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Smart Urbanization

Emerging Paradigms of Sensing and Managing Urban Systems

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Proliferation of communication and mobile technologies in recent years had led to the open availability of massive data in how we are 'connected'. Discourse of *smart cities,* developed through integration of this stored and real time data has made useful contributions to the management of traditional urban infrastructure including water, energy, transportation and other urban systems. However, the increasing role of data analytics corporations in urban management focusing on efficiency have only resulted in fragmented approaches highlighted by individual definitions of 'sustainability' in cities. This research explores the historical development of these systems, especially corporations', through the lens of three key components of technological, ecological and socio-cultural patterns and their integration; and provides a provisional framework for smarter urbanization and its management.

Keywords: Smart Cities, Urban Management, Urban Systems

1. Introduction

The defining role played by Information and Communication Technologies (ICT) in how cities communicate and learn has been a much debated issue for the past couple of decades (Castells M., 1989; McFarlane C., 2011). Ever since the introduction of the first website of the CERN in 1991 by Berners-Lee on a NeXT computer, the Internet has been redefining how we live in today's society. The pervasiveness of computing in everyday lives has also come to the forefront of how cities are functioning, especially in governance and management of city systems (McFarlane C., 2011; Cuff D., 2003). This phenomenon is at the core of emerging theories of Intelligent Cities and Smart(er) Cities. Although the concept of smart cities is a subject of debate (Campbell T., 2012; Komninos N., 2008), the number of cities rebranding as *Smart* has been growing in recent years. Along with provisions for basic human needs like water, waste and energy, cities are increasingly placing a larger emphasis on e-governance to keep up with the digital revolution (Dawes S. S., 2009). This revolution has had profound implications on how institutions and organizations gather behavioral data from users. As more users share information about their daily lives, both knowingly and unknowingly, the role of data analytic corporations has become of paramount importance in both storing and utilization of data. It is indeed obvious that the massive technological transformation that took place at the turn of the 20th century is having profound implications on how we manage our cities. However, it has equally allowed the transformation of trans-national corporations into *urban management* through a technologically deterministic, efficiency agenda, which is the focus of this paper. The investigation will trace technological innovations in the fields of computing and analytics fueling advancements in sensing and managing urban systems.

2. 'Smart Cities' or Being Smart in Cities?

The idea of looking at cities through a lens centered on information has been around for few decades now as technological advancements in the fields of computing and data transfer have facilitated the proliferation of Internet and rapid information exchange [1]. This restructuring has contributed to the suppression of traditionally power holding organization deeply rooted in the notion of place and space according to Castells (1989; Castells M., 1996). The recent upward trend in labeling 'Smart Cities' or 'Intelligent Cities', however, is a functional derivative of mobile computing and handheld devices emerging as primary tools for rapidly transferring information. Nevertheless, there is no clear consensus on what constitutes a smart city. European Smart Cities (smart-cities.eu) characterizes a smart city as "a city well performing in 6 characteristics, built on the 'smart' combination of endowments and activities of self-decisive, independent and aware citizens;" these characteristics being Smart Economy, Smart Mobility, Smart Environment, Smart People, Smart Living, and Smart Governance[1]. Whereas the Natural Resource Defense Council (NRDC) classifies smart(er) cities as those "putting in place best practices, test new innovative new programs, passing model legislation, etc., in sustainability factors: Municipal Energy; Transportation; Water; Green Building; Smart Growth; Environmental Justice; Waste Prevention; Food Security; Air Quality; Green Space; Standard of Living"[2]. Despite being a loosely connected milieu, the idea of smart cities has inadvertently allowed corporations to take an active part in urban environments with the goal of inducing *smarter* technologies into everyday systems.

This new wave of pressure for cities to become smarter through technological innovations set forth by data analyst corporations like IBM, Siemens, and Cisco have certainly resonated in cities around the world. This is evidenced in the recent surge of cities rebranding themselves as *smart* or through their unveiling of ambitious plans that aim to create a *smart(er)* city, centered on ICTs (Deakin M., Waer H. A., 2012). Graham (2002) argues that these attempts are merely different versions of business-dominated industrial capital production, only replaced by technological products (Graham S., 2002). Whereas Hollands (2008), posits the difficulties with the definitions as well as the techno-centric ideologies of cities in economic regeneration (Hollands R. G., 2011). The arguments here only suggest the opportunities that emerged from this transformation allowing technology firms like IBM to commodify information gathering and analysis in urban areas. Some of the preconditions for this can be traced to commercialization of spatial data (Lee M., 2010) during the later parts of 20th century.

