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Ethical Analyses of Smart City Applications

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Abstract: When it comes to smart cities, one of the most important components is data. To enable smart city applications, data needs to be collected, stored, and processed to accomplish intelligent tasks. In this paper we discuss smart cities and the use of new and existing technologies to improve multiple aspects of these cities. There are also social and environmental aspects that have become important in smart cities that create concerns regarding ethics and ethical conduct. Thus we discuss various issues relating to the appropriate and ethical use of smart city applications and their data. Many smart city projects are being implemented and here we showcase several examples to provide context for our ethical analysis. Law enforcement, structure efficiency, utility efficiency, and traffic flow control applications are some areas that could have the most gains in smart cities; yet, they are the most pervasive as the applications performing these activities must collect and process the most private data about the citizens. The secure and ethical use of this data must be a top priority within every project. The paper also provides a list of challenges for smart city applications pertaining in some ways to ethics. These challenges are drawn from the studied examples of smart city projects to bring attention to ethical issues and raise awareness of the need to address and regulate such use of data.

Keywords: smart cities; ethics; data privacy; Internet of Things; smart city applications

1. Introduction

The smart city, as it is known today, has had a handful of names throughout the history of its establishment. Before the shift to smart city, it was known as the digital city. This latest change reflects the ways information and communication technologies (ICT) are implemented for smart cities. They have become more than isolated service systems. In fact, they are evolving into a diverse ecosystem, which includes sensors, software, robots, networks, real time surveillance, and even humans. For example, Amsterdam is using ICT to slowly push citizens' behavior towards a more "sustainable lifestyle". They also plan to introduce smart ports to streamline shipping traffic. London is looking to develop new markets for its waste and its utilization as a resource. They also aim to use 3D visualization to bring safety and efficiency to agencies in construction and other public works. The main goal is to improve the living standards for smart cities residents [1]; however, there is a price to pay when it comes to ethics.

The extensive use of ICT and connected technologies like the Internet of Things (IoT) [2], Cloud and fog computing [3], and Cyber Physical Systems (CPS) [4] to name a few has led to data being generated and gathered at lightning speeds. This data comes from various sources and may carry increasingly sensitive and private information about smart city residents. To a certain extent, data gathering has become an integral part of our lives to a point where some see it as invasive. Assuming an ideal world where everything is done correctly, gathering and using this data poses no threat to

anyone and the benefits far outweigh the risks. Unfortunately, in the real world, there are always issues and problems to be addressed when dealing with such data. Some may be intentional, while others are accidental. Issues with data privacy and ethical use of gathered information are always present. Yet, not many have attempted to address them or provide solutions to minimize the risks. Researchers and developers are always concerned with the technologies, approaches, architectures, and methods they introduce and their correctness and benefits. Business people are more interested in what will make them more profits, while policy makers want to make their lives easier and use the technologies to support their decision-making processes. All together they are aiming to better serve the residents who are mainly concerned about high quality of life and financial stability. The main players concerned about ethics and ethical use of the data are the residents. Yet, they are the ones who at the current state have the least control over who collects the data, how it is used, and what it is used for. As a result, we see that it has become imperative to consider the ethics and ethical conduct issues in smart city applications.

Our research started with the premise of reviewing works that considered ethics and studying how much emphasis there is on the ethical issues involved when smart city applications are considered. Thus our methodology relied on finding scholarly work discussing ethics within the context of smart cities. However, over time, we realized, there is not much discussed in this regard. Therefore, we redefined our approach to pursue the idea of instigating a conversation on the topic. Therefore, we decided to first identify representative smart city applications and use them to highlight the challenges and the types of ethical issues that may be involved. We investigated several current and proposed projects for smart cities and attempted to identify how ethics and ethical conduct issues may impact such projects and their outcomes. Using these examples we were able to identify some issues and create an overview of the challenges and impacts in terms of observing ethical conduct when creating and using smart city applications. Since going smart in any field mainly involves data collection and analysis, in smart cities, this becomes of significant importance because most of the data pertain to humans and their lives. Using the projects we identified, we created a list of challenges that could lead to ethical problems. For example, when talking about the smart grid, it becomes evident that issues like who knows what about residents and what rules are used to regulate consumption must be clearly defined. Questions like "what would stop the smart grid from favoring certain clientele over others, maybe because they pay at higher rates?" would arise and require answers. This paper can be considered an attempt to shine a light on the ethics of smart city applications and start a serious discussion of these issues for current and future projects.

In the rest of this paper, Section 2 offers background information on smart cities and their applications, including a brief overview of privacy, security, and safety of smart city applications. In Section 3, the ethics concept within smart cities is introduced to provide a general basis for ethical discussions concerning smart city applications. Section 4 reviews present and future smart city applications in terms of the previously defined ethical concepts. Then, the challenges of smart city applications are identified and applied to the aforementioned applications in Section 5. Section 6 provides some discussion highlighting our findings, while Section 7 concludes the paper and offers a look into the future in this topic.

2. Background

To adequately discuss ethical issues in smart cities, it is necessary to create some level of understanding of what constitutes a smart city and the impact ICT use to create smart city applications has on humans. To begin, there is no clear definition for a smart city and the development of smart cities themselves have been scrutinized for being ineffective and a waste of capital and resources to produce merely "questionable" convenience. In addition, some residents are questioning the risks involved with such approaches in terms of security and privacy and also the legal and ethical use of smart city applications. ICT plays a significant role in making a city smart. These technologies "encourage urban governance systems to be more interconnected and interactive, not only to share information, but also

to allow transactional relationships between stakeholders in the governance system" [5]. This forces new relationships between different stakeholders to be created for systems to work as intended. It gives an example of how a city with systems equipped for two-way communication between technologies can work together to provide real-time details and safety for citizens; for example, the detection of a gas line leak under the city streets.

Regarding smart cities and their development over time there are many related labels such as "information city", "wired city", "intelligent city", "digital city", "virtual city", "smart community", "ubiquitous city", "knowledge city", "sustainable city", and "green city". In our context we are more concerned about what is currently being referred to as the "smart city". In literature we found that "smart city" and "digital city" are the most used and in various occasions used interchangeably although the two have different meanings [6,7]. The "digital city" term appeared in the nineties as the Internet became widely used. The concept is to enhance the quality of life of a city's residents through a set of e-services utilizing the Internet, virtual environments, and other technologies [8]. One of the good definitions of a "digital city" is "The digital city is as a comprehensive, web-based representation, or reproduction, of several aspects or functions of a specific real city, open to non-experts. The digital city has several dimensions: social, cultural, political, ideological, and also theoretical" [9]. The digital city concept was more used in literatures than smart city until 2010 [7]. Although the term smart city started in 1994, there were very limited papers in the field until 2010, when the number of references to the term greatly increased to exceed the digital city term. For example, in 2017, there were 16,700 documents using "smart city", while there were only 1090 documents using "digital city" indexed by Google Scholar (as observed on 8 August 2018). This increase of using the smart city term began when the European Union began to use the term "smart" with sustainability projects for turban areas [6]. At the same time, Apple consumer devices known as smart devices such as the iPhone, which was the first "smart" phone, were becoming popular.

Unlike the digital city concept, which was mainly motivated by the Internet and e-services, the smart city concept is broader and more ubiquitous, involving humans, infrastructures, resources, and technology. It is also greatly motivated by both sustainable technologies and new computing and communication technologies [7]. The sustainable technologies aim to reduce pollution, energy consumption, and wastes in different city components and services, while the computing and communication technologies are used to provide interactive and value-added features for different city services by utilizing not only regular ICT but also a large number of devices including sensors, IoT devices [10], and smart phones, which can all collect and generate big data [11] that can be utilized to enhance different city services. These value-added features can improve the operations, efficiency, safety, utilization, reliability, quality, and cost-effectiveness of the city services. Another parallel label used for cities is the "Sustainable city" [12]. It is defined in [13]: "[The] sustainable city uses technology to reduce CO_2 emissions, to produce efficient energy, to improve buildings efficiency. Its main aim is to become a green city". In this regard green and sustainable cities focus on green growth and optimized use of resources, and how humans can become more aware and involved in the process. This growth also includes economic and technological development and preserving biodiversity, while lowering pollution, greenhouse gas emissions, waste disposal, and inefficient use of natural resources.

Overall many of the terms currently in use in regards to advancements in cities can be considered relevant and in many cases part of broader term "smart city". In essence, the smart city vision aligns very well with the original vision of "urban design", which emphasizes the deployment of skills and resources to achieve a specific vision for an area [14]. A smart city vision aims to introduce smartness to a city, "an area", using available human skills and ICT resources. The term smart city can be defined as a combination of numerous data collection technologies and services that are used to make a city environmentally cleaner, safer, more productive, and more efficient [15,16]. There is no one specific interpretation of what is a smart city and what is not a smart city, rather, smart city is a term used in academia to discuss the various implementations of complex data gathering sensors and the accompanying analysis and decision-making services that can be implemented. As advancements

in data gathering and monitoring are made, the definition of what a smart city is will also evolve. "Smart city" also refers to the various people and institutions that work together with the sensors and systems to ensure the smart city concept can be carried out to its fullest capacity. An attempt to gather and conceptualize the various definitions of a smart city can be seen in [17,18]. In both articles, the authors put together impressive lists of working smart city definitions and identify its dimensions. These include humans, technology, economy, and governance, and may include additional dimensions depending on how a smart city is viewed.

