# The Real-Time City? Big Data and Smart Urbanism

Rob Kitchin, NIRSA, National University of Ireland Maynooth, County Kildare, Ireland
Rob.Kitchin@nuim.ie

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## Abstract

‘Smart cities’ is a term that has gained traction in academia, business and government to describe cities that, on the one hand, are increasingly composed of and monitored by pervasive and ubiquitous computing and, on the other, whose economy and governance is being driven by innovation, creativity and entrepreneurship, enacted by smart people. This paper focuses on the former and how cities are being instrumented with digital devices and infrastructure that produce ‘big data’ which enable real-time analysis of city life, new modes of technocratic urban governance, and a re-imagining of cities. The paper details a number of projects that seek to produce a real-time analysis of the city and provides a critical reflection on the implications of big data and smart urbanism.

**Keywords**: big data, smart cities, urbanism, real-time analysis, data analytics, ubiquitous computing

## Introduction

For the past two decades, urban analysts and theorists have been charting the evolution of cities during an era where information and communication technologies (ICTs) have been exerting a growing and pervasive influence on the nature, structure and enactment of urban infrastructure, management, economic activity and everyday life. Cities which have embraced ICT as a development strategy, being pioneers in embedding digital infrastructure and systems into their urban fabric and utilising them for entrepreneurial and regulatory effect, have been variously labelled as ‘wired cities’ (Dutton *et al*., 1987), ‘cyber cities’ (Graham and Marvin 1999), ‘digital cities’ (Ishida and Isbister 2000), ‘intelligent cities’

(Komninos 2002), ‘smart cities’ (Hollands 2008) or ‘sentient cities’ (Shepard 2011). Whilst each of these terms is used in a particular way to conceptualise the relationship between ICT and contemporary urbanism, they share a focus on the effects of ICT on urban form, processes and modes of living, and in recent years have been largely subsumed within the label ‘smart cities’, a term which has gained traction in business and government, as well as academia.

The term ‘smart city’ has been variously defined within the literature, but can broadly be divided into two distinct but related understandings as to what makes a city ‘smart’. On the one hand, the notion of a ‘smart city’ refers to the increasing extent to which urban places are composed of ‘everyware’ (Greenfield 2006); that is, pervasive and ubiquitous computing and digitally instrumented devices built into the very fabric of urban environments (e.g., fixed and wireless telecoms networks, digitally controlled utility services and transport infrastructure, sensor and camera networks, building management systems, and so on) that are used to monitor, manage and regulate city flows and processes, often in real-time, and mobile computing (e.g., smart phones) used by many urban citizens to engage with and navigate the city which themselves produce data about their users (such as location and activity). Connecting up, integrating and analysing the information produced by these various forms of everyware, it is argued, provides a more cohesive and smart understanding of the city that enhances efficiency and sustainability (Hancke *et al*., 2013, Townsend 2013) and provides rich seams of data that can used to better depict, model and predict urban processes and simulate the likely outcomes of future urban development (Schaffers *et al*., 2011; Batty *et al*., 2012). Everyware thus works to make a city knowable and controllable in new, more fine-grained, dynamic and interconnected ways that “improve[s] the performance and delivery of public services while supporting access and participation” (Allwinkle and Cruickshank 2011: 2). It also provides the supporting infrastructure for business activity and growth and stimulates new forms of entrepreneurship, especially with respect to the service and knowledge economy.

On the other hand, the notion of a ‘smart city’ is seen to refer more broadly to the development of a knowledge economy within a city-region (Kourtit *et al*., 2012). From this perspective, a smart city is one whose economy and governance is being driven by innovation, creativity and entrepreneurship, enacted by smart people. Here, ICT is seen as being of central importance as the platform for mobilising and realising ideas and innovations, especially with respect to professional services. In and of itself, however, the embedding of ICT in urban infrastructure is not seen to make a city smart (Hollands 2008). In other words, it is how ICT, in conjunction with human and social capital, and wider economic policy, is used to leverage growth and manage urban development that makes a city smart (Caragliu *et al*., 2009). Whereas the first vision of a smart city focuses on ICT and its use in managing and regulating the city from a largely technocratic and technological perspective, the second encompasses policies related to human capital, education, economic development and governance and how they can be enhanced by ICT. In this scenario, networked infrastructures are enabling technologies, the undergirding platform for innovation and creativity, that facilitates social, environmental, economic, and cultural development (Allwinkle and Cruickshank 2011).

