were presented, which can be considered as samples or pilot projects for future comprehensive smart cities. The IoT through its functionality and specifications should indeed employ smart systems and sensors to ensure residents' rights.

Author Contributions

All authors have worked on this manuscript together and all authors have read and approved the final manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

References

1. Rathore, M.M.; Ahmad, A.; Paul, A.; Rho, S. Urban planning and building smart cities based on the Internet of Things using Big Data analytics. *Comput. Netw.* 2016, *101*, 63–80. [Google Scholar] [CrossRef]
2. Zhu, C.; Leung, V.C.M.; Shu, L.; Ngai, E.C.H. Green Internet of Things for Smart World. *IEEE Access* 2015, *3*, 2151–2162. [Google Scholar] [CrossRef]
3. Botta, A.; de Donato, W.; Persico, V.; Pescapé, A. Integration of Cloud computing and Internet of Things: A survey. *Future Gener. Comput. Syst.* 2016, *56*, 684–700. [Google Scholar] [CrossRef]
4. Jaradat, M.; Jarrah, M.; Bousselham, A.; Jararweh, Y.; Al-Ayyoub, M. The Internet of Energy: Smart Sensor Networks and Big Data Management for Smart Grid. *Procedia Comput. Sci.* 2015, *56*, 592–597. [Google Scholar] [CrossRef]
5. Hancke, G.; Silva, B.; Hancke, G., Jr. The Role of Advanced Sensing in Smart Cities. *Sensors* 2012, *13*, 393–425. [Google Scholar] [CrossRef] [PubMed]
6. Kyriazis, D.; Varvarigou, T.; White, D.; Rossi, A.; Cooper, J. Sustainable smart city IoT applications: Heat and electricity management amp; Eco-conscious cruise control for public transportation. In Proceedings of the 2013 IEEE 14th International Symposium on “A World of Wireless, Mobile and Multimedia Networks” (WoWMoM), Madrid, Spain, 4–7 June 2013; pp. 1–5. [Google Scholar]
7. Strategic Opportunity Analysis of the Global Smart City Market. Available online: http://www.egr.msu.edu/~aesc310-web /resources/SmartCities/Smart%20City%20Market%20Report%202.pdf (accessed on 24 February 2017).
8. Gubbi, J.; Buyya, R.; Marusic, S.; Palaniswami, M. Internet of Things (IoT): A vision, architectural elements, and future directions. *Future Gener. Comput. Syst.* 2013, *29*, 1645–1660. [Google Scholar] [CrossRef]
9. Atzori, L.; Iera, A.; Morabito, G. The Internet of Things: A survey. *Comput. Netw.* 2010, *54*, 2787–2805. [Google Scholar] [CrossRef]
10. Internet of Things in 2020: Roadmap for the Future. Available online: http://www.smart-systems-integration.org/public/documents/publications/Internet-of-Things_in_2020_EC-EPoSS_Workshop_Report_2008_v3.pdf (accessed on 24 February 2017).
11. Six Technologies with Potential Impacts on US Interests Out to 2025. Available online: https://fas.org/irp/nic/disruptive.pdf (accessed on 24 February 2017).
12. Alamri, A.; Ansari, W.S.; Hassan, M.M.; Hossain, M.S.; Alelaiwi, A.; Hossain, M.A. A Survey on Sensor-Cloud: Architecture, Applications, and Approaches. *Int. J. Distrib. Sens. Netw.* 2013, *9*, 917923. [Google Scholar] [CrossRef]
13. Kosmatos, E.A.; Tselikas, N.D.; Boucouvalas, A.C. Integrating RFIDs and Smart Objects into a UnifiedInternet of Things Architecture. *Adv. Internet Things* 2011, *1*, 5. [Google Scholar] [CrossRef]
14. Rawat, P.; Singh, K.D.; Chaouchi, H.; Bonnin, J.M. Wireless sensor networks: A survey on recent developments and potential synergies. *J. Supercomput.* 2014, *68*, 1–48. [Google Scholar] [CrossRef]
15. Zanella, A.; Bui, N.; Castellani, A.; Vangelista, L.; Zorzi, M. Internet of Things for Smart Cities. *IEEE Internet Things J.* 2014, *1*, 22–32. [Google Scholar]
16. Medagliani, P.; Leguay, J.; Duda, A.; Rousseau, F.; Duquennoy, S.; Raza, S.; Ferrari, G.; Gonizzi, P.; Cirani, S.; Veltri, L.; et al. Internet of Things Applications—From Research and Innovation to Market Deployment. In *Bringing IP to Low-Power Smart Objects: The Smart Parking Case in the CALIPSO Project*; The River Publisher Series in Communication: Delft, The Netherlands, 2014; pp. 287–313. [Google Scholar]
17. Elmangoush, A.; Alhazmi, A.; Magedanz, T.; Schuch, W.; Estevez, C.; Ehijo, A.; Wu, J.; Nguyen, T.; Ventura, N.; Mwangama, J.; et al. Towards Unified Smart City Communication Platforms. In Proceedings of the Workshop on Research in Information Systems and Technologies, Chillán, Chile, 16 October 2015. [Google Scholar]

18. IEEE-SA—IEEE Get 802 Program—802.15: Wireless PANs. Available online: https://standards.ieee.org/about/get/802/802.15.html (accessed on 24 February 2017).