Regardless of the definition adopted, it is agreed that technology is the key enabling dimension for a smart city. Technology provides the hardware and software to implement the features and functionalities of smartness. Although the technological advancements of smart cities allow for a multitude of both societal advancements and improvements to the quality of life, they also come with unsettling concerns, which could lead to possible vulnerabilities to the general population. These concerns pertain to the following categories: privacy, security, safety, and ethics. These issues always arise with the invention and implementation of new technology-based systems. These systems are important to both consider and elaborate upon to ensure that the systems cannot be exploited or even be determined to lead to a potential infringement upon basic human rights. Privacy, security, and safety issues lead into one another and primarily go hand-in-hand in terms of data usage.

Privacy can be defined as the state of being free from unwanted observation [19]. There are three main dimensions that people tend to focus on when determining whether or not they have an apparent privacy concern in smart cities. These dimensions are: the kinds of data being collected, the purpose of collecting the data, and who is collecting the data [20]. The data being collected ranges on a scale from personal to impersonal data, whereas the purposes of the data range on a scale from basic services being offered to constant surveillance. On the aforementioned scales, impersonal data and data with a service purpose are most trusted and of least concern. As the ranges move towards the other side of the scales, the concerns about privacy rise. At some point, the risks of violating people's privacy will outweigh the benefits of the services being provided. Unfortunately, there is no clear way to find that point as people's sensitivity to privacy varies greatly.

Security, in terms of technology, can be defined as the state of being protected against unauthorized access to computer systems or their components [19]. Since smart cities focus solely on the implementation of technology, this concern is quite prevalent. An intrusion of this caliber could result in major breaches, making personal data more susceptible to being accessed by uninvolved parties. When components are implemented into smart cities, the general population should not only feel secure, but also believe and trust that their data is truly protected and available to only those who need access to it. Security issues have been extensively studied and huge progress have been made for many types of applications. Many of these can apply to smart city applications and offer some level of security for them. However, there is still more that can be done and there are risks that have not yet been identified.

Although privacy and security are both major issues that need to be considered and resolved during the implementation of a new technological system within a smart city, safety of the public must also be the major concern. Safety can be defined as the condition of not being exposed to danger, risk, or loss [19]. Safety is important because most smart city applications involve technologies that are integrated with humans. Many applications use and control various types of devices that are in direct contact with humans and may control some aspects of their everyday lives. For example an insulin pump connected to a diabetic patient, self-driving cars, and automatic traffic light controls. Any application that can have any level of control over humans or their environment must be designed not just for security and privacy, but also for safety. Smart city applications should demonstrate the capability to put human lives and their safety as first priority. A potential threat to a human life would render the preceding concerns practically irrelevant. Without the protection of the existence of the humans, the privacy or the security of the person's data is no longer the major concern.

3. Ethics

In the smart city context, ethics is a subject that has not been considered as strongly or thoroughly as the concerns of privacy, security, and safety. Smart technology can be extremely invasive when it is not regulated by proper policies and control mechanisms; however, it can also prove to be extremely effective in propelling our society forward in a positive manner when implemented correctly. The goal of utilizing current and new smart city technology is to make a positive change in how a society lives and works, but ethical issues are often overlooked as they are considered a non-vital variable or a negligible side effect of new technologies. For example, utility providers may use smart capabilities to monitor and control appliances in private residences or buildings to efficiently distribute resources to allow for cost effective services [21,22]. A case like this brings up concerns over the privacy of the data and the rights of all of the individuals affected. However, it also brings up concerns about the prospects of improper or unethical use of this data. Ethical misconduct is not limited to humans: systems capable of making their own decisions can learn to misbehave as well.

Humans are not perfect. When decisions have to be made, a lot of factors usually come into the picture, some of which may lead to biased or discriminatory actions. In a smart city, there is more data to deal with than anyone can imagine. The availability of this data increases the possibilities of misuse by those who have it. Observing ethical conduct becomes more necessary than ever. Rules, policies, regulations, and laws can limit misconduct, but there is always room for major problems given the vast amount of data available and the deep penetration of the data collection process in every aspect of residents' lives. In controlling this data, its flow and use need to be considered not only from the technical perspective (i.e., proper storage, access, security, etc.), but also from the ethical perspective. Ensuring proper use and limiting the possibilities of ethical misconduct is the key to implementing a successful livable smart city.

Furthermore, the collection of data in smart cities is performed through distributed systems throughout the urban environment. These systems indiscriminately collect the data they were designed to capture and some may have access to very private data. Such systems include, but are not limited to, surveillance cameras, temperature recorders, and traffic sensors, as well as devices that can detect human interactions and motion. The existence of such technologies is not inherently negative, but the data they collect can be subject to policies and biased agendas that can compromise citizens' privacy and safety. This is one of five concerns laid out by Kitchin who noted that such biased use of data can alter social values and inflate social privilege in systems like law enforcement [23]. Another concern presented is the "corporatization of city governance and a technological lock-in", which can be explained as the act of private organizations attempting to propose technologies that would rely on said organization's support to maintain. This can then be used to create a monopoly-like control of smart technologies within a city resulting in a city's dependence on said organization for their smart public services [23].

On another note, autonomous machines and systems are becoming more of a reality in various areas like healthcare, manufacturing, transportation, and several others. These are widely controversial in terms of ethical conduct as they are designed to learn as they operate. One future requirement for completely autonomous machines should be for ethical values to be embedded in these systems and given high precedence over any other. There are certain situations which require choosing between some equally unappealing options. One example of such dilemma would be the ability for an autonomous transportation vehicle to "choose" who or what to crash into when a situation is unavoidable [24]. If a machine is unequipped to handle these challenges, the possibilities are endless. Regardless of the ethical capabilities of such systems, questions and judgments will almost always rise after such action takes place. These are advanced philosophically presented ethical theories which really constrain the abilities of these systems. Currently autonomous machines have no predetermined ethical stance and are forced to be decided upon under human control [25]. Intelligent machines are designed and trained by humans. They can only be as intelligent and as prejudice as the humans who

made them. Bias, discrimination, although not intended to exist in such systems, can still creep out and lead to unethical behaviors by these systems.

In an age where civil rights movements are becoming more bountiful, it is hard to imagine that applications lacking ethical constraints or ethical decision guidelines would not be scrutinized. People have the right to be involved in the process and be assured that they are treated fairly by such systems. It is very important for these systems to be unbiased based upon user design and insusceptible to learned discriminations. The result of incomplete implementation could lead to disastrous consequences for the specific application as well as applications as a whole. In the following sections we offer some insight into some of the ethical issues through a study of example smart city applications, which then lead us to identifying the challenges and their implications in terms of ethical conduct.

4. Review of Smart City Applications

As the concept of smart cities evolved, many applications emerged in support of this concept and various cities around the world put in motion plans to become "smart cities". The approaches taken and technologies used differ everywhere and the applications vary and expand across all aspects of city life. Research and development efforts are continuous and new models and solutions emerge every day. Yet, the wealth of outcomes from these efforts have not been strongly linked to the ethical implications associated with them.

In an effort to initiate this type of conversation as smart cities continue to evolve and grow, we try to provide a link between different applications for smart cities and the impact they make in terms of ethics and ethical conduct. The following are some examples of smart city applications and approaches and a brief view of how ethics come in the picture. The list is by no means comprehensive; however, the selected projects in the literature can be considered a representative sample of different areas where smart applications can contribute towards building a smart city. Some of the examples are actual projects that have been developed and used, while others are in their design or research phase. However, collectively these projects offer a general view of what technology offers and as a result allow us to identify where and how ethical issues may arise.

4.1. Water Monitoring System, Korea

Vender cooperation proves to be a major key to the success of a smart city. The water monitoring system introduced in a Korean city showcases how the lack of cooperation in the private sector can hinder any meaningful progress. A water supply system in a South Korean "U-City" is designed to provide real time information on the health and operational characteristics of the main water supply infrastructure for the city. It includes many sensors and software systems from a number of different private companies that collect this information and feed it to a central location for monitoring and evaluation. Currently, when a sensor fails they must contact the company that owns and operates it and have them fix it, but to fix it they must shut down or interact with other systems that are maintained by other vendors leading to excessive time delays [5]. This example shows that all vendors, public and private, must create a clearly defined process to diagnose and repair any issues that may occur, otherwise projects incur time delays and wasted resources. Such needs are not always governed by laws and regulations that can be enforced. They are more about collaboration and agreement across vendors and if some vendors choose to favor certain outcomes, ethical issues could easily arise. There are always issues with getting the private sector more involved for two reasons: legislation that has impeded this progress and the lack of profit incentives. In addition, they present a list of general issues in the development of the Korean U-Cities that is largely technology-influenced, yet design, privacy and digital inequality are not fully addressed. The overhyped premise is leading to a lack of credibility and no way to monitor and evaluate the smart city projects.

