Value Sensitive Design of Smart Cities

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ABSTRACT
This paper explores the opportunities of using Value Sensitive Design for creating smart cities. Smart cities are larger in scale than the technologies to which Value Sensitive Design has been applied so far. The large size of the endeavor introduces new challenges for Values Sensitive Design. This paper discusses the following five challenges: complexity and emergent phenomena, collaboration between multiple parties, involvement of citizens, diversity of values, and the role of the designer. For each challenge, directions for solutions are suggested.

Categories and Subject Descriptors
K.4.1 [**Public Policy Issues**]

General Terms
Design.

Keywords
Smart city, Internet of Things, Value Sensitive Design, participatory design, human values.

1. INTRODUCTION
In recent years, more and more cities have adopted the aim to become a *smart city* [Bowerman *et al.*, 2000]. Smart cities can be defined as "well-defined geographical areas, in which high technologies such as ICT, logistic, energy production, and so on, cooperate to create benefits for citizens in terms of well-being, inclusion and participation, environmental quality, intelligent development; governed by a well-defined pool of subjects, able to state the rules and policy for the city government and development" [Dameri, 2013]. This leads, for instance, to a more efficient organization of transport, more effective distribution of water, or higher-quality health care. Smart cities often contain an *Internet of Things*, a network in which intelligent systems, devices and services are connected to each other [Atzori *et al.*, 2010].

This paper explores the opportunities of using Value Sensitive Design to contribute to the human dimension of smart city design. Value Sensitive Design is a design approach that systematically accounts for human values in the design of technology [Friedman *et al.*, 2013]. The motivation for explicitly addressing values is that values of designers affect the technology they design, and technology, in turn, affects the values of its direct and indirect

stakeholders, either by hindering or supporting them. For a technology to be successfully adopted, it is important that it is in line with its stakeholder's values. Value Sensitive Design thus seems to be a valuable approach for the design of smart cities.

There is related work in which Value Sensitive Design has been applied to UrbanSim [Borning *et al.*, 2005], a large-scale simulation system that models the development of urban areas [Waddell, 2002]. This project concerns urban development and attention is paid to creating a simulation that is responsive to the values held by different stakeholders. However, the project's primary concern is the design of simulation software, whereas this paper is about the design of smart cities.

Value Sensitive Design has been developed within the field of Human Computer Interaction, and most projects in which it has been used concern a single technology for a relatively specific target group, e.g. blind and deaf-blind public transit riders [Azenkot *et al.*, 2011] or teens and their parents [Czeskis *et al.*, 2010]. Smart cities, in contrast, involve a network of technologies and stakeholders, with many interactions and independencies between them. The interconnected systems in a smart city each have their own stakeholder group, of which some may expand to all of the city's inhabitants. In short, smart cities are much larger in scale than the technologies to which Value Sensitive Design has been applied so far.

The large scale of smart city design introduces new challenges for Values Sensitive Design. This paper discusses five of these challenges and points towards directions for possible solutions.

2. CHALLENGES
We discuss the following five challenges of applying the Value Sensitive Design approach to design smart cities: complexity and emergent phenomena, collaboration between multiple parties, involvement of citizens, diversity of values, and the role of the designer.

2.1 Complexity and emergent phenomena
Smart cities are much larger in scale than stand-alone applications or devices. This not only means that the design of a smart city amounts *more* work than the design of a single technology, it also *changes* the nature of the work.

The network of connected intelligent, adaptive, and self-learning devices and services in a smart city can be considered as a complex system [Holland, 2006]. This implies that due to the interactions of the individual parts new phenomena emerge, which may hinder human values. For example, if self-driving cars all follow the same alternative route in case of a traffic jam, new traffic jams quickly emerge, thus hindering well-being. To avoid such undesired effects, the interaction between different parts of the system needs to be coordinated, for instance, by designing communication protocols, standards, rules and policies.

Policy design traditionally has not been the focus of Value Sensitive Design. However, rules and policies do (indirectly) affect human values and are indispensable in smart cities. The complexity of smart cities in which self-learning and adaptive systems interact with each other makes it particularly hard to oversee the consequences of design choices [Holland, 2006]. Complex systems and emergent phenomena thus pose a challenge to Value Sensitive Design of smart cities.