What unites these two visions of a smart city is an underlying neoliberal ethos that prioritises market-led and technological solutions to city governance and development, and it is perhaps no surprise that some of the strongest advocates for smart city development are big business (e.g., IBM, CISCO, Microsoft, Intel, Siemens, Oracle, SAP) that, on the one hand, are pushing for the adoption of their new technologies and services by cities and states and, on the other, are seeking deregulation, privatisation and more open economies that enable more efficient capital accumulation. For city officials, national governments and supra-national states such as the European Union, smart cities offer the enticing potential of socio-economic progress -- more liveable, secure, functional, competitive and sustainable cities, and the renewal of urban centres as hubs of innovation and work (Kourtit *et al*., 2012, Townsend 2013). Hollands (2008) thus identifies five main characteristics of a smart city as evidenced by industry and government literature: widespread embedding of ICT into the urban fabric; business-led urban development and a neoliberal approach to governance; a focus on social and human dimensions of the city from a creative city perspective (*alia* Florida 2004); the adoption of a smarter communities agenda with programmes aimed at social learning, education and social capital; and a focus on social and environmental sustainability. These five characteristics, Hollands (2008) suggests, leads to an inevitable tension within smart cities between: serving global, mobile capital and stationary ordinary citizens; attracting and retaining an elite creative class and serving other classes; top-down, corporatized, centralized development and bottom-up, grassroots, decentralised and diffuse approaches.

Another vital conjoin between these two visions of a smart city is the prioritisation of data capture and analysis as a means for underpinning evidence-informed policy development, enacting new modes of technocratic governance, empowering citizens through open, transparent information, and stimulating economic innovation and growth. Data are thus viewed as essential constituent material to realising a smart city vision. Such data are seen as providing objective, neutral measures that are free of political ideology as to what is occurring in a city, with the weight of data speaking an inherent truth about social and economic relations and thus providing robust empirical evidence for policy and practice (Mayer-Schonberger and Cukier 2013). And yet, there has been to date been little critical focus on the new forms of data being produced (or not produced), how they are being mobilised by business, government and citizens, and the implications of real-time data analytics.

In this paper, the data explosion that has occurred over the past decade, the role of cities as key sites in the production of such data, and how these data are being used to re-imagine and regulate the urban life are examined. In particular, the analysis concentrates on the new phenomena of 'big data' and the generation of enormous, varied, dynamic, and interconnected datasets that hold the promise of what some see as a truly smart city -- one that can be known and managed in real-time and is sentient to some degree (Batty *et al*., 2012; Townsend 2013). I detail a number of projects that aim to produce a real-time overview and analysis of the city, and provide a critical reflection on big data and smart urbanism.

**Big data and cities**

There has long been the production of very large datasets, such as national censuses and government records, that provide information about cities and their citizens. Likewise, businesses have collated significant amounts of data about their operations, markets and customers. However, these datasets often rely on samples, are generated on a non-continuous basis, the number of variables are quite small, are aggregated to a relatively coarse spatial scale, and are often limited in access. As a result, these large datasets have been complemented by what might be termed 'small data' studies – questionnaire surveys, traffic counts, case studies, and interviews and focus groups -- that capture a relatively limited sample of data that are tightly focused, time and space specific, restricted in scope and scale, and relatively expensive to generate and analyze. Much of what we know about cities to date then has been gleaned from studies that are characterised by data scarcity (Miller 2010). The hype and hope of big data is a transformation in the knowledge and governance of cities through the creation of a data deluge that seeks to provide much more sophisticated, wider-scale, finer-grained, real-time understanding and control of urbanity.

There is no agreed academic or industry definition of big data, but a survey of the emerging literature denotes a number of key features. Big data are:

- huge in *volume*, consisting of terabytes or petabytes of data;
- high in *velocity*, being created in or near real-time;
- diverse in *variety*, being structured and unstructured in nature, and often temporally and spatially referenced;
- *exhaustive* in scope, striving to capture entire populations or systems (n=all), or at least much larger sample sizes than would be employed in traditional, small data studies;
- fine-grained in *resolution*, aiming to be as detailed as possible, and uniquely *indexical* in identification;
- *relational* in nature, containing common fields that enable the conjoining of different data sets;
- *flexible*, holding the traits of extensionality (can add new fields easily) and scaleability (can expand in size rapidly).
  (see Boyd and Crawford 2012; Dodge and Kitchin 2005; Laney 2001; Marz and Warren 2012; Mayer-Schonberger and Cukier 2013; Zikopoulos *et al*., 2012)

In other words, big data consists of massive, dynamic, varied, detailed, inter-related, low cost datasets that can be connected and utilised in diverse ways, thus offering the possibility of studies shifting from: data-scarce to data-rich; static snapshots to dynamic unfoldings; coarse aggregation to high resolution; relatively simple hypotheses and models to more complex, sophisticated simulations and theories.

