19. Binding the smart city human-digital system with communicative processes

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ABSTRACT

This chapter will explore the dynamics of power underpinning ethical issues within smart cities via a new paradigm derived from Systems Theory. The smart city is an expression of technology as a socio-technical system. The vision of the smart city contains a deep fusion of many different technical systems into a single integrated "ambient intelligence" (Ikonen et al., 2010, p. 102). Citizens of the smart city will not experience a succession of different technologies, but a single intelligent and responsive environment through which they move (Dainow, 2017).

Analysis of such an environment requires a framework which transcends traditional ontologically-based models in order to accommodate this deep fusion. This chapter will outline a framework based on Latour's Actor-Network Theory (ANT) and Luhmann's treatment of society as an autopoetic (self-organising) system. We shall use this framework to map the influence of relevant factors on ethical issues, irrespective of their composition or type. For example, under this treatment, both human praxis and technical design can be viewed as comparable tools of domination.

This chapter will provide a framework for the analysis of relations between any elements of the smart city, ranging from top-level urban management processes down to individual device operations. While we will illustrate the use of this schema through examination of ethical issues arising from power dynamics within the smart city, it is intended that this example will demonstrate the wider utility of the model in general.

KEYWORDS

Ethics, systems, city, information, power

0. Introduction

This chapter offers a new way of viewing the complex phenomena which is humans living in a technologically advanced city. Using Actor Network Theory (Latour, 2005), the concepts of autopoiesis (Luhmann, 1995), symbolic capital (Bourdieu, 1986), affordances (Hutchby, 2001) and fields of contention (Bourdieu, 1990), a new framework will be developed which provides a way of describing people and technology as a single unified system. We will use this framework to characterise the system's nodes and patterns of connection, identify fields of contention and how they impact technology design, and derive consequent ethical issues.

The sophistication of modern technology is what separates modern cities from those of the past. Today's cities are becoming dependent upon advanced digital systems embedded throughout them. The life of a citizen in such a city is incomprehensible without understanding the technology of their built environment. We may therefore regard modern cities as complex socio-technical systems (Taylor, 2005). The future for technology in cities is held in the image of the smart city, in which intelligent digital systems and personalised services are dominate urban existence. If we can develop an all-encompassing framework to describe the smart city, we can use it to understand trends in urban technology today. By anticipating the ethical concerns in future smart city technology, we can identify current trends which may not be of concern today, but will give rise to issues in the future. Such knowledge offers the chance to change innovation paths now in order to prevent future issues developing in the first place.

The key characteristic of the smart city is the ubiquity of digital devices and systems. Smart cities are based on the foundation of an omnipresent sensor network which provides information about the inhabitants and environment (Balakrishna, 2012). These sensors will communicate with devices and systems to provide analysis and response. Some of these communication patterns can be predesigned, but some will appear and disappear as people move about ("ad hoc networking") (Guo, Wang, Zhang, Yu, & Zhou, 2013). Digital devices will be embedded in the civic environment, the home and other personal spaces (such as the car), worn on the person and implanted within the body (Perera, Zaslavsky, Christen, & Georgakopoulos, 2014). While some devices will be embedded in traditional materials, the rise of smart materials will often render the distinction between device and material meaningless (Addington & Schodek, 2005). Data will be processed locally ("fog computing") as well as in the cloud (Bonomi, Milito, Zhu, & Addepalli, 2012). People will be tracked individually and in aggregate. The urban environment will change in response to the movements and needs of individuals and groups. Ethical exploration of technologies is usually limited to issues associated with specific technologies, such as cars (Jaisingh, El-Khatib, & Akalu, 2016) or location detection (Martínez-Ballesté, Pérez-Martínez, & Solanas, 2013). However, many ethical issues emerge from the interaction of different technologies. Furthermore, smart cities will not be like today's cities with some digital technology laid over the top, any more than the modern city is just a Victorian one with cars instead of horses. The mature smart city will be a fundamentally different type of environment from any we have previously seen (Batty et al., 2012). Through all of history, the human built environment has been a largely dumb. It has not had the ability to initiate action, nor has it had the capacity to know us. The ability of the environment to obtain data and to respond to human action represents a fundamentally new type of built environment for human living (Picon, 2015). The number, ubiquity, heterogeneity and invisibility of digital systems in the urban fabric will force humans to deal with intelligent spaces, rather than individual devices (Rolim et al., 2016). We must therefore cease to talk in terms of technical components and instead develop a vision of the smart city which encapsulates all aspects of its operation. The starting point for analysis is to identify the functional characteristics which can unite the various heterogeneous technical forms found in the smart city. These are ambient intelligence, artificial intelligence and robotics.

Ambient intelligence is technology which embeds input, processing or response throughout the environment (Ikonen, Kanerva, Kouri, Stahl, & Wakunuma, 2010). As a lived experience, people will not experience the smart city as individual components and discrete processes isolated within atomised sections of their lives. Instead, the smart city will be experienced as a seamless experience as one moves from house to car to work, from one context to another (Dainow, 2017a). Similarly, smart cities will integrate data about people from multiple sources, creating a *digital environment*, a pervasive digital ecosystem which saturates the built environment, interacts with devices carried or worn by people and embedded within their bodies (Balakrishna, 2012) to create an integrated sensing and response environment (Psyllidis, 2015), an "intelligent information infrastructure" (ITU-T, 2008, p. 2), or ambient intelligence.