4.2. 100 Smart Cities, India

Since coming into power in 2014, the National Democratic Alliance started an initiative to have 100 smart cities across India with the goals to bring quality of life, high tech infrastructure, improved mass transit, pollution free areas, energy efficiency, and transparent governance. These cities are divided into nine satellite cities with a population of four million or more, 44 cities with a population of one to four million, 17 state and union territory capitals, 10 of tourist and religious importance, and 20 with a population of half a million to a million [26]. Resources have been redirected to accomplish this goal, leading to shortages of resources in other areas. As a result, the Indian community is currently facing a more obvious separation of classes than previously defined. The introduction of smart cities throughout the country is seemingly advancing the upper-class cities while overlooking the poorer cities. The country's previous mission of 1980, before the smart city initiative, was to make every Indian city achieve sustainable living conditions. Decades later, this mission has still not been accomplished. The means to advance substandard cities are now being abandoned and the cities themselves are becoming overlooked, while the efforts are being focused on enhancing the exclusive and already sustainable, upper-class cities to reap the societal advantages and living conditions of smart cities. This unbalanced advancement concerning the middle and upper classes is a direct ethical concern revolving around smart city implementation.

4.3. Performance Measurement System, Europe

Smart city initiatives in Europe have increased over time leading to different, usually independent, efforts from each city. As a result, it has become obvious that some form of measurement standards are needed to identify successful smart city projects. The CITYKeys research project aims to create a performance system to measure how Smart Cities are performing all across Europe and how new smart cities can use the system. It outlines six steps to formulate the system: specifying the needs of the city; compiling existing indicators; building new indicators to fill existing gaps, defining the framework; studying available data for calculations; and developing a prototype system for data collection and visualization. The researchers in the project determined that an average of 72% of the data needed was available from public and private sources for the calculations used to create the system [27]. The data is defined as any relevant information collected from smart technologies that would help enable all stakeholders to learn from each other and monitor their progress. During the course of the project they determined that the main issue with their collection of the data was that there was a clear lack of centralization and management. They also suggested that there should be better standard practices for sharing and publishing data emphasizing that it is important to have output indicators that measure the implementation of smart technologies and "impact indicators that measure progress towards overall targets". Using emissions reduction as an example, smart cities could monitor traffic flow then adjust the appropriate systems to minimize congestion and prevent unnecessary idling in confined areas. The major concern in this scenario is how data is shared or published. If this data include personal and private information about city residents, there are various concerns regarding ensuring ethical access and use of this data. Moreover, for a measurement system like this one to operate successfully, strong collaboration efforts and willingness to adapt and share data are needed across all organizations, which again raise the question, "how to trust each other?"

4.4. Crime Prediction

Crime prediction software is geared to use collected data within a smart city to identify potential risks in terms of criminal activities. A software is created to monitor and collect information on communications and interactions across certain locations, or among certain groups of people may offer some insight into possible unlawful activities. This software works by aggregating and anonymizing mobile phone metadata along with demographic and geographic data [28]. This data is then used to predict where the heaviest concentration of criminal activity will occur and law enforcement may

then focus on the hotspots predicted by the software. Other than securing and protecting this data, we also run into other important issues. For one, this software will inherently work best in areas where more mobile phones are available, which are usually better areas economically, thus leading to better protection for these areas over other, possibly poorer areas. Another issue that may arise is that over time, the results obtained will get skewed by the higher arrest and preventions rates in the highly monitored areas. This may also raise ethical issues when considering possible discrimination based on some prominent factors in certain areas. Furthermore, issues may arise when accessing and sharing this data with other organizations.

4.5. Smart Grid

Much like the smart city itself the smart grid has an exciting array of beneficial effects on the quality of life of people using it. However, the smart grid also opens up ethical concerns on various levels. Smart grids would allow companies and consumers to better monitor and control energy use [29]. This means that a consumer's privacy has the potential to be violated, specifically when the data collected can reveal the types of electrical devices a consumer uses as well as how often an individual device is used. In addition, this type of fine-grain data collection and analysis could also reveal other types of private information about the consumers, such as time they spend away from home, travel periods, and other habits. Considering that the smart grid is well protected, this may not be a huge issue; however, any security breaches and leaks of such data could lead to disastrous effects. Moreover, the smart grid owners may also be tempted to use this data for other benefits, like targeted advertisements or specialized marketing, which could in many cases violate consumers' privacy. Smart grid integration into the IoT and other smart applications in a smart city also opens up the possibility of cyber-attacks that could deny individuals or whole cities power. Once again, the issue of social class arises in the fact that power can be throttled during peak usage times, and that consumers that are better off economically will possibly have the option to opt out of this peak usage throttling. In a worst-case scenario, a poorer family might lose heat during a cold day due to electrical usage being at a peak.

4.6. Occupancy Detection

Occupancy detection focuses on whether or not a space is occupied, instead of the number of occupants within a space. This binary form of occupancy monitoring tends to focus solely on private spaces, such as office buildings [30]. This form of occupancy monitoring could possess the ability to control systems within the building or the office space. Some example systems could include: lighting, heating air conditioning and ventilation (HVAC) systems, and electricity use as a whole. With the potential ability to autonomously control these systems based on occupancy detection, not only would bills be significantly reduced at a larger scale, but less pollutants would be released into the air. On one hand, there are advantages that could be used by the building owner to operate their business efficiently while also providing emergency personnel information regarding the building being occupied or not in case of an emergency. On the other, it could produce potential safety and ethical concerns if the information was intercepted or used to ensure a higher success rate of criminal activity. An example of this would be using this software to rob an office of confidential information or a business of their property. Another possible issue to consider is using his type of monitoring to greedily reduce buildings operational costs even when certain occupants are still in certain areas of the buildings. For example, setting the system to turn off HVAC systems in the offices even when the cleaning staff are there outside regular working hours.

4.7. Occupancy Counting

Unlike occupancy detection, occupancy counting focuses on the actual number of people in a building or a structure. Occupancy counting seems like a very helpful approach to solving occupancy issues that could lead to violations of fire safety laws within buildings, for example. There is one

problem, however; that is counting all of the people in the building. The current solutions involve the use of mobile devices and cameras [30]. The main concern is that not all individuals carry mobile devices, which may default into the use of cameras being the primary source of occupancy detection. Although most buildings are already equipped with camera-monitoring systems, these systems would function differently. Some of these systems would track the number of people within the structure by extracting features of the individuals which could describe body parts and shapes of an individual [30]. This basically means that individuals are identified and labeled with personal information and locations at any point of time. This form of monitoring could ethically infringe upon rights concerning confidentiality or anonymity if this information is used to label a person by their name. If this form of occupancy counting is accepted, it is important to focus solely on the component originally being monitored, which is the number of people in the building or structure, instead of who is in the building. Accurate measures need to be in place to control the collection and labeling of the data to ensure the privacy of the occupants of the buildings. The ethical emphasis in this case is higher on making sure the personalized data is not misused or directed to purposes other than the original intent. In addition, sharing this information with other organizations should be highly regulated and adequate mechanisms for authorizations and permissions are needed to ensure the individuals' rights to privacy.

4.8. Occupancy Tracking

Occupancy tracking is the combination of the two aforementioned occupancy monitoring systems. This system not only monitors both the binary and numerical occupancy in a building, but also locates and tracks people within these buildings [30]. Binary occupancy is used to determine whether or not a building is occupied whereas numerical occupancy is used to determine the actual number of occupants within a specific location. The same ethical concerns that affect occupancy detection and occupancy counting also affect occupancy tracking; however, this form of occupancy monitoring contains even more ethical constraints as it offers more high-grain details about the individuals in these buildings. Individuals' whereabouts would always be known to the system. Instead of being identified solely as an individual at a location, an individual's identity will be determined and tied to their specific location. Such monitoring may be acceptable in public facilities to ensure safety and security. However, it could become a big concern when used in more private locations such as workplaces or residences. This type of access could easily lead to infringements on the basic individual's right to privacy.

4.9. Event Recognition

Occupancy event recognition focuses on the behavior and activities of the people detected within the monitored location [30]. This form of occupancy monitoring tracks these behaviors and activities to produce more intelligent HVAC system controllers, for example, as well as determining potential behaviors associated with criminal activities, as another example. Event recognition could be used in buildings that may have large crowds such as: sporting arenas, banquet rooms, theatres, and schools. Aside from obvious privacy issues resulting from this form of occupancy monitoring, these technologies could actually repress basic human nature and interactions due to the simple knowledge of being watched. This repression could infringe upon the principle of respect for the individual. It is an elementary concept that when being watched, your behavior is likely to change to avoid being labeled as suspicious, or so as not to mistakenly do something that may trigger an alert within the system. This form of monitoring could also embarrass an individual or group of people if their actions were misinterpreted. These issues relate to the common awkwardness of leaving a store without buying anything. Although you may not be stealing something, you still feel like everybody is watching you. Your behavior changes, putting on a false persona of who you really are just to remain unsuspected and unnoticed. Such systems may not identify individuals personally, but they accumulate enough data that could easily be used to do so later. Unfortunately, this type of data can be easily misused

for seemingly harmless activities, like targeted advertising, or to cause intentional harm, like creating dangerous situations for some individuals or falsely incriminating someone.

4.10. GPS Tracking

Geographical Positioning Systems (GPS) tracking is becoming more common in various areas in smart cities and it offers location-monitoring capabilities outdoors. In this case the concern is who and how the location data provided by GPS devices is used. Several smart city applications rely on location information to operate effectively [31]. For example, providing smart traffic light controls based on GPS information collected about the vehicles in a given area. Another example is identifying the location of distressed residents and providing emergency support when needed. Location data can be used to find out numerous things about the person or persons being tracked and most of the information that could be revealed by such tracking is legally protected in the United States. GPS tracking in particular is of ethical concern, because it takes up little in the way of resources when compared to other methods of location tracking. In addition, it provides fine-grain and personalized tracking data [31]. This data, in addition to its immediate use, can also be stored and combed through later allowing breaches of privacy to occur long after the data was initially collected. The Supreme Court has already had rulings that forbid the use of GPS tracking by law enforcement unless they have reasonable cause to do so. However, the definition of reasonable cause is ambiguous enough to lead to various infringements on this ruling.