There is little doubt that since the early 2000s there has been a transformation in the volume of data generated. Zikopoulos *et al*., (2012) detail that in 2000 c.800,000 petabytes ($2^{50}$ bytes) of data were stored in the world. By 2010, MGI (cited in Manyika *et al*., 2011: 3) "estimated that enterprises globally stored more than 7 exabytes [$2^{60}$ bytes] of new data on disk drives ... while consumers stored more than 6 exabytes of new data on devices such as PCs and notebooks." They further estimated that in "2009, nearly all sectors in the US economy had at least an average of 200 terabytes [$2^{40}$ bytes] of stored data ... per company with more than 1,000 employees. Many sectors had more than 1 petabyte in mean stored data per company." Based on their review of data volume growth, Manyika *et al*. (2011) projected a growth of 40 percent in data generated globally per year. Such is the phenomenal growth in data production, Hal Varian, Chief Economist at Google (cited in Smolan and Erwitt 2012), estimates that more data are being produced every two days at present than in all of history prior to 2003 and Zikopoulos *et al.* (2012) expects data volumes to reach 35 zetabytes [$2^{70}$ bytes] by 2020.

Such explosive growth in data is due to a number of different enabling and driving technologies, infrastructures, techniques and processes, and their rapid embedding into everyday practices and spaces. These include the widespread roll-out of fixed and mobile internet; the development of ubiquitous computing and the ability to access networks and computation in many environments and on the move; the embedding of software into all kinds of machines transforming them from 'dumb' to 'smart' and the creation of a plethora of purely digital devices; the roll-out of social media and Web 2.0 applications; advances in database design and systems of information management; the distributed storage of data at affordable costs; and new forms of data analytics designed to cope with data abundance (Dodge and Kitchin 2005; Greenfield 2006; Kitchin and Dodge 2011). These developments not only enable the accessing and sharing of data, but are also the means by which much big data are generated. For example, mobile devices such as smartphones allow their users to access information at the same time as they record the information accessed, and when and where it was requested and how it was used.

The sources of big data can be broadly divided into three categories: directed, automated and volunteered. Directed data are generated by traditional forms of surveillance, wherein the gaze of the technology is focused on a person or place by a human operator. Such systems include immigration passport control where passenger details are collected and checked against various databases in real-time, and new data are generated such as CCTV, photographs, fingerprints or iris scans; or spatial video, LiDAR, thermal or other kinds of electromagnetic scans of environments that enables mobile and real-time 2D and 3D mapping. In the case of automated data, data are generated as an inherent, automatic function of the device or system. There are a number of different means by which automated data are produced, including: capture systems, in which the means of performing a task captures data about that task (such as scanning items at a check-out till being used to monitor the till-operators performance, as well as collecting information with regards to the items purchased and who purchased them); digital devices, such as mobile phones, that record and communicate the history of their own use; transactions and interactions across digital networks that not only transfer information, but generate data about the transactions and interactions themselves (such as indexical logs of payments or bank transfers or email); clickstream data that records how people navigate through a website or app; sensed data generated by a variety of sensors and actuators embedded into objects or environments that regularly communicate their measurements; the scanning of machine-readable objects such as travel passes, passports, or barcodes on parcels that register payment and movement through a system; and machine to machine interactions across the internet of things (Kitchin and Dodge 2011). In contrast, volunteered data are gifted by users. These include: interactions across social media such as the posting of comments, observations and the uploading of photos to social networking sites such as Facebook or Twitter; and the crowdsourcing of data wherein users generate data and then contribute them to a common system, such as the generation of GPS-traces uploaded into OpenStreetMap to create a common, open mapping system (Dodge and Kitchin 2013; Sui *et al*., 2012).

Whilst directed and volunteered data can provide useful insights into urban systems and city lives, it is automated forms of data generation that have most caught the imagination of those concerned with understanding and managing cities. In particular, there has been an interest in automated forms of surveillance, sensor networks and the internet of things, and the tracking and tracing of people and objects. Here, the city is envisaged as “constellations of instruments across many scales that are connected through multiple networks which provide continuous data regarding the movements of people and materials” and the status of various structures and systems (Batty *et al*., 2012: 482). As such, the instrumented city offers the promise of an objectively measured, real-time analysis of urban life and infrastructure.

