The Realtimeness of Smart Cities

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Abstract: This essay considers the notion of a 'real-time city' from a temporal perspective. The essay is divided into three sections. The first section examines how smart city technologies seek to utilise real-time computation to transform urban management and governance and the pace, tempo and scheduling of everyday life. The second section considers how ICTs are transforming the nature of time with respect to smart cities. It sets out a set of related notions of real-time temporalities (network time, chronoscopic time, instantaneous time, timeless time, machine time, code/spacetime) and unpacks the nature of 'realtimeness' and the relational, contingent, and heterogeneous nature of real-times operating across smart city platforms and systems. The third section discusses the politics of adopting real-time technologies in urban management and the conduct of everyday life and sets out arguments for the maintenance of asynchronous cities and the adoption of an ethics of temporal dissonance. The conclusion argues that there is a need for philosophical, theoretical and empirical work to understand the realtimeness of smart cities and sets out a number of questions that might guide such research.

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1. Introduction

Starting in the 1950s with the nascent shift from electro-magnetic to computational systems, digital technologies have been used to understand and manage city services and infrastructures, with processing and reaction becoming progressively more timely. In the late 1960s, the promise of digital developments dovetailed with cybernetic thinking, in which the city was envisioned as a system of systems that could be computationally managed (Forrester 1969). Each system, it was argued, could be broken into its constituent parts and processes, be modelled and simulated to capture its essence and to plan and operate its functions. In practice, cybernetic efforts to reform city planning and administration largely failed to materialize, in part because how cities work is more complex, contingent and socio-political than the models permitted (Flood 2011; Townsend 2013). Nonetheless, throughout the 1980s and 90s computation progressively continued to be embedded into the working practices used to plot and manage cities and into the infrastructure used to deliver essential services – such as the use of SCADA (supervisory control and data acquisition) to monitor and control utilities and GIS (geographical information systems) to document and analyse land use and the spatial constitution of city assets, population and economy.

With the extensive roll-out of the internet in the 1990s, more-and-more city systems became networked and reliant on computation and households started to become digitally connected. By the mid-to-late 1990s, urban theorists started to detail the nature of an emerging networked urbanism, wherein ICTs became increasingly critical to how cities and the activities within them functioned and were having profound effects on urban-regional restructuring by enabling pronounced space-time compression and the tempo-spatial reorganization of businesses and institutions (Castells 1996; Mitchell 1996; Graham and Marvin 2001). In the 2000s computation became ever more mobile with the rise of smartphones and other portable digital devices, and urban computation started to become pervasive, ubiquitous and instantaneous (that is, embedded into everything, available everywhere, and responsive in real-time) with increasing scales of economy in digital products, networking, and storage, and the rollout of the internet of things. At this point, many urban spaces were being produced as "code/spaces"; that is, the production of space was reliant on code to be produced as intended (Dodge and Kitchin 2005). By the late 2000s, the concept of 'smart cities' – cities that combine forms of entrepreneurial and networked urbanism – started to gain traction across city administrations, corporations and academic disciplines. Reconnecting with cybernetic thinking and aligning with the project of neoliberalism, smart urbanism envisages a thoroughly digital city in which city services, infrastructures and populations are managed in real-time using ICTs, yet at the same time digital technologies, such as smart phones, enable individual autonomy and consumption choice within a framework of constraints that prioritizes market-led solutions to urban issues (see Luque-Ayala and Marvin 2016; Cardullo and Kitchin 2017).

Over the past decade, accompanying the drive to create and deploy smart city technologies and visions, has been critical analyses of the tenets, workings and effects of smart urbanism. Building on critical scholarship concerning networked urbanism (e.g., Graham and Marvin 2002), such work has focused on mapping out the political economy of smart cities, how smart city technologies reconfigure urban spatiality, governance and development, and the ethical and moral implications of the production and use of urban big data (e.g., Greenfield 2013; Kitchin 2014; Vanolo 2014; Datta 2015; Shelton et al. 2015). To date, however, there has been little analysis of the temporal imperatives and effects of smart city technologies (though see de Waal 2013; de Lange in press; Leszczynski 2015; Coletta 2017; Coletta and Kitchin 2017; Datta 2017).

Smart city technologies produce a new timescape; that is, a set of associated temporal relations (time frames, temporality, pace, tempo, timings, sequencing, and time past, present and future) that work together to produce a particularized temporal landscape (Adam 2004). Smart city technologies and initiatives reconfigure the space-times and temporal rhythms and relations of cities, and re-imagine and utilise the past, present and future to drive smart urbanism. While smart city technologies have effects with respect to all four temporal modalities identified by Adam and Grove (2007) – 'past present', 'present present', 'future present' and 'present future' – the most critical to the logics and operations of smart urbanism, I propose, concerns 'present present' and the ability to be able to monitor, analyse and react in real-time. Indeed, the appeal and promise of smart cities is that they constitute 'real-time cities', composed of systems that work 24/7 and are reactive to unfolding events in order to optimize performance and gain efficiencies (Kitchin 2014). It is this temporal condition that the progressive development of smart urbanism outlined above has been striving to achieve through each iteration of innovation – the instantaneous control of space and spatial relations in real-time.

In this essay, I want to consider in some depth the notion of the 'real-time city'. The first section examines how smart city technologies seek to utilise real-time computation to transform urban management and governance and the pace, tempo and scheduling of everyday life. The second section considers the related temporalities of the real-time city (instantaneous time, timeless time, network time, machine time, chronoscopic time, code/spacetime) and unpacks the nature of "realtimeness" (Weltevrede et al. 2014) in the smart city, contending that ontologically and epistemologically real-time is relational, contingent and heterogeneous, with a diffuse set of realtimeness operating across systems, infrastructures and spatial media. The third section critically reflects on the implications of producing a real-time city and presents the case for asynchronous cities and an ethics of temporal dissonance. In sum, the essay seeks to strongly foreground time and temporality as a key lens through which to make sense of the impact of ICTs on urban life and encourage additional empirical and theoretical work.

2. The Real-time City

> "Imagine a world in which time seems to vanish and space seems completely malleable [...] Where distance equals a microsecond in lapsed connection time. [...] Almost all technology today is focused on compressing to zero the amount of time it takes to acquire and use information, to learn, to make decisions, to initiate action, to deploy resources, to innovate. When action and response are simultaneous, we are in real time"
> (McKenna 1997, 3-4).

> "[A smart city] is a city where you almost know in real-time what is happening. You can identify problems or bottlenecks in real-time and you can manage them and communicate back to citizens or various stakeholders the right information that helps them make better decisions"
> (City administrator, Dublin).