4.11. Autonomous Transportation

An important component of a smart city is its complement of autonomous vehicles. Autonomous transportation provides a cheap and safe alternative to get around the smart cities of the future. The current research in this area is progressing quickly and the industry is already working its way toward achieving fully autonomous vehicles. Some companies that are currently experimenting with autonomous vehicles are: Google, Uber, and most vehicles manufacturers in the automotive industry. The associated press points out that 94% of accidents are caused by human error [32]. This makes self-driving cars a desirable alternative for public transportation. However, some incidents with this technology are posing questions as to how safe it really is. For example, a woman crossing the street in Tempe, Arizona was struck by a self-driving Uber car [33]. The CEO of Uber, in the past, has pointed out that the self-driving cars feature an algorithm that learns as it drives [34]. This means that as they are implemented, the self-driving cars are the most dangerous they will ever be until the algorithm manages to learn. This incident also brings up an interesting question about who is liable in an accident involving a self-driving car. Is the company who owns the car culpable? Is it the back-up driver in the vehicle, or is it the programmer who built the self-driving software? These questions are currently unanswered. Another issue to consider is the minimum harm directive, where the self-driving vehicle should make a decision to cause the smallest possible damage if none can be avoided. This is also a learned behavior that the intelligent software uses, however, as the software learns, it can also easily pick up biased responses that may negatively affect its future decisions.

4.12. Intravehicular Communication

Intravehicular communication focuses on data that is being shared between motor vehicles in a given area, such as multiple vehicles around a specific intersection or near a specific highway exit. This technology mainly works to minimize traffic incidents and improve traffic efficiency [35]. For this type of application to contribute positively, the exchanged data is required to be accurate, relevant, and meaningful during the communication. One major issue is who is able to monitor or receive this exchange of information as well as what information the vehicles are able to communicate to one another. Current vehicular communication applications, such as Waze and Google maps, already present users with data integrity issues. A potential attacker could drive a route to collect data packets. They can then replay the data packets and change the time stamps to falsify data to the server. This

simple attack can be intensified by performing many transmissions with different cookies and platform keys that represent multiple yet unique vehicles [36]. By using this information, an attacker could potentially force other drivers into traffic jams and keep certain roads cleared. In addition, when multiple vehicles are exchanging information, issues of trust arise since these connections are ad hoc and have no way to authenticate each vehicle. With that in mind, it becomes important to consider what ethical or legal problems may occur and how they will be addressed.

4.13. Drone Applications

Drones can provide many applications for smart cities and make a positive impact on society [37]. For example, drones can be used for environmental monitoring, traffic management, pollution monitoring, civil security control, crowd monitoring, infrastructure inspections, tourism support, health emergency services, and merchandise delivery [38]. Drone applications, among several others, can deliver cost-effective services to help achieve the objectives of smart cities [39]. Employing drones for these applications can improve operations and reduce the costs of offering these services. It can also improve safety and security and help save human lives. Drone applications such as security and crowd monitoring, health emergency services, and large-scale disaster management can notably contribute in creating smart cities safer for residents and visitors. Furthermore, some drone applications can stimulate business and offer a good image for a city thus serving to attract new businesses like merchandise delivery, tourism support, and air taxis [37]. Although using drones can provide many benefits to smart cities, there are many safety, security, privacy, and ethical issues involved on these applications [40–42]. Drones in smart cities may be used for diverse applications and under the control of multiple public or private organizations. Consequently, there are potentials that these drones are misused for purposes other than their originally planned functions. Examples include utilizing the drones to spy on residents or organizations, or using data collected by the drones to influence certain persons or organizations when making decisions. This can represent a difficulty for utilizing drone applications in smart cities [40].

5. Challenges

To address the issues related to ethics and ethical conduct when considering, designing, and deploying smart city applications, it is important to understand the underlying challenges affecting them. Smart cities and smart applications enabling them currently being implemented and awaiting implementation face many of these potential challenges. These challenges are centered on three ideas: society, data, and implementation. The challenges that fall into the data category are generally technical challenges which focus on the elements of the data lifecycle. The challenges that fall under the society idea focus more on the personal and societal effects and the possible discriminatory features of the applications. Implementation challenges tend to focus on the implications of moving forward with a specific plan or project towards a smart city. Overall, the wealth of data collectable within a smart city is unlimited and with that managing data access, control and use becomes a great problem. Without proper regulations and codes of ethical use, there are increasing chances for compromise and abuse of this data. The abuse could come from external entities as part of security and privacy attacks, but also can happen internally in forms of bias, improper use or sharing, discrimination to name a few examples. Whether we look at data, societal or implementation challenges, the risks of misconduct are always present and it is important to recognize these risks before they negatively impact the cities and their residents. In the following sections we identify the three types of challenges and how these challenges could lead to risks of ethical misconduct and abuse.

5.1. Societal Challenges

Societal challenges are those affecting or affected by society and people. The variations in skills, wealth, resources, and any other attributes lead to differences in how we create smart city applications capable of recognizing and appropriately incorporating these differences. There are always possibilities

to unintentionally or, in some cases, intentionally create applications that will discriminate based on some characteristic or operate unfairly to certain people or communities.

5.1.1. Skills Inequality

Smart cities are centered on the widespread use of ICT throughout a city. In cities that are less developed and economically downtrodden the implementation of smart city applications is difficult for several reasons. For example, a city like Barcelona, Spain, has been reported to lack the needed skilled human labor to operate the ICT required for smart cities [43]. This lack of skilled labor can be caused by limited access to the required education or lack of access to technology. A weak economy is a contributing factor to both problems [44]. Barcelona has also been shown to lack the required entrepreneurship to innovate and provide new ICT solutions necessary for smart city operations. The quantity of large firms is also not great enough to finance the distribution and operations of smart city ICT to allow for smart city ideas to be properly implemented. Both of these problems are directly related to the economy of Barcelona. Lacking the required skills and capabilities makes becoming a smart city an almost impossible task. Unfortunately, this issue does not have an easy fix and require long-term planning to create the necessary skill sets and innovative capabilities. These issues give rise to inequality between cities as those possessing the necessary skills and resources will have a significant advantage. For example, one possible misuse could be to transfer the majority of development funds to one particular area or city because it has the technologies and skills needed, while other cities become deprived of some essential services.

5.1.2. Wealth and Funding

The attainment of funds for smart cities has become quite the hurdle for the development of smart cities to overcome. These technology-based systems/applications that are becoming aspects of smart cities everywhere are expensive in terms of hardware acquisition, application development, adaptation, and integration. Smart city projects are not only expensive, but funding options are generally limited. Wealth is necessary to create the supporting environment for developing a smart city. Both the human and technical resources must be developed or acquired, and without adequate finances, it becomes practically impossible to achieve the smart city vision. Economic issues are also something that have been historically shown to take a long time to fix. As a result, some cities and countries will have biased implementations of smart city services solely based on how wealthy the city is. India is just one of the many countries focusing on the smart city initiative. India has been experiencing unexpected delays with their developments since their development began even though they took many proactive measures to secure international funding to counter such delays [26,45]. Some other examples of smart cities that have experienced either budget shortages or a significant cost influx include Konza City (Kenya), Songdo (Korea), and Cyberjaha (Malaysia) [46]. Similar to the first challenge, these situations lead to risks of favoring certain cities over others or even specific sectors of residents in a city over others. Problems in resource allocation and proper use of these resources arise regularly leading to question on how appropriate such use is. Another problem could arise when greed and organizational benefits become the priority in these projects, thus affecting the conduct of these organizations during these projects.

5.1.3. Discrimination

Smart cities are inherently based around technological innovations. Without new ICT the idea of a smart city is nothing more than an idea. Consequently, those who are better able to use technology will benefit more from a smart city than those who have trouble using the newest technologies a smart city would implement. One group of people who have difficulty adapting to new technology is the elderly. "Many cities are concerned with the impact of aging society on technology diffusion" [17]. Not only are the elderly not as capable when using ICT, but it is reported that they are afraid of some ICT as well, being referred to as technophobic [47]. Another group that may also fit this category,

although not based on age, is the physically or mentally disabled people who will be at a disadvantage if they could not learn to adapt and use the necessary technologies. This leads to the conclusion that younger and healthier people who have grown around newer ICT will unfairly benefit from smart cities. A city in which a demographic of people is favored over a different demographic is inherently unethical. Another aspect that is important to consider is the discrimination effects caused by the applications being used. Crime detection mechanisms, although useful, also lead to false accusations or improper categorizations of citizens based on gender, ethnicity, race, or region. As a result, the software implemented must be well designed and controlled to avoid possible discriminations. In their proposed crime detection system [48] the researchers emphasize the need to rely on results inferred from objective misbehavior, rather than from sensitive attributes like gender, race, or religion.