Automated forms of surveillance include: anonymous paper tickets being replaced with automatically trackable 'smart cards'; automatic number plate recognition (ANPR) systems that use digital cameras to scan license plates and pattern match the details to owner details and can be used to trace vehicles as they cross a city and provide inputs into intelligent transportation systems (ITS); automatic meter reading (AMR) that communicates utility usage without the need for manual reading and can do so on a continuous basis; and automated monitoring of public service provision, such as RFID chips attached to rubbish bins detecting whether they have been collected (Dodge and Kitchin 2007a; Hancke et al 2013). Sensor networks consist of an array of very small, inexpensive sensors or actuators that can be embedded or placed on different structures to measure specific outputs such as levels of light, humidity, temperature, gas, electrical resistivity, acoustics, air pressure, movement, speed, and so on. Sensors can be passive and read by scanners, or can be active, broadcasting data at regular intervals over local or wide area networks, or they might have near field communication (NFC) capabilities that enables two-way communication (Hancke et al 2013). Sensors networks can be used to monitor the use and condition of public infrastructures, such as bridges, roads, buildings, and utility provision, as well as general environmental conditions within a city.

Urban places are also now full of objects and machines that are uniquely indexical that conduct automatic work and are part of the internet of things, communicating about their use and traceable if they are mobile. These include automatic doors, lighting and heating systems, security alarms, wifi router boxes, entertainment gadgets, television recorders, and so on. Many of these devices transfer data between each other, in turn leading to new derived data. Devices such as mobile phones can be traced through space by triangulation across phone masts and others with built-in GPS receivers, such as mobile phones, tablets, and satnavs, can record and transmit their own trails. Transponders can be used to monitor throughput at toll-booths, measuring vehicle flow along a road or the number of empty spaces in a car park, and track the progress of buses and trains along a route, and smart tickets, such as the Oyster card on the London Underground, can be used to trace passenger travel.

Some of these data are generated by local governments and state agencies, and some by private companies, and by no means are they all open in nature. Nevertheless for urban managers these forms of instrumentation provide abundant, systematic, dynamic, well-defined, resolute, relatively cheap data about city activities and processes, enabling the possibility of a real-time, urban data shadow and adaptive forms of management and governance (Kloeckl *et al*., 2012).

**The Real-Time City**

Many city governments now use real-time analytics to manage aspects of how a city functions and is regulated. Perhaps the most common example relates to movement of vehicles around a transportation network, where data from a network of cameras and transponders are fed back to a central control hub to monitor the flow of traffic and to adjust traffic light sequences and speed limits and to automatically administer penalties for traffic violations (Dodge and Kitchin 2007a). Similarly, the police might monitor a suite of cameras and live incident logs in order to efficiently and reactively direct appropriate resources to particular locations. Data relating to environmental conditions might be collated from a sensor network distributed throughout the city, for example measuring air pollution, water levels or seismic activity. Many local governments use management systems to log public engagement with their services and to monitor whether staff have dealt with any issues. In nearly all cases, these are isolated systems dealing with a single issue and are controlled by a single agency.

More recently there has been an attempt to draw all of these kinds of surveillance and analytics into a single hub, supplemented by broader public and open data analytics. For example, the Centro De Operacoes Prefeitura Do Rio[1] in Rio de Janeiro, Brazil, a partnership between the city government and IBM, have created a citywide instrumented system that draws together data streams from thirty agencies, including traffic and public transport, municipal and utility services, emergency services, weather feeds, and information sent in by employees and the public via phone, internet and radio, into a single data analytics centre (see Figure 1). Here, algorithms and a team of analysts process, visualize, analyze and monitor a vast amount of live service data, alongside data aggregated over time and huge volumes of administration data that are released on a more periodic basis, often mashing the datasets

[1] http://www.centrodeoperacoes.rio.gov.br/

together to investigate particular aspects of city life and change over time, and to build predictive models with respect to everyday city development and management and disaster situations such as flooding. This is complemented by a virtual operations platform that enables city officials to log-in from the field to access real-time information. For example, police at an accident scene can use the platform to see how many ambulances have been dispatched and when, and to upload additional information (Singer 2012). The stated aim of the city's mayor, Eduardo Paes, was "to knock down silos ... [between] departments and combine each one's data to help the whole enterprise" (Singer 2012).