19. Shafie-Khah, M.; Heydarian-Forushani, E.; Osório, G.J.; Gil, F.A.S.; Aghaei, J.; Barani, M.; Catalão, J.P.S. Optimal Behavior of Electric Vehicle Parking Lots as Demand Response Aggregation Agents. *IEEE Trans. Smart Grid* 2016, *7*, 2654–2665. [Google Scholar] [CrossRef]
20. Li, X.; Lu, R.; Liang, X.; Shen, X.; Chen, J.; Lin, X. Smart community: An internet of things application. *IEEE Commun. Mag.* 2011, *49*, 68–75. [Google Scholar] [CrossRef]
21. Stratigea, A. The concept of "smart cities". Towards community development? *Netcom. Réseaux Commun. Territ.* 2012, *26-3/4*, 375–388. [Google Scholar] [CrossRef]
22. Neyestani, N.; Damavandi, M.Y.; Shafie-khah, M.; Catalão, J.P.S. Modeling the PEV traffic pattern in an urban environment with parking lots and charging stations. In Proceedings of the 2015 IEEE Eindhoven PowerTech, Eindhoven, The Netherlands, 29 June–2 July 2015; pp. 1–6. [Google Scholar]
23. Yazdani-Damavandi, M.; Moghaddam, M.P.; Haghifam, M.R.; Shafie-khah, M.; Catalão, J.P.S. Modeling Operational Behavior of Plug-in Electric Vehicles' Parking Lot in Multienergy Systems. *IEEE Trans. Smart Grid* 2016, *7*, 124–135. [Google Scholar] [CrossRef]
24. Neyestani, N.; Damavandi, M.Y.; Shafie-Khah, M.; Contreras, J.; Catalão, J.P.S. Allocation of Plug-In Vehicles' Parking Lots in Distribution Systems Considering Network-Constrained Objectives. *IEEE Trans. Power Syst.* 2015, *30*, 2643–2656. [Google Scholar] [CrossRef]
25. Lee, S.; Yoon, D.; Ghosh, A. Intelligent parking lot application using wireless sensor networks. In Proceedings of the 2008 International Symposium on Collaborative Technologies and Systems, Irvine, CA, USA, 19–23 May 2008; pp. 48–57. [Google Scholar]
26. Niyato, D.; Hossain, E.; Camorlinga, S. Remote patient monitoring service using heterogeneous wireless access networks: Architecture and optimization. *IEEE J. Sel. Areas Commun.* 2009, *27*, 412–423. [Google Scholar] [CrossRef]
27. The Urban Internet of Things. Available online: http://datasmart.ash.harvard.edu/news/article/the-urban-internet-of-things-727 (accessed on 24 February 2017).
28. Shafie-Khah, M.; Heydarian-Forushani, E.; Golshan, M.E.H.; Siano, P.; Moghaddam, M.P.; Sheikh-El-Eslami, M.K.; Catalão, J.P.S. Optimal trading of plug-in electric vehicle aggregation agents in a market environment for sustainability. *Appl. Energy* 2016, *162*, 601–612. [Google Scholar] [CrossRef]
29. Li, X.; Shu, W.; Li, M.; Huang, H.Y.; Luo, P.E.; Wu, M.Y. Performance Evaluation of Vehicle-Based Mobile Sensor Networks for Traffic Monitoring. *IEEE Trans. Veh. Technol.* 2009, *58*, 1647–1653. [Google Scholar]
30. Maisonneuve, N.; Stevens, M.; Niessen, M.E.; Hanappe, P.; Steels, L. Citizen Noise Pollution Monitoring. In Proceedings of the 10th Annual International Conference on Digital Government Research: Social Networks: Making Connections between Citizens, Data and Government, Puebla, Mexico, 17–21 May 2009; pp. 96–103. [Google Scholar]
31. Wang, J.; Chen, D.; Chen, H.; Yang, J. On pedestrian detection and tracking in infrared videos. *Pattern Recognit. Lett.* 2012, *33*, 775–785. [Google Scholar] [CrossRef]
32. Damen, D.; Hogg, D. Detecting Carried Objects from Sequences of Walking Pedestrians. *IEEE Trans. Pattern Anal. Mach. Intell.* 2012, *34*, 1056–1067. [Google Scholar] [CrossRef] [PubMed]
33. Calavia, L.; Baladrón, C.; Aguiar, J.M.; Carro, B.; Sánchez-Esguevillas, A. A semantic autonomous video surveillance system for dense camera networks in Smart Cities. *Sensors* 2012, *12*, 10407–10429. [Google Scholar] [CrossRef] [PubMed]
34. Leadership in Enabling and Industrial Technologies—Horizon 2020—European Commission. Available online: http://programmes/horizon2020/en/h2020-section/leadership-enabling-and-industrial-technologies (accessed on 24 February 2017).