5.2. Implementation Challenges

When we arrive at the point where we actually implement a smart city application, there are issues that arise and must be handled. These issues are generally non-technical and require some careful analysis and laying out appropriate guidelines, rules, and even laws to address them. Some examples are having some types of standards for conforming services, being able to scale the applications to cover the whole city, and having the support and cooperation of all organizations involved. Clearly and fairly defining data ownership is also extremely important when implementing these applications as it should create the basis to how applications will collect and use data and where the boundaries are for such use.

5.2.1. Conforming Services

Smart cities are seen as the solution to the deteriorating levels of natural resources around the world [49]. However, for this to work, the integration of different systems in a city like green buildings, smart grids, and smart transportation systems would be necessary to reduce current energy needs and to provide twenty-four-hour access to these utilities. Energy systems planning is a huge challenge within the development of smart cities. These issues include both energy generation and consumption by city infrastructures residents [50]. This idea is a key paradigm for smart cities. This implementation is very intensive and would become a potential solution to many large-scale energy problems when established. In countries where fresh water and food supplies are scarce or prone to impurities, water services will not be as optimized as they must be to be efficient. The supply networks for this utility deployment must be as efficient as humanly possible to keep distribution losses at a minimum [51]. The challenge here is to ensure some level of conformity across all utility services to allow for their integration. The integration could then be utilized to create smart applications to optimize energy, water, and other resources used in smart cities. Another aspect of smart cities that also alludes to the same requirement is the exchange and sharing of data across different smart city applications that involve resident monitoring. Smart applications intended to monitor and control crowds in large events or respond to emergency situations require direct collaboration between multiple government and private organizations. Police forces, medical institutions, and private companies managing the events or infrastructures involved all must be involved in real-time to be effective. Yet, the lack of standardized exchange protocols and adequate regulations governing such exchange will create a huge obstacle for these applications. In all cases, ethics become part of the story as the possibility of misconduct arises in various dimensions. For example, improper use of personal information obtained by one organization for a specific reason; favoring specific locations or crowds with services over others; or unintentionally discriminating among different groups or locations when responding to a large scale situation.

5.2.2. Scalability

Scalability, the ability to handle a growing amount of work with the same efficiency, is a very important characteristic of modern-day technology. The main contributor to scalable smart city

applications is the ICT infrastructure used. In particular, networking and communication capabilities play a significant role in the success of such applications as they need to span huge geographic areas and simultaneously support millions of users and devices. Today, wireless devices are in abundance and the number of devices is growing at an exponential rate. With the future advancements and elaborations of smart cities, this number is only expected to continue increasing. Due to the fact that smart cities rely on connectivity, the current communication infrastructure will become a bottleneck as it is limited in terms of throughput, bandwidth, and range of transmission. Some technologies will remain effective; however, they need to be updated and enhanced to handle the growing needs. The networking of smart cities needs to be addressed to enable the smart city to withstand not only the amount and frequency of data exchanges, but to also withstand the indisputable presence of interference from devices which can lead to frequent or catastrophic outages or communication errors. As a technical implementation issue, this seems to have minimal concerns when it comes to ethics. However, examining the topic closely could reveal many areas where residents' rights or privacy are violated when resources become scarce. For example, some organizations may selectively offer services to higher-paying customers when they do not have enough network coverage for all customers. Another example would be tapping into personal devices to extend network capabilities, without users' consent.

5.2.3. Application Procurement and Organizational Collaboration

Application procurement refers to the proposal and acceptance of terms for new systems and for updates of current systems. The current procurement processes are not designed for quick and efficient updates and approvals. Konza City in Kenya has experienced this problem [46]. It has caused major delays in the project itself which resulted in unspent yet already allocated funds. This was due to both strict procurement laws as well as the number of government agencies involved in the procurement procedures. The aforementioned water monitoring system located in Korea also faced similar problems due to the lack of cooperation in procurement processes within the private sector due to legislations and lack of incentives [5]. The lack of expedited application procurement can cause very serious delays in smart city deployment, development, and integration. In addition, with different levels of governance and control, some entities may selectively choose to pass certain projects, while delaying others for various reasons. Some of these could be for valid technical or economic reasons; however, there is always the chance to discriminate based on certain knowledge or criteria relevant to the project or the population affected. Another aspect is when problems (especially those related to ethics or privacy) in deployed systems are detected and new applications or projects are needed to remedy these problems quickly. In these cases, delays in approvals could compound the effects of these problems. In addition, these processes can also be compounded by the lack of cooperation and collaboration between the organizations involved. Some level of collaboration could ease the procurement processes to allow projects to move forward with minimal delays. Unfortunately, many organizations view such projects from their own perspective and could easily refuse to cooperate either because they will not benefit from the projects or because they want more benefits. The ethical conduct in these situations is extremely necessary to ensure appropriate processes and timely approvals.

5.2.4. Data Ownership

"Who owns the data?" This question comes up whenever data is collected no matter what the application is. For example, when you sign up for a phone line, you basically give away your right for a private number unless you pay to make it private. That is because the communication company owns this data, which correlates your name and address to that particular phone number. A smart city application can collect data about everything and everyone they affect. The smart grid collects fine-grain data about each house or building using it. This includes personal information about the residents, collected information about the appliances and devices they own and use, usage patterns, and times when residents are in or out of the building, etc. Who owns and controls this data? Is there a

clear definition that identifies who can use it, and who can it be shared with? Does the company own all rights to the data or will the consumers be the owners? Answers to these questions have nothing to do with technology; however, they are essential to ensure all parties involved are aware of their rights and responsibilities when it comes to the data. A lot of ethical issues may arise here if we do not have clear answers to these questions and everyone involved is aware of them and adheres to them.

5.3. Data Challenges

These are mainly technical challenges, yet they also have a great impact on everyone and everything in a smart city. To effectively support a smart city application, data is needed. Some is general and common place; however, most is personal and private. Ethical issues involved in collecting, storing, protecting, accessing, and sharing this data are very common and may lead to major problems in a smart city.

5.3.1. Data Collection

The process of data collection refers to the action of gathering data from various sources. In terms of smart cities, data is the driving force behind the vast majority of applications. Some examples include the smart grid, occupancy monitoring systems, smart city drone applications and crime detection systems. These systems, like many others, continuously collect data about infrastructures, devices and people. They use the collected data to control, manage, and analyze patterns to enable the respective applications and enhance the residents' quality of life. In many cases they indiscriminately collect data, even when it is irrelevant to the application, posing a great challenge for smart city applications and users. A real-time data collection application would most likely be running at all hours of the day to acquire accurate and steady data. In addition, using personal devices for data collection also increases access to private information and intimate knowledge of the residents. This raises the issue of what data should or can be collected and what data should not be collected. In addition, how data is collected is an important issue to address. For example, in occupancy monitoring only the presence of people is necessary, which can be easily monitored through entry and exit points. However, occupancy tracking requires fine-grain data collection and also specific information about the occupants, thus requiring imaging, facial recognition, or other technologies that can provide this information. Having such monitoring devices in public spaces may be acceptable, but in private residences, for example, it becomes problematic as it invades the core privacy of humans. Furthermore, as data is continuously recorded, is there a way to omit or anonymize certain data that may not be relevant to the applications? Moreover, who, if anyone, has the authority to provide the permissions and rules of data collection? Will the smart city residents have control over their own data and what data they are willing to provide? Several questions are raised and the issues involved could easily lead to concerns around ethics.

5.3.2. Data Storage

Collected data along with new information generated as the data is processed need to be stored. This would require large databases and file systems to hold the collected data which could easily grow into terabytes or more per frequency of collection [52]. Depending on its size and usage, data can be stored locally within a certain system or distributed across multiple networked storage devices. For example, many organizations now opt for using cloud-based storage to offload their equipment and management needs [53]. The result of this continuous data collection and storage also led to the creation of what is known as "big data". Data sets are considered big data as they have increased volume, velocity, and variety, as well as being analytically and socially useful [52]. Handling big data requires having the right infrastructure to store and process it within the identified system's constraints and requirements. As soon as data is stored it becomes visible to those who have access to the storage facilities. Once more, we face similar questions regarding who is protecting the stored data, who is or is not allowed to access it, and how it is going to be protected. In house data storage it is the responsibility of the organization that owns it, which limits the implications to a certain

extent. However, cloud-based storage and distributed data centers create larger problems in terms of transporting the data to and from these facilities safely and securely and investing in proper protection tools and mechanisms across the whole system. Ethical conduct plays a role here such as when an organization chooses to limit its investment in securing these storage facilities to reduce costs for example, which may result in leaks or unauthorized access to this data leading to improper use of this data.

5.3.3. Data Protection

"The technologies deployed potentially produce buggy, brittle, and hackable urban systems which create systemic vulnerabilities across critical infrastructure and compromise data security..." [54]. The majority of the technologies that smart cities use require the storage of some kind of data. Within smart cities huge amounts of data, most of which is sensitive and maybe private, is stored locally or on the cloud. All data being stored has a chance to be compromised. More devices connected to a network increase the channels an attacker can use to gain access to the data. A global security survey found that for the Fortune 500 companies, 90% of security breaches come from external attacks [55]. If a network has mostly secure nodes but one node is from a legacy system or has weaker security than the rest of the network, then the entire network's security is essentially as strong as the weakest link. Smart cities represent a large-scale distributed system of networked devices of all types that has not been represented before, thus the vulnerability of the data it stores is not paralleled anywhere else. This is most likely the largest concern for security, privacy and ethical use in smart cities as it is the most universal problem. Even with strong security measures, we still have to consider the risks of insiders compromising security protocols for personal gains, sabotage, or aiding external access.