Through convergence of material and information flows, cities have always provided the perfect breeding grounds for innovative technologies and opportunities for deploying them. By nature, cities are smart based on their ability to adapt. Perlman in 1987 argued the inventions of steel, elevators, indoor plumbing, electricity, the automobile, the subway and the telephone almost a century earlier had shaped cities throughout 20th century (Perlman J. E., 1987). Today, cities are increasingly shaped by the modern inventions of mobile computing and web based technologies through crowd sourcing information and financial flows. Through these powerful technologies we are able to understand, analyze and better manage resources and services provided to the citizens. Glaesser (2011) notes that the modern society is becoming more adept at utilization of tools at its disposal to address the challenges of energy, mobility and other essential urban systems - in other words, *smarter* (Glaeser E., 2011).

[1] European Smart Cities (n.d). Retrieved May 02, 2013, from http://www.smart-cities.eu/model
[2] What are Smarter Cities? (NRDC) (2013). Retrieved May 02, 2013, from http://smartercities.nrdc.org/about

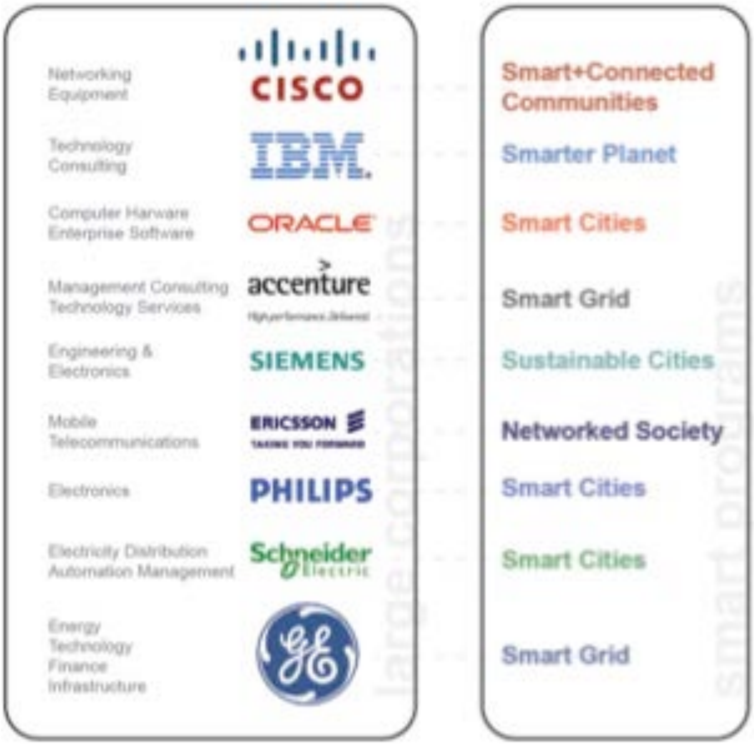

Figure 1. *Large Corporations with diverse expertise have developed their own versions of smart programs. Source: Author*

The foray of Trans-national organizations into urban systems management is contributing to cities' functional structures through e-governance with hopes of 'better' decision making and 'efficient' functioning. This means of efficiency in the governing process is being labeled as *smart* and form the core theoretical underpinnings of business models of Smart Cities of IBM, Cisco, Accenture, Siemens and other large IT consultancies (Figure 1). IBM, a trans-national technology firm, has restructured itself into a consulting firm for managing urban systems through its 'Smart' programs in 2008 (Dirks S., and Keeling M.. 2008). Insofar, the company saw a net increase of 25% in revenue from its 'Smarter Planet' programs in 2012 from previous year (IBM, 2012). As the first IT organization to extend its services into urban management, IBM's transformation story provides a prudent example of the trajectory of technological advancements in data gathering, sensing, mapping, and image processing that have influenced the urban realm.