35. Ballon, P.; Glidden, J.; Kranas, P.; Menychtas, A.; Ruston, S.; van der Graaf, S. Is there a need for a Cloud platform for European smart cities? In Proceedings of the eChallenges 2011

Conference and Exhibition, Florence, Italy, 26–28 October 2011; International Information Management Corporation: Dublin, Ireland, 2011. [Google Scholar]
36. Suciu, G.; Vulpe, A.; Halunga, S.; Fratu, O.; Todoran, G.; Suciu, V. Smart Cities Built on Resilient Cloud Computing and Secure Internet of Things. In Proceedings of the 2013 19th International Conference on Control Systems and Computer Science, Bucharest, Romania, 29–31 May 2013; pp. 513–518. [Google Scholar]
37. ClouT | ClouT: Cloud of Things for Empowering the Citizen Clout in Smart Cities. Available online: http://clout-project.eu/ (accessed on 24 February 2017).
38. Petrolo, R.; Mitton, N.; Soldatos, J.; Hauswirth, M.; Schiele, G. Integrating wireless sensor networks within a city cloud. In Proceedings of the 2014 Eleventh Annual IEEE International Conference on Sensing, Communication, and Networking Workshops (SECON Workshops), Singapore, 30 June–3 July 2014; pp. 24–27. [Google Scholar]
39. Chen, S.Y.; Lai, C.F.; Huang, Y.M.; Jeng, Y.L. Intelligent home-appliance recognition over IoT cloud network. In Proceedings of the 2013 9th International Wireless Communications and Mobile Computing Conference (IWCMC), Sardinia, Italy, 1–5 July 2013; pp. 639–643. [Google Scholar]
40. Han, D.M.; Lim, J.H. Smart home energy management system using IEEE 802.15.4 and zigbee. *IEEE Trans. Consum. Electron.* 2010, *56*, 1403–1410. [Google Scholar] [CrossRef]
41. Ye, X.; Huang, J. A framework for Cloud-based Smart Home. In Proceedings of the 2011 International Conference on Computer Science and Network Technology, Harbin, China, 24–26 December 2011; Volume 2, pp. 894–897. [Google Scholar]
42. Martirano, L. A smart lighting control to save energy. In Proceedings of the 6th IEEE International Conference on Intelligent Data Acquisition and Advanced Computing Systems, Prague, Czech Republic, 15–17 September 2011; Volume 1, pp. 132–138. [Google Scholar]
43. Castro, M.; Jara, A.J.; Skarmeta, A.F.G. Smart Lighting Solutions for Smart Cities. In Proceedings of the 2013 27th International Conference on Advanced Information Networking and Applications Workshops, Barcelona, Spain, 25–28 March 2013; pp. 1374–1379. [Google Scholar]
44. Siano, P.; Sarno, D. Assessing the benefits of residential demand response in a real time distribution energy market. *Appl. Energy* 2016, *161*, 533–551. [Google Scholar] [CrossRef]
45. Siano, P. Demand response and smart grids—A survey. *Renew. Sustain. Energy Rev.* 2014, *30*, 461–478. [Google Scholar] [CrossRef]
46. Graditi, G.; Ippolito, M.G.; Lamedica, R.; Piccolo, A.; Ruvio, A.; Santini, E.; Siano, P.; Zizzo, G. Innovative control logics for a rational utilization of electric loads and air-conditioning systems in a residential building. *Energy Build.* 2015, *102*, 1–17. [Google Scholar]
47. Siano, P.; Graditi, G.; Atrigna, M.; Piccolo, A. Designing and testing decision support and energy management systems for smart homes. *J. Ambient Intell. Human. Comput.* 2013, *4*, 651–661. [Google Scholar] [CrossRef]
48. Strategic Plan for the IEA Demand-Side Management Programme 2008–2012. Available online: http://www.ieadsm.org/wp/files/Exco%20File%20Library/Participation/Final%20strategy%202008-2012.pdf (accessed on 24 February 2017).