5.3.4. Data Access

Accessing data is of utmost importance for any type of smart city application. If data was being collected without further use, the collection of that data itself would become irrelevant and disposable. Data access is known as retrieving and/or using collected and stored data. The retrieval and querying techniques must be efficient and secure. Large-scale data transfers must not only be supported, they must also be secure. In addition, the systems and users who have access to stored data must be limited to certain users and constrained to a certain amount of data. Proper authorization and authentication protocols must be in place to control access to data. Without these, the data may be compromised, becoming fraudulent or corrupted, or could even be redistributed for other unauthorized purposes. Other requirements such as network authentication, blocked extensions, and background programs, as well as other forms of attacks prevention should also be implemented to secure the data from potential unauthorized access of malicious conduct [56]. A user and system audit and activity logs should also be recorded for any form of data access including use, modification, or even deletion. Unlike general databases, the data sets collected from smart cities are likely to be more invasive and should only be accessible from highly qualified and authorized individuals.

5.3.5. Data Sharing

Data sharing in terms of smart cities refers to the practice of making data accessible to other systems and users, usually outside the owner organization. Much like data access, data sharing must ensure that only authorized systems and users access the data and processes of the systems. As soon as data is shared with an entity outside the owner organization, the rules and procedures of the owner do not apply. Therefore, it is important to establish clear and specific agreements between the two parties regarding the use and protection of the shared data. Trust is key in sharing sensitive data and it is not easy or clear who is trustworthy or not. Another important aspect is that by sharing data, high level encryption must be used to ensure the privacy and security of the data in transit. Confidential data leaks are a main concern of big data in smart cities due to the use of cloud-based architectures [57]. Although encryption is very important, one drawback would be efficiency. Higher

level encryptions take an increased amount of time when querying data from databases or transferring large sets across networks. There are trade-offs when working with both security and accessibility that must remain at high standards [58]. The most dangerous threat to data in transit is when an attacker gains access during data transmission using object injection, for example. In this attack, the end user connects through a middleman who then establishes the secure session to the server. The website responds to the middleman with the secure socket layer (SSL) certificate and is replicated and delivered to the end user [59]. Research and designs must be implemented to enhance connection validation and encryption. Data sharing poses a strong threat to smart city applications and raises questions about what could happen of data is wrongly shared or made available to non-authorized parties. Unfortunately, the success of a smart city relies heavily on the ability to integrate different systems and organizations and allow seamless data sharing, yet the risks involved are generally very high and must be well studied and addressed. Technical risks may be solvable with the rapid advances in relevant technologies. However, in such large environments, the legal and ethical risks are hard to control.

6. Discussion

Humans are an integral part of the smart city vision and any application or project designed and built to enable a smart city must consider the human factor. Generally the technical components can be controlled, redesigned, and configured to adhere to agreed-upon standards and specifications of operations, which usually include some security and privacy aspects. However, like everything else, as soon as humans come into the picture; there are other issues to consider that technology, protocols, rules, and procedures cannot fully control. One of these is ensuring the ethical use of the technology, software, hardware, and, most importantly, data in smart city applications. Most of the current research and development work address the technical issues. Very few have seriously considered the ethical aspects. However, recently more attention has been given to this issue. For example, when a smart city application can control how much water a home or building could get, we need to be sure that the decisions are ethically made for this distribution. Additionally, when there is a drone flying overhead and collecting videos, images, and other data; we want to know what exactly is being collected, who will see or use that data, how it will be used, how well is it protected, and most importantly, whether it will be used appropriately. These are just two examples to show the effect.

In Section 4 we discussed several representative applications for smart cities and briefly discussed their purpose and how ethical issues may arise. Every project or application requires different types and volumes of data and the sensitivity of this data varies as well. When an application is more concerned about general attributes and does not involve personalized information like in autonomous transportation systems, intravehicular communication, and smart traffic systems, the concerns are about fair and indiscriminate use of this data. However, when more personalized data is involved that could invade human privacy, as in the smart grid, occupancy tracking, and crime detection, more emphasis on ethics is needed to ensure humans' privacy and rights. In Section 5 we developed a list of challenges to be addressed when considering smart city applications. Many of these challenges apply to almost all types of smart city applications. However, the emphasis and impact of each one varies depending on the type of application and the data required. Table 1 offers a quick view of the different applications we reviewed in relation to the challenges that are most relevant to each application. The correlation in the table is mainly based on the type and volume of data used, the level of privacy involved, and how invasive the data collection is with respect to the humans involved. Accordingly, for each application we highlight the most relevant challenges.

Table 1. Ethical challenges in relation to the smart city applications reviewed.

Smart City Application	Applicable Challenges	Ethical Impact
Water Monitoring System	• Application procurement & organizational collaboration • Scalability • Conforming Services • Data sharing	Organizational level issues like delays and favoring certain entities and when sharing data across different organizations. Minimal impact on residents as most data used is higher level and non-personal.
100 Smart cities	• Skills inequality • Wealth and funding • Scalability	Favoring wealthy cities and ignoring others, unfairly distributing resources, and separation of classes. Minimal impact on residents as most data used is higher level and non-personal.
Performance Measurement System	• All data challenges • All implementation challenges	Being a project focused on measurements, it relies on all types of data available and must address all ethical issues that may arise with data usage of any type. Implementation ethical issues are also involved including ensuring ethical allocation for data ownership.
Crime Prediction	• All societal challenges • All data challenges	Biased AI and learning algorithms could easily lead to discrimination and class separation across communities. Data collected is fine grained and private, which could lead to many concerns about ethical use of it.
Smart Grid	• Discrimination • Data Ownership • Data Collection • Data Access	Smart algorithms may be influenced and become discriminatory. Some data is private thus the definition of who owns it and how it is used may become an issue. Ethical misconduct may happen during data collection and processing.
Occupancy Detection	• Data Access • Data sharing	Most of the data is not personalized, thus the most likely issues of ethics may arise when accessing the data or sharing it with other entities.
Occupancy Counting	• Discrimination • Data Collection • Data Protection • Data Sharing	Methods of collection may raise some questions like using cameras in private spaces. Collected data is highly personalized, hence the need for proper protection and controlled sharing. Data collected may lead to discriminatory actions against some residents.
Occupancy Tracking	• Discrimination • All data challenges	This is most invasive and detailed. Issues with unethical data use may occur at every stage of data usage. Data collected may lead to discriminatory actions against some residents.
Event Recognition	• Data Collection • Data Access • Data Sharing	Since this is mostly used in public events, the main concerns are related to the proper (or improper) methods of collection, for example, using personal devices without permission. Possible issues arise with data access rights and sharing.
GPS Tracking	• Data Collection • Data Access • Data Sharing	Since this is mostly used in public open spaces, the main concerns are related to the proper (or improper) methods of collection. For example, using vehicles' GPS devices without permission. Possible issues arise with data access rights and sharing.
Autonomous Transportation	• Skill Inequality • Wealth Inequality • Data Access • Data Sharing	Ethical questions regarding who gets access to such services arise. When in use, data collected could be accessed or shared in inappropriate ways.
Intravehicular Communication	• Data Collection	This type of application usually operates on demand and do not store a lot of data. However, data collection may be misused when vehicles gain access to other vehicles systems.
Drone Applications	All data challenges Conforming Services	Drones can collect a multitude of data, some of which is personal or private leading to concerns about ethical use in all aspects of data usage. Connectivity and collaboration with other systems may lead to additional issues like creating unnecessary data stores or sharing data without permission.

In general, when we are dealing with technology and data collection and analysis for any application, there will always be challenges in terms of the proper processes used. Adhering to

privacy terms is one issue when collecting, accessing, and sharing data. Using proper security methods is very important when working with data at any level. In addition, having the ethical sense when handling and using the data is a great concern. In some cases, challenges pertaining to ethics may be controlled through technology. However, many of these challenges must be addressed at a different level. Rules, regulations and guidelines are needed to help face these challenges. In addition, extensive research is needed to ensure that intelligent software and algorithms will not be biased and that learning algorithms are trained to recognize appropriate conditions without discrimination or bias. Moreover, there is a pressing need to develop and apply some type of code of ethics for utilizing different applications in smart cities. This code of ethics should clearly and professionally define guidelines and solutions for diverse ethical issues that may arise with smart city applications. Policies and procedures for proper and ethical utilization of smart city applications must be established and lawfully enforced.

As technologies evolve and smart city applications get smarter, we face these ethical use issues at different levels. For some, it may be possible to address using the technology, for example, making sure the algorithms used are not biased and incorporating well-defined boundaries for the operations of different devices within the smart city applications. Another example could be the use of predefined filters to remove any irrelevant collected data before storing and processing it. However, there are issues that the technology cannot directly solve and most of these have to do with the human part of the equation. To put things in context, when cars where first built and used, there were no proper roads, traffic laws, or rules of conduct. It took a very long time to start considering all these issues. Some were solved technically, like building paved roads, installing traffic signs and lights, and creating driving laws. However, to date, there are some who can still abuse the system by speeding, driving under the influence, or not following the traffic signs. Some could go as far as using a car as a weapon. These are more ethical issues than rules and regulations issues. Applying the same model on smart cities, we find that we will be facing a multitude of these ethical challenges to the system and we must start addressing them as soon as possible.