Central to the vision of the smart city is algorithmic intelligence, or "soft AI" (e.g.: expert systems and software agents) (Komninos, 2006). In addition to expectations that soft AI will provide core functionality through cloud computing, it has been suggested soft AI will need to be embedded at local level to support ad hoc networking (Komninos, 2006), to provide contextual awareness (Augusto, Nakashima, & Aghajan, 2010), and simply to handle the sheer amount of data (Komninos, Schaffers, & Pallot, 2011). As a result, the smart city will be filled with many AI systems. These systems will need to interact with each other and the human inhabitants in myriad ways. These AI's will constitute a complementary, but distinct, form of consciousness to the humans within the smart city.

'Robotics' refers to ICT devices possessing the ability to move autonomously (Ikonen et al., 2010). Self-driving cars and drones are expected to exist within smart cities (Jaisingh et al., 2016). Much building construction will occur robotically (Tibbits & Cheung, 2012). The home will see mobile IoT devices, such as robot vacuum cleaners (Cirillo, Karlsson, & Saffiotti, 2012). Public spaces, such as a hospital ward or shopping mall, will see many different types of robot moving about (Mastrogiovanni, Sgorbissa, & Zaccaria, 2010). The specific details of which robotic devices will exist within the smart city need not concern us here. The important point is that the smart city environment will involve both humans and machines moving within the same space. Just as the introduction of the car eventually led to the rise of pedestrian crossings, so an environment of moving machines will require adjustments in human behaviour to take them into account. Similarly, just as the car required the development of petrol stations, so the needs of the smart city's robotic inhabitants must inevitably require the development of specific urban structures and support systems.

The arrival of an intelligent, responsive environment containing autonomously mobile agents brings changes which must affect people. In this respect, the smart city will be created by its digital systems as much as by its human inhabitants. Device activity will respond to human activity. Humans will respond to device activity. Digital devices will have their own needs, many of which will require consideration by humans. This will sometimes bring the needs of the digital agent into conflict with the needs of the individual, just as cars require roads which gives them effective rights over people in some circumstances. Accordingly we must view digital devices as causal agents in a smart city on the same level as humans. If we are to develop a comprehensive view of the smart city, we must therefore include humans and digital systems as equals. Both are active agents capable of producing changes in the other.

Systems theory, long dominant in urban planning (Taylor, 2005), permeates approaches to the smart city (Söderström, Paasche, & Klauser, 2014), treating it as a complex system of systems (Bicocchi, Leonardi, & Zambonelii, 2015). Actor-network theory (ANT) (Latour, 2005) offers a systems approach which puts the smart city's digital agents into an interactive relationship with humans by regarding both as nodes in the same system. By treating both devices and humans as the same type of node within the same system, ANT provides a way of describing the causal effects digital agents have on humans and vice versa (Tabak, 2015). A further advantage of ANT is the lack of need to specify the details of each node within the network (Law, 1992). Instead, under ANT, agents may be a single digital device, an individual person, a group of people, a group of devices, or a mixture of these. However, ANT alone is not sufficient. The range and number of devices, their mobility, the deep interaction with humans, and the dynamic patterns of interaction generated as a result, means smart cities cannot be centrally managed, but must be self-organising, or *autopoietic*.

The concept of autopoiesis originated in biology to account for living organisms as self-sustaining systems (Varela, Maturana, & Uribe, 1981). Systems theory holds that the defining characteristics of a system are not determined by the properties of the components, but by the patterns of their relationships (Boulding, 1956). Autopoietic systems are those which can maintain or regenerate these patterns in the face of changing circumstances (Maturana, 1981). Niklas Luhmann introduced the concept of autopoiesis to the social sciences by treating society as a form of autopoietic system. Under Luhmann, the atoms from which social systems are built were *communicative events* between people. Luhmann defined communicative events as being composed of a sequence of information, understanding, and utterance (Luhmann, 1986).

This communicative atom is also visible in digital devices and systems. It is the minimum necessary characteristic of any digital device that it be able to accept input ("information"), process it ("understanding") and produce output ("utterance"). All digital systems are formed from groups of digital devices acting in such a fashion. However, smart cities will not be constituted by systems in which digital devices communicate only with each other. Humans and digital devices will engage in communicative patterns across the human-digital divide, as well as with each other. Furthermore, significant portions of human-to-human communicative activity will be mediated by the digital environment, while that digital environment's communicative patterns will respond in myriad ways to every human action. Under such circumstances, few nodes can be said to be purely human or digital; the overall patterns of communicative flow will be the result of both human and digital actants - an *Integrated Domain*.

It is important to bear in mind ANT is not explanatory. ANT is more method than theory, and the appellation of 'theory' has been declared misleading (Latour, 2005). The concept of the Integrated Domain is not intended to explain relationships or trace cause and effect. ANT provides a system of describing phenomena which cannot be attributed to exclusively digital or human causes, but does not seek to explain why or how. The descriptive framework offered here is intended to provide a language for such explanations.

1. Integrated Domains

An Integrated Domain is an autopoietic socio-technical system comprised of two collectives integrated into a mutually dependant partnership. One collective consists of a human *smart society*. A smart society is a human society which exists within an ambient digital environment, such that human intersubjectivity is mediated by digital technology (Hartswood, Grimpe, Jirotka, & Anderson, 2014). The other (non-human) collective is a system of digital devices and networks. Operationally, neither collective possesses strict boundaries against the other. Instead, they intermingle to such a degree it is impossible to account for phenomena within the Integrated Domain without reference to both. An example is the search engine manipulation effect, which has shown that the order in which a search engine lists items strongly influences the chance of these items being read and being believed (Epstein & Robertson, 2015). Search engines are significant cognitive tools for many people, which analyse people's behaviour in order to produce search results personalised to them (Dillahunt, Brooks, & Gulati, 2015). Thus, the user's knowledge of the world is mediated by logic created by their behaviour in combination with the search engine's algorithms. The user's knowledge of the world no longer derives from their own efforts, but from the inseparable fusion of human and digital. When the human and the digital are inseparable, we have entered the Integrated Domain.

