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Toward an Ethical Framework for Smart Cities and the Internet of Things

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As smart cities increasingly become real, an ethical framework for them becomes increasingly necessary. Surprisingly, current approaches largely disregard such a framework and concentrate primarily on challenges pertaining to the data lifecycle. However, a smart city involves much more than data gathering: it involves the interactions of residents, businesses, and government agencies with respect to public and private resources subject to potentially subtle regulations and other norms. This article introduces a sociotechnical view of smart cities and shows how it may be profitably mapped to the moral foundation theory to provide a comprehensive ethical framework.

A *smart* city is one that involves the digitalization of its infrastructure and services to meet goals, such as improving residents' well-being and realizing gains in terms of efficiency, cost, sustainability, and resilience to natural and societal disruptions. Definitions by the Organization for Economic Co-operation and Development (OECD, an international body)[1] and the National Institute of Standards and Technology (NIST, a US body)[2] agree on this core idea though they may differ in some details and phrasing.

The vision of smart cities unites progress in sensor technologies, storage, communications, information processing architectures, and data analytics to build an Internet of Things (IoT) system at city scale. This vision is attractive because it brings together complementary technologies to generate innovative solutions that can help ordinary people.

Smart cities are motivated by several potential goals, including the following extracted from a recent report by NIST.[2]

1) Faster and wider delivery of urban services.
2) A reduction in costs of operating a resident-responsive infrastructure.
3) Increased opportunities for interaction, collaboration, and commerce between residents, businesses, and government agencies.
4) Enhanced environmental sustainability.
5) Support for equitable access to city services and related services, such as healthcare.
6) Improved quality of life for residents.

Important themes in smart cities include transportation[3] and the smart grid,[4] although the applications include virtually all aspects of civic life, including healthcare, education, space usage, and waste management.[a]

Smart cities and IoT

We conceive of a smart city as an agglomeration of IoT applications with a human and societal flavor. Indeed, when we think of the IoT in general, besides the purely technical development—such as the miniaturization of sensors, power packs, and radios—the major concerns of the IoT are reflected in smart cities. This is because smart cities bring together heterogeneity, multiple stakeholders and administrative domains, and continual negotiation of functional and nonfunctional requirements of multiple interacting

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[a][Online]. Available: https://www.asme.org/topics-resources/content/top-10-growing-smart-cities

IoT applications. For this reason, we see smart cities as a challenging exemplar of an IoT application. Although we focus on an ethical framework for smart cities, we see this framework as applying to even narrower IoT settings, such as individual applications.

Scope of this article

This article outlines the key elements of a comprehensive ethical framework for smart cities. To this end, it adopts a sociotechnical, yet computational stance on smart cities. Ethics can refer to a variety of concerns. This article adopts a viewpoint based on the well-known moral foundations theory (MFT).[5] This theory is well-suited to smart cities because it encompasses the key moral dimensions or *foundations* that pertain to interactions in a city: impacts on the interests of individuals (e.g., residents and businesses) and institutions, statistical properties of gains and losses, imposition of power on individuals, and protection of residents' values. In this way, MFT goes beyond a focus on data privacy to the essence of the lives of the people who form a city. Further, this article maps interactions in a smart city viewed as a sociotechnical system to the moral foundations.

TRADITIONAL THINKING AND ITS LIMITATIONS

The first generation of smart cities is organized around well-defined existing services and is realized mainly through technology upgrades for sensing, communications, and computing. For example, the US Department of Transportation[3] identifies efforts on creating plans for improving street lighting, measuring congestion and improving transportation throughput on road networks, measuring air pollution, and improving mobility for residents.

OECD[1] motivates the fact that the introduction of smart cities may lead to challenges, such as privacy and widening inequality as well as challenges in regulation, broadly concerning government contracts and labor laws.

Current discussions of smart cities often involve little more than inserting the word "smart" before virtually anything that one may associate with a city. As a case in point, a recent NIST publication,[2] [Figure 3, p. 6] lists smart education, smart resource and waste management, smart communications, smart health, smart urban planning, smart building, smart grid, smart security, smart mobility, smart environment, and (quite mysteriously) smart citizens. The repeated use of "smart" as a buzzword does little to lend clarity to the conception. Even without the buzzword, the conception is very much based on the services available in traditional cities.[b] Consequently, a major concrete shortcoming of current thinking is that it either involves interactions between a resident and a government agency or leaves the interactions unspecified and amorphous.

