# SMART CITY INFRASTRUCTURES

## A RESEARCH ON THE WIFI SENSORS PROJECT IN ENSCHEDE

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# SMART CITY INFRASTRUCTURES

*A research on the WiFi sensors project in Enschede.*

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“There is no foreground or background, only a continuity of interlacing relationships”

- LYONEL FEININGER

**SUMMARY**

Modern cities strive to become ‘smart’, something which can be achieved by incorporating smart city infrastructures into urban landscapes. By placing sensors – or other computational technologies – in city centres, a lot of data can be gathered from urban landscapes and thereafter analysed. This data collection and analysis in turn influences the urban planning and the experience of the city by the city-user. This is why this thesis highlights the impact smart city infrastructures have on our view of urban spaces and our relationship with them. Therefore, the following research question is posed: *How do smart city infrastructures shape urban space and the relation between city-users and the city?*

This question is answered by first looking into how infrastructures and smart city infrastructures shape urban landscapes and the relation of the city-user to the city. By framing smart city infrastructures as relational and political entities with shaping agencies, the importance of further reflection and analysis is stressed as smart city infrastructures are not just technical artefacts but also social artefacts. To allow an analysis an example of a smart city infrastructure is introduced: the WiFi sensors project in Enschede. The project is discussed in light of three societal perspectives, each explaining the use and impact of the project. The project is thereafter analysed and reflected upon with the help of political studies, postphenomenological mediation theory, and studies on the surveilled subject.

The WiFi sensors project exemplifies the impact smart city infrastructures can have on urban landscapes and the relation between the city-user and the city. Not only are smart city infrastructures politically shaped, they also shape politics and urban governance as they are part of extrastatecraft and stimulate data-driven, networked urbanism. Moreover, smart city infrastructures seem to transcend the boundaries of existing relations as described by mediation theory, as they are part of a background and hermeneutic relation. Last, but not least, smart city infrastructures impact the experience of the surveilled subject and their exposure to surveillance. This is not just done by coercing the city-users but also because the city-users comply to the politically framed surveillance.

The example offered is just one smart city infrastructure and the findings might thus not immediately apply to other smart city infrastructures. Despite this, the thesis still shows a lack of philosophical research and reflection concerning smart city infrastructures. Additionally, the thesis provides recommendations for the municipality of Enschede and their WiFi sensors project. Hopefully, the thesis will stimulate more reflection on smart city infrastructures from not only an academic but also a social perspective. Careful deliberations on the shaping agency of smart city infrastructures and the impacts they bring about are important in political, philosophical, and sociological discussions concerning contemporary urban technologies, as smart city infrastructures are becoming ubiquitous and unavoidable.

**KEYWORDS:** SMART CITY INFRASTRUCTURES; WIFI SENSORS PROJECT IN ENSCHEDE; DATA-DRIVEN, NETWORKED URBANISM; EXTRASTATECRAFT; POSTPHENOMENOLOGY; MEDIATION THEORY; BACKGROUND RELATION; HERMENEUTIC RELATION; THE SURVEILLED SUBJECT; EXPOSURE.

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| | |
|---|---|
| DPA | Data Protection Agency |
| GDPR | General Data Protection Regulation |
| ISO | International Organization for Standardization |

## INTRODUCTION

"When the city has data, what you actually need is to build a City Brain" (AlibabaTech, 2017). This is how Alibaba, an e-commerce giant, promotes their big data service packages – the City Brain – in the hope that city governments will buy their services. In return, Alibaba offers cloud services which use artificial intelligence, big data and computing infrastructures in order to analyse data gathered by the city. Hangzhou, a Chinese city, already uses the City Brain services in order to improve city life. To run such analyses, the City Brain gathers vast amounts of data, from social media to traffic information, which are produced in the urban space. For now, the focus of the City Brain packages is on traffic infrastructures, with the idea to aid with town planning and the route planning of emergency services. Yet, the scope of the City Brain service packages will be eventually expanded to other areas of city life, areas which might be more of interest for entrepreneurs or research (Russell, 2018).

The gathering and analysis of data in an urban context has been done more often throughout the last few decades. It is believed that by doing this, cities can become 'smart': cities in which decisions are based on data gathering and analysis and where infrastructures become responsive to the gathered data. In a world in which smartphones, smartwatches, smart materials and smart cars exist, it was only a matter of time for the idea of creating smart cities (Ballon, 2016, p.25). One route to creating a smart city, is by making their infrastructures smart.

The City Brain project also focuses on making city infrastructures smart, as it aims to connect 300 traffic lights and 500 traffic cameras in a city in Kuala Lumpur (Fahran, 2018). It is important to research such smart city infrastructures as they enable and connect city structures which are vital for urban life (Leigh-Star & Bowker, 2002). This is why the following question is posed in this thesis: *How do smart city infrastructures shape urban space and the relation between city-users*[1] *and the city?*

This question will be answered in three chapters. The first chapter provides a framework for infrastructures, and thereafter smart city infrastructures, by answering the question: What are smart city infrastructures and how do they shape urban space? In this chapter infrastructures are framed as relational and political entities. By looking into social studies on infrastructures, it is argued that infrastructures circulate and facilitate as well as that they are shaped but also have shaping agencies. Because of this, it is important to consider an infrastructure not merely as a technical but also a social artefact. A vital aspect of it being a social artefact is its politics.

[1] The term citizen is a legally and politically loaded term which does not necessarily include all the users of the city and its urban spaces, infrastructures and technologies. To avoid this exclusion, the term of city-user will be used in this thesis.

This is why political studies on infrastructures are discussed. These studies show that infrastructures are used as tools to exercise political power. Next to infrastructures having shaping agencies, they also mediate the relation between the city and the city-user. This is discussed in light of a postphenomenological framework. Thereafter, a framework for smart city infrastructures are discussed. The framework provided for regular infrastructures still applies for smart city infrastructures, yet the addition of computational technologies to infrastructures indicate the shift from regular to smart city infrastructures.

To be able to analyse a smart city infrastructure, a local example is introduced in the second chapter: the WiFi sensors project in Enschede. Therefore, the following question is asked in the second chapter: What is the WiFi sensors project in the inner city of Enschede and how is it perceived by the municipality, the public discussion, and by its city-users? As smart city infrastructures are social and relational artefacts, the three perspectives mentioned in the question are subsequently introduced.

The third chapter analyses and reflects on the WiFi sensors project by asking the question: How is the WiFi sensors project a smart city infrastructure and why is it important to research and reflect upon such smart city infrastructures? The chapter starts off by considering it as a smart city infrastructure and analyses the various difficulties of it being a smart city infrastructure. Thereafter, the politics behind the WiFi sensors is discussed, looking into how CityTraffic's extrastatecraft shapes the WiFi sensors project. This is followed by an analysis concerning the mediation relation between the WiFi sensors project and its users. The chapter finishes with a discussion on the impact of the project on the surveilled subject.

The three chapters allow for the main research question to be answered, highlighting the impact of smart city infrastructures on urban spaces and our relationship with them. Yet, more social and philosophical research on the shaping agency of smart city infrastructures is required for further fruitful research. This research is needed in order to discuss whether or not city-users even want to be surrounded by smart city infrastructures. Additionally, the conclusion offers recommendations to the municipality of Enschede concerning their WiFi sensors project and how to proceed. Hopefully, the outcomes of this thesis will stimulate reflection on the WiFi sensors project and smart city infrastructures in general, possibly leading to a reconsideration of the design and use of smart city infrastructures.

*Methods*

This thesis includes an example of a smart city infrastructure, the WiFi sensors project, to bring philosophical, sociological and political studies to the public realm. As smart city

infrastructures are often intertwined with the lives of city-users it is important to include the perspectives of the social groups involved. This is why the WiFi sensors project is introduced and discussed in this thesis as it exemplifies the impact of smart city infrastructures.

Research concerning the WiFi sensors project was conducted with the help of three interviews, as they provided information from various societal perspectives (D. Borghuis, personal communication, December 19, 2017; G. Looman, personal communication, December 15, 2017; W. Louwes, personal communication, December 6, 2017).[2] For these interviews, approval by the faculty's ethics committee was granted. These interviews provided the insights needed to fully understand the WiFi sensors project and its impact.

[2] Following APA guidelines, conducted interviews are not to be listed in the references list as it is not reasonable data. Yet, as proof, brief interview notes and consent forms are provided in the annexes. The interviews will be cited as 'Borghuis, 2017', 'Looman, 2017', and 'Louwes, 2017' in this thesis.

# CHAPTER 1: INFRASTRUCTURES & SMART CITY INFRASTRUCTURES

This chapter frames infrastructures by looking into sociological, political and philosophical studies. Infrastructures are regarded as relational and political entities which have the ability to shape. Becoming even more intricate with the rise of smart city infrastructures. This is why the end of this chapter provides a brief framework for smart city infrastructures.

> Beneath the visible city an invisible city grows apace: a buried city of water pipes and sewers and gas mains and electric cables and steam pipes and telephone wires and vast cellars where heat and electricity are produced for the buildings above: a city of ramifying subways and ominous tunnels in which the entire population spends no inconsiderable part of the day (Mumford, 1970, p.239).

*Infrastructures*

Modern societies and cities are surrounded and penetrated by infrastructures, circulating and facilitating the flow of people, ideas, and goods over time and space (Larkin, 2013, p.328). Due to this penetration, infrastructures have become circulation architectures necessary for our modern societies (idem., p.328). This circulation and facilitation leave no inconsiderable marks on our urban spaces, as they for instance create certain directions of movement.

Lewis Mumford (2010) highlights this by looking into the effects of motorcars on the urban development of American cities during the mid-twentieth century. Throughout the twentieth century, motorcars became a commodity to the masses rather than staying an exclusive ‘toy’ for the elite. Because of this, urban planners in the United States developed plans to accommodate the rising number of motorcars on the roads. Yet, Mumford argues that this happened at the cost of other transportation methods and infrastructures, such as pavements, and therefore criticized those plans heavily as cities exists “for the care and culture of men” (Mumford, 2010, p.367) and not for shallow motorcar passageways.

Portraying the motorcar as the big bad evil, Mumford sees the technology as deterministic as it heavily impacted the urban planning and city-life of his time. If not for the existence of motorcars those new passageways did not even have to be planned and designed. Yet, the rise of the motorcar demanded such passageways in order to prevent congestions and dangerous situations. This in turn impacted and shaped the urban planning of many American cities. Yet, it has to be noted that it was not solely the impact of the motorcar that led to the changes in urban planning but governmental policies as well. It was not only the motorcar that

determined the urban planning, but governmental agencies also determined how the road system should be planned and implemented.

This is why, in this thesis, infrastructures are not researched with the old dichotomy between subject and object in mind. Instead, infrastructures are seen as entities which shape but are also being shaped: “the actions of human beings shape the ways in which they realize their existence, while the form of that existence, in turn, shapes human actions” (Verbeek, 2005, p.147). This ability of infrastructures to shape is not seen as intrinsic, as that would suggest that infrastructures can be studied independently from the humans that engage with it (idem., p.11. Rather, infrastructures always stand in relation to other entities such as other infrastructures, technologies or humans. Infrastructures are thus relational.

As infrastructures facilitate interaction, they are relational entities and should never be researched without any relation to other infrastructures or societal aspects. This means that infrastructures can be studied as parts of infrastructural regimes, as one infrastructure is always related to others which form the infrastructural regime. By framing infrastructures in this way, research on a city’s essential aspects and relational networks is required (Leigh-Star, 1999).

Because infrastructures are shaping and being shaped, they should not be considered as mere technical artefacts but also social artefacts: “The relationships and ecologies shaped by and shaping infrastructure are social as much as they are material” (Tonkiss, 2013, p.142). This means that infrastructures can also be framed in a political perspective as they are often shaped by the needs of politics or the economy. This is why it is important to look into the *design politics* behind infrastructures (Tonkiss, 2013, p.139).

According to Tonkiss (2013), infrastructures can be used to exercise political power, as can be seen with the creation of socialist cities in the past. Additionally, infrastructures are also able to reinforce disparities in communities by producing urban inequalities as it could allow for further segregation of the rich and the poor (p.139). This political aspect of infrastructures is, however, not often perceived.