The node which binds the Integrated Domain as a system is the *Integrated Node*, a unit of operation consisting of input, processing and output. In ANT terminology, a Integrated Node is a mediator, a node in a system which transforms what flows through it (Latour, 2005). A Integrated Node may be a person, a single device, a group of devices, a group of people, or any combination thereof. A Integrated Node is not defined by what it is made of, but by its mode of operation.

As the digital develops more cognitive capabilities through AI, so it's impact on the human becomes more varied and more complex. The internal nature and logic of these digital systems, their *logos*, therefore becomes more important in understanding their outcomes. As a consequence, it becomes imperative that we consider the digital perspective - how the world looks and is understood by digital systems (Picon, 2015). The terms 'looks' and 'understood' do not indicate anthropomorphism. Digital cognition is not the same as human cognition. However, if cognition is accepted as "the action or faculty of knowing taken in its widest sense" ("Cognition, n.," 2018), then it is clear that digital systems do possess a form of cognition. The most important aspects of the digital perspective are time, design, logic, epistemology and energy.

Descriptions of digital systems are inherently time-bound. Digital systems only "exist" to the degree that data flows through them. Without data on which to operate, a digital device is inert, no more able to cause effects in the world than a rock. Accordingly, a digital system is not best considered as a state but as a process (Dodge & Kitchin, 2005). For example, a service commences with anticipation of user requirements, organises processes to deliver the service to the user, is processed by the user (possibly mediated by other devices) and terminates in a stream of output data comprised of user activity and the recording thereof. Integrated Nodes are regions through which data and activity flow, defined by the manner in which they change what flows through them. Digital systems cannot be understood as actants by considering their material composition, only through understanding how they operate over time.

Digital constructionism is the view that there is nothing natural, and little inevitable, in the manner any digital system accomplishes its task. For example, it is often assumed that improving online security must require reducing online privacy, but these two values are not in competition. Enhancing privacy can actually make systems more secure (Langheinrich, 2001). The assumption that security and privacy are oppositional reflects current practice, not the necessary characteristics which must adhere in any and all digital systems (Dainow, 2015b). Any system which improves one by reducing the other is a result of decisions made by developers, who chose to code in such a manner. The algorithms, interfaces and other implementations of digital design are therefore to be understood as artificial and engineered social constructions, and always open to alternatives (Dong, 2004).

All digital systems stem from the place of toolmaking in the human. It is the primary defining characteristic of the digital that digital systems are created by humans for specific purposes. We do not create any digital systems simply so that they can exist, returning nothing to us. All digital systems are therefore inherently teleological systems. Any attempt to understand them must consider the purpose for which they exist. We can only arrive at a complete understanding of other goals, processes and values within a digital system by considering them in reference to the ultimate purpose for which that system was built. We must therefore consider digital systems in terms of whom their primary beneficiaries are and the benefits they derive. Processes within digital systems are driven by their *digital logos*, the heuristics, values and other elements which govern the design of digital cognitive processes and thus determine their outcomes. The nature of the digital logos is therefore important to those who desire control. Consequently, contention and power dynamics are concentrated around the digital logos in the form of competition for dominating values and heuristics (Albrechtslund, 2007). The overarching function of the digital logos is to serve the system's ultimate purpose. The ultimate purpose may be different from the obvious purpose. The obvious purpose is the reason why users make use of the system. For example, a commercial navigation system's obvious purpose is to guide a user to their destination. However, as a commercial system, its ultimate purpose is to generate profit. During design, elements of the system will therefore be evaluated against their profit-making capacity as well as their capacity to aid navigation. Potential elements which help the user but compromise profit generation will be unwelcome, and may not be included (Bogliacino & Pianta, 2013). The user may not get the best solution if such a solution would reduce profitability. All systems, especially those operated for profit, must therefore be regarded as, at least potentially, compromising the user in favour of some other goal. We can never assume that the user is always the primary beneficiary of any digital service.

By its very nature a digital device cannot know the physical world. What a device knows is only what its sensors generate as input. For example, an air conditioning control system does not respond to actual room temperature, but to what the sensors tell it the temperature is. If the sensor gives a false reading, the air conditioning will still respond to what the sensor tells it, not what the reality is. Hence digital devices do not know the physical world, but inhabit a totally digital environment. What they know of us is determined by our representation in digital data. Smart city systems will not respond to us; they will respond to our digital representations. If those digital representations are incorrect or incomplete, then the analysis of us and our needs will be compromised (Mittelstadt, Allo, Tadeo, Floridi, & Watchter, 2016). *Digital scepticism* is the epistemological position that digital systems can only detect that limited set of reality which they are designed to receive as input. If a system is not designed to process a certain input, then the corresponding aspect of the world does not exist for the digital system. Should this aspect of the world represent an important goal to the user, their attempts to achieve that goal will be frustrated. When combined with digital constructionism and the politics of the digital logos, the digital system's knowledge of the world becomes a product of stakeholder interests, not some "objective" view of reality.