Similarly, the Office of Policy and Strategic Planning for New York city has sought to create a one-stop data analytic hub to weave together data from a diverse set of city agencies in order to try and manage, regulate and plan the city more efficiently and effectively. Terabytes of data stream through the office on a daily basis enabling the analysts to cross-reference data, spot patterns and identify and solve city problems (Feuer 2013). They have also started to make some of the data available in open form[2], enabling developers to build apps that take the data and rework and repackage it for daily consumption by city dwellers. Likewise, Dublinked[3], provides operational data from Dublin's four local authorities in an open format, and many other municipal governments around the world have started to release various kinds of administrative and operational data using various kinds of open data models (see Ferro and Osella 2013 for an overview of eight different models). An example of an app using such open municipal data is SmartSantanderRA an augmented reality app that provides information on about 2700 places in the city of Santander (beaches, park and gardens, monuments, points Of interest (POI), tourism offices, shops, galleries, museums, libraries, public buses, taxis, bikes, parking places, and so on), along with real time access to traffic and beaches cameras, weather reports and forecast, public buses information and bike-rental service[4] (see Figure 2).

In other cities, such as London, live feeds of real-time data are being communicated to citizens through what have been termed 'city dashboards'. For example, in the London case[5]

[2] https://nycopendata.socrata.com/
[3] http://www.dublinked.ie/
[4] http://www.smartsantander.eu/index.php/blog/item/174-smartsantanderra-santander-augmented-reality-application
[5] http://citydashboard.org/london/

(Figure 3), developed by CASA at UCL, citizens can find out real-time information about the weather, air pollution, public transport delays, public bike availability, river level, electricity demand, the stock market, twitter trends in the city, look at traffic camera feeds, and even the happiness level. These data can also be mapped. This is complemented by the London Dashboard[6], a data visualisation site that tracks the performance of the city with respect to twelve key areas -- jobs and economy, transport, environment, policing and crime, fire and rescue, communities, housing, health, and tourism -- though these data are more administrative in nature and not in real-time. Rather than simply providing the raw data, these sites produce visualisations that aid the interpretation and analysis, especially for non-expert users, and allow citizens to monitor the city for themselves and for their own ends.

For those developing and using integrated, real-time city data analytics, such centres, apps and dashboards provide a powerful means for making sense of, managing and living in the city in the here-and-now, and for envisioning and predicting future scenarios. Rather than basing decisions on anecdote or intuition or clientelist politics or periodic/partial evidence, it is possible to assess what is happening at any one time and to react and plan appropriately. Moreover, the use of large samples and the linking of diverse forms of data provide a deeper, more holistic and robust analysis. For advocates of such systems it thus becomes possible to develop, run, regulate and live in the city on the basis of strong, rationale evidence rather weak, selective evidence and political ideology. As such, it is argued, the use of such big data provides the basis for a more efficient, sustainable, competitive, productive, open and transparent city. But just as smart urbanism underpinned by big data offers a seemingly attractive vision of future cities, it also raises a number of concerns, three of which I will now examine in brief.

[6] http://data.london.gov.uk/london-dashboard


Figure 1: The Centro De Operacoes Prefeitura Do Rio in Rio de Janeiro, Brazil
*Source: George Magaraia, http://ultimosegundo.ig.com.br/brasil/rj/2012-05-03/ig-visita-o-centro-de-operacoes-do-rio-de-janeiro.html*