It is not only the political aspect which is often hidden away, it is sometimes the infrastructures themselves as well. Matthew Gandy (2008) notes a tension when the modern city and the complex infrastructure meet. He claims that the modern city does not want to show its workings, having infrastructures only break the surface at for instance a subway entrance. Infrastructures therefore form their own “underground city” (Gandy, 1999, p.23). Yet, all of these infrastructures which are part of the underground city do become visible, even if less articulate, via the expressed form of exostructures. These exostructures are networks of infrastructures which serve, connect and carry all of the infrastructure systems (Tonkiss, 2013,

p.139). An example of an exostructure could be a meter cupboard in a house. Meter cupboards connect individual houses to larger networks (e.g. electricity) and allow for individual measurements of those networks, but the meter cupboard also provides one place for various networks to meet.

Even though infrastructures can become visible due to exostructures, where they breakthrough the surface, they still go unnoticed more often than not (Tonkiss, 2013). Albeit that meter cupboards provide meters which allows for measurements of electricity usage, they still do not show the workings of the electricity grids of which they are part. In such cases, infrastructures are only noticed upon breaking down, when there is a power outage in the electrical grid for example. Due to infrastructures being unnoticed and only becoming 'present' upon breakdown, it is hard to recognize and define infrastructures. Yet, Susan Leigh-Star (1999) offers nine means to do so nonetheless.

| Typification | Explanation |
|---|---|
| Embeddedness | Infrastructures are embedded into and inside of other structures, social arrangements and technologies. Distinguishing embedded infrastructures is not often done by people. |
| Transparency | Infrastructures do not have to be reinvented every time for a specific task, invisibly supporting different tasks. |
| Reach or Scope | Infrastructures have a reach beyond a single event or a one-site practice. |
| Learned as part of Membership | Infrastructures are taken-for-granted in communities of practice. |
| Links with Conventions of Practice | Infrastructures shape but are also shaped by conventions of a community of practice. The QWERTY keyboard was designed out of a technological necessity on typewriters, and ever since many computers producers have stuck with it. |
| Embodiment of Standards | Infrastructures become more transparent due to embodying standards from other infrastructures and tools they are related to or part of. |

| | |
|---|---|
| Built on an Installed Base | Infrastructures grow from an installed base and uses the strengths and limitations of already existing infrastructures. |
| Becomes visible upon Breakdown | The normally non-visible infrastructure becomes visible upon failure. Even when back-up infrastructures take over, the failure of the initial infrastructure is highlighted. |
| Is fixed in Modular Increments, not all at once or globally | As infrastructures are very complex, big and layered, they are never changed from above but are influenced locally. Changes in infrastructures have to be discussed, especially considering the adjustment with other aspects of the involved systems, which takes time. |

Table 1: Susan Leigh-Star's (1999) typification of nine means to recognize infrastructures (pp.381-382).

These nine means for recognising infrastructures once again stress the social aspects of infrastructures and the co-shaping processes between infrastructures and other entities: stressing that infrastructures should never be studied outside of their infrastructural regimes. Looking into infrastructures from a political perspective therefore could offer an interesting view.

*Infrastructures as Extrastatecraft*

As argued, infrastructures should be researched in a relational context and as part of infrastructural regimes. To do this, it is important to take political perspectives on infrastructures into account. Especially as such infrastructural regimes can be considered to be "like an operating system, the medium of infrastructure space makes certain things possible and other things impossible" (Easterling, 2014, p.14). It is not the infrastructure itself, but rather how it is politically designed that dictates its uses and potential in the urban environment. This is why contemporary infrastructure space should be researched, as it could be used to orchestrate something which remains implicit but at the same time has far-reaching consequences (idem., p.15).

In her book Kelly Easterling (2014) introduces the notion of infrastructure space being used as extrastatecraft, a term used to describe undisclosed activities outside of statecraft (Easterling, 2014, p.15). Because of these undisclosed activities, she argues that infrastructure

space can have a lot of political power and even states that “some of the most radical changes to the globalizing are being written, not in the language of law and diplomacy, but in these spatial, infrastructural technologies” (idem, p.15).

Easterling gives an example of extrastatecraft by looking at the International Organization for Standardization (ISO). She introduces the ISO as a private nongovernmental organization and extrastate parliament which manages global standards in collaboration with private companies and national representatives (idem., p.18). ISO provides standards from pitches of screw threads, credit card thickness to quality management standards (p.18-19). ISO, as a private organisation, therefore creates ‘laws’ –in this case the standards – to which many products and other organisations have to comply. Such extrastatecraft does not only occur with daily used products, or management standards, but also with the incorporation and design of infrastructures. Many parties are involved when creating new networks and infrastructures, ranging from governments to telecom companies. Extrastatecraft therefore happens next to or independently from governmental agencies and policies, staying rather in the private sector. This notion of extrastatecraft highlights the importance of looking into infrastructures from a political perspective, as it showcases that there are parties involved which could work around global legislation and statecraft yet at the same time have extensive implications for our daily lives.

To understand this extrastatecraft, Easterling argues that it is important to look into the disposition of an infrastructure as they are relational actors (idem, p.72). Only by researching the disposition of an infrastructure, it can be uncovered which secret, rigid and accidental forms of power are hidden within the infrastructure (idem., p.73). Researching the partners involved in creating an infrastructure therefore highlights an infrastructure’s positioning in a city or country. In this case, disposition stands for the activities the infrastructure was created for, but also for the activities which deviate from the stated intent: “disposition, in common parlance, usually describes an unfolding relationship between potentials” (idem., p.72). This also goes for infrastructures, as they are still relational without ‘acting’ or being used. To be able to research such dispositions, several markers are introduced by Easterling (2014) which will be discussed in the third chapter. Only by uncovering the politics behind the infrastructures, the impacts of the infrastructure on city-life and its city-users can be analysed.

*Infrastructures and Postphenomenology*

As mentioned earlier, many infrastructures work in the background, only being noticed upon failure. Yet, this certainly does not mean that they do not influence the city-user’s behaviour or

actions. Infrastructures, although in the background, are mediating the city-user's view of the world.

In the tradition of phenomenology, everything is put in the perspective of how entities are related to human beings as it is humans that give meaning to an entity (Verbeek, 2005, p.50). From this perspective, co-shaping does also occur but rather than using the earlier referred to terms of 'action' and 'existence', the terms 'perception' and 'experience' are used. These terms were also important to Heidegger when questioning the relationship between humans and technology, and the role modern technology plays in a human's interpretation of and encounter with the world (Heidegger, 1977). Heidegger concluded that modern technological entities are now understood as a means and not as an end in itself, as something with a potential for humans without being something in itself (idem.).

However, current views on technology argue for the notion that technologies are not solely constituted but also constitute themselves. The relation between a technology and a human being can be seen as a dance, both impacting each other's moves. Postphenomenologists, such as Don Ihde, therefore argue that technologies are mediators in how humans interpret reality. Subject and object are not merely interwoven, they also shape one another (Ihde, 1990). Don Ihde explained this mediating role of technology with the help of *technological intentionality*. Verbeek explains this intentionality by stating that technologies have an inherent intentionality which allows mediation between the subject and object. With this in mind technologies are never neutral as they determine how humans are present in and interpret the world (Verbeek, 2005, p.116). In the case of infrastructures, this intentionality is often shaped by politics and economy which depend on the circulation architecture.

To explain how technologies shape the relation between the human and the world, Don Ihde introduces three relations between technologies and humans: (1) the relation of mediation, (2) the alterity relation, and (3) the background relation (Ihde, 1990, pp.72-112; Verbeek, 2005, pp.122-123).

The relation of mediation occurs when human perception is mediated by a technology. Such relations can be sub-divided into two categories. The first category is the *embodiment relation*, which refers to how humans use technology to broaden their perception and experience of the world. Eyeglasses are an example of an embodiment relation, as the wearer does not look at the technology but looks through the glasses and thus use it to experience the world (Ihde, 1990, pp.72-80; Verbeek, 2005, pp.125-126).

The second category is the *hermeneutic relation*, in such a relation the technology is not used to perceive the world through the technology but to perceive the world by the means of it.

A thermometer acts as a representation of the room's temperature, instead of offering a sensory experience of the actual temperature. Because of this we are connected to the world as we see the room's temperature in this case, we are not involved with the artefact itself but rather with its representation. The artefact is therefore visible and represents certain aspects of the world. Such representations require interpretations in order to be useful. Since the hermeneutic relation between humans and an artefact is in need of such interpretations, it is referred to as hermeneutic (Ihde, 1990, pp.80-98; Verbeek, 2005, pp.126).

The second type of relation is referred to as the alterity relation. Such a relation occurs when a human is linked directly to the technology, rather than the technology linking a human to the world. Technologies are described as a quasi-other, something which seems just like a person but is not. This is because technologies in this relation give rise to interaction but also have some kind of independency. An example of this is the ticket machine at train stations, which do not only sell tickets but also provide useful travel information (Ihde, 1990, pp.97-108; Verbeek, 2005, pp.126-127).

The third type of relation is the background relation. Background relations exist when a technology shapes our relation to reality, but without our awareness. Technologies are not consciously experienced or interacted with, but still play a role in our experience of the world. The only time one is aware of the technologies functioning in the background and their context is when they malfunction (Ihde, 1990, pp.108-112; Verbeek, 2005, pp.127-128).

Infrastructures could therefore often be seen as technologies which are part of background relations, as one takes them for granted and unconsciously uses them. When we drive in our car we use the road, yet do not continuously think of it and rather take it for granted. Yet, we do make use of road and they do enable or disable certain transportation routes. Having a road from A to B but not from A to C, limits our mobility and our views on connectivity. We only become aware of such limitations when new roads are being built, connecting more places. Moreover, we become aware of the influences of the road network on our daily life when the road is maintained or renewed due to malfunction, which creates slower mobility, traffic jams or alternative routes. It is at the moments of breakdown that the infrastructure leaves the background and breaks through the surface.

This does not mean that infrastructures are always invisible in a background relation. It is interesting to note that infrastructures always have to break through the surface as they are relational structures on which cities are built, despite the efforts to keep them hidden in the background. Roads are an example of physical manifestations, which even though they are not always reflected upon or made aware of, are visible and break through. With the rise of digital

technologies and infrastructures, this visibility often decreased. However, when the infrastructures' visibility decreases they are often given artificially created interfaces. It is only via such interfaces that infrastructures can be used and connected to other infrastructures. This could mean that digital infrastructures need to also be explained with another mediation relation as they provide interfaces which do not only offer representations but also require interpretations. Thus, it might be good to also include a hermeneutic explanation when looking into digital technologies or digital infrastructures.

However, this postphenomenological approach focuses heavily on the impact of actualized technologies. Expanding this view, Kiran (2012) introduces the notion of *presence potentiality* (p.86). He explains this notion with the help of the concept of 'virtuality'. The virtual refers to what is present, but not per say in use. The hammer can be used to hammer down nails, but it also has the potential to weigh down on a stack of paper or to even kill (idem., p.85). Yet, one has to be aware that the virtual aspect of a technology only goes as far as its materials allow, as a hammer cannot be virtualized as a fine-grained brain surgery. Thus, the actualities of a technology allow and limit our view on the technology's virtuality.

By expanding the notions of technological mediation to the possible use of technologies, rather than just the actual use of the technology, Kiran argues for a more encompassing notion of technical mediation. Infrastructures do not only co-constitute what we are becoming but also what we *may* become.

*Smart City Infrastructures*

In a world where everything has to become 'smart', it was only a matter of time for the ideology of a 'smart' city to be developed (Ballon, 2016, p.25). One way of becoming a modern smart city is by incorporating 'smart' elements into existing infrastructures or creating new 'smart' infrastructures. By placing sensors – or other computational technologies – in city centres, a lot of data can be gathered from urban landscapes and thereafter analysed. This data collection and analysis makes a city 'smarter' as data generated through city life and gathered by technologies can provide a lot of insights and knowledge with which we can better understand urban problems, city life, urban policies and plans and other city-related matters.