Every process uses energy. This means we can validly apply many concepts related to energy to both digital processes and human interactions with digital systems. We can talk in terms of capacity, frequency, resistance and so forth. We can apply these same concepts to the human as well as to the digital because we do not depend upon any particular material composition for the concept of energy to be applicable. Consequently, we can discuss both digital and human systems and the interactions between them in the same terms. The amount of energy required to utilise a digital service is an important factor in its usability. Energy is expended for a purpose, as a cost towards achieving a goal. Goals have a cost threshold, beyond which the cost is not worth the goal. Increasing ease of use is a way of reducing the energy required for a task. This is a significant factor in the spread of digital technology and an important driver of innovation (Fontana & Nesta, 2009). By contrast, *nudging* is a process of gradually leeching energy through micro-thresholds in order to produce a strong cumulative effect, either to discourage input, prevent or influence processing, or reduce output (Johnson et al., 2012).

2. Contention and affordances

As creations of human society and as sources of value, digital systems are inevitably included in the *fields of contention* (Bourdieu, 1990) which permeate other aspects of society (Pursell, 2007). Many of the characteristics of any digital system can be sites of contention (Mansell, 2017). Any aspect of a digital system can be designed to increase domination more than to serve the user. Characteristics of digital systems should therefore be considered as potential strategies for competition. Within the Integrated Domain digital actants are not passive spaces, but support or inhibit the competitive strategies of human actants. Bourdieu's theory of multiple forms of *capital* (Bourdieu, 1986) allows us to understand human-digital interaction as being engaged in generation, exchange and transformation of capital. Digital systems can produce multiple forms of capital – economic (OECD, 2013), cultural (Shifman & Nissenbaum, 2017), social (Jiang & Carroll, 2009) and political (Epstein & Robertson, 2015).

Generation of non-economic capital in digital systems occurs through *affordances*, which bring cognitive associations to sensory input. Any technology may be understood in different ways, according to a person's education, social environment and other factors (Hutchby, 2001), all of which are constrained by the capabilities of the technology in question (Norman, 2002). These dictate a person's affordances; how they perceive a technology and how they understand what they perceive. The concept of affordances holds that perception does not consist of a physical activity onto which understanding is overlaid *post hoc*. Instead, the perceptive process itself contains cognitive elements, such as motivation and context (Gibson, 1986). We use affordances to build conceptual models of how something works (Hutchby, 2001). There are always two conceptual models involved; the model the designers held when they constructed the artefact and the user's model when they use it. These models are never the same and user error or difficulty is usually the result. There is a significant body of analysis which argues that the design and operation of digital services today is primarily tuned to the exploitation of users to their disadvantage (Andrejevic, 2012; Vaidhyanathan, 2012). Owners use marketing to manipulate values so as to attribute symbolic capital to use of their systems (Bernays, 1928), such as creating socially aspirational personalities whose use of a system makes it desirable to their followers (Lamb & Kling, 2003). Designers of digital systems use control of development to determine which forms of capital are generated through use of their systems (Dainow, 2015a) and which are repressed (Cirucci, 2015). A common example is making privacy controls hard to locate in order to stop people using them (Liu, Gummadi, Krishnamurthy, & Mislove, 2011).

3. The Integrated Node

As a system, we do not understand the smart city's digital environment as being composed of states so much as processes. A *Integrated Node* is a node in an Integrated Domain which binds the system together through the activities of input, processing and output. This is the model for mediators of any composition within the Integrated Domain, whether composed of single or multiple actants, digital or human, or any combination thereof. Integrated Nodes are recursive. They are usually made from autopoietic systems of sub-nodes, each of which is a Integrated Node itself. Each of these will usually be constituted by their own autopoietic system of Integrated Nodes, and so on. For example, a digital device will contain CPUs and other types of chips, all of which accept input, process it and produce output, just as the device of which they are part does, and so these chips can be considered Integrated Nodes themselves. Similarly a person may interact with their digital environment through a combination of their physical body and carried digital "assistants" such as a smartphone. Here the Integrated Node is composed of both the human and the digital devices, both of which can individually accept input, process it and produce output, and thus are Integrated Nodes in their own right. Hence, the Integrated Node constitutes both the atomic unit and the essential pattern of interactions between these atomic units, transcending normally distinct ontological boundaries.

Many Integrated Nodes will be concerned with internal states of operation within both digital assets and humans. Much of the communication between digital agents concerns management of digital technology. This monitoring represents a form of digital self-awareness, though 'self-awareness' does not imply sentience. Meanwhile, the human element confers on the Integrated Domain the human level of understanding and meaning-giving. An Integrated Domain is therefore a self-aware system. We are already witnessing early examples of hybrid systems which combine human and digital devices. *Social machines* are "socio-technical systems which involve the participation of human individuals and technological components…able to extend the reach of both human and machine intelligence [by] supporting capabilities that less integrated systems might find difficult to accomplish" (Smart, Simperl, & Shadbolt, 2014, pp. 55–56). Social machines are early fore-runners of the Integrated Domain's Integrated Nodes which will bind together the fabric of future smart cities.

The Integrated Node is both its own field of contention and a site within other fields of contention, in which attributions of symbolic capital determine value, some of which are convertible into economic capital. The initial basis for contention is the degree to which the user's needs align with the service provider's or designer's aims. Where the user is paying directly for the service and has a choice of service provider, the interest of the service provider is primarily to maintain the satisfaction of the user. However, where the service is free to users but paid for by other means, the service provider's concern for the user is merely to keep them using the service while value is derived from that usage of the system by other means.