One way to deal with the complexity of smart systems is the use of (agent-based) simulations [Helbing *et al.*, 2013; Holland, 2006]. This allows to model technologies, stakeholders, stakeholder values and their interactions (technology-technology, human-human and human-technology interaction), and run simulations to investigate the effects of different designs on stakeholders and their values [Harbers *et al.*, 2014]. Simulations can be used for both design of technology [Waddell, 2002] and policies [Mayer, 2009]. Simulations can be used for prediction, but besides that, they can also increase understanding of the design problem at hand or raise new relevant questions [Epstein, 2008]. The latter is in line with Value Sensitive Design's focus on progression rather than perfection [Friedman *et al.*, 2013].

2.2 Collaboration between multiple parties
The design of a smart city is a huge endeavor and cannot be done by a single design team. Furthermore, as argued in the previous section, creating a smart city involves more than 'just' the design of technology. It also includes activities such as the coordination of technological developments and policy making. This means that not only different design teams have to collaborate and coordinate their activities, but different parties such as designers, politicians, policymakers and scientists have to collaborate.

In the field of innovation studies, the triple helix model of university, industry and government has been used to study the collaboration of different parties in the design of smart cities [Leydesdorff, 2011]. Carayannis and Campbell argued that in a 'glocal' knowledge-based economy, innovation processes should also account for the culture and values of the public, and therefore they proposed the quadruple helix [Carayannis *et al.*, 2009]. Figure 1 shows a quadruple helix model that distinguishes between 1) state/ government, 2) industry/ business, 3) academia/ universities, and 4) media- and culture-based public/ civil society. Van Waart *et al.* [2015a] argue that these should all be involved in the design of smart cities. This collaboration is a challenge since all of the parties have different interests and concerns, which may conflict with each other, and there is no single authority that has the lead.
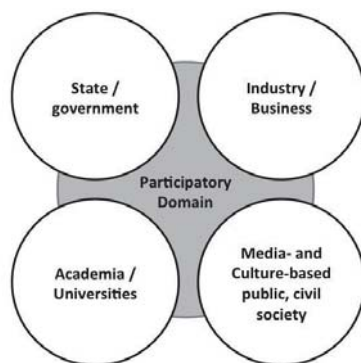

Figure 1. Quadruple helix model [Van Waart et al., 2015a].

Loorbach argues that existing approaches cannot cope with the complexity and magnitude of current urban development [Loorbach, 2007]. He proposes a framework that lays out the process as well as the tasks and activities of different stakeholders and professions in societal transitions. An application of the framework, for instance, is an Urban Transition Lab that serves as the locus within a city to bring actors from the current 'regime' together with innovators, and thus provide space and time for learning, reflection and development of alternative solutions [Nevens *et al.*, 2013].

Value Sensitive Design could learn from this, and related work, to shape the collaboration between the amount and variety of parties involved in smart city design, such that human values are accounted for.

2.3 Involvement of citizens
Value Sensitive Design stresses the importance of involving direct and indirect stakeholders in the design process [Friedman *et al.*, 2013]. The stakeholders of a smart city, i.e. the people affected by it, are its citizens. Thus, in line with Value Sensitive Design, citizens should be involved in the elicitation of current practices, concerns and wishes, in the evaluation of prototypes, and possibly even in the co-design of new solutions. However, of the parties distinguished in the previous section, it is particularly challenging to involve the fourth group: media-and culture-based public/ civil society, or in short, citizens [Van Waart *et al.*, 2015a]. The involvement of citizens thus forms a challenge to Value Sensitive Design of smart cities.

Caryannis *et al.* [2009] presented the quadruple helix model shown in Figure 1 as a framework for the analysis of current practices. Van Waart et al. [2015a] describe how the model may inspire future collaborations of universities, governments, industry and citizens to envision future smart cities that take the concerns and values of all stakeholders into account. They propose to involve citizens in the design process through events lasting one to three days, such as design jams and hackathons. In these events, representatives from all parties in the quadruple helix are brought together for exploring the issues and possibilities regarding the Internet of Things application in the context of the city. They also suggested a neighborhood lab as a platform for participatory design with citizens in a specific urban area [Van Waart *et al.*, 2015b].