According to Kitchin (2015), such data generation and gathering led to data-informed urbanism. The gathered and analysed data is used to provide, for instance, infographics to the city-users and government. Yet, Kitchin (idem.) gradually sees this data-*informed* urbanism being complemented and replaced by data-*driven*, *networked* urbanism (p.2). This form of urbanism causes city services and urban governance to be highly responsive and reliant on big

data. Data will set the urban agenda and control as well as influence how the city systems respond and perform (idem.).

> In short, we are moving into an era where cities are becoming ever more instrumented and networked, their systems interlinked and integrated, and the vast troves of data being generated used to manage and control urban life (idem., p.2).

Cities' infrastructures are gradually becoming embedded with computation, which leads to the production of contextual and actionable data. At the same time the computation immediately acts on the gathered and analysed data. This means that data is shared across various infrastructural systems, creating a holistic view of city services and infrastructures. Cities thus become responsive to the data they gather themselves. And this is exactly, according to Kitchin (2015), why data-driven, networked urbanism is of key importance for the production of smart cities.

Smart city infrastructures are thus seen as regular infrastructures but with the addition that they use computational technologies. These computational technologies allow smart city infrastructures to produce data, act on this data at the same time, and share this data across various systems. This addition of computational technologies is done either to 'upgrade' already existing or traditional infrastructures or to create whole new infrastructures. An example of the former is for instance traffic sensors, as those enable roads to gather data from vehicles passing by. Roads are thus 'upgraded' with computational technologies, allowing the gathering and analysis of data from the urban landscape. The second type of smart city infrastructures is the creation of a whole new infrastructure. This does not occur often, as new smart city infrastructures are often developed in a niche. The creation of the world wide web is an example of an entirely new smart city infrastructure. Computational technologies were used to create a digital packet switching network developed by the military from the United States of America. This digital packet switching network was the first to implement the TCP/IP protocols, distinguishing it from every other digital packet switching network at the time. Of course, when the isolated project was introduced to the public it became a world-wide network on which many other modern infrastructures currently rely.

*Conclusion*

In sum, infrastructures are material, social, and relational artefacts. Infrastructures always connect or are connected to other systems or networks. Because of this connectivity and relationality, the existence and perception of networks can be shaped by infrastructures. In turn,

infrastructures are also shaped by political and economic needs. Infrastructures are therefore co-shaping the world in which we live but are also in turn shaped.

Because infrastructures are politically laden and used as tools for political power, it is important to research infrastructures from a political perspective. The notion of extrastatecraft offers a view on how decisions on infrastructures take place outside of statecraft, outside of the governmental domain. To understand this extrastatecraft, it is important to research an infrastructure's disposition. Studying an infrastructure's disposition reveals how an infrastructure is positioned and related to other infrastructures as well as how the infrastructure is moulded by decisions taken by private companies. This is important as it highlights the intent and potential of an infrastructure.

Since infrastructures can be used to exercise political power and to shape urban space, it is interesting to see how they influence the experience of the city-user and the city with the help of postphenomenology. It can be summed up that infrastructures often form a background relation between the city-user and the city, but that modern digital infrastructures often also engage in a hermeneutic relation with the city and the city-user. Yet, it should also be pointed out that an infrastructure's potential has to be considered, as not only the physical or digital manifestation of an infrastructure impacts urban spaces but the potential use and experience of it as well.

Infrastructures are therefore quite complex entities. Yet, with the incorporation of computation technologies as part of an infrastructure, an even more multifaceted infrastructure is created. Computational technologies enable the infrastructure to not only gather data, but also to immediately act on this data. On top of this, computational technologies allow for a constant flow of information between other networks and systems based on similar computational technologies.

By adding computational technologies, it is often thought that 'smart' infrastructures are created, allowing the creation of a smart city. The smart city ideology sees the gathering of data and the analysis of it as vital for the innovation and creation of a smart city. With the help of such 'neutral' data, cities can objectively develop and create smarter environments and urban landscapes: the data gathered and analysed by these infrastructures will set the urban agenda. In this thesis, a smart city infrastructure will thus be regarded as an infrastructure which integrates computational technologies.

However, an explanation is required to bring together all the perspectives on infrastructures as brought forward in this thesis. From the perspective of Tonkiss (2013) and Leigh-Star (1999), infrastructures are relational entities as their main purpose it to be connected

to or to connect other entities. Changes in infrastructures take time and are discussed on a local level, as those changes will impact all the other involved systems. Yet, from the extrastatecraft perspective of Easterling it is argued that important decisions on infrastructures are taken in the private sector and not in the public or local domain. From this perspective, it could thus be said that infrastructures are shaped independently from the context in which they function.

Yet, even though extrastatecraft occurs outside of the local or governmental infrastructural contexts it can still be relational. The example of the ISO shows that standards set by the organisation have far-reaching global consequences. Even when infrastructures are developed through private companies, they are created to be part of bigger systems and networks. The mobile phone application Uber would not be able to function without being connected to GPS infrastructures and road networks. Infrastructures can therefore still be considered as relational, even when developed via extrastatecraft.

This relational aspect is also still valuable when studying smart city infrastructures and their computational technologies. After all, smart city infrastructures have to be connected to other systems in order to fruitfully gather and analyse the data. Smart cities aim to develop urban landscapes where many aspects of life are improved and it is believed that connectivity and communication between various (data) infrastructures is the key to realize this.

Smart city infrastructures remain relational entities, even with the addition of computational technologies. Because smart city infrastructures and their computational technologies are deemed vital for the creation of a smart city – and that infrastructures are able to shape urban landscapes – it is important to understand the meaning given to such an infrastructure.

## CHAPTER 2: THE WIFI SENSORS PROJECT

This chapter introduces the WiFi sensors project in Enschede from various perspectives. First, Enschede as a smart city is introduced. Thereafter, the project is explained from the municipality perspective. This is followed by the public discussion on WiFi sensors and privacy. The chapter finishes off with discussing the project from the perspective of a city-user.

> Imagine a city where citizens can benefit from the advantages of new technology almost immediately […] Imagine a city where entrepreneurs can test and demonstrate their new concepts, products and services in an open field lab (Living Smart Enschede, n.d.).

With their brochure, the municipality of Enschede aims to profile the city as the perfect ecosystem for becoming ‘smart’. Focusing on offering a range of test environments, they divide the city up into three parts: (1) Smart Campus, (2) Smart Base and (3) Smart City. They claim that these environments accelerate the development of any technology as it can easily be practically and socially applied and needs less time to market. This is due to ‘direct’ interaction of scientists, students, city-users, entrepreneurs and the local government (Living Smart Enschede, n.d.).

Enschede frames the Smart Campus, the campus of the University of Twente, as a perfect location for fully-controlled experiments since it is low-urbanised and attracts scientific research and innovations with medium to low risks. It offers a dynamic community with around 10.000 students and various research institutions. Apart from the university campus, Enschede has a campus in the city which houses the Saxion University of Applied sciences and the ROC. Both these campuses are put forward as nurseries for research in, the manufacturing of and, the maintenance of smart materials as well as the application of such innovative solutions for social problems (Living Smart Enschede, n.d.).

Additionally, the municipality highlights the Smart Base in Enschede as a testing ground for companies with innovative research and products. Usually such innovations involve high-risk experiments which can be tested on the Smart Base as it is highly controlled, offers a lot of space and is non-urbanised. The municipality of Enschede therefore deems the Smart Base to be a perfect part of the city for testing new materials, systems and innovations. Moreover, they claim that the Smart Base allows the instruction and training of people in dealing with dangerous situations (Living Smart Enschede, n.d.). Because of this, the Smart Base is being in

the race as the test grounds for a 5G network, something which would also further improve the data connectivity of and the infrastructure in Enschede ("Enschede in de race", n.d.).

The last part as brought forward by the municipality is the Smart City, a high-urbanized location in the city which allows for experiments that have no environmental risks. The municipality pride themselves by stating that they facilitate various locations in the city which are ideal for new ideas to be explored. According to them, the Smart City facilitates and accelerates the innovations of the other two parts as the municipality tries to eliminate the legislation obstructions. By applying the innovations, developing mobile applications and by gathering data, the Smart City and the municipality try to positively influence city life. One example of this is the city's SMART mobile application. This application enables people to travel more consciously and smarter within the Twente region (Living Smart Enschede, n.d.).

*WiFi Sensors*

In 2016, the University of Twente started the Living Smart Campus initiative. This initiative does research which would help scientists to understand futures of smart societies in a better and more advanced way. To do this, researchers look into the potential smart uses of ICT technologies and how these could solve societal problems. This initiative strives to create an open for innovation campus which brings governments, city-users and industries together ("About the project", n.d.).

One project of this initiative focuses on collecting data via 115 WiFi sensors placed in campus buildings. This project is called *Measuring Meaning of Spaces* and its aim is to see how the space in campus buildings is used by students and employees and how they move around in the buildings. To do this, sensors collect data from WiFi enabled mobile devices such as smartphones, laptops and tablets. With the help of such data, the research can pave the way for new ICT applications which would enrich campus life or better navigation systems in buildings ("FAQ", n.d.).

A similar project was started by the municipality in Enschede on the 6th of September 2017. From that day onwards, the municipality started to count passers-by with the help of 8 WiFi sensors placed in various spots in the inner city. The sensors are placed and operated by CityTraffic, a research office in shopping areas. CityTraffic[3] does not only provide and operate the sensors, they also measure and visualize the data gathered by the sensors. This data could

[3] It might be interesting to note that the name CityTraffic already indicates and reveals the office's perspective on urban landscapes, as cities are seen as areas which are measurable by counting visits, similar to the online traffic of the world wide web.

then be used to count the number of passers-by, show the visiting frequency, how long a visitor has stayed, how the visitor moved around in the inner-city, the influence of weather on the number of visitors and the exact number of visitors by filtering out returning visitors ("De metingen die CityTraffic", n.d.). This research method and analysis has made CityTraffic one of the major players in this field, and they currently gather data in 105 cities in the Netherlands ("Al onze meetpunten", n.d.).

Similar to the campus project, the WiFi sensors in the inner city of Enschede pick up signals from all mobile devices which are WiFi enabled. Such a mobile device constantly sends out signals to find WiFi networks close in its reach. These signals are picked up by the sensors, even if the mobile device is not connected to a network. When these signals are picked up, the sensors gather a specific number linked to the mobile device: the MAC address. As this MAC address can easily be traced back to an individual, it has to be encrypted. This is done with the help of a *hash*[4]. The hash encryption of the MAC address is done on the sensor itself, which means that servers from CityTraffic only receive hashes. The method of encryption is developed by CityTraffic and confidential (Borghuis, 2017).

After receiving the hashed data, CityTraffic processes and analyses it. Their analysis is made into a fact sheet and given to the municipality. This sheet contains statistics of the number of passers-by in certain city areas and does not incorporate any information on individual visitors.

The WiFi sensors project in Enschede has not been without any discussion and concern. To understand the project better, three interviews were conducted with stakeholders. First of all, a municipality representative shed light on their views on Enschede becoming a smart city and how the WiFi sensors and their data are intended to be used. Additionally, a journalist from the Tubantia, a regional newspaper, was interviewed to talk about the public discussion on the WiFi sensors. Lastly, a city-user from a local hacker space, called Tkkrlab, raises concerns about the project by filing a complaint against the municipality of Enschede. By looking into these three perspectives, the meaning given to the WiFi sensors project can be highlighted.

[4] A hash code is a numeric value which helps with the identification of objects. As MAC addresses are not legally allowed to be used or stored, a hash code is instead linked to the specific MAC address. This hash code provides a different string of numbers, making it hard for the code to be traced back to the individual without knowing the used encryption methods.

*Municipality of Enschede*

Prior to the placement of WiFi sensors, the municipality of Enschede already did research in the number of passers-by in the inner city. However, as this counting was done by manual labour, the municipality only requested for this research to be done once a year. This research was part of the Binnenstadsmonitor, an initiative which focuses on the functioning of the inner city, including the visitor flows. Yet, this sample taken once a year could not really provide many insights into various days and situations, such as the impact of weather, as it only provided a very general image of the number of visitors all year around. The municipality therefore decided to invest into more accurate, pragmatic and objective measurements and calculations and hired CityTraffic to place and operate the WiFi sensors in the inner city which would allow for 24/7 measurements. These measurements also allow for looking into returning visitors, something which could not be filtered in the numbers counted by hand. Data fetishism thus seems to be the reason for which the municipality wants to apply the WiFi sensors.