Each person inhabits a digital environment comprised of a variety of devices and systems. Some of those devices are "personal" in the sense that they are worn, carried, or embedded in the body. In addition to providing direct services to the user, these devices mediate between the person and their digital environment. The smart city will not interact with people directly, but with this assemblage of human-with-personal-devices. At the level of the Integrated Domain, each individual is thus located within an *Integrated Personage* comprised of themselves plus their personal digital devices. Should one subscribe to theories of the extended self (Belk, 2013), an Integrated Personage may be regarded as a self which has been extended into the personal digital devices. However, the concept of the Integrated Personage is not dependent on the concept of an extended self, but on practical necessity - many digital systems are not designed to interact with humans, only with other digital technology, and so humans must use digital tech to access these systems. *Integrated Devices* are those devices used within the Integrated Personage. They have a special relation to the human by virtue of their role as critical mediators with the Integrated Domain and within the human smart society. They may also have, under some accounts, special relation to the user as extensions of the self, especially if they are embedded within the physical body. As a result they have a special ethical status not accorded to other owned objects.

4. Ethics and the Three Modes of the Integrated Node

We need an account of the technological city which does not function at the level of the thousands of individual technical systems of which it is made. Not only is such a level of analysis is too complex, it is misleading because technologies do not work in isolation but are experienced as a unified digital environment. Likewise, we need to avoid separating the digital from the human because it is often impossible to understand the one without reference to the other. In similar fashion, consideration of individual ethical concerns is to be avoided. Individual ethical concerns are many and frequently specific to particular technologies, usages or historical circumstance. The approach taken here is to instead identify a single point of ethical concern which is not dependent on specific details. This single point can be used to identify features of ethical concern which could be found in any digital environment. Autonomy is just such a foundational ethical value. It forms the legal and ethical basis for human rights and provides the justification for treating people as we do under international law and democratic politics (Dworkin, 1988). All rights given under the Universal Declaration of Human Rights derive from the premise that all humans have the capacity for autonomy (Marshall, 2008). The capacity for autonomy is what gives humans dignity and the right to be treated as an end in themselves, not a means to an end (Kant, 1998). Autonomy is thus the single point of ethical interest with the widest range of implications and shall therefore be our point of ethical concern.

However, there are many different definitions of autonomy (Dainow, 2017b). The term was initially restricted to morality by Kant, who argued that all humans had the innate capacity to determine what was morally right and wrong (Kant, 1998). This version of autonomy has become known as 'moral autonomy.'

Since Kant we have added political autonomy (participation in political processes) and individual, or personal, autonomy (being the final determinant of one's actions) (Christman, 2015). In addition to these spheres of application, there are many different accounts of what constitutes autonomy in any sphere. Here the focus lies on the internal processes by which one exercises autonomy. The general concerns are to distinguish the degree of external influence which can be allowed before we can say autonomy has been lost and what, if any, specific cognitive elements are required in order for self-reflection to count as autonomous (Dainow, 2017b). Even the same definition of autonomy can lead to people living incompatible lives because they hold different values. However, it is possible to work with a generic understanding of autonomy without getting bogged down in these details by allowing that it is for each person to determine how they want to define autonomy for themselves. This means we need to assess digital environments in terms of the degree to which they enable or prevent the exercise of all forms of autonomy. At the level of the Integrated Domain, the Integrated Personage occupies the point of autonomy for the individual and so our account of the operations of the Integrated Node shall focus on the ways in which autonomy is in play within the input, processing and output phases of an Integrated Personage.

Input

Input may be defined as change at the interface between the Integrated Node and its environment. It is through design of digital interfaces that the most significant efforts at control occur within the Input phase. Interfaces are material elements which generate energy for internal processing. Data is a cognitive form of energy and may be analog or digital. When meaning is applied to data or use made of it, data becomes information (Ackoff, 1989). Different meanings may be applied to the same data, just as different uses can be made of it. The same data is thus capable of giving rise to variable amounts of information (Floridi, 2008). Someone's capacity to control their input is both empowered and constrained by the nature of the interfaces which exist between the human user and the digital environment. Control of interface design and operation is therefore fundamental to domination and commodification (or "monetisation") of the digital environment.

One cannot process something which has not entered the system. Input therefore determines the constraints of processing. Control of input is a fundamental determinant of the exercise of autonomy. No matter how one defines it, autonomy is always dependant on one's knowledge of the external world because it is with this knowledge that one makes deliberations. One important way in which input is restricted is through *epistemic control*. Epistemic control is the strategy of restricting the delivery of data or designing its delivery so as to hide information. A common example is the creation of privacy policies which are lengthy and difficult to understand. By doing so, the privacy policy becomes too large or too complex to be accepted as input by the user (McDonald & Cranor, 2008). Because the policy cannot be input, the website's privacy practices cannot be processed, and so the user cannot generate a response (output) which the service provider wishes to avoid (such as not using the service) (Acar, Van Alsenoy, Piessens, Diaz, & Preneel, 2015). Epistemic control is also exercised by simply hiding what is being done. For example, digital systems may make use of hidden technologies, such as Flash Long Storage Objects, which bypass privacy systems (Soltani, Canty, Mayo, Thomas, & Hoofnagle, 2010). User systems which attempt to preserve privacy by blocking cookies are an example of *epistemic contention*, in which two parties attempt to gain epistemic control of each other. In effect, the user's cookie-blocking technology is an attempt by the user to limit the tracking organisation's input, and so prevent the tracking organisation processing information about them, while the tracking organisation's attempt to hide their tracking is an attempt to prevent information about their practices becoming input to the user. This exposes an on-going conflict between service provider and user, in which each seeks epistemic control over the input of the other as a means of influencing their respective processing. A more subtle strategy for epistemic control lies through association and design, as we have seen with the search engine effect (Epstein & Robertson, 2015), whereby the mode of presentation of data at the interface can influence the affordances through which it is input to the human. More complex factors emerge in concerns as systems become more sophisticated. Factors such as cultural bias may mean the input systems for ambient intelligence, affective systems (which seek to detect emotion) and voice recognition, force people into behaviours which are foreign to their culture in order to use the system (Soraker & Brey, 2007). Epistemic control can also be achieved through preventing restriction of input, effectively "force feeding" data into the Integrated Node. Advertising technology which bypasses ad blocking is an example of such force feeding, as is subliminal messaging (Verwijmeren, Karremans, Stroebe, & Wigboldus, 2011). The actions of data brokers in seeking to keep their very existence hidden (Federal Trade Commission, 2014) are an extreme example of epistemic control.

