Cambridge Journal of Regions, Economy and Society 2015, **8,** 79–92
doi:10.1093/cjres/rsu013
Advance Access publication 11 August 2014

Smart cities: moving beyond urban cybernetics to tackle wicked problems

Robert Goodspeed

Taubman College of Architecture and Urban Planning, University of Michigan, 2000 Bonisteel Boulevard, Ann Arbor, MI 48109-2069, USA, rgoodspe@umich.edu

Received on September 25, 2013; accepted on June 17, 2014

This article makes three related arguments. First, that although many definitions of the smart city have been proposed, corporate promoters say a smart city uses information technology to pursue efficient systems through real-time monitoring and control. Second, this definition is not new and equivalent to the idea of urban cybernetics debated in the 1970s. Third, drawing on a discussion of Rio de Janeiro's Operations Center, I argue that viewing urban problems as wicked problems allows for more fundamental solutions than urban cybernetics, but requires local innovation and stakeholder participation. Therefore the last section describes institutions for municipal innovation and IT-enabled collaborative planning.

Keywords: smart cities, cybernetics, wicked problems, information technology, urban planning
JEL Classification: H7, R59, Z18

Introduction

In cities around the world, residents and government officials are increasingly inundated with smart city hype as they make decisions about how to utilise information technologies (ITs). In order to sell their products and services, the emerging smart city industry has coalesced behind a definition focused on improving efficiency through real-time control systems. Meanwhile, a jumble of definitions of a smart city has emerged in the scholarly literature. This article argues that we can gain new insight on contemporary smart cities by resurrecting an earlier debate about cybernetics, which reminds us of the practical challenges and limited scope of the idea, no matter how advanced IT has become.

The argument proceeds as follows. The literature review describes the current literature on smart cities, summarises the historical debate about urban cybernetics, and argues contemporary corporate statements and publications about smart cities are equivalent to urban cybernetics. Second, I analyse this literature through the concept of 'wicked problems,' which was developed to critique the early push for IT-aided urban management. Next, I explore the limitations of urban cybernetics through the example of the Rio de Janeiro's Operations Center, where the idea has been put into action. The final section describes two alternative strategies better suited to applying IT to wicked problems: institutions for municipal innovation and IT-enabled collaborative planning.

Literature review

This article draws on three bodies of literature. First, recent publications on smart cities have proposed a variety of smart city definitions. These articles generally lack historical perspective and overlook non-academic smart city publications and projects. Second, I describe an older debate about urban cybernetics, which provides a needed historical and critical perspective. Third, I examine smart cities definitions proposed by companies selling smart city products and services, arguing the idea they promote is urban cybernetics.

Contemporary smart cities literature

Most of the recent scholarship on smart cities takes two diverging perspectives: one strand focuses on the knowledge economy and urban development, and the other relates to governments' use of technology. As technology-focused economic clusters emerged in select regions in the 1980s, a literature developed that described the characteristics of these places and their relationship with institutions, technical networks and culture (Castells, 1989; Markusen et al., 1986). More recent scholarship describes smart cities as home not only to high-tech clusters but also to educational institutions, public services and high quality of life (Caragliu et al., 2011; Etzkowitz, 2008; Leydesdorff and Deakin, 2011; Mahizhnan, 1999). Similarly, some have described large top–down government efforts to plan cities that combine high-tech firms, IT infrastructure and social amenities as a *technopolis* (Hudak, 1992; Tatsuno, 1986) or, more recently, as *smart cities* (Gibson et al., 1992; Greenfield, 2013; Yigitcanlar and Lee, 2013). Some scholars have questioned whether these smart cities demonstrate novel uses of technology, arguing that they are merely conventional real estate development projects that use technical gadgets to cultivate a brand for marketing purposes (Harrison and Donnelly, 2011; Washburn and Sindhu, 2010; Watson, 2013; Yigitcanlar and Lee, 2013).

Within this recent scholarship, a second research strand focuses on government activities and the related statements of corporations promoting smart cities. As IT has become pervasive in society, it has sparked practical and scholarly efforts to develop IT for improved government administration. In this view, in smart cities, governments make savvy use of large information systems (Chourabi et al., 2012) or foster learning required to keep pace with IT development within government and across society (Coe et al., 2001). Corporations have become increasingly vocal in describing how and why governments should use their technologies, leading several scholars to scrutinise this emerging discourse (Hollands, 2008; Vanolo, 2013; Viitanen and Kingston, 2013; Wolfram, 2012). Vanolo fears that the idea of the smart city will become so powerful and it will squash local innovation in IT. Similarly, Viitanen and Kingston (2013) fear that the outsourcing of technology to corporate vendors will tilt power towards private contractors, citing Birmingham, UK officials, who describe a lack of technical skills in the public sector. Finally, some have viewed smart cities as a new category of infrastructure that bridges the public and private sectors (Anthopoulos and Vakali, 2012; Bakici et al., 2012; Lee et al., 2013; Zygiaris, 2013). In their view, shared technical infrastructure produces the need for cross-sector innovation, an issue taken up in the final section.

Notably, few authors mentioned thus far examine in detail the concrete projects, publications and materials produced by corporate smart city promoters. The two authors who do so draw broad conclusions about what they find. Greenfield (2013) focuses on three high-profile, self-proclaimed smart cities: Masdar City, Songdo International Business District and the Living PlanIT project in Portugal.[1] These cases lead him to sweeping conclusions, for example, that smart cities are tied to authoritarian politics and modernist urban design. Townsend's (2013) argument frames smart cities as a struggle between corporations and activists for control of cities, although he does observe the parallels between contemporary smart cities projects, urban modelling and cybernetics.

In summary, the previous literature on smart cities helpfully relates the idea to several fields. Although some authors have begun exploring corporate statements and projects, most overlook or gloss over the ideas proposed by this emerging industry. As a whole, the literature reflects diverse disciplinary perspectives. In order to foster a constructive dialogue, the next section introduces the general theoretical perspective used to analyse smart cities in this article.