The municipality would like to have these insights so they can measure and see the effects of investments in the inner city. By gathering this data, they would like to see (1) how attractive the inner city is, (2) the influence of spatial modifications in the inner city and (3) the effects of events, promotions and opening times ("Wifi-tellingen binnenstad", n.d.). Moreover, the municipality would like to see if and how investments in the inner city take effect, which could lead to further and maybe even more sustainable investments in the inner city and attract more entrepreneurs to the city. With all this data and insights, the visitor's experience of the inner city could be improved as more knowledge is gathered on how the public space is being used.

During the interview with Gerdien Looman, a municipality representative, it was stressed that the municipality does not want to track its city-users via the WiFi sensors, but simply count the number of passers-by. The municipality is of the opinion that there is no talk on crowd control and privacy infringement as the personal data (the MAC address) is immediately encrypted with a hash on the WiFi sensor itself. Therefore, the CityTraffic servers only receive encrypted data and this data cannot be traced back to the individuals walking around in the city centre.

However, there was a concern raised regarding privacy infringement by the Dutch Data Protection Authority (Dutch DPA) and a letter was sent to various municipalities in the Netherlands, including the municipality of Enschede. In this letter a summary was provided of a research conducted in 2015 on WiFi tracking. The Dutch DPA regards the MAC addresses as personal data, which are part of a person's privacy. Measuring and monitoring this data has a

great impact on a city-user's daily life and should only be done by the government with good grounds. Therefore, the Dutch DPA has set limitations and rules to WiFi tracking and announced to Dutch municipalities via a letter (Tomesen, n.d.):

1. Information: The tracker needs to inform the one being tracked with information on who tracks and why their personal data is gathered. Anyone should have the right to file a request for inspection or deletion of data and the right to protest. These rights start from the moment the individual gets in contact with tracking or measurements based on such WiFi signals.
2. Foundation: Consent is needed prior to the gathering of WiFi data and there needs to be proper justification for gathering personal WiFi data. On top of this, a period of time and area has to be set in order for proportionality to be ensured. Additionally, the data has to be anonymised within 24 hours of its gathering.

   The Dutch DPA makes a distinction between gathering WiFi data in shops, offices or institutions, and the gathering of WiFi data in the open air and public spaces. This distinction is based on the notion that the WiFi tracking in public spaces has a bigger impact on the city-user's behaviour than within a context of a specific office or shop. People should be able to move freely throughout public spaces without being spied on. This is why more guarantees and requirements have to be met if one wants to apply WiFi tracking in public spaces. One important requirement for this application is the immediate and irreversible anonymization of the gathered WiFi data as it reduces chances to track individuals.
3. Retention Period: As the gathered data consists of location data and unique identifiers from mobile devices it can only be stored for a certain period of time. The tracker therefore needs to determine a reasonable retention period for the goal of the WiFi tracking. After the retention period passed, the data needs to be destroyed or irreversibly anonymised. The research done in 2015, however, has shown that a standard hashing algorithm does not per say lead to the anonymization of the unique identifiers.
4. Other Requirements: When an organisation wants to use WiFi tracking or similar techniques, it needs to meet extra requirements. Examples of such requirements are the guarantee of data gathering and processing, including reporting any infractions, or providing clear goals for the data gathering and how the gathering will be limited to meet those goals.

According to Gerdien Looman, the WiFi sensors project in Enschede meets all of those requirements set by the Dutch DPA. She is aware of the privacy concerns raised, but is still of

the opinion that no privacy infringement occurs, as the gathered data is locally and immediately anonymized. Moreover, Gerdien Looman is of the opinion that the city-users have been informed properly and repeatedly about the project, this via stickers in the inner city, newspaper articles as well as information on the municipality website. She does admit that the stickers (see figure 1) are small and often not perceived. The municipality therefore ordered signs to be placed in the inner city (see figure 2). These signs will be in similar size as CCTV signs and therefore more noticeable and informing. Moreover, the new signs will portray a link to an informational website on the WiFi sensors in the inner city. This page in turn offers a link to the opt-out page from CityTraffic ("Wifi-tellingen binnenstad", n.d.).


*FIGURE 1: CURRENT STICKERS*


*FIGURE 2: NEW SIGNS*

An online open data platform is currently being developed by the municipality. It is being looked into which data can be provided and visualized as some data is quite complex to start with. This open data platform will not only show the gathered WiFi data but also data from for example Statistics Netherlands (CBS), Kennispunt Twente and groundwater meter data. This open data platform will be another met requirement as it is part of the overall information requirement.

The municipality of Enschede will continue with the WiFi sensors project as they want to improve city life. Gerdien Looman thinks it is important for the municipality to continue looking into technologies such as WiFi sensors, as it is the municipality's responsibility to take care of public places in Enschede. Ensuring the quality of public places could be easier or nicer with the help of digital technologies and Looman is of the opinion that Enschede has already come a long way in this regard. Especially when it comes to its implementation of digital

mobility infrastructures and services (e.g. SMART application). Even though the intentions are good, people are sometimes still not convinced that the positive impact outweighs the negative impact and concerns are voiced in the public discussion.

*Public Discussion*

The start of the WiFi sensors project caused the regional media to raise critical voices and concerns. The Tubantia, the regional newspaper, has written several articles on the project, informing the city-users of Enschede about its impact. Wilco Louwes, a journalist from the Tubantia, has written most of these articles, under his name or as part of Newsroom Enschede. He mentioned that there were not many responses or replies to the articles on a local level (Louwes, 2017). During the last year, topics such as trash removal and new laws concerning household waste sparked more interest and engagement than the WiFi sensors project in the inner city. Nonetheless, the Tubantia published about an article a month dedicated to the WiFi sensors project. In addition to the newspaper articles, TVEnschedeFM published several videos and hosted radio interviews concerning the WiFi sensors project.

The articles, radio interviews and videos do not just give information concerning the WiFi sensors project but also bring forward a critical voice. Why does the municipality want to implement the WiFi sensors and how can that affect the residents and passers-by? Are the grounds given by the municipality reasonable and is the gathered data handled with care? The media outlets try to answer these questions by interviewing politicians, concerned city-users and passers-by.

These questions are given an extra dimension after the Tubantia published an article on the employment of WiFi sensors back in 2012, something which was discovered by going through the history records from CityTraffic. The municipality states that they were not the client at the time and that three retailers in the inner city made use of the WiFi sensors (Louwes, 2017a). The use of WiFi sensors do not necessarily seem to be a new thing in Enschede, as some were already employed by private parties before the municipality asked for the sensors to be placed. Yet, many people in Enschede were or are not aware of the WiFi sensors and of the reasons for why their data is being gathered. When being confronted about the WiFi sensors, many reply that they do not feel too bothered about it as they ‘got nothing to hide’ (Louwes, 2017).

In contrast to the lack of local engagement concerning the WiFi sensors and data gathering, a discussion regarding such smart cities and data gathering has instead arisen on a national and even international level. An article in the *Trouw*, a national Dutch newspaper,

critically evaluates the promises of smart cities; the time of wearing rose-tinted glasses is over as the reality is starting to set in. The article brings the lack of awareness about sensors placed all over city centres to the foreground. In the case of Rotterdam, city-users are not even made aware of the sensors, and the municipality is not informed about the client behind the sensor. The municipality simply assumes that the sensors are placed by the shopkeepers (Teeffelen & Naafs, 2017).

The article also highlights another current and important aspect of data gathering in smart cities: the collaboration between the private and public sector. Private sectors often invest in pilots and new projects, enabling the public sector to make use of them with less costs. However, this collaboration raises questions about the ownership of the gathered data: does the client own the data, the company who placed the sensors, or does it belong to the city-user who provides the data? Moreover, the inclusion of private companies makes it more difficult for the city-user to have insights in the agreements concerning the use of the data. The journalists claim that this lack of transparency is worrisome as city-users should be properly informed about the grounds for and use of data gathering (Teeffelen & Naafs, 2017).

Next to the questions on privacy, one could ask questions on whether or not we want to live in a city where every movement is gathered, tracked, stored and analysed. Many times, city-users are not even able to refrain from participating. Even if they had such a choice it would be a rather unrealistic one, as city residents cannot easily avoid the city's infrastructure (Teeffelen & Naafs, 2017). This topic is also touched upon in a radio interview during a national radio broadcast (Bosman, 2017). City-users tend to find it easy and handy to see how crowded it is in certain parts of the city as long as they are able to walk around freely (idem.).

When being asked about their awareness of their data being gathered a woman stated that *when* you think about it it is very bothersome, but she could not really be bothered to think about it at the same time. Another man mentioned that he did not really care as he has nothing to hide. These are opinions one often hears, yet we should not think so lightly of the data gathering. During the radio interview Danny Mekic states that sensors, even as part of a small project, definitely could have a psychological impact on the city-users (Bosman, 2017). He compares them with tests concerning the effect of CCTV cameras on people. The tests show that people can become scared and more cautious on how to act and what to say due to their loss of freedom. Of course, he realizes that in this case it is just a few WiFi sensors, yet it is still a small building stone for a society where we could be tracked and registered all the time. Mekic is therefore of the opinion that the government is responsible for acting and intervening in time as they need to lay down the law (idem.).

This links to the national discussion and referendum on a new Dutch law regarding security and intelligence services. The new law will replace an outdated version from 2002, but has given rise to a lot of criticism concerning the vague terms and words used. Due to those unclarities, intelligence and security agencies are allowed to gather data from anyone at any time, even if they are not a suspect. Concerns regarding privacy infringement have been voiced and a referendum was petitioned for and will take place ("Sleepwet Referendum", n.d.).

Opposite to the Dutch law which seems to infringe privacy is a new European law which will apply from May 2018 onwards, replacing an older law from 1995. The *General Data Protection Regulation* (GDPR) intends to unify and guarantee data protection for all European city-users. The aim of the law is to provide some digital rights to the city-users. It also allows for stricter penalties to be handed out by national and international Data Protection Authority agencies. The biggest changes are that the conditions for consent are strengthened, meaning that the request for consent must be given in an intelligible and accessible form and that it must be easy to withdraw from the consent. Additionally, city-users have the right to access and the right to be forgotten ("GDPR Key changes", n.d.). Yet, many of these requirements seem not to be met by the WiFi sensors project in Enschede.

A distinction between data privacy and data security has to be made. Even though the Dutch DPA and the GDPR strive to unify data security policies, they are still influenced by societal needs. Smart city infrastructures have politics, yet they only can be applied because of certain political measures. Even though the laws and regulations limit data collection and analysis, they also allow the data collection and analysis as long as they meet the requirements and boundaries set. The rules and regulations therefore try to "balance the free exchange of data while protecting the privacy rights of state citizens" (Dowty, 2005, p.326). This means that the Dutch DPA and the GDPR still allow certain forms of privacy infringement. Thus, the aim of the rules and regulations is not to fully protect the privacy of the city-user but rather to limit the infringement of the privacy: Privacy issues might still arise despite their best efforts.

*Resistance*

The fact that the municipality of Enschede is unable to meet the requirements set by the Dutch DPA and the new GDPR law is worrisome according to concerned city-users Dave Borghuis. Borghuis, founder of local hackerspace Tkkrlab, raises critical questions concerning the WiFi sensors project and even filed a complaint to the municipality. By posting articles on his blog, he archives key moments of and responses to the WiFi sensors project.

First of all, Borghuis thinks that there are no good grounds given for the WiFi sensors project. The motives behind the project seem to be purely commercial as the municipality wants to keep the streets in the city centre as lively as possible. An example of good grounds was the use of WiFi sensors during the 2012 edition of Serious Request, a big event in the city centre. The municipality used the WiFi sensors to control the crowd for the safety of the public. Borghuis deems public safety to be a reasonable ground for employing WiFi sensors and approves the example for its specified time frame and locations. This is both not the case with the current WiFi sensors project as they are employed 24/7 and all around the city centre. In addition to this, the WiFi sensors apply an opt-out system, whereas the city-users have to be informed about the data gathering via an opt-in system once the GDPR will come into force.