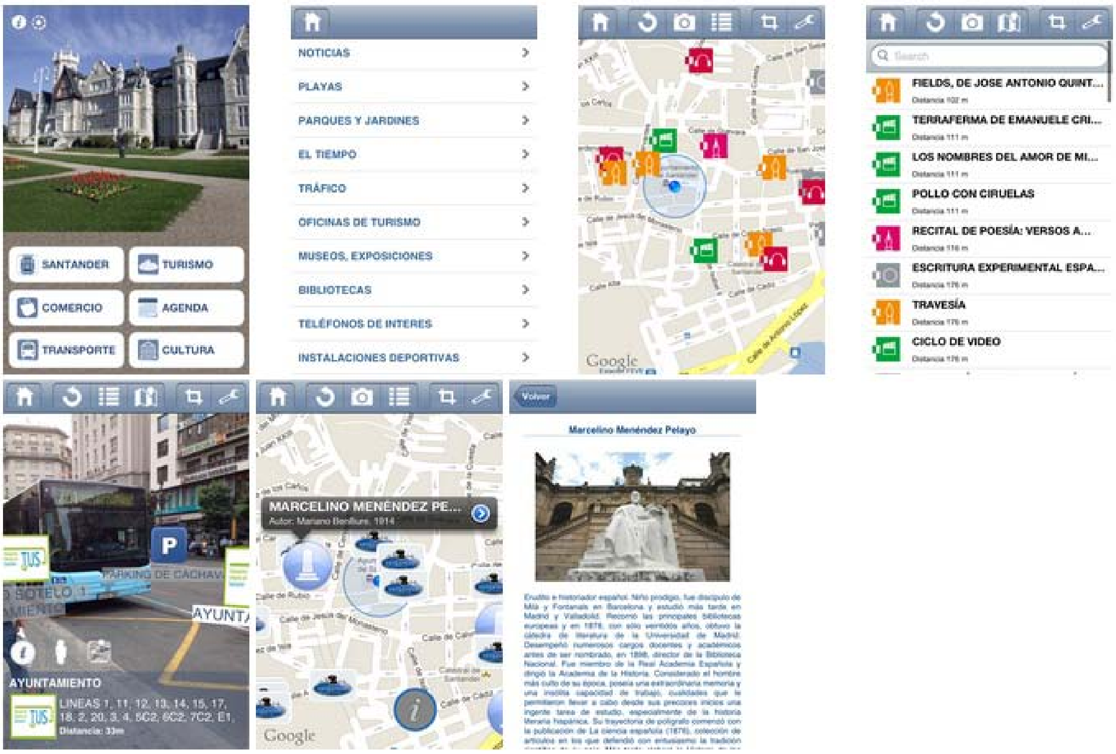


Figure 2: SmartSantanderRA augmented reality app
*Source: http://www.smartsantander.eu/index.php/blog/item/174-smartsantanderra-santander-augmented-reality-application?template=retro*