Smart city as a sociotechnical theory of action

At a theoretical level, the smart city idea should be viewed as a *sociotechnical theory of action*. The term *sociotechnical* reflects an emphasis on both social and technical factors. Drawing from the science, technology and society (STS) literature, I adopt the *ensemble* view of technology (Orlikowski and Iacono, 2001). According to this perspective, a smart city is not defined by IT alone, but also by the use of IT artefacts (such as databases, sensors and networks) embedded within broader organisational and social contexts. Similarly, Roche et al. (2012) emphasise *technology in use* in their discussion of smart cities and spatial data infrastructures. While this theoretical perspective calls attention to the use of artefacts and context, it poses challenges for analysis. Primarily technical views on smart cities, like those of Zygiaris (2013) and Batty et al. (2012), describe types of computer models or the nature of new data sources but do not describe which organisations will oversee and implement these technologies. More social views, such as that of Bakici et al. (2012), provide greater details about the concrete institutions and places involved but do not describe IT in detail.

This leads to the second part of the phrase: a theory of action. Argyris and Schon (1974) define a *theory of action* as a set of interconnected propositions that take the following form: "in situation *S*, if you want to achieve consequence *C*, do *A*." Such a theory can be used several ways: for the actor, it is a theory of control; when attributed to an actor, it serves to explain or predict behaviour (Argyris and Schon, 1974, 4–6). In the case considered here, the situation is a city, the consequence is improved efficiency and the action is IT-intensive real-time monitoring and control. This idea collapses the separation between *normative* and *descriptive* theories. While much of the smart cities discourse may now be normative, as soon as the ideas are used to change practices, they become descriptive. The next section describes the specific theory of action seen in current smart city statements and projects in greater detail.

Urban cybernetics

One of the most important theories of action developed for IT is cybernetics. Norbert Wiener popularised the term *cybernetics* to refer to the science of communication and control of organised systems (Wiener, 1948). The fundamental unit of cybernetics is the *control loop* used to monitor and control a specific system. The loop is made up of *sensors* to detect conditions, *actuators* that can make changes and an intelligent *controller*. According to this logic, complex systems such as an engine can be kept running smoothly by, for example, adjusting fuel and air inputs automatically with electrical circuits. The proponents of this idea extended the logic to larger and more complex systems, which they argued could also be intelligently controlled if the systems could be sufficiently understood. As a result, applying this promising technology to cities required urban computer models.

Propelled by experts with ties to the US military, the idea of cybernetics was used to develop computer systems to guide urban renewal in Pittsburgh, New York and Los Angeles in the 1960s (Light, 2003). American experts hoped computer analysis would provide insights to tackle problems like decaying housing and increasing crime. Despite initial high hopes, these efforts foundered. Not only was data sorely lacking in many cities, but the model builders also lacked good theories. More seriously, urban complexity made constructing a 'general purpose' model impossible. One close observer (Lee, 1973) concluded that such issues were 'fundamental flaws' that doomed large-scale urban modelling.

While urban modelling fell under criticism, others examined cybernetics' political assumptions. Savas (1970) issued a pessimistic prognosis for the political feasibility of urban cybernetics in *Science*. He described how the five elements of the cybernetic loop, shown in Figure 1, would play out in the city: (i) goal setting, (ii) actuator or administration, (iii) disturbances, (iv) system or city and (v) information feedback. He observed that implementing urban cybernetics would face many challenges: city residents disagreed about goals, mayors pursued short-term objectives, administrative fragmentation limited management and the complexity of cities thwarted accurate predictions.

The disappointing record of actual cybernetics projects, as well as the critiques of urban cybernetics and the urban computer models required, considerably dampened enthusiasm for the topic (Lee, 1973; Rittel and Webber, 1973; Savas, 1970). However, the idea lingered on among some adherents. Melvin Branch (1981) promoted military-style command centres for cities to manage land development and infrastructure in his book *Continuous City Planning*. In the early 1990s, a new generation of urban model builders (Wegener, 1994) caused Lee to reiterate that his critique could not be addressed through improved data and computing power, but rather hinged on the 'command-and-control' assumptions that lay behind the use of complex models (Lee, 1994). In 2000, researchers associated with the Brookhaven National Laboratory, USA, described a vision of a city "made safe, secure, environmentally green and efficient" through "sensors, electronics and networks … and decision-making algorithms" that facilitated feedback and self-monitoring (Hall, 2000). They did not use the term *cybernetics*; instead, they called the proposed project a 'smart city.'

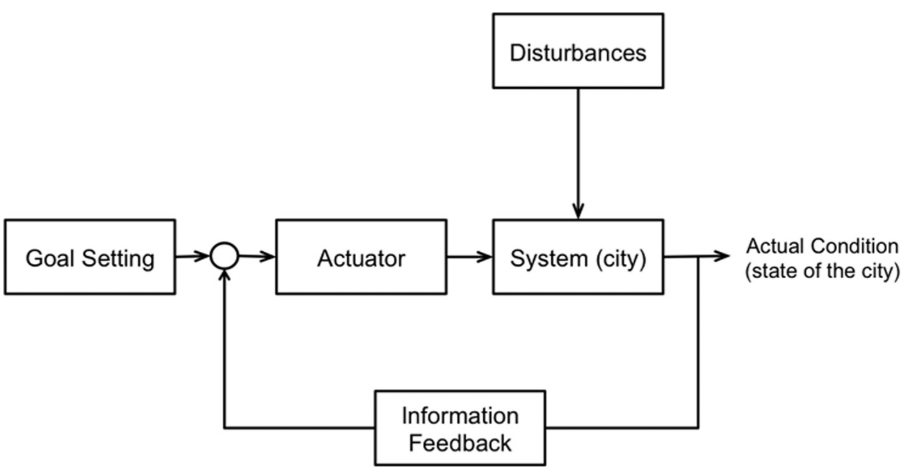

Figure 1. A basic feedback-control diagram for urban cybernetics.
Source: Redrawn from original in Savas (1970). Reprinted with permission from American Association for the Advancement of Science.