Despite the promise of smart cities and the recent progress in deploying IoT technologies, the current thinking on these topics focuses heavily on the technological element. That is, there is ample discussion of sensors and technological challenges, such as powering the sensors and processing the data streams they produce. However, current research is limited with respect to the human and social elements.

Some researchers mention the importance of human and social elements and acknowledge the need for a sociotechnical approach to understanding smart cities. However, when researchers talk of social aspects, they largely mean either: 1) the economic aspects, such as the relationship between the adoption of smart city technologies and pricing and incentives, or 2) the concerns inherent in the collection of data from smart infrastructure.

Specifically, current scholarship largely eschews discussions of ethics and safety in a computational manner. The closest studies address privacy and cybersecurity.[6] We found only one substantive study on ethics in smart cities[7] and even that is focused on big data and privacy. The study identifies transportation as the main illustration and considers only the aspects of transportation by itself (i.e., the data obtained through it, and the potential benefits and harms). It thus exemplifies another shortcoming of current thinking, which is to view smart city applications in a siloed manner.

TOWARD A COMPREHENSIVE ETHICAL FRAMEWORK

In contrast to the previous approaches, we posit that an ethical framework for smart cities must be comprehensive in three respects so that smart cities achieve the positive vision that computer scientists and laypeople have for them. First, it must tackle the synthesis of multiple applications. Second, whereas privacy is indeed important, the framework must address broader ethical challenges. Third, the ethical framework must accommodate relevant interactions between different types of stakeholders.

Figure 1 shows a schematic of the ethical framework we envision for smart cities.

[b][Online]. Available: https://www.visualcapitalist.com/anatomy-smart-city/

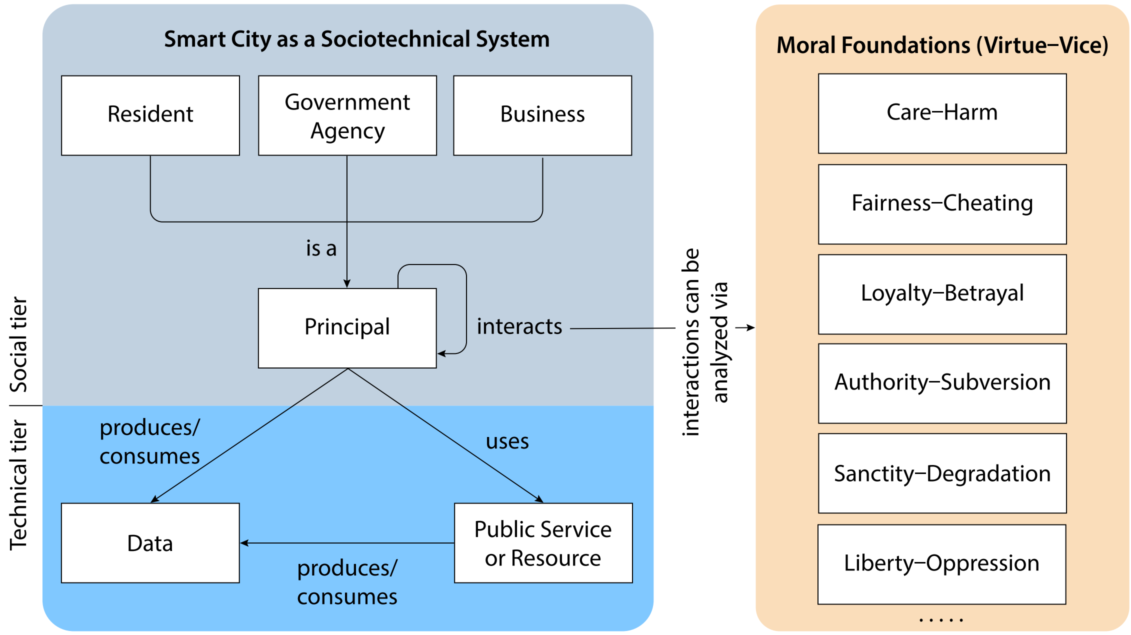

FIGURE 1. We view a smart city as a sociotechnical system, where principals interact, use public services and resources (e.g., transportation), and produce or consume data. Addressing the ethical challenges of a smart city requires shifting the understanding of ethics from the technical tier (involving data and resources) to the social tier where principals interact.