Heim (1993, 49) defines real-time as "simultaneity in the occurrence and registering of an event", with little to no latency in temporal duration. Increasingly we live in a world in which we expect real-time connection and response (see Figure 1). Indeed, people seem to have become fixated on knowing and taking part in the present – checking for new emails and responding, seeking out current news or weather, discovering when the next bus/train is due or avoiding congestion, browsing the newest posts on social media and commenting, being able to instantly connect with other people while on the move and to schedule meetings on-the-fly, being able to discover details about places close-by including opening times and reviews, and performing consumption on demand. Companies expect to be able to do business 24/7, to be able to access real-time data on their performance across different metrics, and to implement just-in-time production and delivery. And city administrations and utilities expect to be able to manage city services and infrastructures as they unfold, reacting to present conditions in order to optimize performance. For example, an intelligent transport system uses real-time data from cameras and sensors located across a road system, which are communicated back via telecommunications networks to a central hub for processing to regulate traffic light sequences in order to keep traffic flowing and minimize congestion. In many cases, the aim is not to simply be reactive but anticipatory, using present and past data to predict what will happen in the short-term (micro-seconds to a few months) and adapt system performance accordingly to head-off potentially negative outcomes. Such practices are known as nowcasting (Bańbura et al. 2010) and as well as being used in the management of infrastructures are central to activities such as predictive policing. Here, I want to consider in more detail how real-time technologies are transforming management and governance of city systems and the pace, tempo and scheduling of everyday life.

Fig. 1 – Real-time city

2.1 Management and Governance

For city administrations and utility infrastructure providers, smart city technologies offer the possibility of dynamically managing urban systems in real-time taking account of present conditions (Bleecker and Nova 2009; Kitchin 2014; de Lange in press; Luque-Ayala and Marvin 2016). Such systems seek to manage road, rail and water traffic, energy supply, telecommunication connections, safety and security, as well as monitor environmental conditions relating to the weather, noise and pollution. They work by continuously generating data about the performance of a system via networked sensors, actuators, transponders and cameras (the internet of things) that are fed back to a control room for human oversight or processing by an automated management system which can instantaneously handle and analyse data and respond as required. Such systems seek to monitor and maintain everyday "normal conditions" in order to create more efficient and optimized operations, but also to respond to exceptional circumstances providing instantaneous corrective actions before problems grow and multiply (de Lange in press; Kitchin et al. 2015). In all cases, there is an operational emphasis on maximizing the speed of monitoring and responding to events, and to managing in the present (Virilio 1997).

Real-time control rooms utilising SCADA have been in operation from the mid-twentieth century, but they have multiplied in number in the last couple of decades and have also changed in terms of how they operate.

Early control rooms were used to monitor and manage the performance of a closed system such as an electricity grid. More recently, their remit has been expanded to include more open and unbounded systems such as public spaces (CCTV, emergency management response) and transportation with multiple types of users/interactions (car, public transit, cyclists, pedestrians) (Luque-Ayala and Marvin 2016). In addition, the siloed nature of control rooms – that they generally concern the functions of a single domain such as electricity, water, security – has started to be broken down with the creation of more integrated, interoperable, and interagency control apparatus that provides a more holistic view of city operations. For example, the *Centro De Operacoes Prefeitura Do Rio* in Rio de Janeiro is an integrative city operations and coordinated, emergency management centre that draws together into a single location real-time data streams from thirty two agencies and twelve private concessions (e.g., bus and electricity companies), including traffic and public transport, municipal and utility services, emergency and security services, weather feeds, information generated by employees and the public via social media, as well as administrative and statistical data (Kitchin 2014; Luque-Ayala and Marvin 2016). Increasingly, rather than being reliant on human decision-making, control rooms are becoming automated, with either humans-in-the-loop, wherein decision-making is automated but overseen by a human controller who can actively intervene, or humans-off-the-loop in which the system works in an entirely automated fashion (Docherty 2012). In the latter case, computation is used to monitor and regulate systems in wholly automated, automatic and autonomous ways (Dodge and Kitchin 2007). Such automation enables massive volumes of data from thousands of devices scattered across a city to be tracked and controlled in real-time that far exceeds the capacity of human attention. In other words, the control room enacts a form of algorithmic governance; what Dodge and Kitchin (2007) term "automated management". While the work of control rooms is largely hidden from direct public view, some of the data they process is being shared via publicly-facing dashboards, APIs, open data repositories, on-street dynamic signs, and radio bulletins, and plugged into mobile apps (Kitchin et al. 2015).

The power of control rooms is to actively manage the temporal rhythms of the city in the present and to enact new forms of governmentality. As Lefebvre (1992/2004) noted, cities consist of multiple intersecting rhythms and beats – traffic flow, timetables, work shifts, rush hours, night and day, and so on (see also Edensor 2010). These rhythms can be eurhythmic (harmonious and stable), isorhythmic (equal and in sync), and arrhythmic (out of sync and disruptive) (Conlon 2010). Urban life thus pulsates rhythmically, but not always harmoniously. Control rooms work to augment and regulate the rhythms of cities; "to limit arrhythmia and produce eurhythmic systems that maintain a refrain" (Coletta and Kitchin 2017, 3). In other words, the algorithms at the heart of the control room operations act as "algorhythms", seeking to produce consistent and desired rhythmic patterns (Miyazaki 2012). A traffic control room that processes real-time data generated by a dense network of sensors and cameras to sequence traffic lights works to algorhythmically synchronize the flow of vehicles (Coletta and Kitchin 2017). In such a system, the nature of governmentality (the logics, rationalities and techniques that render societies governable and enable government and other agencies to enact governance; Foucault 1991) shifts from a disciplinary form (in which people self-regulate behaviour based on the fear of surveillance and sanction) towards control (wherein people are corralled and compelled to act in certain ways) (Deleuze 1992). Control systems work by constantly modulating behaviour to act in a certain way within prescribed comportments; to be nudged and directed rather than self-disciplined (Braun 2014). In the case of the traffic system, the control room modulates the flow of vehicles across the network. This is not to say that such control is not negotiated, resisted and subverted, but that it is the govermentality logic at work.

2.2 Everyday Time-geographies

While real-time control rooms work to modulate and control behaviour, real-time mobile and locative media such as location-based social networking (e.g., Foursquare) and journey planner smartphone apps seek to provide flexibility and serendipity in individual time-geographies (Sutko and de Souza e Silva 2010; Evans 2015; Kitchin et al., 2017). Indeed, ICTs in general are having a number of temporal effects on the spatial practices and time geographies of everyday life (in a Hägerstrand (1970) sense of movement through time and space).