In the IT context, Moser (2001) observes that the term *smart* arose to describe artificial intelligence technologies like IBM's chess-playing computer Deep Blue, which "do not necessarily embrace the same grand goals of replicating human intelligence, writ large" but instead are "pragmatic implementations of technology rather than intellectual pursuits" (Moser, 2001). Similarly, Forester defines *smart computing* as integrated hardware, software and networks designed to react to conditions in the real world (Washburn and Sindhu, 2010). Along with this shift in terminology—from *cybernetics* to *smart*—came a shift from a specific, largely discredited concept to a word with broader connotations that Moser (2001) points out can mean not only *intelligent* but also *brisk*, *witty* and *neat*. The next section argues that while the terminology has changed, the underlying concept remains the same.

Smart cities today

Leading technology companies and consultants have proposed smart city definitions in a variety of articles, reports and websites. These definitions—published by the companies themselves, or their employees—highlight two primary goals: effective city services and efficient city systems in general. They also share a strong similarity with the concept of cybernetics.

- **ARUP**: In smart cities, "urban activity is instrumented and monitored by sensors, which feeds data to an organizational layer or model, which is then fed back via informatics, such that it can affect urban activity, that is, modify the operation of infrastructure … or inform citizens" (ARUP, 2010).
- **Cisco**: In smart cities, urban "challenges" can be "mitigated through the adoption of scalable solutions that take advantage of information and communications technology to increase efficiencies, reduce costs, and enhance quality of life" (Falconer and Mitchell, 2012).
- **Forester**: Smart cities involve "the use of Smart Computing technologies to make the critical infrastructure components and services of a city […] more intelligent, interconnected, and efficient" (Washburn and Sindhu, 2010).
- **Hitachi**: Smart cities involve the "overall optimization" of infrastructure to "deal comprehensively" with urban issues by fusing information and control systems (Hitachi, 2012).
- **IBM**: Smart cities are "urban areas that exploit operational data, such as that arising from traffic congestion, power consumption statistics, and public safety events, to optimize the operation of city services" (Harrison et al., 2010). Cities are "a 'system of systems'— a set of interdependent public and private systems that the city can integrate and optimize to achieve a new level of effectiveness and efficiency" (Naphade et al., 2011), and where "operations are instrumented and guided by performance metrics, with interconnections across sectors and silos" (Kanter and Litow, 2009).
- **Siemens**: In a smart city project in Austria, "power supply, building systems, intelligent power grids, and information and communication technologies will interact optimally. The result will be the most efficient resource management possible, with maximum comfort for residents and users. … New IT solutions [will] detect faults in the system, recognize inefficient consumption patterns, and identify potential opportunities for savings" (Siemens, 2013).

To summarise these definitions, a smart city pursues the goals of effective services and efficient city systems through real-time monitoring and control. The city is a *system* to be *optimised* or run *efficiently*. To do this, the city is *instrumented*, which means using both *sensors* for data collection and *actuators* or control devices that might include city residents themselves. These instruments are used to achieve the goal of efficiency by providing managers *intelligence* through the use of *smart technology* such as algorithms or computer models for analysis. The entire system relies on digital networks.

Several of these definitions have used the word *optimisation*, which should be briefly clarified. Greenfield rightly observes that the use of the word *optimisation* by smart city promoters betrays sloppy thinking (Greenfield, 2013, Chapter 8). After all, he argues, unlike a factory or a firm, a city does not have a single overriding goal. Here the word should be interpreted as it is used in engineering—to mean maximising efficiency given a particular set of constraints. However, the inappropriateness of narrow engineering concepts for cities lay at the heart of the old critique of urban cybernetics.

Although similar, this new literature does differ from the early history of urban cybernetics in one important respect. Smart cities proponents have generally focused on the short-term management issues, eschewing the more ambitious scope of earlier urban cybernetics. This tactic can reduce but not eliminate the challenge of uncertainty to cybernetic management principles, which rely on intelligent decision-making. One notable exception has been IBM that attempted to construct a general urban model for Portland, Oregon (Lindsay, 2011; Townsend, 2013, 82–90). Ironically, the model was based on Jay Forrester's (1969) *Urban Dynamics*, one of the urban computer models discussed and critiqued in Lee (1973).

Analysis

In this section, I provide a brief example to illustrate what the smart city concept looks like in action, pointing out its strengths and weaknesses as a theory of action to address urban problems. I then argue that the concept of *wicked problems*, which was developed as a critique of cybernetics in the early 1970s, provides just as useful a critique of smart cities today.

Rio de Janeiro Operations Center

The city of Rio de Janeiro has attempted to implement the concept of a smart city described above. Briefly considering this story illustrates the potential and limitations of the smart city idea in a democratic context. Examining Rio de Janeiro also allows us to focus on the smart city idea as distinct from the design principles and political baggage of huge real estate development projects that are now frequently using the term *smart* as a marketing term.

An unusually strong rainstorm hit the city of Rio de Janeiro on the 5th of April 2010. In the following 24 h, a total of 28.8 cm (11.5 inches) of rain fell on the city, causing hundreds of mudslides in the city's famous hillside *favelas*. The storm left thousands homeless and resulted in 68 deaths within city limits. In the immediate aftermath, an exasperated Mayor Eduardo da Costa Paes told the BCC the situation was 'chaos' and preparedness had been 'less than zero' (BBC, 2010). Paes later reported that he had improvised his response, calling a state of emergency in the early hours of the 6th of April 2010 by personally calling TV and radio stations (Singer, 2012). Officials like Paes lacked not only good information during the event, but also a place to coordinate the government's response. The incident convinced Paes and other officials that the city needs to improve its crisis response capacity, especially in light of the city's upcoming role hosting the 2014 World Cup and the 2016 Summer Olympics.

The centrepiece of this response is the Rio Operations Center, or *Centro de Operações*, which opened in December 2010 at a reported cost of $14 million (Singer, 2012). At the centre, representatives from city departments monitor the city in a large control room, where city employees have access to 560 cameras and other sensors, and monitor a detailed weather forecasting computer model (Centro de Operacoes, 2014). Officials have also installed sirens and an SMS system in 100 high-risk neighbourhoods across the city to distribute alerts should predict the damaging rain forecast (BBC Brasil, 2014). In recent years annual rainfall has been less than in 2010; still, deaths from mudslides are down in Rio, and the early warning system seems to be working (BBC Brasil, 2014). For IBM, the lead contractor on the project, the control centre is a key achievement of its smart cities initiative.