As the municipality is unable to meet the requirements set by the law, Borghuis filed a complaint to the municipality in November 2017. In this complaint he points out all the requirements which should be met (Borghuis, n.d.). The reply given by the municipality was that they did meet all requirements and that there is no privacy infringement. Borghuis deems this answer to be inadequate (Borghuis, 2018).

He is also concerned regarding the collaboration between CityTraffic and the municipality. The MAC address is personal data, as it can be directly linked to someone's private mobile device. Even with the hashed encryption, Borghuis is concerned about reverse encryption possibilities, something which is being tested at the moment. When he approached CityTraffic to ask about their hashing method, they answered not to share the specific coding steps they take to ensure the anonymization process. The only aspect he knows is that the coding used by CityTraffic is based on a publicly known method. Borghuis thinks the use of their own coding processes is not transparent enough, as it asks us just to trust them with our data and encryption. He would therefore suggest CityTraffic to publicize the method used for the hashing processes, but not to disclose any of the encryption processes (Borghuis, 2017).

If the municipality wants to continue with the WiFi sensors project, Borghuis suggests them to take charge of it. They should create a department with privacy experts and start from the bottom up, following 'privacy-by-design' principles. Thereafter, the data can be easily publicized and make people aware of being watched, on which grounds and what is being gathered. Only if this occurs, Borghuis is of the opinion that the system will be transparent and the trust can be regained.

*Conclusion*

This chapter presents Enschede as a smart city, discussing their own masterplan and smart city infrastructures projects. One of these projects is the WiFi sensors project, which is thereafter understood, based on interviews and other materials, via the inclusion of three perspectives: (1) the municipality of Enschede, (2) the public discussion, and (3) the city-users.

First off, the municipality's reasons to use the WiFi sensors is discussed. The main reasons for using the WiFi sensors is that the data which is gathered is more accurate, objective and pragmatic in contrast to the previous gathering methods. This data fetishism perfectly portrays the move from data-informed urbanism to data-driven networked urbanism. The municipality thinks that the manual labour of counting passers-by did not provide enough data for forming plausible conclusions. Additionally, they think that the data gathered through the 'traditional' method was also bound to a specific context and did not allow for comparisons. By implementing the WiFi sensors project, the municipality strives for more objective and neutral data with which they form more educated conclusions. Thus, the municipality perceives the data gathered and offered by the WiFi sensors as important for improving the liveability and attractiveness of a city based on the data. To fully understand this, it is interesting to look into how the liveability of a city is framed by policy documents.

With their *New Urban Agenda* (2017) the United Nations tries to create better and sustainable futures for city life. In their agenda, liveability is mentioned twice together with economical terms such as "vibrant urban economy" (U.N. General Assembly, 2017, p.14) and "sustainable economic growth" (idem., p.29). Additionally, the only time the notion of a smart city is mentioned it also linked to "sustainable economic growth" (idem., p.19).

The New Urban Agenda is a global policy document which leaves its traces in local statecraft. The policy frames liveability in economic terms, or closely linked to economic developments. This in turn influences local smart city infrastructures, as well as the WiFi sensors project in Enschede. The municipality of Enschede also uses the project to focus on the economic state of the inner city. This is for instance done by looking into the number of passers-by, how often passers-by return and how well the shopping streets are visited under certain weather circumstances. Another aspect of the project which highlight the economic context is that the sensors are only placed in or nearby the inner-city shopping streets. The gathered data is thus used in order to create smart urban landscapes and smart economies. Once again, data drives city life and is considered to be of vital importance for pursuing the smart city ideology. The more data we gather and analyse, the smarter we become.

Thus, the smart city philosophy drives the urban development in Enschede. The need for becoming a smart city requires the implementation and application of data technologies in the inner city. One might even think of the smart city ideology to be deterministic. Data is needed to become a smart city yet at the same time the data is determining many urban developments in current smart cities.

Such developments should be regarded with caution as it could lead to technocratic societies: societies in which human lives are defined by data and technologies. Jacques Ellul (1964) describes such societies as technological societies. In technological societies, technologies become autonomous and beyond the control of humans. When this happens, human life and freedom will be constricted by technological gridlocks.

The WiFi sensors project is driven by the need for data and this data in turn drives urban developments. The project is therefore determined by the smart ideology. Yet, the project is not autonomous as it still is shaped and designed by CityTraffic. Because of this, the project still can be considered a co-shaping smart city infrastructure.

The public discussion on the WiFi sensors project, the more national and international concerns on privacy, and the perception of the project by the concerned citizen show that the gathering and use of the data by the government is not the sole problem. The involvement of private companies – such as CityTraffic – in such projects raise questions about who the data belongs to as well as how the data is gathered and stored. Private companies do often not share specifics on their methods and practices, whereas they do have an impact on the framing of a smart city infrastructure as they partake in extrastatecraft. Not only the physical design of the system, but also the ideologies behind it shape the use and potential of a smart city infrastructure and in turn urban landscapes. Researching how CityTraffic frames the WiFi sensors project is thus vital.

# CHAPTER 3: THE WIFI SENSOR PROJECT AS A SMART CITY INFRASTRUCTURE

This chapter reflects on the WiFi sensors project by framing it a smart city infrastructure in the light of data-driven, networked urbanism (2015). Thereafter it highlights the importance of researching and reflecting upon smart city infrastructures by discussing the politics behind the WiFi sensors project, the relation between the WiFi sensors and the passers-by, and the impact of the project on the surveilled subject.

*Data-Driven, Networked Urbanism*

In the past, the municipality of Enschede already gathered data concerning the number of passers-by in the inner city. This counting was done by manual labour and only once a year. With this data they created an annual report (Scholte, Wiel van de, & Seker, 2017) on the liveability of the inner city of Enschede, taking into account the number of passers-by. In turn, this report is used to understand how the urban spaces in the inner city of Enschede are used.

Such a dataset is considered to be part of data-informed urbanism according to Kitchin (2015). The municipality did have the ability to gather the data, but this gathering was spatially and temporally limited in scope. As discussed in the previous chapter, the municipality of Enschede decided to invest in the WiFi sensors to allow measurements to take place 24/7, all over the inner city and for being more accurate. The data is now continuously gathered, fine-grained and related to other data. This move from small data to big data is a move from a scarcity of data to a data overflow (p.4). Traditional city infrastructures, in this case the shopping street, become digitally networked with the help of WiFi sensors. The WiFi sensors pick up individual data, counting the passers-by. So far, this individual data has not yet been combined with other big data such as facial recognition or payment details, due to the privacy laws from the Dutch DPA and the upcoming GDPR. Yet, once the data gathered by the WiFi sensors is visualised and made public, the data can be used in combination with other open data such as the heatmap (“Heatmap”, n.d.) to create a live feed map of the flow of traffic and passers-by in the inner city of Enschede. Via such maps, data is integrated with and connected to other datasets gathered by other smart city infrastructures. As Gerdien Looman mentioned, the municipality is looking into how to present and visualize the data best to the public (Looman, 2017). Part of the considerations for such visualizations is which data is presented, how and for what reasons. The visualized data will therefore always be shaped to the needs of the municipality and city-users, possibly causing some data aspects to be lost in translation. Apart from such visualizations, the municipality is also considering to eventually provide the data via an open data platform. If they would pursue this, the potential use as well as integration

of the data would increase since all interested could work with the data, potentially leading to new links and insights as well as innovations in the context of urban landscapes.

For such visualizations and informing to happen, data analytics is needed to gain insights in what the datasets can offer. Such data analytics can only be performed with the help of machine learning and computational power. Data is now explained via data-driven science where insights and hypothesis are "born from the data" (Kelling et al., as cited in Kitchin, 2015, p.5) instead of explanations being based on theories. This leads to urban informatics and urban science. Where urban informatics focus on the interactions between people and space, urban science focuses not just on the present city but also how to predict future scenarios under different conditions (Kitchin, 2015, p.7).

The cumulation of urban informatics, urban science, data analytics and urban big data forms a basis for new urban governance and control: data-driven, networked urbanism. This new governance allows real-time monitoring and the steering of urban systems, leading to the creation of a smart city (idem., p.7). Smart cities use networked infrastructures, urban big data and data analytics to create smart city-life (e.g. smart economy, smart living, smart people, smart mobility, etc.) (idem., p.8). Thus, smart cities aim to solve fundamental city-life problems with the use of the earlier mentioned cumulation.

Another aspect of a smart city is the involvement of its city-users. The public is asked to contribute in decision-making or navigation via mobile applications, open data sites or public dashboards (idem., p.8). An example of this is the SMART phone application promoted by the municipality of Enschede. This application strives to make city-users aware of traveling around Twente (e.g. costs, time, sustainability, etc.). The involvement of the public with the WiFi sensors project has not yet been established, most likely because the data has not yet been visualized or made public.

Ownership and Transparency

The promises of smart cities and data-driven, network urbanism are not without any concerns. As mentioned in the previous chapter, questions on data ownership and data access emerge with smart city initiatives (idem., p.11). The data from the WiFi sensors is being gathered and analysed by CityTraffic, a private and commercial company. For the company, the data is a commodity for which the client has to pay. Data is thus privatised and not shared freely. The access to the data is limited or completely inaccessible. This is also the case for CityTraffic, as they do not provide the data via an open data platform, but instead commodify it by selling it to the municipality. If the datasets would be part of an open data platform the data gathering

would already become much more transparent, however this does not yet mean that the data is also useful to enhance city life (idem., p.12).

Security and Privacy

Often concerns about glitching systems are linked to networked infrastructures and smart cities initiatives. People fear that networked devices can be hacked and the data stolen for criminal intents or to spy on the users. By combining city life and computational technologies the data-driven, networked urbanism has inherent vulnerabilities. These vulnerabilities can multiply once urban systems become more interconnected and complex (idem., p.12). Smart city infrastructures should thus be designed and developed with secure big data systems in order to maintain or regain the trust of the public in the benefits and use of such smart city infrastructures. In the case of the WiFi sensors, Dave Borghuis (2017) questioned the encryption method conducted by CityTraffic as he was not able to get any insights in the method used without signing a non-disclosure agreement. He is very sceptical of the WiFi sensors project because of this lack of transparency, as he can make no estimation on whether or not the systems used are secure and follow the privacy regulations set by the Dutch DPA. Dave Borghuis would suggest to the municipality to create their own department with experts, developing a WiFi sensors project following privacy-by-design principles to guarantee everyone's privacy (Borghuis, 2017).

Politics

Another critique on the data-driven, networked urbanism approach is the lack of recognition regarding the politics of urban data. The reasons given by the municipality of Enschede for the switch from a small dataset to big data mostly rely on costs and accuracy. The municipality brings forward the argument that the gathered data by the WiFi sensors is more accurate, objective and valuable. Political authorities often justify the use of the gathered data by stating that sensors are not inherently political as they simply measure certain values. This means that the data can be used to objectively shed light on city life (Kitchin, 2015, pp.9-10). This does, however, not apply in reality. First of all, the gathered data is a result of specific technical settings and configurations, the placement of the sensor and its calibrations are examples of this. Secondly, the system used for the WiFi sensors is based on for instance technological expertise, funding, institutional collaborations, and policies and regulations (idem., p.10). Big data is thus always relational to, shaped for and contextual to certain goals and aims: "As such, data-driven, networked urbanism is thoroughly political seeking to produce a certain kind of

city" (idem., p.10). It is thus important to research how the WiFi sensors are constituted, work, what data they produce and how the data is used for whose benefits (idem., p.11).

For now, the municipality of Enschede only receives the analytics regarding the number of passers-by and they do not combine the data with other existing datasets (e.g. payment records, mobile phone providers, etc.). The gathered data is so far used solely for the intended purposes ("Beantwoording vragen", 2017). However, this should not take away the caution concerning the potential use of the gathered data. Nowadays, profiles, which are for instance used for criminal profiling, are sometimes based on not only the individual's behaviour but also its data footprint. This can lead to forms of "data determinism" (Kitchin, 2015, p.13) which causes the individuals to be judged based on computational predictions instead of what they have actually done. Using the data gathered by the WiFi sensors could add to this digital footprint and create an even more accurate profile. What is worrisome is the fact that these computational predictions are often supported by algorithms which are "black boxed" (idem., p.13) and without any adequate oversight.