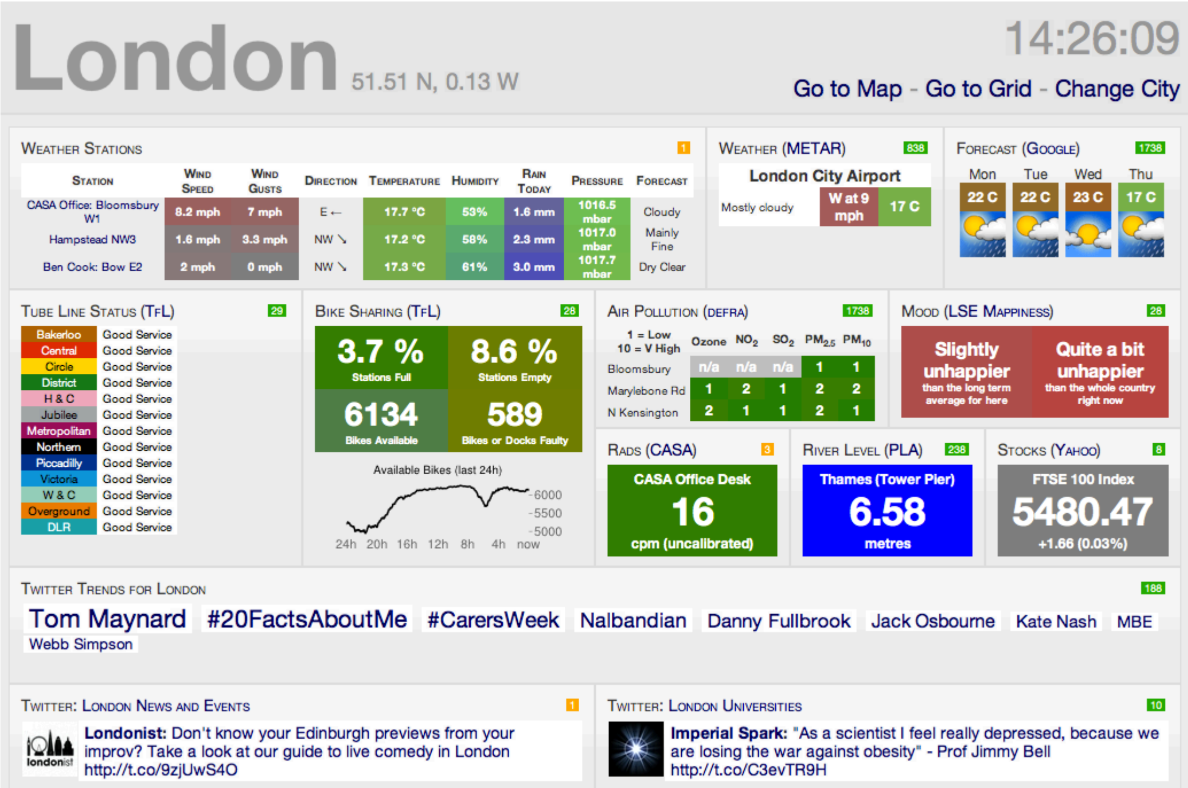


Figure 3: CASA's London City Dashboard
*Source: http://citydashboard.org/london/*

### Three concerns about a real-time city

#### *Technocratic governance and city development*

The drive towards managing and regulating the city via information and analytic systems promotes a technocratic mode of urban governance which presumes that all aspects of a city can be measured and monitored and treated as technical problems which can be addressed through technical solutions. By capturing a phenomena as real-time data it seemingly becomes possible to model, understand, manage and fix a situation as it unfolds. As Hill (2013) puts it: "[smart city thinking] betrays a technocratic view that the city is something we might understand in detail, if only we had enough data—like an engine or a nuclear power station—and thus master it through the brute force science and engineering." Within such thinking there is "an often-explicit assumption that the universe is formed with knowable and definable parameters [that] assures us that if we were only able to measure them all, we would be able to predict and respond with perfection accordingly" (Haque 2012). Employing an evidence-based, algorithmic processed approach to city governance thus seemingly ensures rational, logical, and impartial decisions. Moreover, it provides city managers with a defence against decisions that raise ethical and accountability concerns by enabling them to say, ‘It’s not me, it’s the data!’ (Haque 2012).

However, technocratic forms of governance are highly narrow in scope and reductionist and functionalist in approach, based on a limited set of particular kinds of data and failing to take account of the wider effects of culture, politics, policy, governance and capital that shape city life and how it unfolds. Technological solutions on their own are not going to solve the deep rooted structural problems in cities as they do not address their root causes. Rather they only enable the more efficient management of the manifestations of those problems. As such, whilst smart city technologies, such as real time analytics are promoted as the panacea for tackling urban governance issues, they largely paper over the cracks rather than fixing them, unless coupled with a range of other policies. Further, control and command systems centralise power and decision making into a select set of offices, at the same time that they make elements of the data publicly available. There is clearly a delicate balance to maintained as new forms of technologically-rooted monitoring and management are rolled out. On the one hand, such technologies enable aspects of the city to managed more efficiently and effectively on a dynamic basis rooted in a strong evidence-base. On the other, these data and technologies need to be complemented with a range of other instruments, policies and practices that are sensitive to the diverse ways in which cities are structured and function.

***The corporatisation of city governance and a technological lock-in***

Alongside the critique that smart city governance is too technocratic in nature is a concern that it is being captured and overtly shaped by corporate interests for their own gain (Townsend 2013). The smart city agenda and associated technologies are being heavily promoted by a number of the world’s largest software services and hardware companies who view city governance as a large, long-term potential market for their products. Either through being major partners in building cities from the ground up (e.g., Songdo or Masdar City), or partnering with established cities to retrofit their infrastructure with digital technology and data solutions, these companies have been seeking to make their wares a core, indispensible part of how various aspects of city life are monitored and regulated. As such, as Schaffers *et al*. (2012: 437) note, “smart city solutions are currently more vendor push than city government pull based", with companies working to build working relationships, put in place favourable market conditions, divert funding streams and create public-private partnerships.