Although the expensive control centre and computer models may be useful management resources, they do not address the root problem of mudslides. Policies that might do that include new wastewater infrastructure or the planned removal of vulnerable structures. Solving the problem of mudslides then extends to broader issues, such as what land should be developed and who should bear the cost of reconstruction if disaster strikes. In fact, Rio officials are pursuing such solutions through their urbanisation initiative, the Morar Carioca Program and the Municipal Plan for the Integration of Informal Settlements, which includes new infrastructure for favelas to reduce flooding vulnerability (Rio de Janeiro, 2013).

The Rio example thus raises the broader challenge of urban problem definition. The next section describes in theoretical terms the critique that urban problems are 'wicked' problems and not engineering ones. The conclusion offers two alternative ways to use technology to improve cities.

Wicked problems

The idea of wicked problems was developed in direct contrast to the idea behind smart cities in its earlier incarnation in the 1960s. Calling this perspective an "on-going, cybernetic process of governance," Rittel and Webber (1973) critiqued the relevance of cybernetics for cities. They argued that consensus on goals for urban policy was giving way to a greater diversity of values. In the late 1960s, simmering frustrations over racial inequality had sparked dozens of incidents of civil unrest in the US cities and anger over urban renewal and freeway construction sparked widespread protest (Mohl, 2004; US National Advisory Commission on Civil Disorders, 1968). Furthermore, Rittel and Webber argued that urban complexity would thwart attempts at scientific management since interventions frequently result in unexpected side effects. The subject of urban planning, they argue, is *wicked problems*, which have no definitive description, involve value judgments, and take place in unique contexts that make it difficult to accurately test solutions. As a consequence, any method of addressing them is inherently political. Many of the problems targeted by smart cities projects, from mudslides to climate change, are wicked problems.

The concept of wicked problems provides a useful reminder that not all problems can be solved by technical solutions, as illustrated by the Rio case. Skaburskis (2008) correctly observes that Rittel and Webber's ideas are not entirely novel; rather, they concisely summarise existing critiques of instrumental rationality. Subsequent theorists have added theoretical context to Rittel and Webber's ideas by drawing links to pragmatic philosophy (Blanco, 1985; Verma, 1998) and complexity theory (Zellner and Campbell, 2013).

If urban problems are wicked problems and cybernetic solutions are inadequate, what are the alternatives? Writing in 1973, Rittel and Webber saw few options. Expert rule simply imposes the values of experts, not necessarily those of residents. Similarly, deferring to individual choices is itself an ideological stance and results in challenges such as public goods, externalities, prisoners' dilemmas and distributional questions (Klosterman, 1985). The conclusion describes two possible avenues forward.

Alternatives

The concept of a smart city described here has been loudly and widely promoted. Some observers fear that the idea is so dominant it may reduce urban policy to a "single technology-centric vision of the city of the future"

(Vanolo, 2013). This section begins by considering the emerging empirical research on smart cities to discover whether a project like Rio's control centre is typical or exceptional. The picture emerging from empirical research shows tremendous variety in how cities are using IT. I argue this local diversity is necessary to construct sociotechnical theories of action appropriate for wicked problems. Finally, this section identifies two general strategies cities can use: institutions for municipal innovation and IT-enabled collaborative planning.

Local variation

Despite the fears of scholars like Vanolo (2013) and Greenfield (2013) that corporate smart city visions will infiltrate city halls, empirical studies show that city officials actually reflect a healthy diversity of ideas about how IT can best be used in cities. A recent quantitative analysis of smart city innovations across six policy domains found a few patterns: Asian cities were more likely to have innovations in transport and European cities in government, economy and people. However, the study's dependent variable is based on a limited review and the explanatory power of the model is limited (Neirotti et al., 2014). Qualitative research has found similar diversity. Researchers conducting interviews with city officials in Seattle found a diverse set of definitions. The officials defined the smart city as involving proactive government services and efficient utilities, but they also mentioned ideas rarely included in industry literature, such as open and transparent government and a people-centred approach to technology (Alawadhi and Scholl, 2013). Similarly, a recent thesis explored whether six cities fit four possible definitions of a smart city: smart machines, engaged communities, learning and adaptation, and investing for the future. The author concludes that the six cities—Boston, San Francisco, Amsterdam, Stockholm, Singapore and Rio de Janeiro—do not fit neatly into any single category but rather boast projects reflecting a diversity of approaches (Ching, 2013). Not all city experiments are successful: a municipal-led smart city initiative in the German city of Friedrichshafen resulted in a variety of projects lacking any coherent focus (Hatzelhoffer and Kolar-Thompson, 2012). The authors of a retrospective report observed that although the city is home to several technology companies, the city "lacked a creative milieu for a Smart City project" (Hatzelhoffer and Kolar-Thompson, 2012). What can cities do to be more purposeful in their use of new technology?

First, IT is fundamentally 'ambivalent' and can evolve in quite different directions (Feenberg, 2002, 91–113). As a result, cities face the challenge of encouraging the development of IT that fits local institutions and serves local values and priorities. Private companies cannot be relied on to create the needed technology for several reasons: a sufficient market may not exist, implementing them requires government action or private companies may lack knowledge or creativity to create locally useful IT. Since cities vary considerably in physical conditions and social institutions, so must sociotechnical theories of action. Following this logic, one trend that holds promise is the municipal innovation movement, which seeks to foster locally appropriate IT development through public or quasi-public laboratories, events, centres and districts.

However, collective action remains a sticking point in this type of creative activity. How can cities move beyond political gridlock to take collective steps to address problems, such as investing in new infrastructure or relocating residents from vulnerable slopes in Rio? No amount of innovation can avoid the necessity of making hard collective decisions. The field of collaborative planning has developed techniques to corral stakeholders and forge consensus agreements (Susskind et al., 1999), accompanied by theoretical interest in consensus (Healey, 1997; Innes, 1996; Innes and Booher, 2010). These methods and theories, many developed since

1973, are often presented as exclusively social. The final section argues that this purely social consensus is not enough and policy discussion must involve computer models, databases, sensors and other IT artefacts. This section highlights initiatives to integrate computer models into policymaking in ways that address concerns about technocracy.