The designer of a digital system may restrict input intentionally or through ignorance. Where this is intentional, it may be done either to help the user, make life easier for the developer, or exploit the user. Where it is done to exploit the user, it constitutes an intentional attack upon their autonomy. Many theories of autonomy hold that autonomy is preserved if the person would have consented had they been given the opportunity to do so at the time (Dainow, 2017b), so hidden factors do not necessarily constitute a restriction on autonomy. However, preventing choice *post hoc* does constitute a restriction of the user's autonomy no matter what the action. Where this prevents someone taking actions they would have chosen if they had possessed full information, it also constitutes a restriction on their freedom. Where input is restricted to suit the service provider it constitutes a secondary, but still intentional, attack on the user's autonomy, in that the user is not being considered as an end in themselves, but as a means to the service provider's end. Where input is restricted to help the user, it can be described as an accidental restriction on autonomy and should be weighed against the benefit derived. This happens fairly frequently. For example, it is often easier for users to restrict input by forcing people to choose from pre-set options, rather than allowing them to type freely. A free choice opens the possibility of unprocessable input, and so requires checking which may force the user to retry. As a result, restricting user's to pre-set choices is the preferred strategy in design.

Processing

Processing is the bridge between input and output. Processing therefore heavily influences which connections are made at output, although output is also constrained by material limitations. Input is what is processed. We use the term 'energy' for that which is input, including both data and physical activity (such as hearing aids and traffic lights). Because affordances append attributions of meaning and implied use, processing is strongly influenced by the affordances with which the input was received .

Processing may be described as the reorganisation of input energy patterns through manipulation. The heuristics of this manipulation are driven teleologically by the goals for which they are deployed. How input is transformed is also determined by the material composition of the Integrated Node and its internal processing structure. The processing structure may be divided into a material component and a cognitive component. Examples of the material component include biology and chip design. The material component has a determining effect on many aspects of the data, such as granularity, processing speed, computational complexity and so forth. The factors affecting processing are always defined so that they can be applied to a device, human, individual or group, no matter whether digital, organic or both. Since it is attributions of value which determine the heuristics of processing, contention occurs for attributions of value in an attempt to influence the processing. For example, placing values on using digital devices in certain ways (Zhao, Grasmuck, & Martin, 2008) is an attempt to influence the way a person processes information using these devices. In an Integrated Personage processing is also instantiated in communication patterns between the Integrated Devices, and between these devices and the human. For example, a GPS device communicates location information to a mapping device which then communicates instructions to a bluetooth headphone which then communicates sound to the human, who then changes direction and thereby communicates new location data to the GPS device. It is not only the data processed and transmitted which constitutes the processing, but the devices themselves as nodes within the autopoietic system which is the Integrated Personage.

Many of our existing issues with regard to ICT ethics today are focused on processing; issues of algorithmic justice, the moral status of autonomous systems, and use of personal data, are all examples of concerns over processing. One of the most important ethical issues here is the role of previous experience. It is indubitable that individuals bring their previous experience to their processing. Physical practice to develop muscle memory and trained reflex, central to music and sports, are a way of encoding previous experience as processing structures in the physical body. Education is a way of producing previous experience which can be used in cognitive processing. Previous experience is held to be a critical factor in processing by designers of personalisation systems, which analyse our history in order to predict and influence our future actions (Schneier, 2015). The internet economy today is based on knowledge of previous experience (OECD, 2013), as are all personalisation services of the future.

Because ANT is not an explanatory theory, it brackets how processing works. Being silent as to the internal details of processing, the exact mechanism by which human processing occurs may be described according to one's theories regarding the nature of the human mind. All that is required here is an acceptance that people have internal states of some form, determine their own actions in some way, and respond to changes in their environment. For our purposes, it is sufficient to say that processing involves the production of information and determination of action, and that input comes with a use value (Hartson, 2003), which implies how it is to be processed.

It is important to bear in mind that each human exists within the Integrated Domain at the level of the Integrated Personage, an autopoietic system composed of human + digital. The Integrated Personage is therefore the point of autonomy within the Integrated Domain, not the individual. Since autonomy involves self-governance (Kant, 1998), the ability to have control over processing within the Integrated Personage is necessary for autonomy in an Integrated Domain. The individual must be able to control processing to the degree that they are able to generate output intended to produce the states of affairs that the individual desires. It is not required that they are actually *able* to produce their desired states of affairs. Autonomy is not threatened simply because the world does not give in to whatever you wish. But the individual must be able to *try* (Christman, 2004).