We envision a holistic approach to designing and developing smart city applications. Researchers, developers, and governing bodies need to approach ethical issues as part of the requirements and specifications in the development life cycle for any smart city application. Unfortunately, this may be an impossible task. Technical requirements are usually very difficult to define, and it is even harder (if not impossible) to identify every possible ethical aspect of an application beforehand. There are issues and scenarios that we may never imagine until they actually happen when an application is in operation. However, that does not mean that we should abandon the whole idea of smart cities. Just like the car example, it will take time to discover the issues and more time to solve them appropriately and efficiently.

We are a long way from fully understanding the impact of ethical issues in smart cities, while the technology is moving so fast making it difficult to focus on these aspects and find the proper solutions. As a result, it is now time to start considering these issues more seriously and trying to make them part of the process rather than addressing them as an afterthought. Collaborative efforts across all stakeholders and also among different applications can help speed up this effort by providing a bigger pool of information about the possible issues. When one organization deals with some issues and another faces a different issues regarding ethical conduct, sharing this information will help everyone who may face similar issues.

Another aspect to consider is the involvement of non-technical researchers in this field. Humans are the center of smart cities and to implement a successful smart city application, human involvement is a major contributor. Therefore, it is imperative that researchers in human aspects like psychology, social interactions, learning models, and even physical health are involved. In addition, studies in law, corporate operations, governmental regulations, and management are necessary to identify where and how these fields will be useful. Once more, traffic laws where put in place after cars became popular and accessible to ensure safety. Business rules and corporate operations had to adapt as well.

In the context of smart cities, the same needs to be done. Research on possible new laws, rules, and regulations is needed. Work on more appropriate business models and corporate relations is necessary. Open discussions about the impact of smart city applications on humans in all aspects must be initiated and used to guide future developments. Humans are generally resistant to change because they fear the losses associated with it: loss of privacy, the need to learn new technologies, or loss of control on their own information. However, if the research and development communities can include them in the conversation and highlight the gains as well, we may have a better chance for success.

7. Conclusions

Smart cities are an aspiration to many countries aiming to achieve optimal operations, sustainability, and high levels of residents' quality of life. ICT and new emerging technologies like IoT, CPS, cloud, and fog computing provide the bases for developing and deploying smart city applications. However, smart city applications require monitoring and gathering data continuously to achieve their goals. This data may be generic, such as environmental and traffic data, but can also be very personal and private, such as people's identities, locations, utility usage, and private activities. As a result, many questions may arise regarding the safekeeping of this data and the ethics involved in its gathering, ownership and utilization. Unfortunately, researchers and developers are rarely concerned about this aspect of smart cities. As a result, in this paper we investigated the issues in light of some relevant smart city projects and applications. We first discussed the general aspects of ethics and ethical use of data in smart cities. Then we reviewed several projects around the world working on some types of smart city applications and attempted to highlight the ethical aspects involved. Then we used this information to build a list of challenges facing smart city applications in light of the review. The challenges involve several aspects, some of which can be solved with technology, while others need more human intervention in terms of rules, regulations, guidelines, laws, and ethical codes of conduct. Like every other technology, the discussion of the ethical and legal implications starts with the public's concerns and views. However, a deep understanding and clear outline of how to control smart city applications to avoid ethical misconduct is very important for the success of these applications and the people's acceptance of them.

There is a lot to be done and the picture seems dark at the moment. However, like every new invention in the past, a point arrives when all aspects involved are identified and addressed. The main problem when we investigate smart city applications is the vast set of domains involved and the fast rate at which the technologies are changing and penetrating our everyday lives. At such a rate, it is not easy to keep up with this growth, which makes it essential to incorporate these concerns into the design and development processes of smart city applications. Here, we tried to shed some light on the importance of considering the ethical issues involved, and of including them as part of the application's requirements. We hope that this work will be the beginning of more investigation and research to address this topic and try to create a more systematic approach to identify and deal with possible ethical issues. Researchers and developers need to be more open about their experiences and sharing information about ethical issues to create a wider knowledgebase for everyone to use. Individual efforts are important and can make an impact on the specific application at hand; however, sharing this success with others will allow them to address similar issues faster and more efficiently. As more information emerges on AI bias, software discrimination, and unlawful use of data, to name a few examples, there is a strong need to find ways to isolate these problems and create some workable solutions. In our work, we intend to further study the impact of smart city applications on city residents, businesses, and governing bodies. As we investigate our technical approaches for smart city applications, we will incorporate the ethical issues and try to address them concurrently.

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References

1. Dirks, S.; Gurdgiev, C.; Keeling, M. *Smarter Cities for Smarter Growth: How Cities Can. Optimize Their Systems for the Talent-Based Economy*; IBM Inst. Business Value: Somers, NY, USA, 2010.
2. Al-Fuqaha, A.; Guizani, M.; Mohammadi, M.; Aledhari, M.; Ayyash, M. Internet of things: A survey on enabling technologies, protocols, and applications. *IEEE Commun. Surv. Tutor.* **2015**, *17*, 2347–2376. [CrossRef]
3. Mohamed, N.; Al-Jaroodi, J.; Jawhar, I.; Lazarova-Molnar, S.; Mahmoud, S. SmartCityWare: A Service-Oriented Middleware for Cloud and Fog Enabled Smart City Services. *IEEE Access* **2017**, *5*, 17576–17588. [CrossRef]
4. Al-Jaroodi, J.; Mohamed, N.; Jawhar, I.; Lazarova-Molnar, S. Software engineering issues for cyber-physical systems. In Proceedings of the IEEE International Conference on Smart Computing (SMARTCOMP), St. Louis, MO, USA, 18–20 May 2016; pp. 1–6.
5. Kim, J.S. Making smart cities work in the face of conflicts: Lessons from practitioners of South Korea's U-City projects. *Town Plan. Rev.* **2015**, *86*, 561–585. [CrossRef]
6. Cocchia, A. *Smart and Digital City: A Systematic Literature Review*; Springer: Berlin, Germany, 2014; pp. 13–43.
7. Dameri, R.P.; Cocchia, A. Smart city and digital city: Twenty years of terminology evolution. In Proceedings of the X Conference of the Italian Chapter of AIS, Milan, Italy, 14 December 2013.
8. Anthopoulos, L.G.; Tougountzoglou, T.E. *A Viability Model for Digital Cities: Economic and Acceptability Factors. Proceedings of Web 2.0 Technologies and Democratic Governance*; Springer: New York, NY, USA, 2012; pp. 79–96.
9. Couclelis, H. The construction of the digital city. *Environ. Plan. B Plan. Des.* **2004**, *31*, 5–19. [CrossRef]
10. Zanella, A.; Bui, N.; Castellani, A.; Vangelista, L.; Zorzi, M. Internet of things for smart cities. *IEEE Internet Things J.* **2014**, *1*, 22–32. [CrossRef]
11. Al Nuaimi, E.; Al Neyadi, H.; Mohamed, N.; Al-Jaroodi, J. Applications of big data to smart cities. *J. Internet Serv. Appl.* **2015**, *6*, 25. [CrossRef]
12. Ahvenniemi, H.; Huovila, A.; Pinto-Seppä, I.; Airaksinen, M. What are the differences between sustainable and smart cities? *Cities* **2017**, *60*, 234–245. [CrossRef]
13. Batagan, L. Smart cities and sustainability models. *Inform. Econ.* **2011**, *15*, 80–87.
14. Lang, J. *Urban Design: A Typology of Procedures and Products*; Routledge: Abingdon, UK, 2017.
15. Kummitha, R.K.R.; Crutzen, N. How do we understand smart cities? An evolutionary perspective. *Cities* **2017**, *67*, 43–52. [CrossRef]
16. Neirotti, P.; De Marco, A.; Cagliano, A.C.; Mangano, G.; Scorrano, F. Current trends in Smart City initiatives: Some stylised facts. *Cities* **2014**, *38*, 25–36. [CrossRef]
17. Nam, T.; Pardo, T.A. Conceptualizing smart city with dimensions of technology, people, and institutions. In Proceedings of the 12th Annual International Digital Government Research Conference: Digital Government Innovation in Challenging Times, University of Maryland, College Park, MD, USA, 12–15 June 2011.
18. Albino, V.; Berardi, U.; Dangelico, R.M. Smart cities: Definitions, dimensions, performance, and initiatives. *J. Urban Technol.* **2015**, *22*, 3–21. [CrossRef]
19. Merriam-Webster. *Merriam-Webster's Collegiate Dictionary*, 11th ed.; Merriam-Webster: New York, NY, USA, 2008.
20. Zoonen, L.V. Privacy concerns in smart cities. *Gov. Inform. Q.* **2016**, *33*, 472–480. [CrossRef]
21. Mohamed, N.; Al-Jaroodi, J.; Jawhar, I. Service-Oriented Big Data Analytics for Improving Buildings Energy Management in Smart Cities. In Proceedings of the 14th International Conference on Wireless Communications and Mobile Computing (IWCMC), Limassol, Cyprus, 25–29 June 2018.
22. Mosannenzadeh, F.; Bisello, A.; Vaccaro, R.; D'Alonzo, V.; Hunter, G.W.; Vettorato, D. Smart energy city development: A story told by urban planners. *Cities* **2017**, *64*, 54–65. [CrossRef]
23. Kitchin, R. The real-time city? Big data and smart urbanism. *GeoJournal* **2014**, *79*, 1–14. [CrossRef]
24. Bonnemains, V.; Saurel, C.; Tessier, C. Embedded ethics: Some technical and ethical challenges. *Ethics Inform. Technol.* **2018**, *20*, 41–58. [CrossRef]
25. Bryson, J.J. Patiency is not a virtue: The design of intelligent systems and systems of ethics. *Ethics Inform. Technol.* **2018**, *20*, 15–26. [CrossRef]