Institutions for public sector innovation

Cities need a place-based creative milieu to spark development of effective use of IT to address urban problems. This view echoes a theme raised by the broader smart cities literature. Drawing on ideas from the field of knowledge management, Campbell (2012) argues that we should look "beyond smart cities" (presumably characterised by IT) and instead focus on processes of learning and innovation that unfold across networks of city leaders. Other authors who identify the crucial role of innovation in smart cities include Zygiaris (2013), who places it at the top of the proposed framework and Bakici et al. (2012), who emphasise the role of specific districts and spaces for experimentation. The conclusion will briefly highlight innovation activities in three areas: within city governments, by non-governmental organisations (NGOs) and through cross-sector events.

Within city governments, new innovation offices and an open government reform movement have spurred organisational change. Several cities have created offices dedicated to innovation that a recent report has dubbed *government innovation labs*, spanning the fields of human-centred design, technology and social innovation (Parsons Desis Lab, 2013). These include Mexico City's *Laboratorio Para La Ciudad*, Dublin's The Studio, Boston and Philadelphia's Offices of New Urban Mechanics, Copenhagen's MindLab, San Francisco's Office of Civic Innovation and Singapore's Human Experience Lab. A loose network of open government technology and government reform advocates have encouraged data sharing and technology innovation in city governments worldwide (Goldstein and Dyson, 2013; Lathrop and Ruma, 2010).

In a related development in the USA, the non-profit Code for America has launched a programme that places computer programmers and other professionals in city governments for short-term fellowships, to inject skills and values from San Francisco's Silicon Valley into the public sector (Scola, 2013). Recently this project has spread worldwide under a Code for All initiative, and it now includes branch organisations in the Caribbean, Poland, Germany, Mexico and Japan (Code for America, 2014).

Outside of city halls, technology innovation activities extend to a burgeoning network of NGOs and professional networks. A recent report on the future of cities and technology concludes that new technologies will "turn every city into a unique civic laboratory—a place where technology is adapted in novel ways to meet local needs" (Institute for the Future, 2010). NGOs focused on improving cities with technology have emerged in several cities. For example, the Smart Chicago Collaborative connects city hall with individuals with technology skills (Smart Chicago Collaborative, 2014), and in India, Transparent Chennai seeks to empower the poor by combining municipal information with new data the group collects (Transparent Chennai, 2014).

Beyond formal organisations, informal events have proliferated that play a crucial role in cultivating local connections. Cities that have hosted CityCamp, a conference focusing on innovative technology for municipalities and community organisations, include St. Petersburg, Buenos Aires, Monterrey and London (CityCamp, 2013). In a related development, the New York City-based OpenPlans has hosted a series of informal conferences in the USA called TransporationCamp and PlanningCamp where public officials, citizens and technology enthusiasts mingled outside of traditional professional organisations. Finally, a host of more conventional innovation mechanisms are at work, including municipal-led pilot projects, university centres, professional associations and specific neighbourhoods, a full accounting of which is beyond the scope of this article.

IT-enabled collaborative planning

Efforts to improve short-term management of cities often concern issues that are also typically the domain of planning, causing some to speculate that planners and managers might share the same datasets, analysis problems and computer models (Batty et al., 2012; Tao, 2013). Taking the argument even further, Batty et al. argue that technical developments are eroding the distinction between planning and smart cities. They fear that the flood of new data from urban sensors is "compressing time scales in such a way that longer term planning itself faces the prospect of becoming continuous as data is updated in real time" (Batty et al., 2012, 498). While correctly identifying the technical links between the two, this perspective misses the important differences between the two theories of action. Grounded in theories of negotiation and consensus, collaborative planning seeks to integrate technical analysis into a discussion among stakeholders about what should be done. This section describes two ways this is happening: by developing new infrastructures to leverage new data sources, and by developing tools to better integrate IT resources into deliberation.

The Australian Urban Research Infrastructure Network (AURIN) is an initiative to develop a technical infrastructure for urban research in Australia. While it is being developed for research purposes, it provides a template for what fully developed IT-enabled planning might involve. The general ingredients of the initiative's technical infrastructure are (i) a variety of dynamic data sources, (ii) facilities for collection, filtering and data access, (iii) a distributed inventory and (iv) a 'tool bench' for access, modelling and analysis (Australian Urban Research Infrastructure Network, 2010). The tool bench currently includes modules to evaluate walkability and visualise health indicators, as well as an online implementation of Klosterman's What If? planning support system (PSS) (Pettit et al., 2013).

Collecting and making sense of dynamic data sources for infrastructures like AURIN poses several challenges. Batty et al. (2012) argue that new administrative data sources, such as records produced by electronic farecards used in the London Underground, will require new data systems and integration techniques to make these datasets useful for modelling. Sharing data and tools in planning typically currently relies on ad-hoc cooperation. Evans and Ferreira (1995) correctly observed nearly two decades ago that building "data pipes" between administrative systems and planning not only involves technical challenges but also requires a "highly skilled 'data tamer' to convert and manipulate data" given the "messy" nature of both the technology and organisations involved in planning.

Since IT-enabled collaborative planning involves multiple stakeholders, computer models must be transparent and interoperable. PSS developers have begun working on data standards to facilitate interoperability between tools (Holway et al., 2012; Singh, 2003; York, 2012). These tools are increasingly moving online, as AURIN's online PSS is made possible by new developments in server GIS technology, and PSS developers in the USA are also converting existing desktop tools into interactive websites (Calthorpe Associates, 2012). Another stream of work has analysed how best to integrate IT into a planning or policy-making process to foster dialogue and learning (Costanza and Ruth, 1998; Goodspeed, 2013; Van den Belt, 2004; Zellner et al., 2012).