It is thus of importance to research the motives behind the infrastructures which are part of data-driven, network urbanism. These motives are more often than not based on political intentions and goals. This is why the politics behind the WiFi sensors project will be uncovered next by looking into its disposition as part of the extrastatecraft by the municipality of Enschede.

*Extrastatecraft*

As discussed in the first chapter, the disposition of infrastructures can be found in studying the relationships between components. Yet, the disposition does not necessarily have to be active aspects of the infrastructure, as it can also be part of relative positions. To understand this disposition, it is important to look into disposition markers, which make the disposition of an infrastructure more tangible (Easterling, 2016, pp.72-73). The WiFi sensors project in Enschede can also be analysed with the help of some active disposition markers as discussed in Easterling (2016).

One marker is to see the sensors as multipliers. In September, CityTraffic placed 8 WiFi sensors in the inner-city of Enschede. The sensors are not too complex, as they just gather signals and encrypt those before sending it to a central server. By themselves, the sensors in Enschede do not have an immediate impact on urban space and urban planning. Yet, the sensors can be easily multiplied in Enschede, just as they are also placed – or multiplied – in 105 other cities in the Netherlands. This aspect of multiplying should not be ignored, as it could potentially reshape city life, just like the arrival of the car in urban space created a cause for

garages and parking spots. Streets might be designed differently based on the data provided by the sensors, as data can show the usage of urban spaces and the movement of the city-users. The impact could grow bigger when the sensors are re-designed or when different functions are added to the sensors, as those changes could easily 'hitchhike' with the technology which already exists in so many cities. This means that the urban space could be entirely rewritten by just a new addition to or change in propagation of an existing technology, rather than a newly invented technology – the wheel does not have to be reinvented but rather upgraded. Of course, the WiFi sensors will most likely not have as big an impact as the introduction of new conveyance vehicles, since they do not require much space to operate.

However, the multiplication of the sensors might impact the behaviour of its city-users or the way shopping streets are designed based on the results and hypotheses of the gathered data by the sensors. If the sensors gather data that indicate that more people walk into the shopping street from the left, rather than from the right, shops can customize their windows to accommodate a better view from the left. Additionally, the municipality can change the access to the routes from the right, in order to make the streets more liveable. The aspect of multipliers seems to be immanent to the WiFi sensors project in Enschede, as they are multiplied throughout different Dutch cities. However, the aspect of multiplying is not the only factor to assess when looking into the disposition of the WiFi sensors (Easterling, 2016, pp.74-75).

Another disposition marker of the WiFi sensors project is its topology (Easterling, 2016). Topologies can be seen as the connection between the multipliers which influences the actions of the infrastructure. A linear topology connects several multipliers along a line, which is for instance the case with trains. Yet this disposition is different from, for instance, a multi-centered topology as is the case with mobile phones. The WiFi sensors project could be considered to be both a radial and parallel network. It could be seen as a radial network, because the flow of information is regulated from one central point: the servers from CityTraffic. The servers regulate the sensors as the information from people who chose to opt-out should not be gathered. This might indicate that all of the sensors in Dutch cities are regulated by the central servers of CityTraffic. Yet, the WiFi sensors project could also be regarded as a parallel network in the future. Parallel networks work by having information flow simultaneously from various points. Right now, the only information flow that exists is from the sensor to the central server. However, when the data gathered by the WiFi sensors will be used via an open data platform or heatmap, the information flows are exchanged from different points.

The information flows thus become part of urban space. Topologies are therefore active forms which highlight the political disposition as it shows how information is circulated and

concentrated by authorities, such as the municipality and CityTraffic (idem., pp.76-78). Yet, the topology marker is not the only political influence which is part of the WiFi sensors project.

Governance and regulations also politically shape the WiFi sensors project. At the moment, the municipality of Enschede buys the data gathered from the WiFi sensors from CityTraffic and with it the analytics and informatics. Yet, both sides have to be responsible for following the law concerning what data is gathered, how it is gathered and how it is stored. The acts of governance – in this case the GDPR and the Dutch DPA – influence the disposition of the WiFi sensors. This shows that all active forms are interlinked to each other and that one active form can be enough to balance or redirect the other(s). In this case, the regulations and laws about data protection and privacy impact the use and scope of the WiFi sensors and its surrounding procedures. A change in the law can change the manner in which the WiFi sensors gather the data and how the people should be informed about the project. Thus, active forms of infrastructures, just like infrastructures themselves, are never isolated but always part of a bigger machine – the extrastatecraft (idem., pp.78-81).

As argued in the second chapter, Enschede's aim to become a smart city determines the use of the WiFi sensors. The masterplan for becoming a smart city influences the active forms of the smart city infrastructures which gradually become part of city life. The ideal of becoming a smart city does not just shape objects, but also the interplay and the active forms between such objects. The WiFi sensors are for now quite isolated from other data streams and flows in the city. However, when the data will be incorporated with other data sources, connecting smart city infrastructures, both the object, or objective in this case, and active forms are shaped by the municipality and CityTraffic. Of course, some of the active forms, as mentioned before, might limit the intended design of the objective.

The WiFi sensors project is thus a very powerful political tool and the disposition markers highlight this. As the WiFi sensors are designed and developed by CityTraffic, a private company, it is important to understand these dispositions as they are shaped as part of extrastatecraft. As part of extrastatecraft, the workings of the WiFi sensors are not made public but that does not mean that the sensors do not have an impact on the relation between the city-user and the city.

*Philosophy of Technology*

So far, it is argued that the WiFi sensors project in Enschede can be regarded as data-driven, networked urbanism as well as that it is a highly political tool. What has not yet been discussed is how the WiFi sensors project shapes the relation between the city-user and the city. To

analyse this, the postphenomenology mediation theory of Don Ihde is used. His theory has already been introduced in the first chapter to explain how infrastructures can be seen as a mediation between ourselves and the world. In the first chapter, it was stated that infrastructures are seen as part of both a background and hermeneutic relation. This type of relation is to a certain extent applicable to the WiFi sensors project.

The WiFi sensors in the inner-city of Enschede are part of the shopping streets, yet are not directly experienced by the city-users passing by. As the sensors only gather data, city-users do not directly interact with the sensors. But, as required by law, they are made aware of the sensors via stickers and eventually signs. Those are located around the streets in which the sensors are placed, notifying the passers-by about the presence of the sensors and offering a link to a website for more information (see figure 1 and 2). Amusingly, one can even argue that the stickers and signs portray the WiFi sensors as if they are part of a background relation, as the waves from the WiFi enabled device seem to spread out behind your back. The stickers and signs are in this case also the tools with which the infrastructure breaks through to the surface. As discussed in the first chapter, infrastructures can never fully be part of a background relation as they always need to break through the surface via interfaces or physical manifestations. Normally the physical manifestations come with the infrastructures themselves, such as a physical road or street lamp. However, with the WiFi sensors project, breakthrough points for the city-users had to be created artificially (i.e. signs and stickers) as is required by law. Whereas the breakthrough point for the municipality is the report and analysis handed over by CityTraffic. The WiFi sensors project might therefore not conform entirely to the background relation as the project always breaks the surface via artificially-made interfaces and therefore is brought to the foreground.

Another aspect of the background relation, which is also not necessarily the case for the WiFi sensors project, is that the technology does not directly influence the life of the passers-by. It can be concluded that the passers-by could become aware of the WiFi sensors by either spotting the sensors, by reading such stickers or signs, or by following the local news. However, many passers-by are either still not aware of the sensors or it does not interest them as much as other topics in the community. This disinterest might come from the fact that the city-users themselves do not directly rely on the data gathered by the WiFi sensors, but rather the municipality does. This does not take away the previously argued notion that the urban landscape is shaped by the data from the passers-by as there is still an indirect use of the WiFi sensors by the passers-by.

The breakdown of the WiFi sensors network or malfunctioning of it does not impact anything for the city-user – as usually would be the case for any infrastructure – which is another indication of the WiFi sensors project not conforming to the framework of a background relation. During a malfunction, only the data stream to the CityTraffic server is disabled and in turn less data is provided to the municipality. It has to be noted that the direct users of the WiFi sensors are not per se the passers-by, but rather the municipality and CityTraffic, who engage with the technology as part of a hermeneutic relation rather than a background relation.

In a hermeneutic relation the technology provides representations of the world and those representations are in turn interpreted by the users. The WiFi sensors gather data of the number of passers-by and how they move around the inner city. CityTraffic and the municipality believe that the sensors offer an accurate representation of phenomena which are very hard to perceive by ourselves. In fact, the main reason for the employment of the WiFi sensors is exactly because the manual labour surveys were too costly and time-consuming as well as that those surveys provided a small and incomparable dataset. However, what this relationship entails is that the users are not involved with the artefacts themselves – with the exception of governance interventions such as new laws – but rather with the representations they offer. The data is interpreted by algorithms developed by CityTraffic, which in turn is provided as representations to the municipality on a fact sheet. This relation between the users and the WiFi sensors can therefore also be considered to be hermeneutical.

This postphenomenological analysis of the WiFi sensors project underscores the co-shaping ability of a smart city infrastructure. By researching the project from a background relation perspective, a dynamic between awareness and unawareness is shown. For certain users the project remains in the background whereas it is more noticeable for other users – especially if the infrastructure would break down. However, many aspects of the WiFi sensors project take place in the background and are unknown or unclear to almost all users. The WiFi sensors are developed and maintained by CityTraffic, but how this is exactly done remains a mystery. Openly getting access to the methods used by CityTraffic is impossible, yet the municipality does not mind this and still works together with CityTraffic in good faith.

Thus, no one really seems to know how the system works. Yet, the data provided by the sensors is still used without suspicion. The municipality seems trust the coding and data expertise of CityTraffic without fully understanding how all practices work. Not only this unquestioned trust is worrisome but also the trust in the data provided by the sensors. The hermeneutic relation between the city-user and the city is based on the data provided and

represented by the WiFi sensors and algorithms of CityTrafic. It is therefore important to understand how the data is gathered.

Even if there is no information on the specifics of the algorithms and construction of the sensor, one can still critically evaluate the project. The sensors count people with WiFi enabled mobile devices, as currently only MAC addresses are being gathered. This idea is based on the assumption that most people carry mobile devices with them when going into the inner-city. Whether this assumption is true or not, it still is an interesting aspect of the project.

From the sensor's perspective the only passer-by that 'counts' is the passer-by which can be literally counted. This in turn is reflected in the data, as that data is only based on the passers-by with mobile devices. The municipality uses this data and has faith in the accuracy of those data representations, basing their urban development decisions on the data. This faith goes unquestioned, as data is believed to make everything 'smart'. The WiFi sensors therefore mediate our experience and perception of the world through the data – data which we blindly trust.

Not only is the gathered data used for decision making, it also carries a potential for other projects and smart environments. As discussed earlier, the data gathered by the WiFi sensors can be potentially used for creating even more accurate profiles of city-users. Even if the data is not yet used for such purposes, as well as that the law prevents the users from doing so, it still carries the potential. Therefore, there is always the potential to the technology which influences the way the users shape the world as well as that it could shape the behaviour of the ones whose data is being gathered. Not only can the data have an effect on the design of the shopping streets, it can also have an impact on the surveilled subjects themselves.

*The Surveilled Subject*

When reading studies on surveillance, one philosopher in particular is always mentioned and elaborated upon: Michel Foucault. His book *Discipline & Punish* (1995) paved the ground for a lot of contemporary surveillance research. Foucault's notion about the "panopticon" (Foucault, 1995) as being a spatial artefact of importance for modern societies is still reflected upon today. Foucault (1995) portrays societies in which the members are constantly being disciplined through the use of social and technological structures based on the panopticon. One part of this disciplining is the notion of continuously perceived surveillance. This surveillance creates a situation in which individuals are constantly being surveilled, the individual becomes a surveilled subject. The response to this surveillance was, according to Wood (2003),

"panopticism": the drive to self-monitor. Both of these aspects are interesting to consider, as the WiFi sensors project has the potential to be used for surveillance purposes.