The concern around such a move is three-fold. First, that it actively promotes a neoliberal political economy and the marketisation of public services wherein city functions are administered for private profit (Hollands 2008). Second, that it creates a technological lock-in that beholden cities to particular technological platforms and vendors over a long period of time creating monopoly positions (Hill 2013). The danger here is the creation of a corporate path dependency that cannot easily be undone or diverted (Bates 2012). As Hill (2013) details, the strategy adopted by IT corporations mirrors that of US car manufacturers in the mid-twentieth century in creating a form of technology-led urbanism centred on car transportation. Here, public transport networks were closed down to be replaced by a vast road building programme that then shaped patterns of urban development in the following decades. Haque (2013) thus wonders "what the smart city equivalents might be of Robert Moses' tangled, congested and polluted freeways or the failures of the Pruitt Igoe housing complex." Third, that it leads to 'one size fits all smart city in a box' solutions that take little account of the uniqueness of places, peoples and cultures and straightjackets city administrations into a narrowly visioned technocratic mode of governance (Townsend *et al*., nd). Indeed, IBM is now selling a product called 'IBM Intelligent Operations Center', which combines a number of the systems that were designed for Rio into a single product that can be applied to any city (Singer 2012). Given these concerns, Hill (2013) thus warns that "[l]iterally hardwiring urban services to a particular device, a particular operating system, is a recipe for disaster, not efficiency ... Put simply, city fabric changes slowly yet technology changes rapidly ... There is a worrying lack of thought about adaptation in this desire to install the consumer tech layer as if it were core building services." That's not say that such a corporate lock-in is inevitable, but it is clear that is the desire of a number of very large corporate players.

***The panoptic city?***

Over the past couple of decades, with the development of various forms of directed, automated and networked digital technologies, there have been increasing concerns over the rising level of surveillance in societies. It is now possible to track and trace individuals and their actions, interactions and transactions in minute detail across a number of domains (work, travel, consumption, etc). This level of monitoring has been driven by a growing 'culture of control' that desires 'security, orderliness, risk management and the taming of chance' (Garland 2001, cited in Lyon 2007: 12). However, despite systems becoming more widespread, fine-grained and sophisticated, they have largely operated as independent systems and the notion of a panopticon (an all-seeing vantage point) has remained open to vertical (within an activity) and horizontal (across activities) fragmentation due to agencies communicating imperfectly or being unable or unwilling to exchange or compare information (Hannah 1997). Governance has thus consisted of a set of oligopticons – partial vantage points from fixed positions with limited view sheds (Amin and Thrift 2002).

Big data and data control centres, such as the Centro De Operacoes Prefeitura Do Rio, that integrate and bind data streams together, work to move the various oligopticon systems into a single, panoptic vantage point and raise the spectre of a Big Brother society based on a combination of surveillance (gazing at the world) and dataveillance (trawling through and interconnecting datasets), and a world in which all aspects of a citizen's life are captured and potentially never forgotten (Dodge and Kitchin 2007b). There is an inherent tension then in the creation of systems that seek to enable more effective modes of governance that also threaten to stifle rights to privacy, confidentiality and freedom of expression. As more and more aspects of urban life are captured as data in dynamic ways at finer resolutions, this tension is set to grow and it will be important to balance the benefits of data analytics with individual and societal rights in order to maintain democracy and trust in government, especially when so much of the data will be processed by corporate systems. Without regulated oversight and enforcement concerning abuses of data, then there is likely to significant resistance and push-back against real-time analytics by citizens.

## Conclusion

The notion of smart cities has gained much traction in recent years as a vision for stimulating and supporting innovation and economic growth, and providing sustainable and efficient urban management and development. One significant aspect of the smart cities concept is the production of sophisticated data analytics for understanding, monitoring, regulating and planning the city. As cities have become increasingly embedded with all kinds of digital infrastructure and networks, devices, sensors and actuators, the volume of data produced about them has grown exponentially, providing rich streams of information about cities and their citizens.  Such big data are varied, fine-grained, indexical, dynamic and relational enabling real-time analysis of different systems and to interconnect data across systems to provide detailed views of the relationships between data.  For citizens such data and its analysis offers insights into city life, aids everyday living and decision-making, and empowers alternative visions for city development.  For governments, big data and integrated analysis and control centres offer more efficient and effective city management and regulation.  For corporations, big data analytics offers new, long term business opportunities as key players in city governance.

Over the next decade, the real-time city is likely to become a reality in many cities as urban administrations seek to capitalise on new data streams and new commercial products are bought to market that help governments and citizens make sense of the city.  Whilst such big data analytics offers a number of opportunities, they also raise a number of concerns with respect to technocratic governance, the corporatisation and further neoliberalisation of city management, the possibilities of a technological lock-in, ethical issues with respect to surveillance, dataveillance and control, as well as other concerns relating to data quality, fidelity, security, the validity of analytics that utilise data dredging techniques, and how data are interpreted and acted upon.  Given the role that such systems are likely to play in shaping urban governance there is a pressing need to interrogate the nature and production of urban big data, the composition and functioning of urban analytics and control centres, and the implications of technocratic, corporatised and real-time forms of governance.

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