First, ICTs are facilitating an acceleration in the pace of activities and service delivery by enabling tasks to be undertaken more quickly, efficiently, and at a distance (obviating travel time and bypassing physical queues) (Virilio 1997; Rosa 2003). Undertaking activities in real-time, which previously would have taken time to respond, is illustrative of such acceleration. Second, the always-on nature of networked technologies and the availability of mobile access enables the "time shifting of activities to formerly unavailable time slots" (Crang 2007, 71). Time outside of work can be colonized by work-related activities and so-called "dead time" or "wasted time" endured during various forms of commute can be transformed into "productive time" (such as phoning, texting, emailing, searching information, sending files, and copyediting academic papers) (Lyons and Urry 2005; Wajcman 2008). Increasingly people then are becoming "always-everywhere available" (Green 2002), though they have also developed practices to manage such hyper-connectivity and changing patterns of activity (Lyons and Urry 2005). Third, ICTs increase the ability to multitask and to interleave activities so that several tasks can be performed simultaneously rather than sequentially (Crang 2007; Wajcman 2008). While ICTs facilitate such multitasking, nonetheless new practices and competencies have been developed to manage simultaneous and/or competing tasks and technologies (e.g. pagers and mobile phones) that can be used to interrupt and summon users (Licoppe 2010). In some cases, automation might take a task away all-together, freeing up time to undertake other activities.

Fourth, the temporal organization of activities is becoming more flexible and de-coupled from clock-time. Instant and mobile communication and the sharing of location information is altering coordination in space by enabling "perpetual contact" and on-the-fly scheduling of meetings (Katz and Aakhus 2002), and serendipitous encounters with nearby friends (Sutko and de Souza e Silva 2010). The scheduling and planning of activities and events thus shifts from planned actions at specific times and places to continual recalibration and reaction for any time, any place (Crang 2007). Spatial media have also enabled access to information about the real-time conditions of transportation networks, facilitating dynamic route planning; spatial search and location based services provide information on nearby businesses permitting contextual choice- and decision-making rather than advanced search and planning. Importantly, these tasks can be undertaken in situ, on-the-move and in real-time (Leszczyski 2015; Kitchin et al. 2017).

Fifth, instantaneous networked connections enable significant time-space distanciation, wherein activities are disembedded from local contexts and re-organized across large time-space distances (Giddens 1990). For example, labour might be organized across several global sites, with decisions made in one location, that may be in one time zone, affecting outcomes in another. Similarly places across the globe can experience shared moments (e.g., simultaneously watching a global sporting event or media story). Places are thus interdependent through dispersed sociotechnical systems that enable real-time interconnectivity.

Collectively, these shifts are producing 'faster' and more temporally flexible subjects, with urban life in the smart city becoming more frenetic, fragmented and lived in-the-moment (Adam 2004; Crang 2007; Hassan and Purser 2007). Indeed, the temporal organization of the city is increasingly being disconnected from the natural, social and clock time that operated in the late twentieth century. In addition, as Wajcman (2008) notes, smart city technologies do not simply speed-up or fragment time, but introduce new material, temporal and cultural practices. In other words, people are not simply "doing the same things, but at a faster pace", but are performing new kinds of tasks and producing new socio-spatial-temporal relations. As such, the temporal shifts occurring alter how we understand, relate to, move through, coordinate and communicate in, interact with, and build attachments to space/place (Kitchin et al. 2017). The real-time city then is not simply a faster city, but one whose spatiality, temporality and sociality have been fundamentally reconfigured.

3. Real-time Temporalities and Realtimeness

For philosophers of time, such as and Hassan (2003; also see Hassan and Purser 2007) and Virilio (1997), the changes to management, governance and the time-geographies of everyday life result from ICTs producing a new temporal modality. This modality is characterised by instantaneity and fragmentation and has been variously termed and described. For example, Hassan (2003) argues that ICTs produce what he terms "network time" – time fragmented and made simultaneous across globally connected digital networks. Network time is "globally networked rather than globally zoned. It is instantaneous rather than durational or causal. It is simultaneous rather than sequential" (Adam 2007, 1). People across the globe can share temporal alignments in play (online games) and work (online conferencing), organizing themselves temporally around their interactions rather than local clock-time. Hassan contends that just as the clock changed the meaning and experience of time by shifting the temporal organization of society from natural (e.g., seasons; diurnal cycles; body clocks) and social (e.g., religious events) registers, networked technologies are undermining the dominance of clock-time. Fixed meal times, pre-arranged meetings, social calendars, conventional working times (9am-5pm; weekdays/weekends) are being replaced by temporal flexibility and time shifting. For Urry (2000, 126-30) ICTs are producing what he calls "instantaneous time" – real-time, on-demand, at-a-distance, synchronous connection and response – which is having profound, complex and non-universalising spatiotemporal effects on social and economic life. Similarly, Castells (1996) argues that ICTs produce what he terms "timeless time", wherein localised clock-time is erased, suspended and transformed – "all expressions are either instantaneous or without predicable sequencing" (Castells 1998, 350) with networked systems being "simultaneously present" across time zones.

Likewise, Virilio (1997) contends that chronological time is being replaced with what he terms "chronoscopic time". Considering the ability to perceive and respond to distant events in real-time, such as 24/7 global media coverage of news and sports or communicating with co-workers located in different time-zones, he argues that audiences and workers have become accustomed to narrative time imploding (Purser 2002). Rather than unfolding successionally as before, during and after, or events being documented after the fact, people have become used to time being "perceived more in terms of abrupt and discontinuous irruptions of varying intensities"; to be focused on the real-time instant (Purser 2002, 162). 24/7 media coverage creates an eternal unfolding present of spatially and socio-politically disconnected snapshots, with instant rather than reflective analysis. Likewise, real-time control rooms and spatial media produce chronoscopic time in which cities and personal time-geographies are managed in the perpetual present, responding to emerging irruptions and serendipity.

Critical to this new temporality is the seeming annihilation of time and space by ICTs. Places can be instantly connected and actions can occur simultaneously across space (e.g., stock markets working in concert between time zones; networks of traffic lights concurrently being controlled based on present conditions; consumers buying goods or downloading online content). Urban life – shopping, communicating, banking, play, travelling, etc. – increasingly operates in a distributed "perpetual present" (de Lange, in press). This is the appeal and power of the real-time city – instant, always, and everywhere. Yet, what is the ontological nature of real-time?