Smart City as a Sociotechnical System

A key feature of our framework is the representation of a smart city as a sociotechnical system.[8] This representation broadens the focus of ethics from a purely technical perspective (e.g., statistically mitigating biases in data) to a sociotechnical perspective, where ethics is about understanding one principal's concern for another as observed in the (technology-mediated) interactions among the principals (e.g., tracing biases in data to the data originators).[9]

The left part of Figure 1 shows the key components of a sociotechnical system in a schematic form. A principal is a social actor, such as an individual (e.g., a resident), a private institution (e.g., a business), or a public institution (e.g., a transportation agency). The principals use the services and resources available in the system and interact with each other in that process. The purpose of technology is to mediate the interactions among the principals to yield a high quality of service (e.g., in terms of efficiency, accessibility, flexibility, and so on).

Moral Foundations

We seek to analyze whether the technology-mediated interactions in a sociotechnical system yield ethical outcomes or not. To do so, we adopt a theory of moral constructs available in the literature.

The MFT advocates that "morality is about how individuals ought to relate to, protect, and respect other individuals," in line with several other moral philosophers.[5] MFT subscribes to the idea of moral pluralism, i.e., ascribing an individual's morality to a combination of multiple *moral foundations*. Thus, the moral foundations provide a language in which to describe moral behavior.

MFT includes the following six moral foundations, where each foundation is represented as a dimension ranging between a virtue and a vice (also shown on the right-hand side of Figure 1).

Care–Harm is about protecting the vulnerable, especially one's kin.

Fairness–Cheating is about ensuring that others are treated fairly.

Loyalty–Betrayal is about acting in the interest of one's social group.

Authority–Subversion is about respecting hierarchies to ensure obedience and deference toward authoritative institutions, such as courts.

Sanctity–Degradation is about disgust toward contamination.

Liberty–Oppression is about resisting domination, including working in solidarity to oppose oppression.

Illustrating the Framework

The foregoing schematic identifies the key types of principals in a smart city. In the following, we discuss the kinds of ethical challenges that arise in a smart city.

As a running example, consider that public transportation is the main means of travel in a smart city. The transportation agency of the city collects data about the occupancy of the vehicles, including the number of passengers and how they traveled (e.g., first-class versus economy) in each vehicle. For transparency, the agency shares these data publicly.

Although the transparency is desirable, as we show in the following, many ethical challenges arise in how the data are used when the transportation service is combined with other public services and business activities occurring in a city. To this end, imagine that this city has a public park that has been endowed with sensors (including cameras) and actuators (such as gates). In the social tier, we would see norms (whether regulations or informal), such as using the park only within daylight hours and avoiding a picnic area where a family is already enjoying a meal.

Residents interacting with government agencies: This is the setting most discussed in the smart cities literature. When residents use a tram or enter a park, they interact with the respective municipal agencies.

As existing approaches indicate, such interactions raise the expected privacy concerns of resident data being gathered, stored, and used. In addition, the ubiquity of smart city services can lead to fine-grained tracking and control of residents. For example, the government can combine information on when someone boards or alights from a tram and when they enter and exit a park to determine their entire schedule and who they likely interact with.

The concern highlighted by these examples is consent for actions pertaining to a resident's information. Consent maps to the Care–Harm foundation because obtaining consent legitimately[10] is a way of protecting a resident's interests and values.

Residents interacting with public resources: A more important situation is when residents who use a public resource want to specify the applicable norms so they can share—more broadly, govern[8]—the resource effectively. For example, residents would need to agree on whether cameras as installed in a park (technical tier) and norms about when recording is turned ON, whether they are live monitored without recording, and how the recordings are used (social tier).

With live monitoring, cameras could enable crime prevention as well as apps to avoid congestion (by letting people know if there was space). With recording, cameras could enable solving crime. Besides crimes, behaviors, such as littering or public urination that make a space unusable for others, are common challenges with public infrastructures. Cameras can serve as deterrents and enable better routing of cleaning crews when needed. Different residents may have competing values and preferences. For example, monitoring and recording would promote safety and may be desirable to parents of young children but demote privacy, which may be dear to others. Even for people who have no intention of acting wrongly, the possibility of being observed can have a chilling effect on their behavior.

This concern maps to the Authority–Subversion foundation because of the need for residents to establish a legitimate authority (in the nature of the norms) and avoid subverting it. The specific concern of exposure resulting in a chilling effect maps to the Liberty–Oppression foundation. The concern about cleanliness maps to the Sanctity–Degradation foundation.

Residents interacting with residents: Smart cities enable residents to share resources belonging to one another or directly engage with each other in using public services. The technology in a smart city can enhance the quality of such interactions among the residents. For instance, in our example, since the transportation agency shares occupancy data, residents can choose to travel during less-crowded hours (indicating sharing of a public resource) and have conversations with fellow passengers (indicating peer-to-peer interactions). Moreover, the smart city may enable residents to carpool from their homes to and from a tram station and possibly chaperone each other's children to dance practice.

