Conceptual Smart Cities Using Big Data Solutions

Mrs.Reshma Yogesh Totare
Assistant Professor
Department of Information Technology
AISSMS IOIT, Pune, India
Email-reshma.gaykar@gmail.com

Dr.J.NaveenKumar
Professor
Department of Computer Engineering
BVDU COE, Pune India
Email-pro_naveen@hotmail.com

***Abstract*—'Smart cities' is a buzzing word that has got traction in government and business to describe cities that, on the one hand, provide core infrastructure and give a decent quality of life to its citizens, a clean and sustainable environment using application of Smart Solutions 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 with a number of examples, details of how cities are being instrumented with digital devices and infrastructure that produce 'Big Data'. Smart city solutions uses such data that enables real-time analysis of city life, new modes of urban governance, and provides the raw material for envisioning and enacting more efficient, sustainable, competitive, productive, open and transparent cities. The final section of the paper provides a critical reflection on the implications of big data and smart urbanism, examining three emerging concerns: the security of big data, E-governance and city development, corporatization of city governance and technological lock-ins**

Keywords-Smart city, Urbanism, Big data, Data analytics, Governance

I. INTRODUCTION

In the last decades, analysts and theorists have been discussing the evolution of cities during an era where information and communication technologies have been exerting a growing and pervasive influence on the nature, structure and enactment of city infrastructure, management, economic activity and everyday life. Cities which have adopted information and communication technologies as a development strategy, being pioneers in embedding digital infrastructure and systems into their urban fabric and utilizing them for entrepreneurial and regulatory effect, have been variously labeled as 'wired cities' , 'cyber cities' , 'digital cities', 'smart cities'. Whilst each of these terms is used in a particular way to conceptualize the relationship between technology and contemporary urbanism, they share a focus on the effects of technology 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.

The buzzword 'smart city' has been variously defined, 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 pervasive and ubiquitous computing and digitally instrumented devices built into the very fabric of urban environments (e.g., fixed and wireless telecom networks, digitally controlled utility services and transport infrastructure, sensor and camera net-works, 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, tabs) 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 analyzing 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 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. 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''. 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, 'smart city' is seen to refer more broadly to the development of a knowledge economy within a city. 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, information and communication technology is seen as being of central importance as the platform for mobilizing and realizing ideas and innovations, especially with respect to professional services. First vision of a smart city focuses on technology and its use in managing and regulating the city from a largely technocratic and technological perspective, the second version encompasses policies related to human capital, education, economic development and governance and how they can be enhanced by technology. Another vital conjoin between these two visions of a smart city is the prioritization 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

realizing a smart city vision. Such data are seen as providing objective, neutral measures that are free of political ideologyas 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. 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 mobilized by business, government and citizens, and the implications of real-time data analytics.

II. BIG DATA AND CITIES

There are many sources that will provide a huge datasets about the cities such as national censuses, government records and geomatic surveys 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 numbers 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, case studies, city audits, interviews and focus groups, and ethnographies 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, to provide additional depth and insight with respect to specific phenomena. 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 peta-bytes 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, 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 scalability (can expand in size rapidly).

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

In 2013, EU commissioner for Digital Agenda, stated that 1.7 million billion bytes of data per minute were being generated globally. Such a huge 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. 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 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 metro card on the Mumbai Metro, can be used to trace passenger travel. All of these forms of data are growing rapidly.

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 real-time analytics and adaptive forms of management and governance.

III. THE REAL TIME CITY

Many city governments now use real-time analytics to manage aspects of how a city functions and 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. 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 has dealt with any issues. In nearly all cases, these are isolated systems dealing with a single issue and are controlled by a single agency. In cities like 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 citizens can find out real-time information about the weather, air pollution, public transport delays, public bike availability, river level, electricity demand, 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, a data visualization 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 visualizations 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.