What becomes clear when one examines real-time systems closely is that they are never quite in real-time, they always include latencies. This is apparent if one records a real-time stream of data, wherein it is clear that the data are sampled with a small latency between discrete data points (Mackenzie 1997). Moreover, this latency varies across systems rendering them asynchronous: "there exists instead an open-ended continuum within the network (…) measured in picoseconds upwards" (Hassan 2007, 50). In their comparison of different streaming social media and news platforms, Weltevrede et al. (2014) noted that each platform had variances in back-end processing and delivery of content, producing variances in their temporalities. When myself and Gavin McArdle examined the velocity of 26 types of urban big data it became clear that these data were temporally differentiated in two ways: how they were generated and how they were analysed, acted upon and shared (Kitchin and McArdle 2016). With respect to data generation, we categorized data as either "real-time constant" to denote data that are endlessly generated (e.g., a weather sensor that continuously records measurements), or "real-time sporadic" to denote data that are generated only at the point of use (e.g., clickstream data that is continually measured but only whilst a user is clicking through websites). In both cases, there is latency in data recording, with data being sampled every few milliseconds, or every ten seconds, or every five minutes, or whatever temporal rate the system had been programmed to perform. Similarly, with respect to data analysis and sharing in some cases as the data are recorded, analytics are performed, and the data published with only slight latency (e.g., as a tweet is tweeted it is recorded in Twitter's data architecture and micro-seconds later it is published into user timelines). In other cases, the data are sampled in real-time but their transmission, processing or publication is delayed (e.g., mobile LIDAR scanning by vehicles captures scans of streetscapes every second, but are stored on a local hard disk and transferred to a data centre at the end of each day) (Nokia 2015; Kitchin and McArdle 2016).

The temporal rate of data measurement and sharing is in part chosen and in part imposed. How a system is configured involves making decisions about balancing data resolution and noise (data quality) with respect to the task requirements against system configuration and performance (e.g., life of batteries, costs of data transmission/storage). The system components and architecture also affect temporality. All digital processing involves latencies related to memory buffering, CPU scheduling, and process interrupts, and visualizations are temporally framed by the "number of frames per second, or by refreshing cumulatively displayed information" (de Lange, in press). Similarly, different networking technologies (broadband, wifi, GSM, 3G, 4G, Bluetooth, Near-Field Communication) have different process rates and latencies. Computation for some tasks can take time to complete, even with high specification machines, due to the complexity and size of the endeavour. As Mackenzie (2007, 89-90) notes system performance and data recording is affected by the nature of device and network "machine time", including "seek time, run time, read time, access time, available time, real time, polynomial time, time division, time slicing, time sharing, time complexity, write time, processor time, hold time, execution time, compilation time, and cycle time". He continues, "[w]hile many of these are related (for example, read and write time), many are unrelated or antagonistic to each other (for example, real time, polynomial time)", noting that "[t]he relations between different timings are heterogeneous". In complex systems composed of many devices and networks (e.g., sensors, computers, routers, servers, etc) there are multiple machine times at play.

Mackenzie (1997) thus contends that real-time is a fabricated temporal condition, and Weltevrede et al. (2014, 127) conclude that there are varying forms of "realtimeness". This realtimeness produces distinct "real-time cultures" within platforms and systems. Weltevrede et al. (2014, 140-141) thus conclude that real-time "does not unfold as a flat, eternal now or as a global, high-paced stream, but (…) unfolds at different speeds in relation to different devices.". Moreover, realtimeness is provisional, always potentially subject to disruption through faults such as network outages and software crashes, and more malicious interventions such as hacking (Kitchin and Dodge 2011). The production of realtimeness has to be maintained through practices of upgrades, patching, and repairs in order for constant contact and action to occur. Even so, real-time systems often fail, with other modes of operation having to be deployed until the system is back online and working again. In case study research concerning the real-time operations used by a large retailer to manage stores, staff, stock, suppliers and customers, and to direct operations, Evans and Kitchin (2017) document how systemic system and equipment failures lead to partial and precarious real-time systems, with staff having to revert to old practices or invent new workaround solutions that often involve significant delay.

Realtimeness then is relational, heterogeneous and contingent; the product of the technicity of socio-technical arrangements and subject to all kinds of interruptions and contextual unfoldings. As such, there is a diffuse set of realtimeness operating within smart cities across infrastructures and spatial media (Kitchin and McArdle 2016), yet the nature of real-time across platforms and systems is little understood, as are their distinct real-time cultures and how they make a difference to the nature, experience and meaning of time, but also the culture, practices and institutional operations of everyday life. Similarly, the effects of realtimeness on the transduction of space is little understood. In terms of the smart city, my contention is that time and space unfold as code/spacetime (not simply code/space as I have previously theorised; Dodge and Kitchin 2005), wherein space-time relations are dependent on computation to function. For example, the algorhythms of a traffic control room seek to mediate the flow of traffic through junctions (sites) by altering the sequencing (timing) of traffic lights (Kitchin and Coletta 2017). If the code or computational infrastructure fails, then the realtimeness of the system is suspended, with the traffic lights either failing to work or operate on default settings; space-time is not transduced as intended. The realtimeness of smart city systems, and the code/spacetimes they transduce, work to create particular spatio-temporal rhythms and tempo, and facilitate new spatio-temporal relations and behaviours. As yet, however, we have little detailed understanding of how such realtimeness and code/spacetime work in practice both in a general sense and with respect to particular smart city technologies/domains (such as control rooms for utilities, real-time dashboards and passenger information, smart meters for energy management, sensor networks for monitoring sound/pollution/flooding, etc).

Given the drive to produce the real-time city, with ever-more aspects of everyday life computationally mediated and operating in real-time, there is a pressing need to critically unpack the nature and consequences of realtimeness. It is to the task of unpacking consequences I now turn.

4. The Case for Asynchronous Cities

A number of scholars have started to consider the implications and politics of real-time, arguing that a fixation on the present and speed of response creates a number of issues that need to be countered by the production of asynchronous smart cities. In essence, they challenge whether acting in real-time is always the right to time to act and consider the consequences of such responsiveness. There are four main, inter-related critiques, the first two of which concern the ability of individuals to manage and cope with thinking and acting in real-time, the second two with the nature of real-time governance and how societies are regulated. In all four cases, there is a sense that living and managing in the here-and-now overemphases the present at the expense of learning from the past and planning for the future (Bleeker and Nova 2009) and erases the frame of duration and trends (de Lange in press). Purser (2002, 160) goes as far as to contend that "[t]o think and act in real-time terms requires a certain kind of wilful blindness to the past and future."