26. Souvanic, R. The Smart City Paradigm in India: Issues and Challenges of Sustainability and Inclusiveness. *Soc. Sci.* **2016**, *5*, 29–48.
27. Huovila, A.; Airaksinen, M.; Pinto-Seppà, I.; Piira, K.; Bosch, P.R.; Penttinen, T.; Neumann, H.M.; Kontinakis, N. CITYkeys Smart City Performance Measurement System. *Int. J. Hous. Sci. Its Appl.* **2017**, *41*, 113–125.
28. Bogomolov, A.; Lepri, B.; Staiano, J.; Oliver, N.; Pianesi, F.; Pentland, A. Once upon a crime: Towards crime prediction from demographics and mobile data. In Proceedings of the 16th International Conference on Multimodal Interaction, Istanbul, Turkey, 12–16 November 2014; pp. 427–434.
29. Kostyk, T.; Herkert, J. Computing Ethics: Societal Implications of the Emerging Smart Grid. *Commun. ACM* **2012**, *55*, 34–36. [CrossRef]
30. Akkaya, K.; Guvenc, I.; Aygun, R.; Pala, N.; Kadri, A. IoT-based occupancy monitoring techniques for energy-efficient smart buildings. In Proceedings of the IEEE Wireless Communications and Networking Conference Workshops (WCNCW), New Orleans, LA, USA, 9–12 March 2015; pp. 58–63.
31. Elmaghraby, A.S.; Losavio, M.M. Cyber security challenges in Smart Cities: Safety, security and privacy. *J. Adv. Res.* **2014**, *5*, 491–497. [CrossRef] [PubMed]
32. Krisher, T. Can Self-Driving Cars Withstand First Fatality? *U.S. News & World Report*. 20 March 2018. Available online: https://www.usnews.com/news/business/articles/2018-03-20/arizona-death-brings-calls-for-more-autonomous-vehicle-rules (accessed on 9 September 2018).
33. Kissler, M.; Levin, A.; Beene, R. Uber Victim Stepped Suddenly in Front of Self-Driving Car. Available online: www.bloomberg.com/news/articles/2018-03-20/video-shows-woman-stepped-suddenly-in-front-of-self-driving-uber (accessed on 9 September 2018).
34. Newcomer, E. Uber CEO's Commitment to Self-Driving Cars Tested by Fatality. *Bloomberg.com*. 20 March 2018. Available online: https://www.bloomberg.com/news/articles/2018-03-20/uber-ceo-s-commitment-to-self-driving-cars-is-tested-by-fatality (accessed on 9 September 2018).
35. Cheng, X.; Yao, Q.; Wen, M.; Wang, C.X.; Song, L.Y.; Jiao, B.L. Wideband Channel Modeling and Intercarrier Interference Cancellation for Vehicle-to-Vehicle Communication Systems. *IEEE J. Sel. Areas Commun.* **2013**, *31*, 434–448. [CrossRef]
36. Jeske, T. Floating Car Data from Smartphones: What Google and Waze Know about You and How Hackers Can Control Traffic. *Black Hat*. March 2013. Available online: https://media.blackhat.com/eu-13/briefings/Jeske/bh-eu-13-floating-car-data-jeske-slides.pdf (accessed on 9 September 2018).
37. Mohamed, N.; Al-Jaroodi, J.; Jawhar, I.; Idries, A.; Mohammed, F. Unmanned Aerial Vehicles Applications in Future Smart Cities. echnol. *Forecast. Soc. Chang.* **2018**, in press. [CrossRef]
38. Mohammed, F.; Idries, A.; Mohamed, N.; Al-Jaroodi, J.; Jawhar, I. UAVs for smart cities: Opportunities and challenges. In Proceedings of the International Conference on Unmanned Aircraft Systems (ICUAS), Orlando, FL, USA, 27–30 May 2014; pp. 267–273.
39. Mohammed, F.; Idries, A.; Mohamed, N.; Al-Jaroodi, J.; Jawhar, I. Opportunities and challenges of using UAVs for dubai smart city. In Proceedings of the 6th International Conference on New Technologies, Mobility and Security (NTMS), Dubai, UAE, 30 March–2 April 2014; pp. 1–4.
40. Finn, R.L.; Wright, D. Unmanned aircraft systems: Surveillance, ethics and privacy in civil applications. *Comput. Law Secur. Rev.* **2012**, *28*, 184–194. [CrossRef]
41. Rodday, N.M.; Schmidt, R.D.O.; Pras, A. Exploring security vulnerabilities of unmanned aerial vehicles. In Proceedings of the 2016 IEEE/IFIP Network Operations and Management Symposium (NOMS), Istanbul, Turkey, 25–29 April 2016; pp. 993–994.
42. Vattapparamban, E.; Güvenç, I.; Yurekli, A.I.; Akkaya, K.; Uluağaç, S. Drones for smart cities: Issues in cybersecurity, privacy, and public safety. In Proceedings of the 2016 International Conference of Wireless Communications and Mobile computing Conference (IWCMC), Paphos, Cyprus, 5–9 September 2016.
43. Bakıcı, T.; Almirall, E.; Wareham, J. A smart city initiative: The case of Barcelona. *J. Knowl. Econ.* **2013**, *4*, 135–148. [CrossRef]
44. Eamon, M.K. Digital divide in computer access and use between poor and non-poor youth. *J. Soc. Soc. Welf.* **2004**, *31*, 91.
45. Adapa, S. Indian smart cities and cleaner production initiatives—Integrated framework and recommendations. *J. Clean. Prod.* **2018**, *172*, 3351–3366. [CrossRef]

46. Angelidou, M. Smart city planning and development shortcomings. *Tema J. Land Use Mobil. Environ.* **2017**, *10*, 77–94.
47. Pollack, M.E. Intelligent technology for an aging population: The use of AI to assist elders with cognitive impairment. *AI Mag.* **2005**, *26*, 9.
48. Hajian, S.; Domingo-Ferrer, J.; Martinez-Balleste, A. Discrimination prevention in data mining for intrusion and crime detection. In Proceedings of the 2011 IEEE Symposium on Computational Intelligence in Cyber Security (CICS), Paris, France, 11–15 April 2011; pp. 47–54.
49. Silva, B.N.; Khan, M.; Han, K. Towards sustainable smart cities: A review of trends, architectures, components, and open challenges in smart cities. *Sustain. Cities Soc.* **2018**, *38*, 697–713. [CrossRef]
50. Yamamura, S.; Fan, L.; Suzuki, Y. Assessment of Urban Energy Performance through Integration of BIM and GIS for Smart City Planning. *Procedia Eng.* **2017**, *180*, 1462–1472. [CrossRef]
51. Monzon, A. Smart cities concept and challenges: Bases for the assessment of smart city projects. In Proceedings of the International Conference on Smart Cities, Green ICT Systems, Lisbon, Portugal, 20–22 May 2015; pp. 1–11.
52. Jin, J.; Gubbi, J.; Marusic, S.; Palaniswami, M. An Information Framework for Creating a Smart City through Internet of Things. *IEEE Internet Things J.* **2014**, *1*, 112–121. [CrossRef]
53. Al Nuaimi, K.; Mohamed, N.; Al Nuaimi, M.; Al-Jaroodi, J. A Smart Storage Optimization Technique on the Cloud. *Int. J. Grid Util. Comput.* **2017**, *8*, 109–119. [CrossRef]
54. Kitchin, R. *Getting Smarter about Smart Cities: Improving Data Privacy and Data Security*; Data Protection Unit, Department of the Taoiseach: Dublin, Ireland, 2016.
55. Byres, E.; Lowe, J. The myths and facts behind cyber security risks for industrial control systems. In Proceedings of the VDE Kongress, Berlin, Germany, 18–20 October 2004; pp. 213–218.
56. Kumar, P.R.; Raj, P.H.; Jelciana, P. Exploring Data Security Issues and Solutions in Cloud Computing. *Procedia Comput. Sci.* **2018**, *125*, 691–697. [CrossRef]
57. Olanrewaju, R.F.; Islam, T.; Khalifa, O.O.; Fajingbesi, F.E. Data in Transit Validation for Cloud Computing Using Cloud-Based Algorithm Detection of Injected Objects. *Indones. J. Electr. Eng. Comput. Sci.* **2018**, *10*, 348–353.
58. Pallas, F.; Bermbach, D.; Müller, S.; Tai, S. Evidence-based security configurations for cloud datastores. In Proceedings of the Symposium on Applied Computing, Marrakech, Morocco, 3–7 April 2017.
59. Shafi, A.; Shah, S. Big Data Analysis and Deterministic Encryption Challenges. *Int. J. Adv. Res. Comput. Sci.* **2017**, *8*, 40–43. [CrossRef]