Conclusions

Spurred by new technology, the term *smart city* has emerged to describe a set of ideas that has invaded the domains of urban management and planning. The emerging scholarly literature on smart cities contains a confusing jumble of theory and a lack of historical perspective. This article has proposed viewing smart cities as a sociotechnical theory of action that encompasses assumptions about the nature of urban problems and how they should be solved. To do this, I utilised the concepts of urban cybernetics and wicked problems, ideas debated during the first generation of computation in cities. The article concludes by arguing that two areas hold promise in light of this critique: local municipal innovation and the incorporation of IT into collaborative urban planning. Technology has always had a large role to play in utopian visions of the future. Although IT artefacts can play a role in social change, they do not eliminate the social and political dimensions of cities. By injecting historical concepts into the evolving smart cities debate, I hope to push the discussion towards practices and research that will make a practical difference in improving urban life.

Endnote

[1] Other notable examples include Malta's SmartCity (Washburn and Sindhu, 2010), Russia's Skolkovo Tech City (Butcher, 2013), provincial 'smart' cities in each of India's 28 states (The Indian Express, 2012), Indian smart cities focusing on manufacturing (Basu, 2012), large-scale urban projects in Africa such as Lagos' Eko Atlantic (Watson, 2013), and less well-known projects, such as Siemens' €40 million Aspern Smart City project in Vienna, Austria (Siemens, 2013).

Acknowledgments

Thanks to Scott Campbell, Joe Ferreira and Larry Vale for providing feedback on earlier versions of this paper, as well as to Julie Steiff for editing assistance. Comments from the editors and two anonymous reviewers helped clarify the argument. This research received no grant from any funding agency in the public, commercial or not-for-profit sectors.

References

Alawadhi, S., Scholl, H. J. J. (2013) Aspirations and realizations: the smart city of Seattle. Presented at the 46th Hawaii International Conference on System Sciences, IEEE Proceedings, pp. 1695–1703, Wailea, Maui, HI. 7–10 January 2013.

Anthopoulos, L. G., Vakali, A. (2012) Urban planning and smart cities: interrelations and reciprocities. In: Alvarez et al. (ed) *The Future Internet*, pp. 178–189. Berlin: Springer.

Argyris, C., Schon, D. A. (1974) *Theory in Practice: Increasing Professional Effectiveness*. San Francisco, CA: Jossey-Bass.

ARUP (2010) Smart cities: transforming the 21st century city via the creative use of technology. Available online at: http://publications.arup.com/Publications/S/Smart_Cities.aspx [Accessed 13 January 2014].

Australian Urban Research Infrastructure Network (2010) Final project plan and appendices. Available online at: https://aurin.org.au/resources/aurin-documents [Accessed 13 January 2014].

Bakici, T., Almirall, E., Wareham, J. (2012) A smart city initiative: the case of Barcelona. *Journal of the Knowledge Economy*, **4**: 135–148.

Basu, N. (2012) Land talks on for 'smart cities'. *Business Standard (India)*, 5 August. Available online at: http://smartinvestor.business-standard.com/market/Marketnews-127896-Marketnewsdet-Land_talks_on_for_smart_cities_project.htm [Accessed 13 January 2014].

Batty, M., Axhausen, K., Giannotti, F., Pozdnoukhov, A., Bazzani, A., Wachowicz, M., Ouzounis, G., Portugali, Y. (2012) Smart cities of the future. *The European Physical Journal Special Topics*, **214**: 481–518.

BBC (2010) Flooding in Rio de Janeiro state kills scores. *BBC News*, 7 April.

BBC BRASIL (2014) Sistema de alertas reduz mortes, mas desastres ainda desafiam Rio. Available online at: http://www.bbc.co.uk/portuguese/noticias/2014/01/140109_enchentes_rio_jp_lk.shtml [Accessed 13 January 2014].

Blanco, H. (1985) Pragmatism, abduction and wicked problems. *Berkeley Planning Journal*, **1**: 93–119.

Branch, M. C. (1981) *Continuous City Planning: Integrating Municipal Management and City Planning*. New York, NY: Wiley.

Butcher, M. (2013) Russia hopes the Skolkovo tech city will produce its great leap forward [online]. Available at: http://techcrunch.com/2013/05/31/russia-hopes-the-skolkovo-tech-city-will-produce-its-great-leap-forward/ [Accessed 13 January 2014].

Calthorpe Associates (2012) Urban footprint technical summary model version 1.0. Available online at: http://www.calthorpe.com/scenario_modeling_tools [Accessed 20 January 2014].

Campbell, T. (2012) *Beyond Smart Cities: How Cities Network, Learn and Innovate*. New York, NY: Earthscan.

Caragliu, A., Del Bo, C., Nijkamp, P. (2011) Smart cities in Europe. *Journal of Urban Technology*, **18**: 65–82.

Castells, M. (1989) *The Informational City: Information Technology, Economic Restructuring, and the Urban-Regional Process*. Cambridge, MA: Blackwell.

Centro De Operacoes (2014) Institucional [online]. Available at: http://centrodeoperacoes.rio.gov.br/institucional [Accessed 13 January 2014].

Ching, T. (2013) Smart Cities: Concepts, Perceptions and Lessons for Planners. Master's thesis, Department of Urban Studies and Planning, Massachusetts Institute of Technology. Available online at: http://hdl.handle.net/1721.1/81146 [Accessed 13 January 2014].

Chourabi, H., Nam, T., Walker, S., Gil-Garcia, J. R., Mellouli, S., Nahon, K., Pardo, T. A., Scholl, H. J. (2012) Understanding smart cities: an integrative framework. Paper presented at the 24th Hawaii International Conference on System Sciences, Maui, HI, 4–7 January 2012.

Citycamp (2013) Cities [online]. Available at: http://citycamp.govfresh.com/cities/ [Accessed 20 January 2014].

Code for America (2014) Code for all: program overview [online]. Available at: http://codeforamerica.org/about/international/ [Accessed 29 May 2014].

Costanza, R., Ruth, M. (1998) Using dynamic modeling to scope environmental problems and build consensus. *Environmental Management*, **22**: 183–195.

Coe, A., Paquet, G., Roy, J. (2001) E-governance and smart communities: a social learning challenge. *Social Science Computer Review*, **19**: 80–93.

Etzkowitz, H. (2008) *The Triple Helix: University-Industry-Government Innovation in Action*. New York, NY: Routledge.