First, the emphasis on speed and instant reaction means there is no time for reflection, contemplation, slow rational deliberation, considered answers, or affect and emotion in decision making and response (Purser 2002; de Lange in press). As Hassan (2007, 55) notes: "Users are compelled by the momentum of the now. Control in this context is almost impossible: take your time and you lose the sale, suffer a drop in efficiency, or miss the 'valuable' connection.". Compressed time for thought and action means that actors, such as urban infrastructure managers, have to fall back on either learned routines or established unconscious cognitive biases (Purser 2002), or come to rely on forms of automated management enacted through algorithmic systems (Coletta and Kitchin 2017). Family and friends become hustled into decisions and actions that they might not take if given time to reflect. Acting in real-time thus erodes choice and reflexive and meaningful action and limits alternative and creative intervention (Leccardi 2007). In other words, *kairos* (the right time to act judiciously) is trumped by *chronos* (action with respect to the measure of a clock).

Second, the demands of living and acting in real-time – of always being connected and cognitively engaged through email, mobile phones, social and spatial media, etc. – creates a temporal regime that compels never-ending engagement, and produces stress through increased demands on peoples' time and attention, with few opportunities to disengage and relax (Gleick 1999). As Crang (2007) details, while ICTs hold the promise of helping people cope with the compression, densification and fragmentation of time by actively managing "temporal density" (intense, overlapping temporal rhythms caused by multitasking) (Southerton and Tomlinson 2006) and "time scarcity" (the experience of being rushed or harried) (Wajcman 2008), at the same time they compress and fragment time further. ICTs often produce ever-more-extended and complex network of tasks to attend to, producing time crunches in which it never feels there are enough hours in the day to do all the things needed (Hassan 2007).

Third, the reliance on algorithmic systems to process and respond to real-time data creates forms of technocratic governance in which an intense instrumental rationality (that is reductionist and functionalist in approach) and technological solutionism (that presumes that complex urban situations can be solved or optimized through computation) are applied (Kitchin 2014; Mattern 2014). Such an approach prioritizes optimization, efficiency and rational decision-making as the key bases on which to manage and improve urban living (Bleecker and Nova 2009) and assumes that the same technological solutions can be easily transplanted between cities to produce similar effects (Kitchin 2014). Such solutionism tends to map events in isolation, reducing them to singularities in which systems identify and respond to out-of-the-ordinary occurrences so that dealing with the exceptional becomes routinized (de Lange, in press). In other words, managing the city in real-time creates a disengaged, decontextualized, rote, rule-based approach that lacks reflection, deliberation, communal debate, learning trajectory, and framing to local socio-spatial-temporal conditions beyond instrumented metrics. They thus fail to take account of the wider effects of culture, politics, policy, governance and capital that shape city life and how it unfolds (Kitchin 2014; de Lange, in press). Moreover, they tend to manage issues in instrumental ways rather than addressing their underlying structural causes; that is, a traffic control room seeks to optimize flow and minimize congestion, rather than shifting people from private vehicles to public transport. As Bleecker and Nova (2009), Greenfield (2013) and others have argued, part of the appeal of cities is their messy, emergent, qualitative experiences, their anonymity, serendipitous encounters, and the unexpected. The "hygienist model of efficiency" (Bleecker and Nova 2009) – the desire to assert order and control – thus does structural violence to what we might call 'cityness'. In so doing, technocratic forms of governance run counter to democratic politics, with real-time computationally-mediated management excluding meaningful public participation in governance, bypassing the creative, political and messy role of people in shaping their own environments. As de Lange (in press) concludes:

> Creativity, always asynchronous and unpredictable in comparison to computerized systems, becomes ballast rather than a resource. Unless they allow room for differential tempi of people using them, real-time technologies that aspire to infinitely speed up their own working quite literally preclude the latent potential of people to use these technologies for truly democratic collective self-mastery, governance and creation.

Fourth, the immediate actions of the present create a recursive, iterative path dependency for the future with decisions taken shaping a system's imminent performance (Uprichard 2012). Moreover, as Uprichard (2012, 133) notes, the aim is often not simply to know now, but "to know about now before now has happened". Algorithmic and technocratic governance thus works to prefigure, through pre-determined, programmed responses and feedback loops, the unfolding of socio-spatial-temporal life. This is leading, she contends, to the present being increasingly embedded into institutional structures and vice versa, with the result that the "present itself becomes more and more plastic, to be stretched, manipulated, moulded and ultimately 'casted' by those who can access more of it in the supposed 'now'." From this perspective, urban control rooms cast the present by iteratively pre-figuring it through on-going responses. The consequence of always living in the now, Uprichard (2012, 134) argues, is we will increasingly "cut our coats according to our present cloths", becoming rooted in a constant series of "plastic presents" that limit the possibilities of alternate emergent futures and largely ignores the past or the future present.

For Virilio (1997, 19) there is thus an emerging "tyranny of real time", a "dromospheric pollution" (*dromos* being the Greek for race, which Virilio associates with speed/acceleration) in which the temporal demands of real-time exceed our capacity to cope with them and take effective action (Purser 2002). Moreover, real-time smart city systems produce the condition of continuous geosurveillance, in which spaces and individual mobility are monitored at fine-grained temporal and spatial scales, enabling a detailed tracking and tracing of people, objects, transactions and interactions, and producing numerous privacy harms (Kitchin 2016). Real-time systems produce a smart city then in as far as they seek to provide stability and control in urban governance by reacting to unfolding situations, albeit in a limited, technocratic means, but they do not necessarily produce greater understanding or forms of smart citizenship (Kitchin 2014; de Lange in press).

For some, the fixation on operating in real-time needs to be countered by maintaining asynochronicity in the smart city. Leccardi (2007), for example, calls for an opposition to the "detemporalized" logics of a real-time present and for a reappraisal of the value of the lived dimensions of time and space and the connections between the past and present. Hassan (2007, 46) likewise calls for people to be able to have more control over their time and to be able to "refuse to be swept up into the acceleration of society and the time-squeeze that is taking its toll on cultures and societies". Just as the continuous geosurveillance of IoT needs to be tempered by an ethics of forgetting (Dodge and Kitchin 2007), the tyranny of real-time requires an ethics of temporal dissonance. For de Lange (in press) asynchronicity would enable citizens to live in the city at their own pace, not just slowing down but operating at differential speeds. Bleecker and Nova (2009, 19) contend that such an aspiration requires urban computing to be citizen-focused and not simply about operational efficiency and optimization, concluding "computing in an urban setting should first of all not be about data and algorithms, but people and their activities". They venture that real-time computation should have layers or routines that do not work instantaneously, are out of alignment and incongruous or decentralised, and are more speculative, poetic and unexpected. Real-time systems configured in such a way would produce lively cities, not simply ordered, optimized ones.