2.4 Diversity of values
Technology that is part of a smart city can be used by any of its inhabitants. The inhabitants of a city usually comprise a diverse collection of people with different cultural backgrounds, socio-economic statuses, preferences, priorities and values. Designing smart city technology thus implies designing for a broad group of stakeholders with a diverse set of values. This increases the change of *value tensions* to occur, i.e. when supporting one value undermines another [Miller *et al.*, 2007]. The challenge is to design solutions that are still meaningful for all its users, despite their diverse values. Only then will the innovations will be fully accepted and make true impact.

An illustration of this challenge is formed by the design of a payment solution for public transportation. A digital solution saves time and thus improves the wellbeing of most travelers. However, the solution may be less suitable for elderly people that are not used to interacting with information technology. This group of people should be taken into account in the design of the payment solution. Other particularly complex value tensions in

the context of smart city design arise when the government wants designs for all citizens in order to enforce a pluralistic and egalitarian democratic society, but a dominant group of citizens wants to exclude certain groups from the design in protection of particular local interests.

Current work in Value Sensitive Design on value tensions can be a starting point to cope with the diversity of values [Denning *et al.*, 2010; Czeskis *et al.*, 2010; Miller *et al.*, 2007]. A possible direction, suggested by Denning *et al.* [2010], is to design multiple solutions for different stakeholders, rather than coming up with one solution that serves all. Another direction to cope with diversity of values is to develop technology that adapts to the (changing) norms and values of its users [Van Riemsdijk *et al.*, 2015]. One step further is to use an open design approach that enables people to co-create their own designs according to their personal needs and values [Van Abel *et al.*, 2014]. This last step moves us to the next challenge.

2.5 Role of the designer: in who's name?

In the relatively new context of a smart city, the role of a designer becomes less clear. Above we argued that designers of technology also have to consider policy design (section 2.1), or at least have to collaborate with policy makers and other parties (section 2.2). Furthermore, we argued that citizens should be involved in the design process (section 2.3), and co-design or even design technology themselves (section 2.4).

Whereas designers used to "design for" their stakeholders and nowadays increasingly often "design with" them, in the future they will more and more facilitate "design by" stakeholders [Sanders & Stappers, 2008]. In other words, designers scaffold the design process of the parties distinguished in the quadruple helix, rather than that they design themselves, following the interests of a client who commissioned a design challenge to them. This means that designers leave design choices up to other stakeholders, e.g. they let stakeholders decide how to balance between values.

Nevertheless, even when designers only facilitate a design process by others, their values will still affect the selection of design challenges to work on and the way they shape the design process. Therefore, it is advisable to make the designer's values and perspective explicit to the different parties involved in the design process. Furthermore, designers keep a certain responsibility for the design, and should interfere when they believe a design causes unacceptable harm.

By embarking on the challenges of smart city design, Value Sensitive Design is faced with a number of questions regarding the role of the designer. For instance, does Value Sensitive Design of smart cities include policy design? How can Value Sensitive Design facilitate design by citizens, or by politicians? What do these developments mean for the role of the designers and their values? In who's name do designers act? To enter the field of smart city design, the Value Sensitive Design community has to reflect on which tasks it entails to be a designer.

3. CONCLUSION

In this paper we explored the possibility of applying Value Sensitive Design to the design of smart cities. We discussed five challenges and gave suggestions on how to cope with them. The list provided in this paper is not exhaustive and there surely are many other challenges to the Value Sensitive Design of smart cities. However, the suggested directions for solutions show that the hurdles are not impossible to overcome. This yields interesting

directions for future research, and the potential for Value Sensitive Design to provide useful and valuable contributions to smart city design.

4. REFERENCES

[1] Atzori, L., Iera, A., and Morabito, G. 2010. The internet of things: A survey. *Computer networks*, 54(15), 2787-2805.

[2] Azenkot, S., Prasain, S., Borning, A., Fortuna, E., Ladner, R. E., and Wobbrock, J. O. 2011. Enhancing independence and safety for blind and deaf-blind public transit riders. *Proceedings of the SIGCHI conference on Human Factors in computing systems*, 3247-3256. ACM.

[3] Borning, A., Friedman, B., Davis, J., and Lin, P. 2005. Informing public deliberation: Value sensitive design of indicators for a large-scale urban simulation. *Proceedings of ECSCW*, 449-468. Springer Netherlands.