Evans, J., Ferreira, J. (1995) Sharing spatial information in an imperfect world: interactions between technical and organizational issues. In: H. Onsrud, G. Rushton (eds) *Sharing Geographic Information*, pp. 448–460. New Brunswick, NJ: Rutgers Center for Urban Policy Research.

Falconer, G., Mitchell, S. (2012) Smart city framework: a systematic process for enabling smart + connected communities. Cisco internet business solutions group. Available online at: http://www.cisco.com/web/about/ac79/docs/ps/motm/Smart-City-Framework.pdf [Accessed 5 September 2013].

Feenberg, A. (2002) *Transforming Technology: A Critical Theory Revisited*. New York, NY: Oxford University Press.

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

Gibson, D. V., Kozmetsky, G., Smilor, R. W. (1992) *The Technopolis Phenomenon: Smart Cities, Fast Systems, Global Networks*. Savage, MD: Rowman & Littlefield.

Goldstein, B., Dyson, L. (eds) (2013) *Beyond Transparency: Open Data and the Future of Civic Innovation*. San Francisco, CA: Code for America Press.

Goodspeed, R. (2013) Planning Support Systems for Spatial Planning Through Social Learning. Doctor of Philosophy, Department of Urban Studies and Planning, Massachusetts Institute of Technology. Available online at: http://hdl.handle.net/1721.1/81739.

Greenfield, A. (2013) *Against the Smart City (The City Is Here for You to Use)*. 1.3 edn. Amazon Digital Services, Inc.: Do Projects.

Hall, R. E. (2000) The vision of a smart city. Presented at the 2nd International Life Extension Technology Workshop, Paris, France.

Harrison, C., Donnelly, I. A. (2011) A theory of smart cities. Paper presented at the 55th Annual Meeting of International Society for the Systems Sciences. Hull, UK, 17–22 July 2011.

Harrison, C., Eckman, B., Hamilton, R., Hartswick, P., Kalagnanam, J., Paraszczak, J., Williams, P. (2010) Foundations for smarter cities. *IBM Journal of Research and Development*, **54**: 1–16.

Hatzelhoffer, L., Kolar-Thompson, L. (2012) *Smart City in Practice: Converting Innovative Ideas into Reality: Evaluation of the T-City Friedrichshafen*. Berlin: Jovis.

Healey, P. (1997) *Collaborative Planning: Shaping Places in Fragmented Societies*. Vancouver: UBC Press.

Hitachi (2012) Hitachi's vision of the smart city. Available online at: http://www.hitachi.com/products/smartcity/vision/index.html [Accessed 15 December 2013].

Hollands, R. G. (2008) Will the real smart city please stand up? *City*, **12**: 303–320.

Holway, J., Gabbe, C. J., Hebbert, F., Lally, J., Matthews, R., Quay, R. (2012) *Opening Access to Scenario Planning Tools. Policy Focus Report*. Cambridge, MA: Lincoln Institute of Land Policy.

Hudak, J. (1992) Multifuction polis: partnering for a global technopolis. In: V. Gibson, G. Kozmetsky, R. W. Smilor (eds) *The Technopolis Phenomenon:*

Smart Cities, Fast Systems, Global Networks, pp. 69–79. Lanham, MD: Rowman & Littlefield.

Indian Express (2012) Govt plans 2 'smart' cities in each state. *The Indian Express*, 2 October.

Innes, J. E. (1996) Planning through consensus building—a new view of the comprehensive planning ideal. *Journal of the American Planning Association*, **62**: 460–472.

Innes, J. E. & Booher, D. E. (2010) *Planning with Complexity: An Introduction to Collaborative Rationality for Public Policy*. New York, NY: Routledge.

Institute for the Future (2010) A planet of civic laboratories. Available online at: http://www.iftf.org/our-work/global-landscape/human-settlement/the-future-of-cities-information-and-inclusion/ [Accessed 15 September 2013].

Kanter, R. M., Litow, S. S. (2009) *Informed and Interconnected: A Manifesto for Smarter Cities. Harvard Business School Working Papers*. Cambridge, MA: Harvard University.

Klosterman, R. E. (1985) Arguments for and against planning. *Town Planning Review*, **56**: 5–20.

Lathrop, D., Ruma, L. (2010) *Open Government: Collaboration, Transparency, and Participation in Practice*. Sebastopol, CA: O'Reilly Media.

Lee, D. B. (1973) Requiem for large-scale models. *Journal of the American Planning Association*, **39**: 163–178.

Lee, D. B. (1994) Retrospective on large-scale urban models. *Journal of the American Planning Association*, **60**: 35–40.

Lee, J. H., Hancock, M. G., Hu, M.-C. (2013) Towards an effective framework for building smart cities: lessons from Seoul and San Francisco. *Technological Forecasting and Social Change*, in press. Corrected proof available online 3 October 2013. doi:10.1016/j.techfore.2013.08.033

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

Lindsay, G. (2011) IBM partners with Portland to play SimCity for real. *Fast Company*. Available online at: http://www.fastcompany.com/1772083/ibm-partners-portland-play-simcity-real [Accessed 15 September 2013].

Light, J. S. (2003) *From Warfare to Welfare: Defense Intellectuals and Urban Problems in Cold War America*. Baltimore, MD: Johns Hopkins University Press.

Mahizhnan, A. (1999) Smart cities: the Singapore case. *Cities*, **16**: 13–18.

Markusen, A. R., Hall, P., Glasmeier, A. (1986) *High Tech America: The What, How, Where, and Why of the Sunrise Industries*. Boston, MA: Allen & Unwin.

Mohl, R. A. (2004) Stop the road: freeway revolts in American cities. *Journal of Urban History*, **30**: 674–706.

Moser, M. A. (2001) What is smart about the smart communities movement? *EJournal*, **10/11**: 1. Available online at: http://www.ucalgary.ca/ejournal/archive/v10-11/v10-11n1Moser-browse.html [Accessed 15 September 2013].

Naphade, M., Banavar, G., Harrison, C., Paraszczak, J., Morris, R. (2011) Smarter cities and their innovation challenges. *Computer*, **44**: 32–39.