While such calls for temporal dissonance and asynchronous temporal relations may seem appropriate given the growing use of real-time systems and their consequences, as Adam (2004) and Crang (2007) note, urban life remains lively. In fact, temporal relations are being reconfigured not annihilated (Crang 2007), with "instantaneity, simultaneity, networked connections, ephemerality, volatility, [and] uncertainty" running alongside and being superimposed on "linearity, spatiality, invariability, clarity and precision" to create new "temporal multiplicity and complexity" (Adam 2004, 65). The result is that people find themselves enmeshed in several competing temporalities simultaneously. For example, a person heading to a meeting at 10am, using their mobile phone to talk to a colleague on the other side of the planet while waiting at a pedestrian crossing for the network-controlled traffic lights to change is negotiating global time and local time, clock time and network time, as well as social and natural time. She is experiencing pronounced time-space distanciation of a long-distance call, as well as very localised time-space choreographies of negotiating an intersection; both chronoscopic and chronological time. For Crang (2007, 70) then people are negotiating a complex "chronotopia" of varying pace, tempos, rhythms, scheduling, temporal relations and modalities, and these are contingent for different people in different places. The trend towards real-time does have consequences with respect to governance and individual time geographies that require reflection and attention, but the emphasis of critique should be on the maintenance, rather than recovery, of asynchronous and lively cities.

5. Conclusions

Smart city initiatives reconfigure both space and time. In this essay, I have concentrated on examining how temporality is being modulated, focusing on the drive to create real-time cities. Increasingly, urban management is being operated in a perpetual present, with present conditions prefiguring an immediate reaction, and urban life is gaining speed, tempo and temporal flexibility. As I have illustrated, real-time is relational, heterogeneous and contingent, taking different forms across platforms and systems due to varying configurations and operations of machine time. As a result, multiple cultures of realtimeness unfold and these intersect in practice with other temporalities to produce complex chronotopias. However, while operating in real-time has a number of advantages, particularly with respect to responsiveness, efficiency, optimisation and flexibility, it also raises a number of concerns regarding the formulation and practice of governance, the compression and fragmentation of time, and how these impact on individuals, society and economy. To date, however, there has been relatively little critical scholarship on the nature of real-time and its implications with respect to different domains. While I and others have started to fill this lacuna with some initial reflections, much more research and critical analysis – philosophical, theoretical, and empirical – is required to consider several questions concerning the real-time city. There are many avenues for such studies and reflection, but I propose concentrating on four related concerns.

First, there needs to be sustained consideration of the ontology and epistemology of real-time and realtimeness. What is the nature of real-time and realtimeness? How do we best make sense of real-time and realtimeness; to understand and explain theoretically the relations of time, technology and the city? I have posited that real-time is relational, heterogeneous, contingent and provisional, with systems exhibiting varied realtimeness that produce chronotopias and almost but not quite real-time cities; what are plausible alternative conceptions? Also, how should the dimensions of realtimeness be measured? As I have detailed elsewhere with respect to researching the nature and work of algorithms, unpacking the workings of code and computational machines is often tricky to perform (Kitchin 2017). Digital systems are often black-boxed and proprietary, they are heterogeneous and embedded, and they are ontogenetic, being performative, contingent, and mutable. Figuring out the elements of machine time and their broader configuring within social-technical assemblages, as well as how they unfold in practice, is far from straightforward.

Second, there needs to be a systemic analysis of the relationship between real-time ICTs and individual time-geographies, modes of governmentality, and the production of chronotopias. How does the cultures of realtimeness of specific platforms and systems intersect with other temporalities to produce chronotopias? How do those chronotopias unfold in practice and to what extent are they shaped by social relations (gender, sexuality, race, ethnicity, disability, class, caring responsibilities, etc.)? What are the implications of these chronotopias for individual time-space trajectories and for how institutions (e.g., employers) and social structures (e.g., families) organize and regulate time? In what ways does real-time monitoring and response transform regimes of governmentality and what are the implications for city administrations and citizens? In what ways does a prioritisation of acting in real-time alter the ways in which the past, present and future shape social relations? As noted in the essay, there is now a fair body of work that examines such questions with respect to mobile and spatial media, but our understanding is still evolving and advances in technologies produce new, emerging practices and phenomena.

Third, the relationship between realtimeness and space/spatiality needs to be examined and theorised. How does the adoption of real-time platforms and systems affect the experience and meaning of time and space in the contemporary city? How does realtimeness intersect with the transduction of space? Do real-time platforms and systems inherently transduce code/spacetimes? How do code/spacetimes unfold contingently, relationally and contextually with respect to particular smart city technologies and domains (home, work, retail, public spaces, etc.) and practices (governance, mobility, consumption, production, etc.)? In this essay, I have primarily been concerned with exploring the temporality of the real-time city, largely placing the role of space to one side. However, time and space are clearly interdependent, whether that is *chronos* and *choros* (clock time and geometric space) or *kairos* and *topos* (social time and lived place), or *chronos/topos*, or *kairos/choros* (Sui 2012). Indeed, some theorists would posit that time and space are so thoroughly entwined that they operate as a fused dyad – timespace (May and Thrift 2002); in other words, it is impossible to separate time and space into co-productions (time-space) or consider them as separate phenomenon that instigate discrete processes (time and space). From this perspective what are the real-timespaces of cities and what are their tempospatial implications?

Fourth, the politics and ethics of real-time needs to be unpacked, a normative exploration of realtimeness conducted, and consideration given to the resistance and subversion of dromospheric pollution. As detailed in the third part of the essay, operating in an 'eternal now' and 'perpetual contact' produces a set of challenges both with respect to the unfolding of individual time geographies and the practices of governmentality. Speed, efficiency, optimisation, interconnection, and automation are prioritised as virtuous tempo-spatial relations, and *téchne* (instrumental knowledge) is prioritised over *phronesis* (knowledge derived from practice and deliberation) and *metis* (knowledge based on experience) (Parsons 2004; Kitchin et al. 2015). There is thus a politics and ethics in adopting real-time technologies as it prioritises particular values and knowledges, which then have consequences to how urban life is experienced and cities governed. As others have started to argue, there is merit in a counterview of valuing asynchronicity; of valuing *kairos* over *chronos*. As yet, however, an ethics of temporal dissonance, such as the notion of “slow computing” (Fraser 2017), has barely been articulated. Similarly, the ways in which individuals and communities are resisting realtimeness and seeking to act in alternative temporalities are little documented. And we have hardly considered from a normative perspective what kind of real-time city we want to create and live in?

As networked ICTs become increasingly embedded into the fabric and workings of urban systems and everyday living, we will increasing reside, work and play in the real-time city and experience realtimeness. It is imperative then, I believe, to address the questions I have set out above, implementing a series of empirical and theoretical projects that examine in detail the configuration, operation and consequences of real-time systems and the changing tempo-spatiality of smart cities. In so doing, we will start to flesh out the nature, politics and ethics of realtimeness, and produce strategies to ameliorate some of the negative consequences of operating ever-more in the here-and-now; to produce real-time cities that balance *chronos* and *kairos*.