49. Arasteh, H.R.; Parsa Moghaddam, M.; Sheikh-El-Eslami, M.K.; Abdollahi, A. Integrating commercial demand response resources with unit commitment. *Int. J. Electr. Power Energy Syst.* 2013, *51*, 153–161. [Google Scholar] [CrossRef]
50. Balijepalli, V.S.K.M.; Pradhan, V.; Khaparde, S.A.; Shereef, R.M. Review of demand response under smart grid paradigm. In Proceedings of the ISGT2011-India, Kerala, India, 1–3 December 2011; pp. 236–243. [Google Scholar]
51. Koutsopoulos, I.; Tassiulas, L. Control and Optimization Meet the Smart Power Grid—Scheduling of Power Demands for Optimal Energy Management. In Proceedings of the 2nd International Conference on Energy-Efficient Computing and Networking, New York, NY, USA, 31 May–1 June 2011. [Google Scholar]
52. Parvania, M.; Fotuhi-Firuzabad, M. Demand Response Scheduling by Stochastic SCUC. *IEEE Trans. Smart Grid* 2010, *1*, 89–98. [Google Scholar] [CrossRef]

53. Electricity Technology Roadmap: Meeting the Critical Challenges of the 21st Century—Roadmap2003. Available online: http://mydocs.epri.com/docs/CorporateDocuments/StrategicVision/Roadmap2003.pdf (accessed on 24 February 2017).
54. Arritt, R.F.; Dugan, R.C. Distribution System Analysis and the Future Smart Grid. *IEEE Trans. Ind. Appl.* 2011, *47*, 2343–2350. [Google Scholar] [CrossRef]
55. Jaradat, M.; Jarrah, M.; Jararweh, Y.; Al-Ayyoub, M.; Bousselham, A. Integration of renewable energy in demand-side management for home appliances. In Proceedings of the 2014 International Renewable and Sustainable Energy Conference (IRSEC), Ouarzazate, Morocco, 17–19 October 2014; pp. 571–576. [Google Scholar]
56. Zhu, Z.; Tang, J.; Lambotharan, S.; Chin, W.H.; Fan, Z. An integer linear programming based optimization for home demand-side management in smart grid. In Proceedings of the 2012 IEEE PES Innovative Smart Grid Technologies (ISGT), Washington, DC, USA, 16–20 January 2012; pp. 1–5. [Google Scholar]
57. Nguyen, H.K.; Song, J.B.; Han, Z. Demand side management to reduce Peak-to-Average Ratio using game theory in smart grid. In Proceedings of the 2012 Proceedings IEEE INFOCOM Workshops, Orlando, FL, USA, 25–30 March 2012; pp. 91–96. [Google Scholar]
58. Saber, A.Y.; Venayagamoorthy, G.K. Plug-in Vehicles and Renewable Energy Sources for Cost and Emission Reductions. *IEEE Trans. Ind. Electron.* 2011, *58*, 1229–1238. [Google Scholar]
59. Zhabelova, G.; Vyatkin, V. Multiagent Smart Grid Automation Architecture Based on IEC 61850/61499 Intelligent Logical Nodes. *IEEE Trans. Ind. Electron.* 2012, *59*, 2351–2362. [Google Scholar] [CrossRef]
60. Miao, Y.; Bu, Y. Research on the architecture and key technology of Internet of Things (IoT) applied on smart grid. In Proceedings of the 2010 International Conference on Advances in Energy Engineering (ICAEE), Beijing, China, 19–20 June 2010; pp. 69–72. [Google Scholar]
61. Amsterdam Smart City. Available online: https://amsterdamsmartcity.com/ (accessed on 24 February 2017).
62. Smart City | Servei de Premsa | El Web de la Ciutat de Barcelona. Available online: http://ajuntament.barcelona.cat/premsa/tag/smart-city/ (accessed on 24 February 2017).
63. Laursen, L. City Saves Money, Attracts Businesses with Smart City Strategy. Available online: https://www.technologyreview.com/s/532511/barcelonas-smart-city-ecosystem/ (accessed on 24 February 2017).
64. TMBAPP (Metro Bus Barcelona) | Apps | iTunes | apps4BCN | All the Apps You Need for Barcelona! Available online: http://apps4bcn.cat/en/app/tmbapp-metro-bus-barcelona/111 (accessed on 24 February 2017).