Neirotti, P., De Marco, A., Cagliano, A. C., Mangano, G., Scorrano, F. (2014) Current trends in Smart City initiatives: some stylised facts. *Cities*, **38**: 25–36.

Orlikowski, W. J., Iacono, C. S. (2001) Research commentary: desperately seeking the "it" in it research—a call to theorizing the it artifact. *Information Systems Research*, **12**: 121–134.

Parsons Desis lab (2013) Gov innovation labs constellation. Available online at: http://nyc.pubcollab.org/public-innovation-places/ [Accessed 15 September 2013].

Pettit, C., Klosterman, R. E., Nin-Ruiz, M., Widjaja, I., Russo, P., Tomko, M., Sinnott, R., Stimson, R. (2013) The online What If? Planning support system. In: S. Geertman, F. Toppen, J. Stillwell (eds) *Planning Support Systems for Sustainable Urban Development*, pp. 349–362. New York, NY: Springer.

Rio De Janeiro (2013) Morar carioca, cidade olimpica [online]. Available at: http://www.cidade-olimpica.com.br/en/projetos/morar-carioca-2/ [Accessed 25 January 2014].

Rittel, H., Webber, M. (1973) Dilemmas in a general theory of planning. *Policy Sciences*, **4**: 155–169.

Roche, S. P., Nabian, N., Kloeckl, K., Ratti, C. (2012) Are 'smart cities' smart enough? Global Geospatial Conference 2012: Spatially Enabling Government, Industry and Citizens, Québec City, Canada.

Savas, E. (1970) Cybernetics in city hall. *Science*, **168**: 1066.

Scola, N. (2013) Beyond code in the tomorrow city. *Next City*. Available online at: http://nextcity.org/forefront/view/beyond-code-in-the-tomorrow-city [Accessed 15 September 2013].

Siemens (2013) Smart city in Vienna: model project Aspern [online]. Available at: http://www.siemens.com/innovation/en/news/2013/e_inno_1319_1.htm [Accessed 15 September 2013].

Singer, N. (2012) Mission control, built for cities. *The New York Times*. Section BU1, 4 March.

Singh, R. (2003) Speaking the same language: using XML for distributed and collaborative planning analysis and modeling. Presented at the AESOP/ACSP Annual Joint Congress, Leuven, Belgium.

Skaburskis, A. (2008) The origin of "wicked problems". *Planning Theory & Practice*, **9**: 277–280.
Smart Chicago Collaborative (2014) About us [online]. Available at: http://www.smartchicago-collaborative.org/about-us/history/ [Accessed 26 January 2014].
Susskind, L., Mckearnan, S., Thomas-Larmer, J. (1999) *The Consensus Building Handbook: A Comprehensive Guide to Reaching Agreement*. Thousand Oaks, CA: Sage.
Tao, W. (2013) Interdisciplinary urban GIS for smart cities: advancements and opportunities. *Geo-spatial Information Science*, **16**: 25–34.
Tatsuno, S. (1986) *The Technopolis Strategy: Japan, High Technology, and the Control of the Twenty-First Century*. New York, NY: Prentice Hall Press.
Townsend, A. M. (2013) *Smart Cities: Big Data, Civic Hackers, and the Quest for a New Utopia*. New York, NY: W.W. Norton & Company.
Transparent Chennai (2014) About transparent Chennai [online]. Available at: http://www.transparentchennai.com/about/ [Accessed 24 January 2014].
US National Advisory Commission on Civil Disorders (1968) *Report of the National Advisory Commission on Civil Disorders*. New York, NY: Bantam Books.
Van den Belt, M. (2004) *Mediated Modeling: A System Dynamics Approach to Environmental Consensus Building*. Washington, DC: Island press.
Vanolo, A. (2013) Smartmentality: the smart city as disciplinary strategy. *Urban Studies*, **51**: 883–898.
Verma, N. (1998) *Similarities, Connections, and Systems: The Search for a New Rationality for Planning and Management*. Lanham, MD: Lexington Books.
Viitanen, J., Kingston, R. (2013) Smart cities and green growth: outsourcing democratic and environmental resilience to the global technology sector. *Environment and Planning A*, **45**: 803–819.
Washburn, D., Sindhu, U. (2010) Helping CIOs understand "smart city" initiatives. *Forrester Research*. Available online at: http://www.forrester.com/Helping+CIOs+Understand+Smart+City+Initiatives/fulltext/-/E-RES55590 [Accessed 9 September 2013].
Watson, V. (2013) African urban fantasies: dreams or nightmares? *Environment and Urbanization*, **26**: 215–231.
Wegener, M. (1994) Operational urban models state of the art. *Journal of the American Planning Association*, **60**: 17.
Wiener, N. (1948) *Cybernetics; or, Control and Communication in the Animal and the Machine*. Cambridge, MA: MIT Press.
Wolfram, M. (2012) Deconstructing smart cities: an intertextual reading of concepts and practices for integrated urban and ICT development. Presented at REAL CORP 2012, Schwechat, Austria, 14–16 May 2012.
Yigitcanlar, T., Lee, S. H. (2013) Korean ubiquitous-eco-city: a smart-sustainable urban form or a branding hoax? *Technological Forecasting and Social Change*, in press. Corrected proof available online 30 September 2013. doi:10.1016/j.techfore.2013.08.034
York, T. (2012) Sustainable Places Analytical Resources Core (SPARC): A Common Data Schema for Scenario Planning. University of Texas at Austin and criterion planners, Austin Sustainable Places Project.
Zellner, M., Campbell, S. D. (2013) New tools for deep-rooted problems: using complex systems to decode and plan for wicked problems in socio-ecological systems. Symposium on Wicked Problems in Socio-Ecological Systems, University of California, Berkeley, USA.
Zellner, M. L., Lyons, L. B., Hoch, C. J., Weizeorick, J., Kunda, C., Milz, D. C. (2012) Modeling, learning, and planning together: an application of participatory agent-based modeling to environmental planning. *URISA Journal*, **24**: 77–92.
Zygiaris, S. (2013) Smart city reference model: assisting planners to conceptualize the building of smart city innovation ecosystems. *Journal of the Knowledge Economy*, **4**: 217–231.