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References

Adam, B. (2004) *Time*, Cambridge, Polity Press.

Adam, B. (2007) *Foreword*, in R. Hassan and R. Purser (eds.), *24/7: Time and Temporality in the Network Society*, Stanford, Stanford University Press, pp. ix-xii

Adam, B. and Groves, C. (2007) *Future Matters*, Leiden, Brill.

Bańbura, M., Giannone, D. and Reichlin, L. (2010) *Nowcasting*, European Central

Bank Working Paper No. 1275, https://www.econstor.eu/bitstream/10419/153709/1/ecbwp1275.pdf (last accessed 8th November, 2017).

Bleecker, J. and Nova, N. (2009) *A synchronicity: Design Fictions for Asynchronous Urban Computing*, The Architectural League of New York, New York, NY.

Braun, B.P. (2014) *A New Urban Dispositif? Governing Life in an Age of Climate Change*, in "Environment and Planning D: Society and Space", 32, pp. 49-64.

Cardullo, P. and Kitchin, R. (2017) *Being a "citizen" in the smart city: Up and down the scaffold of smart citizen participation*, in "Programmable City Working Papers", 30, https://osf.io/preprints/socarxiv/v24jn (retrieved November 8, 2017).

Castells, M. (1996) *Rise of the Network Society*, Oxford, Blackwell.

Castells, M. (1998) *End of the Millennium*, Oxford, Blackwell.

Coletta, C. (2017) *Rhythm-making, halfway ethnographies and 'city heartbeats'*, in "Programmable City Working Papers", 32, https://osf.io/preprints/socarxiv/ydut4 (last accessed 8th November, 2017).

Coletta, C. and Kitchin, R. (2017) *Algorhythmic Governance: Regulating the 'Heartbeat' of a City Using the Internet of Things*, in "Big Data and Society", online first.

Conlon, D. (2010) *Fascinatin' Rhythm(s): Polyrhythmia and the Syncopated Echoes of The Everyday*, in T. Edensor (ed.), *Geographies of Rhythm: Nature, Place, Mobilities and Bodies*, Farnham, Ashgate, pp. 71-81

Crang, M. (2007) *Speed = distance/time : chronotopographies of action*, in R. Hassan and R. Purser (eds.), *24/7: Time and Temporality in the Network Society*, Stanford, Stanford University Press, pp. 62-88.

Datta, A. (2015) *New Urban Utopias of Postcolonial India: 'Entrepreneurial Urbanization' in Dholera Smart City, Gujarat*, in "Dialogues in Human Geography", 5 (1), pp. 3-22.

Datta, A. (2017) *Introduction: Fast Cities in an Urban Age*, in A. Datta and A. Shaban (eds.), *Mega-Urbanization in the Global South: Fast Cities and New Urban Utopias of the Postcolonial State*, London, Routledge, pp. 1-27.

de Lange, M. (in press) *From Real-Time City to Asynchronicity: Exploring Temporalities of Smart City Dashboards*, in S. Lammes, C. Perkins, S. Hind, A. Gekker and C. Wilmott (eds.), *Time Travelers: Temporality and Digital Mapping*, Manchester, Manchester University Press.

de Waal, M. (2014) *The City as Interface: How Digital Media Are Changing the City*, Rotterdam, Nai010 publishers.

Deleuze, G. (1992) *Postscript on the Societies of Control*, in "October", 59, pp. 3-7.

Docherty, B. (2012) *Losing Humanity: The Case Against Killer Robots*, New York, Human Right Watch, www.hrw.org/sites/default/files/reports/arms1112_ForUpload.pdf (retrieved November 17, 2015)

Dodge, M. and Kitchin, R. (2005) *Code and the Transduction of Space*, in "Annals of the Association of American Geographers", 95 (1), pp. 162-180.

Dodge, M. and Kitchin, R. (2007) *The Automatic Management of Drivers and Driving Spaces*, in "Geoforum", 38 (2), pp. 264-275.

Edensor, T. (ed.) (2010) *Geographies of Rhythm: Nature, Place, Mobilities and Bodies*, Farnham, Ashgate.

Evans, L. (2015) *Locative Social Media: Place in the Digital Age*, London, Palgrave.

Flood, J. (2011) *The Fires: How a Computer Formula, Big Ideas, and the Best of Intentions Burned Down New York City and Determined the Future of Cities*, New York, Riverhead.

Forrester, J.W. (1969) *Urban Dynamics*, Cambridge, MIT Press.

Foucault, M. (1991) *"Governmentality"*, in G. Burchell, C. Gordon and P. Miller (eds.), *The Foucault Effect: Studies in Governmentality*, Chicago, University of Chicago Press, pp. 87-104.

Fraser, A. (2017) *Land grab / data grab*, in "Programmable City Working Papers", 31, https://osf.io/preprints/socarxiv/9utyh (retrieved November 8, 2017).

Giddens, A. (1990) *The Consequences of Modernity*, Cambridge, Polity Press.

Gleick, J. (1999) *Faster: The Acceleration of Just About Everything*, New York, Pantheon Books.

Graham, S. and Marvin, S. (2001) *Splintering Urbanism: Networked Infrastructures, Technological Mobilities and the Urban Condition*, Routledge, London.

Greenfield, A. (2013) *Against the Smart City*, New York, Do Publications.

Green, N. (2002) *On the move: Technology, mobility, and the mediation of social time and space*, in "The Information Society", 18(4), pp. 281-292.

Hägerstrand, T. (1970) *What about People in Regional Science?*, in "Papers of the Regional Science Association", 24, pp. 7-21.

Hassan, R. (2003) *Network Time and the New Knowledge Epoch*, in "Time and Society", 12 (2/3), pp. 225-241.

Hassan, R. (2007) *Network Time*, in R. Hassan and R. Purser (eds.), *24/7: Time and Temporality in the Network Society*, Stanford, Stanford University Press, pp. 37-61.

Hassan, R. and Purser, R. (2007) *Introduction*, in R. Hassan and R. Purser (eds.), *24/7: Time and Temporality in the Network Society*, Stanford, Stanford University Press, pp. 1-24.

Heim, M. (1993) *The Metaphysics of Virtual Reality*, Oxford, Oxford University Press.

Katz, J. and Aakhus, M. (eds.) (2002) *Perpetual Contact: Mobile Communication, Private Talk, Public Performance*, Cambridge, Cambridge University Press.