IV. THREE CONCERNS ABOUT A REAL-TIME CITY

A. The security of big data

Data within smart city initiatives are portrayed as being and lacking in political ideology. Data are simply data: natural and essential elements that are abstracted from the world in neutral and objective ways subject to technical constraints. Sensors and cameras have no politics or agenda. They simply measure light or heat or humidity, and so on producing readings and pictures that reflect the truth about the world. Data can be taken at face value; they are pre-analytic and rhetorical Likewise, the algorithms used to data are neutral and non-ideological in their formulation and operation, grounded in scientific objectivity. Such a framing of data and algorithms enable smart city projects themselves to present an image of being politically benign and commonsensical; that big data urbanism is inherently a good thing, seeking to make a city safer, more secure, efficient, productive, sustainable and so on by employing rigorous, technical practices that capture, process and analyze vast quantities of transparent, neutral, objective data. Data, however, are more complicated than that. Data do not exist independently of the ideas, techniques, technologies, people and contexts that conceive, produce, process, manage, analyze and store them put it, ''raw data is an oxymoron''; ''data are always already 'cooked' and never entirely 'raw'.'' As such, no data are pre-analytic, or are objective, value-free, and benign. What data are generated is the product of choices and constraints, shaped by a system of thought, technical know-how, public and political opinion, ethical considerations, the regulatory environment, and funding and resourcing. Data then are situated, contingent, relational, and framed and used contextually to try and achieve certain aims and goals. It is no different with big data used to underpin smart urbanism. Whilst big data may seek to be all-encompassing, exhaustive and politically benign, as with all data they are a selective sample and are framed within a thought system. What data are captured is shaped by: the field of view/sampling frame (where data capture devices are deployed, what their settings/parameters are, who uses a space or media); the technology and platform used (different surveys, sensors, lens, textual prompts, layout, etc. all produce variances and biases in what data are generated); the context in which data are generated (unfolding events mean data are always situated and contextualized with respect to circumstance); the data ontology employed (how the data are calibrated and classified); and the regulatory environment with respect to privacy, data protection and security. Big data generally captures what is easy to ensnare—data that are openly expressed (what is typed, swiped, scanned, sensed; people's actions and behaviors; the movement of things)—as well as data that are the 'exhaust', a by-product, of the primary task/output. It takes these data at face-value, despite the fact that they may not have been designed to answer specific questions and the data produced might be messy, dirty, full of occlusions and biases. It is less well suited to contextualizing such data or revealing the complex contingent and relational inner life worlds of people and places. Moreover, the data are generated within systems designed to enact a particular political and policy vision. The result is data that are inflected by social privilege and social values, especially within domains that function as disciplinary systems (such as law enforcement). There is no doubt that big data initiatives do produce data that are useful for understanding and managing cities, but the politics and limitations of such data and the methods used to produce and analyze them need to be teased apart and examined as to the values and agendas underpinning them and whose interests they serve.

B. E-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; wherein complex social situations can be disassembled into neatly defined problems that can be solved or optimized

through computation. Here, there is a reification of big data; they can provide the answer to all problems. By capturing phenomena as real-time data it seemingly becomes possible to model, understand, manage and fix a situation as it unfolds.

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 centralize 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 maintain as new forms of technologically rooted monitoring and management are rolled out. On the one hand, such technologies enable aspects of the city to manage 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.

C. The corporatization 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. 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 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 note, ''smart city solutions are currently more vendor push than city government pull based'', with companies working to build working relationships, put in place favorable 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 marketization of public services wherein city functions are administered for private profit. Second, that it creates a technological lock-in those beholden cities to particular technological platforms and vendors over a long period of time creating monopoly positions. The danger here is the creation of a corporate path dependency that cannot easily be undone or diverted details, the strategy adopted by IT corporation's mirrors that of US car manufacturers in the mid twentieth century in creating a form of technology-led urbanism centered on car transportation. Here, public transport networks were closed down to be replaced by a vast road building program that then shaped patterns of urban development in the following decades. 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. 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 thus warns that literally 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.

V. CONCLUSION

The smart city 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 centers 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.

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