[4] Bowerman, B., Braverman, J., Taylor, J., Todosow, H., and Von Wimmersperg, U. 2000. The vision of a smart city. *Proceedings of the 2nd International Life Extension Technology Workshop*.

[5] Carayannis, E.G., and Campbell, D. F. 2009. 'Mode 3' and 'Quadruple Helix': toward a 21st century fractal innovation ecosystem. *International Journal of Technology Management*, 46(3), 201-234.

[6] Czeskis, A., Dermendjieva, I., Yapit, H., Borning, A., Friedman, B., Gill, B., and Kohno, T. 2010. Parenting from the pocket: Value tensions and technical directions for secure and private parent-teen mobile safety. *Proceedings of the Sixth Symposium on Usable Privacy and Security*, 15. ACM.

[7] Dameri, R.P. 2013. Searching for smart city definition: a comprehensive proposal. *International Journal of Computers & Technology*, 11(5), 2544-2551.

[8] Denning, T., Borning, A., Friedman, B., Gill, B. T., Kohno, T., and Maisel, W. H. 2010. Patients, pacemakers, and implantable defibrillators: Human values and security for wireless implantable medical devices. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 917-926. ACM.

[9] Epstein, J. M. 2008. Why model? *Journal of Artificial Societies and Social Simulation*, 11(4), 12.

[10] Friedman, B., Kahn Jr, P.H., Borning, A., and Huldtgren, A. 2013. Value sensitive design and information systems. *Early engagement and new technologies: Opening up the laboratory*, 55-95. Springer Netherlands.

[11] Harbers, M., Aydogan, R., Jonker, C.M., and Neerincx, M.A. 2014. Sharing information in teams: giving up privacy or compromising on team performance? *Proceedings of the 2014 International Conference on Autonomous Agents and Multi-Agent Systems*, 413-420. IFAAMAS.

[12] Helbing, D., and Balietti, S. 2013. How to do agent-based simulations in the future: From modeling social mechanisms to emergent phenomena and interactive systems design. Chapter *Agent-Based Modeling* of the book *Social Self-Organization*, 25-70. Springer, Berlin.

[13] Holland, J.H. 2006. Studying complex adaptive systems. *Journal of Systems Science and Complexity*, 19(1), 1-8.

[14] Leydesdorff, L., and Deakin, M. 2011. The triple-helix model of smart cities: a neo-evolutionary perspective. *Journal of Urban Technology*, 18(2), 53-63.

[15] Loorbach, D. 2007. *Transition management: new mode of governance for sustainable development*. Dutch Research Institute for Transitions (DRIFT).

[16] Mayer, I. S. 2009. The gaming of policy and the politics of gaming: A review. *Simulation & Gaming*, 40(6), 825-862.

[17] Miller, J.K., Friedman, B., and Jancke, G. 2007. Value tensions in design: The value sensitive design, development, and appropriation of a corporation's groupware system. *Proceedings of the 2007 International ACM Conference on Supporting Group Work*, 281-290. ACM.

[18] Nevens, F., Frantzeskaki, N., Gorissen, L., and Loorbach, D. 2013. Urban Transition Labs: co-creating transformative action for sustainable cities. *Journal of Cleaner Production*, 50, 111-122.

[19] Sanders, E.B.N., and Stappers, P.J. 2008. Co-creation and the new landscapes of design. *Co-design*, 4(1), 5-18.

[20] Van Abel, B., Evers, L., Troxler, P., and Klaassen, R. 2014. *Open design now: why design cannot remain exclusive*. BIS Publishers.

[21] Van Riemsdijk, M.B., Jonker, C.M., and Lesser, V. 2015. Creating Socially Adaptive Electronic Partners. *Proceedings of the 2015 International Conference on Autonomous Agents and Multi-Agent Systems*, 1201-1206. IFAAMAS.

[22] Van Waart, P., Mulder I.J., and De Bont, C.J.P.M. 2015a. Participatory prototyping for future cities. *Proceedings of the Participatory Innovation Conference*.

[23] Van Waart, P., Mulder, I.J., and De Bont, C.J.P.M. 2015b. A Participatory Approach for Envisioning a Smart City. *Manuscript under review*.

[24] Waddell, P. 2002. UrbanSim: Modeling urban development for land use, transportation, and environmental planning. *Journal of the American Planning Association*, 68(3), 297-314.