A person may be unable to exercise autonomy in processing due to constraints created by designers. *Internal contention* is contention for the manner in which the Integrated Personage processes information. *External contention* is competition as to whether processing occurs within the Integrated Personage or is done by an external Integrated Node. Internal contention occurs through attempts to influence how the Integrated Personage conducts its processing. Simple examples include blocking interoperability with a device from a competing manufacturer, controlling what apps can be installed on a device, or restricting devices from accessing certain files or formats. A common technique in many systems is to discourage processing by increasing the energy required, for example the use of obscure legal terms in privacy policies. One has no difficulty physically inputting the words into one's mind. However, where the terms are not understood, the affordances providing semantic understanding at input are absent. In order to process these terms, one must look them up in a dictionary first. This raises the energy required to process the term significantly, and may reach a level which exceeds user's willingness to continue (McDonald & Cranor, 2008). It has been argued that is exactly the purpose behind using such terms (Schneier, 2015). Such design elements are examples of the way in which people can be nudged into changing the manner of their processing through design (Acquisti, 2009). When an operating system provider embeds their web browser into the interface in a manner which makes it hard to avoid using, as Microsoft once did (Fisher, 2001), they are similarly seeking to take control of an element of the processing within one's Integrated Personage.

External contention is contention over whether processing will occur within the Integrated Personage or within an external Integrated Node, such as a cloud service. Systems which upload data to the cloud for processing are transferring cognitive load from the Integrated Personage to the service provider's Integrated Node. Systems of rentier capitalism for Integrated Devices, such as software-as-a-service, represent an attempt to own portions of the individual's Integrated Personage. If books and similar digital services represent offloading of personal cognitive capabilities into digital devices, then statements of ownership over content, such as we see with Kindle (Amazon, 2017), constitute claims of ownership over the individual's cognitive capabilities. The argument from tradition that digital devices are optional tools is contrary to modern circumstances. The right to hack and to repair one's own devices contends with intellectual property initiatives and rentier capitalism for control of how individuals process within their own Integrated Personage. A digital service or device which is so commonly used that not having access to it impacts one's ability to participate in society constitutes a component of the smart society. Lack of access means one cannot fully participate in the smart society. As technology spreads deeper into the built environment, so it comes to assume certain minimum technological capabilities on the part of the inhabitants (Dodge & Kitchin, 2005). Increasingly, the city's digital environment has expectations that the Integrated Personage possesses certain capabilities - certain input and output channels and certain processing capabilities. Where an important aspect of the Integrated Domain becomes dependent on such capability, that capability becomes necessary for a full life and full participation in the smart society. At that point one acquires, as a citizen, a right to that capability. To the degree that this capability is necessary for the living of a full life, it becomes a human right.

Output

Output connects a Integrated Node with other Integrated Node's. One Integrated Node's output is the next Integrated Node's input. We can therefore talk in terms of an Output-Input channel (or *O/I*). For the purposes of this discussion, output may be defined as energy released from a Integrated Node in the form of physical movement or data. Some output is intentional, though cases of hidden surveillance show that output need not be originated by the user, or even known to them (Federal Trade Commission, 2014; Sandoval, 2012) . Output also occurs as a by-product of existence because all digital processes leave a *data shadow* (Westin, 1970) in the form of temp files and logs.

Because the function of output within the Integrated Domain is to connect with other Integrated Nodes, output must be *coherent* with its environment. Here 'coherence' means compliance with shared standards, such as languages, protocols and data formats. The requirement for coherence grants power to those who can control it. A significant portion of the contention within digital technology is for control over standards because it confers domination over systems dependent on those standards (Cusumano, 2010). Control of connectivity accords one the status of a gatekeeper, able to control who uses an O-I channel and what they can send through it. The gatekeeper role in connectivity is one of the major points of financial return in digital services. Websites act as gatekeepers for connecting advertisers to users and extract value therefrom, charging an entrance fee for a presence in the user's input stream (Deighton & Kornfield, 2012). Telecoms companies generate income from connecting other digital systems to users (Huston, 1999). Debates over net neutrality show that many believe service providers can use this position as gatekeepers to extract economic capital (Pil Choi & Kim, 2010).

As techniques such as object-oriented programming (Rumbaugh, Blaha, Premerlani, Eddy, & Lorensen, 1991) and Digital Object Architecture (York, 2016) demonstrate, internal processing need not use the same formats as are required for output. As a result, output often requires a translation layer to convert internal information into formats which can be accepted as input by external Collective Triads. For output to humans, this may mean displaying information in a readable format, with consequent constraints on minimum text size, display time, using a particular human language, and conforming to graphical conventions in digital design (McKay, Christian, Matey, & Tufte, 1997). Coherence means providing digital devices with data in a format they can accept, hence the need to create keyboards for human output intended for digital systems. The Graphical User Interface (GUI) and similar systems, such as HTML, provide formats for both data and affordances (Galitz, 2007). API's, networking protocols and similar systems provide shared output formats which can bind digital devices into communicative systems. Physical output is seen in the activation of motors and switches, and the movement of muscles and limbs. Much of the intelligent functionality of the smart city is location-dependent (Picon, 2015), such as controlling traffic flow or delivering location-based services to inhabitants. The movement of the Integrated Personage within the digital environment will be accompanied by a constant flow of output based around movement through an urban space whose digital characteristics change as fast as its physical characteristics (Dodge & Kitchin, 2005). The Integrated Personage will manifest within the digital perspective as a moving cloud of output.

Output currently constitutes the primary point of value extraction for digital service providers in which the recording of user behaviour is monetised through data mining (O'Neil, 2017). As a result, commercial surveillance is one of the foremost ethical concerns regarding output. The ethical status accorded to human beings on the basis of their possession of autonomy (Marshall, 2008) confers special ethical status on data output by the Integrated Personage. This concern is greater where usage of output results in restrictions on autonomy or derivative rights. Autonomy is limited when people's digital systems do not allow them to emit the particular form of output they wish. For practical purposes, we cannot consider something a limitation on autonomy which is physically impossible. If it is not technically possible to instantiate my preferences, then my autonomy is not reduced. Nonetheless, in many cases, systems are designed to make outputting particular desires or in particular ways difficult or impossible - nudging or forcing people into using approximate variations which can be commoditised (Cirucci, 2015; Dainow, 2015a).