Just like the Panopticon was a building designed to create discipline and order, surveillance technologies were designed create discipline and order in urban spaces. Video surveillance technologies such as closed-circuit television (CCTV) cameras constantly surveil city-user, but the city-user never knows when they are seen or by whom. The WiFi sensors project also surveils the city-users from Enschede constantly. Even though the employment of the WiFi sensors is not grounded in public safety, they still surveil all passers-by by counting them. The passers-by are thus "under control but without physical intervention" (Koskela, 2003, p.293). The employee physically counting the number of passers-by has been replaced by the WiFi sensors, shifting the surveillance from the physical domain which we experience via our bodily senses to the digital domain experienced by our minds. Surveillance, or control, is now exercised without any physical involvements.

These changes in cities and the impact it has on its city-users is impossible to avoid in our contemporary cities. Usually, passers-by are not able to choose a route where there are no surveillance technologies present. Thus, cities form a space of coercion (Koskela, 2003, p.300). A space in which the city-user has to conform in order to use its infrastructure. This argument does not fully apply to the WiFi sensors project as the city-users are able to opt-out of the project via CityTraffic. Yet, many city-users are either not aware of this option or do not care as they cannot really be bothered to reflect on the current surveillance systems, since they have nothing to hide. They do not realize the indirect impact of surveillance on themselves and their surroundings, because it does not influence their usage of the shopping streets in that moment.

However, the impact of surveillance goes beyond coercion. According to Kristie Ball (2009) it is also of importance to research how surveillance practices are experienced. Her notions of "the political economy of interiority" (Ball, 2009, p.643) and exposure can act as a starting point for such research. With the former she refers to the process during which the surveilled subject's private world becomes exposed due to data. This process often stems from commercial motives and tries to grasp the hidden and uninscribed aspects of the individual, parts which private companies or governmental agencies normally do not have 'access' to. Surveillance in cities takes place at a distance, is automated and instantly: "no-body is watching, but bodies are watched" (idem., p.644): the person counting manually is not there anymore, yet the city-user is still being surveilled. The sensors gather measurable data from the passers-by, surveilling the passers-by constantly.

Because the city-user is not always aware of the WiFi sensors watching them, many surveillance studies which focus on the vulnerabilities of the city-user when being surveilled cannot be properly used when reflecting. Ball (2009) therefore suggests to look into the notion of “exposure” (p.647). Exposure has two main facets: (1) what is exposed depends on how invasive the data gathering method is, and (2) it depends on the subject’s knowledge of the data gathering and its consequences (Ball, 2009, p.647).

With the help of soft surveillance technologies, such as the WiFi sensors, the exposing the surveilled subject’s body becomes less controversial. This is because data gathering is not intrusive, the surveillance is done via wireless signals, as well as that there is less awareness of the project. Moreover, the subject does often have little to no insight in or influence over what they and their data are exposed to (Ball, 2009, p.649). The WiFi sensors project does offer an opt-out system, which gives the city-user a choice to not participate and be exposed. However, if a city-user does participate, due to a lack of awareness for instance or by choice, they have no say in how the data is used or presented.

Additionally, because the municipality frames the data gathering by the WiFi sensors as ‘counting’ instead of ‘tracking’, the latter term being used by many critical voices, it becomes less controversial than other data gathering technologies. By framing the situation as less intrusive, the society finds it easier to accept such soft surveillance. Additionally, the municipality frames the WiFi sensors project as something which is beneficial for the liveability of the inner city, often perceived as reasonable ground for having such projects. Compliance with soft surveillance thus happens via persuasion, giving reasonable grounds and acceptable methods, instead of simple coercion where city-users are forced to use a product or behave in a certain way. Apart from framing the project positively, compliance is also stimulated because the municipality emphasises the need of the community (i.e. the liveability of the inner city) over the right of the individual. Gathering the data at a distance, which is the case with the WiFi sensors, the road is paved for compliance from the passers-by (idem., p.650).

By looking at the subject’s body as part of an exposure discourse not only the politics behind the surveillance are highlighted but also the reasons for compliance of the surveilled subject. In the case of the WiFi sensors project, the positive connotation given by the municipality allows for more support and participation, the passers-by comply because the WiFi sensors act from a distance and because the passer-by perceive the sensors as entities which do not directly influence their behaviour and movement.

*Conclusion*

To sum it up, the WiFi sensors project in Enschede can be regarded as a smart city infrastructure as it is an infrastructure which reinforces data-driven, networked urbanism. As argued for, this kind of urbanism is thoroughly political and produces a specific kind of city. This is why it is important to research and reflect upon the project, and smart city infrastructures in general.

The political aspects of the project were explained via the concept of extrastatecraft, since the project is developed by CityTraffic. By looking into the disposition of the infrastructure and its active markers, it was argued for that the WiFi sensors project is a very powerful and political tool. Because it is so powerful it is very important to look into the relation between the city-user and the city.

This relation can be explained with the help of two types of relations as framed in the postphenomenological theory of technological mediation. Infrastructures are often in a background relation with the city-users, as it is not constantly perceived as present as well as that it is only noticed upon breakdown. This seems not necessarily to be the case for the WiFi sensors project, as the passers-by do not directly use the sensors. Although this use of the WiFi sensors might change in the future with the implementation of the data in open data sources and heatmaps, framing it also as part of a hermeneutic relation seems to include more aspects of the project. This hermeneutic relation shapes how reality is presented to the users (i.e. the municipality of Enschede and CityTraffic) of the WiFi sensors. The technological presence in this relation influences the way the users shape the world and could have an impact on the surveilled subjects themselves.

The postphenomenological perspective on the WiFi sensors project highlights the co-shaping abilities of the project as well as a dynamic between awareness and unawareness. Even if city-users are aware of the project a lot of questions still remain unanswered. CityTraffic does not share their methods and coding practices, making it difficult for the city-user and municipality to fully grasp the influence of CityTraffic's development. No one really knows how the system works and how the provided data was shaped. CityTraffic's views on data gathering frames their coding, as only passers-by with WiFi enabled mobile devices are subjected to data gathering. As the municipality base their urban decision making on the data, it could be said that smartphones – technologies – shape the policies on urban planning.

Not only do the sensors and the data shape urban planning but also the views on a city's liveability. In chapter two, it was discussed that the municipality want to improve the liveability of Enschede and that they deem this as a valid reason for the WiFi sensors project. The data represented by the sensors 'show' how liveable the inner-city of Enschede is. Yet, only people

with smartphones are included and therefore only those people have an impact on urban policies. The WiFi sensors project thus only values ‘technocity-users’: city-users who are valued for the technology they carry around rather than for being human. City-users thus only have a say because of their smartphones and not for being a city-user.

As can be seen throughout the whole chapter, the WiFi sensors project, as a smart city infrastructure, is interwoven with and related to many aspects of urban space which makes it a complex and influential phenomenon. This influence and complexity surpasses conventional infrastructures which means that smart city infrastructures are in need of more thorough analyses and research.

## CONCLUSION

Smart city infrastructures are highly complex phenomena which concern various layers of society and join together, as well as require the analysis from, several research fields. This thesis shows that smart city infrastructures significantly shape urban spaces and the relation between the city-user and the city. Due to this powerful shaping role of smart city infrastructures, there is a need for more in-detail philosophical, sociological, and political research and reflection.

The first chapter provides a framework that captures the social facets of infrastructures. By looking into sociological and philosophical studies on infrastructures it is shown that infrastructures are not only technical but also social artefacts as they are relational by always connecting or being connected to artefacts. Because of this relationality, infrastructures are able to shape the natures of networks. Understanding how infrastructures shape our urban space is therefore vital, especially since infrastructures are ubiquitous to city life even though they are often hidden. By researching the design politics and extrastatecraft of which infrastructures are part, a political perspective on infrastructures is highlighted. Following that perspective, infrastructures are framed as tools for political authorities to exercise power.

As such a tool for power exercise, infrastructures are enabled to shape the relation between the city-user and the city. Following postphenomenology, technologies shape our experience of ourselves and the world. Infrastructures also shape our experience, although this shaping often takes place in the background or via hermeneutics. Since infrastructures are many times not visible, city-users are not directly aware of them and take them for granted. To expand this relation, the potentiality of technologies is discussed which frames infrastructures not only as tools with which political authorities can shape directly but also indirectly.

This complexity of regular infrastructures is added onto by smart city infrastructures. The basic aspects of a smart city infrastructure remain the same as an ordinary infrastructure, yet the addition of computation creates a difference. Because of the embedding of computation technologies in infrastructures, data is produced, gathered, and shared across various infrastructures.

Following this framework, the case of a particular smart city infrastructure is introduced: the WiFi sensors project in the city of Enschede. The project is discussed from four perspectives: the perspective of (1) Enschede as a smart city, (2) the municipality of Enschede, (3) the public discussion, and (4) a concerned city-user. The discussion which includes various societal perspectives, highlights the impact of WiFi sensors in Enschede.

The impact of the WiFi sensors project as a smart city infrastructure is discussed in the third chapter. First of all, the impact of the involved computation technologies is analysed. By

delving into this analysis, it becomes clear that the WiFi project requires further research into the motives behind the project especially as it is developed as part of extrastatecraft.

This further analysis was done with the help of disposition markers, stressing the political aspects of the project. As argued for, the WiFi sensors can be regarded as multipliers and their topology influences how the data is gathered, used and shared. Additionally, decisions taken by CityTraffic shape the usage and limitations of the sensors, making them part of extrastatecraft. CityTraffic shapes the purpose of the WiFi sensors and define which city-users are valuable for data gathering. As already argued in the first chapter, smart city infrastructures are used as a political tool and it is therefore significant to look into how they shape the relation between the city-user and the city.

The relation between the WiFi sensors project and the passers-by is analysed in light of postphenomenology. As argued in the first chapter, infrastructures are often seen as part of a background relation but can also be part of a hermeneutic relation. In the case of the WiFi sensors project, the relation between the sensor and the passer-by might instead be considered as both a background and a hermeneutic relation. Both of these relations show that the smart city infrastructure directly shapes the perspective via which the world is viewed as well as the behaviour of users and the people affected by the technology. Because the WiFi sensors project also might shape behaviour, it is vital to also look into the experience of the sensors by the subject.

Surveillance studies often investigate the power relations in place, as they seem to drive the modern society in which we live. Studies on CCTV cameras have shown that it is an example of a panoptic technology, yet current panoptic technologies are not intervening physically anymore but rather from a distance. In the case of the WiFi sensors project this intervention happens via coercion rather than choice, as it operates based on an opt-out system. However, the coercion is not the sole shaping method the WiFi sensors project carries out, as the subject's experience of exposure should also be considered. As the WiFi sensors project is considered to be a soft surveillance technology, the municipality can easily frame it positively by stating its use for the common good and by using words such as 'counting' instead of 'tracking'. This framework provided by the municipality shapes the experience of the surveilled subject which shows that coercion consists of more complex aspects. By looking at the exposure as experienced by the surveilled subject, the politics behind surveillance as well as the reasons for compliance from the passer-by are shown.

The sociological, political and philosophical perspectives on the WiFi sensors project, as framed in this thesis, show that – as a smart city infrastructure – it is able to shape urban

spaces and the relation between the city-user and the city. This shaping occurs on various levels and should be researched from as many perspectives as possible, as smart city infrastructures are highly relational and collective which in turn makes them ubiquitous to urban spaces.

This thesis tries to highlight the impact smart city infrastructures have on our view of urban spaces and our relationship with it. Yet, there seems to exist a gap between philosophical reflection on smart city infrastructures and their shaping agency. From a postphenomenological perspective, the WiFi sensors project seems to a certain degree to be part of a background relation but also of a hermeneutic relation. The WiFi sensors project, or a smart city infrastructure in general, therefore transcends the framework of both relations and might require a whole new type of relationship to adequately explain their co-shaping agency. It would thus be reasonable to conduct more research on how smart city infrastructures can be framed as part of the postphenomenology mediation theory, especially since they have such profound impacts on urban spaces and its city-users.