However, the technology can also be misused. For example, pickpockets in the city can use the occupancy data to target crowded vehicles, especially those where riders are chaperoning multiple children. Thus, new interactions enabled by the smart city may lead to both care and harm. Thinking further about this problem based on our ethical framework, a potential solution is to increase security in public transportation during crowded hours, which relates to the Authority–Subversion foundation.

Residents interacting with businesses: A smart city would enable improvements in efficiencies in interactions between businesses and people. Suppose a cafe is placed not far from the city park and a tram stop. Knowing when the next few trams are expected and how full they are, the cafe can plan to have coffee and tea ready and hot buns in the oven in time for the expected influx of customers. This simple optimization would reduce congestion at the cafe and reduce the time to serve customers, benefiting both the cafe's operations and the customers.

The cafe can improve customer experience further if it obtains additional information about the incoming tram riders: their ages and economic statuses and how many are in first-class or regular carriages (even without knowing their identities). But ethical hazards lurk here. The cafe may want to build a customer base focused on rich customers, who buy expensive drinks.

Suppose the cafe uses the transportation data to focus on prepping products for these customers. Thus, rich customers benefit (in terms of wait time and quality of experience) and the cafe benefits (in terms of revenue) from the smart city technology but ordinary residents suffer through increased delay and the discomfort and risk of staying in a congested store longer than otherwise. In other words, the technology would facilitate unethical (or unlawful) discrimination.

The equity concern raised in this example primarily maps to the Fairness–Cheating foundation with the risk (e.g., of exposure to infection) due to congestion secondarily mapping to the Care–Harm foundation.

Businesses interacting with government agencies: These ethical concerns in these interactions resemble those between residents and government agencies in that the government can harm or unfairly treat a small business. However, larger businesses, e.g., those that control valuable real estate, may control governmental decisions to the detriment of residents and small businesses. For example, they could leverage their power to locate tram stations conveniently for their customers as opposed to others—a strike on the Fairness–Cheating foundation. Or, by sporadically donating a large volume of groceries to a food bank (indicative of Care), they could discourage small scale but sustained donors by causing their small donations to be wasted (causing them to feel betrayal after their difficult, albeit meager efforts).

Toward a Framework

As the foregoing examples show, an ethical framework for smart cities must accommodate the moral aspects of interactions between residents, viewed (in a sociotechnical light) in conjunction with sensors and data technologies. To realize a smart city ethically is not merely to deploy the technologies or even launch individual applications but to reflect on their intended and unintended interactions with human behavior and the ramifications of those interactions on the moral foundations that motivate humans. The framework would be instantiated in methodologies for the design, deployment, and continual maintenance and re-engineering of smart city services. These methodologies would evaluate these services individually and in combination through the lens of the interactions they support between stakeholders, evaluating their outcomes on the relevant moral foundations. These methodologies and the services they produce would respect everyone's autonomy and facilitate innovative uses, and continually incorporate creative ideas.[11]

DISCUSSION

The set of moral foundations is not closed and may be extended as additional evidence or understanding of their existence arises.[5] However, the current version is adequate to show the richness of the moral realm that an ethical framework for smart cities and IoT ought to address, not merely privacy.

Approaches focused on local governance in smart cities are well-aligned with our framework. Razaghi and Finger[12] address the limitations of current reductionist approaches to smart cities and propose a sociotechnical approach that would respect residents' autonomy. Their scope differs from ours in that they focus on public administration (including municipal politics). However, their notion of sociotechnical systems is conventional and lacks a computational model. Almeida et al.[13] as well bring out the need for transparency and control.

Kontokosta and Hong[14] highlight how resident–government interactions can suffer from a lack of equity and fairness arising from how data are collected and used. Although their focus is on city services, their discussion of ethical concerns besides privacy is compatible with our framework.

Serrano et al.[2] provide a framework for key performance indicators (KPIs) for smart cities that includes selection and prioritization of city goals to enable their quantification into KPIs based on the available data. Serrano et al. recognize that different members (e.g., communities) of a city may have different priorities as regards the goals and KPIs. Their metrics address the alignment of KPIs with the priorities of the members of a city in terms, e.g., of investments made in a city. However, these metrics are somewhat *ad hoc* and rely on people producing numbers based on intuition. Still, this framework could be enhanced to produce KPIs for the relevant ethical challenges as they are mapped to various foundations.

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