65. Transport & Traffic | IOS | The Best App Selection for Barcelona | Apps4bcn | All the Apps You Need for Barcelona! Available online: http://apps4bcn.cat/en/apps/index/ Category: transport-i-tr-nsit (accessed on 24 February 2017).
66. UrbanStep Barcelona | Apps | iTunes | apps4BCN | All the Apps You Need for Barcelona! Available online: http://apps4bcn.cat/en/app/urbanstep-barcelona/110 (accessed on 24 February 2017).
67. ICT Regulation Toolkit. Available online: http://www.ictregulationtoolkit.org/practice_note?practice_note_id=3244 (accessed on 24 February 2017).
68. Writer, S.B.-S. Staff Modest Gains in First Six Months of Santa Cruz's Predictive Police Program. Available online: http://www.santacruzsentinel.com/ article/zz/20120226/NEWS/120227300 (accessed on 24 February 2017).
69. The Internet of Everything for Cities. Available online: http://pie.pascalobservatory.org/sites/default/files/ioe-smart-city_pov.pdf (accessed on 24 February 2017).
70. Strickland, E. Cisco bets on South Korean smart city. *IEEE Spectr.* 2011, *48*, 11–12. [Google Scholar] [CrossRef]
71. Anthopoulos, L.G.; Fitsilis, P. *Understanding Smart City Business Models: A Comparison*; ACM Press: New York, NY, USA, 2015; pp. 529–534. [Google Scholar]

72. Smart City Pilot Projects, Scaling Up or Fading Out? Experiences from Amsterdam. Available online: http://www.hva.nl/urban-management/over-um/nieuws/content/nieuwsberichten/2016/3/willem-van-winden-discussion.html (accessed on 24 February 2017).
73. Christidis, K.; Devetsikiotis, M. Blockchains and Smart Contracts for the Internet of Things. *IEEE Access* 2016, *4*, 2292–2303. [Google Scholar] [CrossRef]
74. He, W.; Yan, G.; Xu, L.D. Developing Vehicular Data Cloud Services in the IoT Environment. *IEEE Trans. Ind. Inform.* 2014, *10*, 1587–1595. [Google Scholar] [CrossRef]
75. Petrolo, R.; Loscrì, V.; Mitton, N. Towards a smart city based on cloud of things, a survey on the smart city vision and paradigms. *Trans. Emerg. Telecommun. Technol.* 2017, *28*, e2931. [Google Scholar] [CrossRef]
76. Lazarescu, M.T. Design of a WSN Platform for Long-Term Environmental Monitoring for IoT Applications. *IEEE J. Emerg. Sel. Top. Circuits Syst.* 2013, *3*, 45–54. [Google Scholar] [CrossRef]
77. Mitton, N.; Papavassiliou, S.; Puliafito, A.; Trivedi, K.S. Combining Cloud and sensors in a smart city environment. *EURASIP J. Wirel. Commun. Netw.* 2012, *2012*, 247. [Google Scholar] [CrossRef]
78. Atkins, C.; Koyanagi, K.; Tsuchiya, T.; Miyosawa, T.; Hirose, H.; Sawano, H. A Cloud Service for End-User Participation Concerning the Internet of Things. In Proceedings of the 2013 International Conference on Signal-Image Technology Internet-Based Systems, Kyoto, Japan, 2–5 December 2013; pp. 273–278. [Google Scholar]
79. Corsar, D.; Edwards, P.; Velaga, N.; Nelson, J.; Pan, J. Short Paper: Addressing the Challenges of Semantic Citizen-sensing. In Proceedings of the 4th International Conference on Semantic Sensor Networks, SSN’11, Aachen, Germany, 23 October 2011; Volume 839, pp. 101–106. [Google Scholar]
80. Zaslavsky, A.; Perera, C.; Georgakopoulos, D. Sensing as a Service and Big Data. In Proceedings of the International Conference on Advances in Cloud Computing (ACC), Bangalore, India, July 2012. [Google Scholar]
81. Akyildiz, I.F.; Melodia, T.; Chowdury, K.R. Wireless multimedia sensor networks: A survey. *IEEE Wirel. Commun.* 2007, *14*, 32–39. [Google Scholar] [CrossRef]
82. Zhao, F. Sensors meet the Cloud: Planetary-scale distributed sensing and decision making. In Proceedings of the 2010 9th IEEE International Conference on Cognitive Informatics (ICCI), Beijing, China, 7–9 July 2010; pp. 998–998. [Google Scholar]
83. Kim, J.-H.; Shcherbakova, A. Common failures of demand response. *Energy* 2011, *36*, 873–880. [Google Scholar] [CrossRef]