Even though this thesis tries to provide a thorough research in smart city infrastructures, it is not without its limitations. The whole line of argument in this thesis has been based on the notion that infrastructures are shaped, by but at the same time shape our world. Arguments concerning technological or social determinism have only been little elaborated upon. Yet, by using such theories the thesis would have not been able to scrutinise the interplay between the WiFi sensors and community. The approach taken in this thesis is therefore more adequate as it takes into account the co-shaping between the sensors as well as society, encompassing as many aspects as possible.

Furthermore, it has to be acknowledged that the example of the WiFi sensors project is merely one example whose analysis does not automatically apply to all other smart city infrastructures. Moreover, it should be noted that, even though the empirical research conducted did provide many insights into the project, it did not include the perspective of the passer-by. However, such insights were still accounted for in this thesis via secondary sources (e.g. the radio interview). Yet, it has to be kept in mind that this thesis does not aim to conduct social science research but rather provide empirically researched philosophical reflections. The validation of these reflections can be done via more empirical research such as the interviews of passers-by or city-users, something which would be valuable to future research on smart city infrastructures.

Despite these limitations, this thesis offers an inclusive analysis of how smart city infrastructures can shape urban spaces and the relation between the city-user and the city. Hopefully, this analysis can be the spark which ignites more philosophical and social research

on the shaping agency of smart city infrastructures, something which unfortunately has not often been addressed yet.

Such discussions are vital, however, as we should carefully consider the impact of smart city infrastructures on democracy. City-users and the city should be careful using smart city infrastructures as they can bring about technocities, cities where technology and data is giving more value than its city-users. The WiFi sensors project defines what a city-user ought to be: someone with a smartphone. Only those technocity-users have a say in urban policies, as only they will be considered when making decisions for future urban planning – the data shapes the public. This can potentially endanger democracy as the principle of one vote per person shifts to a principle of one vote per smartphone, paving a path for technocracy. This begs the question, however, if we want to live in such technocities and whether we want data to be valued more than our humanity.

Hopefully this thesis will also stimulate some reflection on how the WiFi sensors project in Enschede is run. Of course, the new European GDPR will most likely affect the project set-up, but that is not the only aspect which should be reflected upon. With this analysis, both the municipality and the city-users can carefully consider the current situation and think of other possibilities or approaches to the project.

The biggest concern is the unclarity of the CityTraffic's data gathering and analysis methods, yet the municipality seems to blindly trust CityTraffic's methods. Both of these aspects stay undisclosed in the private sector, but those aspects should be publicized instead. CityTraffic is most likely not willing to do this, so instead of buying their services the municipality should create a new WiFi project themselves. By creating a taskforce consisting of data and privacy experts and by following privacy-by-design principles, the municipality and the public becomes more knowledgeable on which data is used, how it is used and for what reason. Creating this transparency will also allow for refined discussions on the effect of the smart city ideology and the rise of technocratic values in Enschede. These discussions in turn would allow for democratic decisions on the future of urban planning in Enschede.

Of course, a more radical option for the municipality could be to stop the WiFi sensors project altogether. Even if this would be the most ideal option, as city-users will be valued for who they are rather than the data which can be gathered from them, it will be the least plausible as the municipality is set on creating a smart city. Even though the smart city ideology causes data fetishism and influences the value given to data, the municipality of Enschede can still create the WiFi sensors project in a responsible fashion as long as the data gathering methods and meaning given to the data become transparent.

Even if such considerations will not lead to any differences, there was at least a time of reflection concerning the WiFi sensors project and its impacts. Careful deliberations on the shaping agency of smart city infrastructures and the impacts they bring about are important in political, philosophical, and sociological discussions regarding contemporary urban technologies, as smart city infrastructures are becoming ubiquitous and unavoidable.

> Awareness of surveillance may arise far away from the domain of data capture, yet the awareness may be as profound is [*sic*] if one was staring into the empty black lens of a security camera, or submitting a urine sample for a drug test. Spaces for reflection are still relevant, even if these spaces do not emerge while the subject is under surveillance (Ball, 2009, p.653).

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## ANNEX 1A: INTERVIEW NOTES – DAVE BORGHUIS

Interview with Dave Borghuis, 19 December 2017 at Tkkrlab, Enschede.

1. *Can you explain the technical side of the WiFi sensors project to me?*

Basically, the WiFi sensors act as access points which listen to all the 'noises' sent out by mobile devices. These noises can always be picked up as long as your WiFi settings are enabled, connecting to a WiFi network is therefore not required. The 'noise' the sensors receives is the MAC address of someone's mobile device.

Because the MAC address is considered personal data, as the mobile device can be directly linked to an individual, the address needs to be encrypted. This is done with the help of hashes, giving another sequence of identification numbers to the individual's MAC address. In general, the encrypted hash addresses cannot be traced back as you need to know the specific encrypting methods used.

2. *Why is the WiFi sensors project then considered so privacy sensitive?*

Because there might be certain methods with which you can actually trace hashes back to the original MAC address, current testing and research is conducted concerning this retracing. Apart from this, the hashed addresses still can be actually used to track an individual as the data can still be combined together with other data. Because the hashed address is the same for all the sensors placed by CityTraffic, you can easily follow an individual. Of course, with just the hashed address you do not know who that certain individual is, but if you combine it with other data (e.g. payment records) you are still able to find out which hashed address belongs to who.

3. *Is this why you filed a complaint about the WiFi sensors project to the municipality?*

The concern about the sensors being privacy sensitive is not the only one. If you look at the rules and regulations set by the Dutch DPA, you can see that the project does not meet those. There has been no specific times nor spaces defined in the project, something required by the Dutch DPA, as the sensors measure the movement of city-users 24/7 and all over the inner city of Enschede. The project also works with an opt-out system, instead of an opt-in, the latter is also required by the Dutch DPA. Additionally, the data is stored for quite some time, about 6 months, as the municipality wants to gather information on how many city-users return to the inner city over a period of time.

4. *What would you suggest they should change in order for the project to become acceptable?*

They should seriously re-consider the outsourcing of the project the WiFi sensors. Currently there is almost no to none competition between companies such as CityTraffic, simply because not many companies exist in this field. Yet, the lack of companies with such projects does not mean that the approach CityTraffic takes is the correct one. If the municipality would create a taskforce to design the WiFi sensors project, they would be able to keep the principles of privacy-by-design in mind and make the project more transparent. Another way to create such transparency and regain the trust of the city-users is to make the data public, allowing city-users to engage with and make use of it.

# ANNEX 1B: INTERVIEW CONSENT FORM – DAVE BORGHUIS

Informed Consent for standard research

'I hereby declare that I have been informed in a manner which is clear to me about the nature and method of the research. My questions have been answered to my satisfaction. I agree of my own free will to participate in this research. I reserve the right to withdraw this consent without the need to give any reason and I am aware that I may withdraw from the experiment at any time. If my research results are to be used in scientific publications or made public in any other manner, then they will be made completely anonymous. My personal data will not be disclosed to third parties without my expressed permission. If I request further information about the research, now or in the future, I may contact

Denise Op den Kamp, d.s.a.m.opdenkamp@student.utwente.nl or
her supervisor Dr. Michael Nagenborg, m.h.nagenborg@utwente.nl.

If you have any complaints about this research, please direct them to the secretary of the Ethics Committee of the Faculty of Behavioural Sciences at the University of Twente, Drs. L. Kamphuis-Blikman P.O. Box 217, 7500 AE Enschede (NL), telephone: +31 (0)53 489 3399; email: l.j.m.blikman@utwente.nl).

Signed in duplicate:

Dave Borghuis .....

Name subject Signature

'I have provided explanatory notes about the research. I declare myself willing to answer to the best of my ability any questions which may still arise about the research.'

Denise Op den Kamp Kamp

Name researcher Signature

## ANNEX 2A: INTERVIEW NOTES – GERDIEN LOOMAN

Interview with Gerdien Looman, 15 December 2017 at DesignLab, Campus University of Twente, Enschede.

1. *Why did the municipality of Enschede decide to invest in the services offered by CityTraffic?*

Because the 8 WiFi sensors are more pragmatic and accurate, as well as that the data provided is more objective. In the past, surveys were conducted once a year by manual labour, but they did not provide the vast amount of data and accuracy the WiFi sensors can offer. These kinds of datasets are needed in order to increase the mobility, security, and experience of the inner city of Enschede. Furthermore, the effects of investments in the inner city can be studied and this in turn can lead to more potential investments.

We already used WiFi sensors during big events such as the Passion or Serious Request. This was done to enable crowd monitoring and to ensure the public's safety. Those WiFi sensors were temporarily placed and used.

2. *Would you describe the WiFi sensors project as a tracking system?*

No. As the MAC addresses are encrypted directly on the sensor, tracking of individuals cannot occur. Instead, we explain it as a system that 'counts' the number of passers-by in the city centre, seeing how they move around and use the streets.

3. *Are you of opinion that the municipality has informed the city-users about the WiFi sensors project well enough?*

The municipality has informed the city-users via several media outlets as well as stickers placed around the city centre. We are aware that the stickers are not sufficient and small, that is why we will replace the stickers with signs starting in January. The system as it works now and the information provided is sufficient and according to rules and regulations.

4. *Will you make the data gathered by the WiFi sensors public?*

This will be done eventually. For now, we are still struggling with the questions on what we should make public, how to do this and if we can incorporate the flow of passers-by via live feeds. We think it is still too early to create an open data platform in order to offer the data to city-users at the moment.

# ANNEX 2B: INTERVIEW CONSENT FORM – GERDIEN LOOMAN

Informed Consent for standard research

'I hereby declare that I have been informed in a manner which is clear to me about the nature and method of the research. My questions have been answered to my satisfaction. I agree of my own free will to participate in this research. I reserve the right to withdraw this consent without the need to give any reason and I am aware that I may withdraw from the experiment at any time. If my research results are to be used in scientific publications or made public in any other manner, then they will be made completely anonymous. My personal data will not be disclosed to third parties without my expressed permission. If I request further information about the research, now or in the future, I may contact

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Signed in duplicate:

Gerdien Looman gemeente Enschede

Name subject Signature

'I have provided explanatory notes about the research. I declare myself willing to answer to the best of my ability any questions which may still arise about the research.'

Denise Op den Kamp Kamp

Name researcher Signature

## ANNEX 3A: INTERVIEW NOTES – WILCO LOUWES

Interview with Wilco Louwes, 6 December 2017 at Tubantia, Enschede.

1. *Have there been many responses to the articles published on the WiFi sensors project?*

Unfortunately, no. The topic seems not to interest or engage the public as much as for instance the new laws on garbage disposals. I would have liked more responses, but we cannot change the public's opinion and priorities.

2. *What is the most discussed aspect of the WiFi sensors project in the public discussion?*

The most interesting and often discussed aspect is the impact it can have on the city-users. City-users seem often not to be aware of sensors in city centres and when they are made aware they seem not to care stating that they 'have nothing to hide'. Apart from that, is that the project is not abiding the rules and regulations as set by the Dutch DPA and most likely also not those set by the upcoming GDPR. That the municipality is not sharing the gathered data with the public and seems to be quite secretive about it also does not help when it comes to the public's trust.

3. *How can the local media contribute to the discussion on the WiFi sensors project?*

By publishing as often and as much about it as possible. We [the Tubantia] publish about 1 article a month, which is already quite a lot considering it is not per se an engaging topic for many. Yet, we have the responsibility to inform the city-users of the project as it can profoundly impact urban spaces and their privacy. Giving such topics as much spotlights as possible is always important, especially since we as journalists have to follow up on our civic duties.

# ANNEX 3B: INTERVIEW CONSENT FORM – WILCO LOUWES

Informed Consent for standard research

'I hereby declare that I have been informed in a manner which is clear to me about the nature and method of the research. My questions have been answered to my satisfaction. I agree of my own free will to participate in this research. I reserve the right to withdraw this consent without the need to give any reason and I am aware that I may withdraw from the experiment at any time. If my research results are to be used in scientific publications or made public in any other manner, then they will be made completely anonymous. My personal data will not be disclosed to third parties without my expressed permission. If I request further information about the research, now or in the future, I may contact

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Signed in duplicate:

Wilco Louwes .....

Name subject Signature

'I have provided explanatory notes about the research. I declare myself willing to answer to the best of my ability any questions which may still arise about the research.'

Denise Op den Kamp .....

Name researcher Signature