It is in the user's interest that their output is tuned to optimal delivery of the services they desire, in the manner they desire, under the conditions they desire. It is in the interest of a commercial service provider that they offer the services in the manner which generates the greatest income. These two interests are not necessarily aligned. Where they are not aligned the risk arises of reductions to autonomy through the use of that service. Where the service is non-essential we may say that autonomy is not threatened because one has the option of simply not taking the service. However, where the service is essential, or has achieved the status of a public utility (such that participation in society becomes difficult without it), then conditions under which one is forced to accept that service risk threatening autonomy. It is possible therefore, to treat certain aspects of service delivery as public utilities and impose limitations on allowable terms of service. It seems most in accord with the capitalist model to promote competition by requiring alternative service providers offering alternative terms of service. The construction of a smart city in which the citizen has access to alternative providers for each and every service at each and every location is feasible but would require an open technical infrastructure, similar to that offered by TCP/IP and HTML. Such open platforms enable any designer to create new systems in confidence their output will be coherent with the digital environment. No participant in the TCP/IP or HTML ecosystems can prevent a competitor arising (no one can become a gatekeeper to the web). Achieving this situation in the smart city would require standardisation of many protocols, but we can have done this before with many other standards (Mattli, 2001), and indeed it may be argued from history of utilities that it is almost inevitable that we will do so in the future (Clifton, Lanthier, & Schröter, 2011).

5. Summary and Conclusions

We have passed the point where technology can be treated as a dumb hammer, whose use and impact on others is totally dependent upon the human who wields it. Society, now and into the future, can only be understood by considering the human and the technological in combination. This combination results in systems giving rise to emergent features not predictable from the components. We therefore need a theoretical framework, a language, specifically designed to handle that fusion as a thing-in-itself, not as an analogue of traditional concepts. Actor Network Theory, combined with the concept of autopoiesis, offers the vision of an Integrated Domain in which the mediating nodes which provide the motive power and logic to the autopoiesis of the system are created of the interactions of humans with digital systems. The human and the built environment of the city do not directly encounter each other but interact through the medium of digital systems. The nature of their interaction is such that it cannot be split into independent components of the digital and the human, but combines them to the degree that they are indistinguishable. In terms of effects, they become one cause. They also give rise to emergent properties not predictable from their individual characteristics and not present without both.

As a dynamic system, the Integrated Domain consists of the transmission of energy in various forms through connective nodes which are mediators constituted by a three-phase process of input, processing and output. These nodes are therefore, in terms of their operational characteristics, events and processes more than they are objects and states. The ontological priority of process derives from the fact that Integrated Nodes cannot be understood, and do not exist, unless they utilise processes over time. It is true that digital devices will have a material composition, just as humans do. However, the material constituents are separable and understandable without reference to the other. By definition, the Integrated Domain is ontological level at which the digital and the human are fused. That fusing occurs only as a process. Therefore, by definition, material composition and static states are not part of the Integrated Domain. It is only when nodes produce output and pass it as input to other nodes that the Integrated Domain comes into existence. Consequently, it is always through process and connection that we see the Integrated Domain.

Analysis of ethical issues and contention within the Integrated Domain must therefore focus on connectivity and processing, seeking to find mechanisms by which competing stakeholders pursue strategies for control and value extraction. We understand what is being transmitted through the system as energy, using the term ‘energy’ generically so as to allow for both material and cognitive (or symbolic or mental) transmission and activity. In empirical terms observed phenomena are almost always a combination of the two, just as they are a combination of the digital and the human

From an ethical point of view, and to the individual, the most important Integrated Node is their Integrated Personage. The Integrated Personage is the active field within the digital environment constituted by the human in an inseparable fusion with their personal digital devices, such that the aggregated output from the Integrated Personage is a unified product of both human and digital, including not just the individual operations and functions of the component devices, but also the patterns and content of their interaction. The Integrated Personage, like any other Integrated Node, is an element of the Integrated Domain and therefore a combined entity in which the human and the digital cannot be treated as distinct.

Input overlaps with output. The output from one Integrated Node is the input for the next one. This output-input (O/I) connection constitutes the systemic relationships between the nodes maintaining autopoiesis within the Integrated Domain. Output must be coherent with the digital environment in order to connect with it. This means that control over what constitutes coherence dictates control over how, and possibly what, can be output, and to whom. Examples include network protocols, programming languages and data formats. In the absence of contrary forces, we can expect contention over standards to continue as the smart city develops. Given the wide range of functions, spaces, contexts, volume and variety of digital devices and systems within the smart city, we can anticipate many more opportunities for such competition. On the basis of the history of digital innovation, we expect that multiple stakeholders will participate in this contention, few of whom can be assumed to have the user’s best interests as their primary goal. In the absence of countervailing forces, we can therefore anticipate that the individual user of the service is unlikely to receive the best solution to the problem. Rather they are more likely to receive something just good enough to tolerate, while their use of the service is exploited, both in terms of the service delivery and the design of the systems. As the Integrated Domain rises to become more sophisticated and more the dominating feature of modern urban society, so the potential for domination by those who do not have the user at heart becomes more likely and potentially more damaging. We do not know what the future will be like, but by anticipating the flows within future urban socio-technical, we can identify where human autonomy will be threatened and how.

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