Kitchin, R. (2014) *The Real-Time City? Big Data and Smart Urbanism*, in "GeoJournal", 79 (1), pp. 1-14.

Kitchin, R. (2016) *The Ethics of Smart Cities and Urban Science*, in "Philosophical Transactions A", 374 (2083), pp. 1-15.

Kitchin, R. (2017) *Thinking Critically about and Researching Algorithms*, in "Information, Communication and Society", 20 (1), pp. 14-29.

Kitchin, R. and Dodge, M. (2011) *Code/Space: Software and Everyday Life*, Cambridge, MIT Press.

Kitchin, R., Lauriault, T. and McArdle, G. (2015) *Knowing and Governing Cities through Urban Indicators, City Benchmarking and Real-Time Dashboards*, in "Regional Studies, Regional Science", 2 (1), pp. 1-28.

Kitchin, R., Lauriault, T. and Wilson, M. (2017) *Understanding Spatial Media*, in R. Kitchin, T. Lauriault and M. Wilson (eds.), *Understanding Spatial Media*, London, Sage, pp. 1-21.

Kitchin, R. and McArdle, G. (2016) *What Makes Big Data, Big Data? Exploring the Ontological Characteristics of 26 Datasets*, in "Big Data & Society", 3, pp. 1-10.

Leccardi, C. (2007) *New Temporal Perspectives in the 'High-Speed Society'*, in R. Hassan and R. Purser (eds.), *24/7: Time and Temporality in the Network Society*, Stanford, Stanford University Press, pp. 25-36.

Lefebvre, H. (1992/2004) *Eléments de rythmanalyse: introduction à la connaissance des rythmes*, Paris, Editions Syllepse, translated by S. Elden and G. Moore (eds.), *Rhythmanalysis: Space, Time and Everyday Life*, London, Continuum.

Leszczynski, A. (2015) *Spatial Big Data and Anxieties of Control*, in "Environment and Planning D: Society and Space", 33 (6), pp. 965-984.

Licoppe, C. (2010) *The 'Crisis of the Summons': A Transformation in the Pragmatics of 'Notifications', from Phone Rings to Instant Messaging*, in "The Information Society", 26 (4), pp. 288-302.

Luque-Ayala, A. and Marvin, S. (2016) *The Maintenance of Urban Circulation: An Operational Logic of Infrastructural Control*, in "Environment and Planning D: Society and Space", 34 (2), pp. 191-208.

Lyons, G. and Urry, J. (2005) *Travel Time Use in the Information Age*, in "Transportation Research Part A", 39, pp. 257-276.

Mackenzie, A. (1997) *The Mortality of the Virtual Real-Time, Archive and Deadtime in Information Networks*, in "Convergence: The International Journal of Research into New Media Technologies", 3 (2), pp. 59-71.

Mackenzie, A. (2007) *Protocols and the Irreducible Traces of Embodiment: The Viterbi Algorithm and the Mosaic of Machine Time*, in Hassan, R. and Purser, R. (eds.), *24/7: Time and Temporality in the Network Society.* Stanford, Stanford University Press, pp. 89-107.

Mattern, S. (2014) *Interfacing Urban Intelligence*, in "Places Journal", https://placesjournal.org/article/interfacing-urban-intelligence/ (last accessed 13 January 2017).

May, J. and Thrift, N. (2001) *Introduction*, in J. May and N. Thrift (eds.), *Timespace: Geographies of Temporality*, London, Routledge, pp. 1-46.

McKenna, R. (1997) *Real Time*, Boston, Harvard Business School Press.

Mitchell, W.J. (1996) *City of Bits: Space, Place and the Infobahn*, Cambridge, MIT Press.

Miyazaki, S. (2012) *Algorhythmics: Understanding Micro-Temporality in Computational Cultures*, in "Computational Culture", 2, http://computationalculture.net/article/algorhythmics-understanding-micro-temporality-in-computational-cultures (retrieved June 24, 2014)

Nokia (2015) *HERE makes HD map data in US, France, Germany and Japan available for automated vehicle tests*, available at: http://company.nokia.com/en/news/press-releases/2015/07/20/here-makes-hd-map-data-in-us-france-germany-and-japan-available-for-automated-vehicle-tests (retrieved September 16, 2015).

Parsons, W. (2004) *Not just Steering but Weaving: Relevant Knowledge and the Craft of Building Policy Capacity and Coherence*, in "Australian Journal of Public Administration", 63 (1), pp. 43-57.

Purser, R.E. (2002) *Contested Presents: Critical Perspectives on 'Real-Time' Management*, in B. Adam, R. Whipp and I. Sabelis (eds.), *Making Time: Time in Modern Organizations*, Oxford, Oxford University Press, pp. 155-167.

Rosa, H. (2003) *Social Acceleration: Ethical and Political Consequences of a Desynchronized High-Speed Society*, in "Constellations", 10 (1), pp. 3-33.

Shelton, T., Zook, M. and Wiig, A. (2015) *The 'Actually Existing Smart City'*, in "Cambridge Journal of Regions, Economy and Society", 8 (1), pp. 13-25.

Southerton, D. and Tomlinson, M. (2005) *'Pressed for Time' – The Differential Impacts of a 'Time Squeeze'*, in "The Sociological Review", 53 (2), pp. 215-240.

Sui, D. (2012) *Looking through Hägerstrand's Dual Vistas: Towards a Unifying Framework for Time Geography*, in "Journal of Transport Geography", 23, pp. 5-16.

Sutko, D. and de Souza e Silva, A. (2010) *Location-aware Mobile Media and Urban Sociability*, in "New Media & Society", 13 (5), pp. 807-823.

Townsend, A. (2013) *Smart Cities: Big Data, Civic Hackers, and the Quest for a New Utopia*, New York, W.W. Norton & Co.

Urry, J. (2000) *Mobile Sociology*, in "Sociology", 51 (1), pp. 185-203.

Uprichard, E. (2012) *Being Stuck in (Live) Time: The Sticky Sociological Imagination*, in "The Sociological Review", 60 (1), pp. 124-138

Vanolo, A. (2014) *Smartmentality: The Smart City as Disciplinary Strategy*, in "Urban Studies", 51 (5), pp. 883-898.

Virilio, P. (1997) *Open Sky*, London, Verso.

Wajcman, J. (2008) *Life in the Fast Lane? Towards a Sociology of Technology and Time*, in "British Journal of Sociology", 59 (1), pp. 59-77.

Weltevrede, E., Helmond, A. and Gerlitz, C. (2014) *The Politics of Real-Time: A Device Perspective on Social Media and Search Engines*, in "Theory, Culture and Society", 31 (6), pp. 125-150.