3. Punch cards to smart cards

The year of 2011 marked a momentous occasion for IBM. From its inception in 1911, formally as Computing Tabulating and Recording Company (CTR), its century long odyssey is considered by many an epitome of innovation and success in the fields of technology. Big Blue, as it is so often called, was a pure technology company until the turn of the 21st century. Its contributions in the fields of computing, including modern electronics, personal computers, storage, and integrated defense systems, ran parallel to the golden period of computing in the later parts of 20th century. IBM diversified its portfolio into services, outsourcing and software during a financially tumultuous late 1990s. It further transformed itself into a services and analytics provider during the first decade of the 21st century. Tracing the development of modern computers is an arduous task and not the intent of this research. Computers have influenced modern society in almost every imaginable way possible. However, a look into IBM's transformation

provides not only a historical development of technological systems but also the reconfiguration of a computer services company into an urban management services provider and allows for a deeper understanding of evolving technologies that effected urbanization and its management.
In so many ways IBM's venture of Smarter Planet is a table setting and industry leading one. Never before has a technology company as large as IBM invested in a strategy that deals directly with urban issues. However, a careful analysis indicates that IBM's trajectory in development of technological systems has always been connected to urban systems management, right from its first but extremely successful offering of the punch card system to recent smart data centers. The earlier version of punch cards that could record data and be read by a machine was invented by Herman Hollerith in 1889. This was extensively used in 1890 U.S. Census, the first instance of processing large urban data (Pugh E. W., 1996). Hollerith's company Tabulating Machine Company, merging with three other companies, later became CTR (renamed as IBM). IBM built a variety of earlier machines that would record, sort, and tabulate punch card information. For the next sixty years punch cards, also known as IBM Cards, were heavily used in every industry. In short, the memory of punch cards made the scale of modern corporation possible (Maney K., Hamm S., and O'Brien J. M., 2011).

The ideas of economy and efficiency have been the driving forces behind most technology companies. The success of the IBM card has led to many innovations in the field of data storage and computing. The pressure to pack more data into less space inadvertently led to development of magnetic tapes (IBM 2401). The next big innovation came in terms of accessing the data through magnetic disks RAMAC (ancestors to today's RAM and hard disks). While punch cards had three mechanical functions of entering, storing and counting data, the need for better computation systems expanded that idea to integrate sensing, memory, processing, logic, connecting and architecture of complex systems (Maney K., Hamm S., and O'Brien J. M., 2011). This categorization and evolving systemic thinking has helped immensely in learning and analyzing urban data in the same vein as workings of a large organization or an industry. Earlier versions of devices like electric type writing machines (Selectric) acted as input devices that later advanced into keyboards, facilitating entering data faster. The development of barcodes was particularly crucial in managing the inventory of goods. Universal Product Code (UPC), developed by IBM, turned out to be one of most profound contributions to industrial technology (Maney K., Hamm S., and O'Brien J. M., 2011). UPC not only changed how inventory is managed in industries but also contributed immensely to systems of ticketing (mobility), medicine and a variety of different fields where scanning information is needed, making it one of the earliest system of smart nature. IBM's magnetic stripes and UPC technology also contributed to further development of smart cards in circulation today.

The need for processing stored data led to the development of vacuum tubes, ancestors to computing devices. During 1970s, IBM's drive to build microprocessors reshaped high-performance computing (Pugh E. W., 1996; Ceruzzi P. E., 2003). However, the peripheral implications of development in processing power contributed immensely to the fields of image and speech recognition. The advancements in image processing were profound in development of cartography, aerial imagery, and remote sensing that allowed better understanding of urbanization patterns. However, this was not as straightforward as it required innovations in optical character recognition, computer tomography, and remote sensing for satellite and military intelligence in 1960's. IBM's computers were again instrumental, helping early satellites gather much needed data and to analyze it (Pugh E. W., 1996; Hughes A. C., and Hughes T. P., 2000). The 1970's saw improvements in the ability to analyze large amounts of data embedded in images which led to the availability of number of digital image processing software in 1980's (Pugh E. W., 1996; Maney K., Hamm S., and O'Brien J. M., 2011). Early 1990's scanning for similar faces in the folder of images and developments in image recognition continue to advance today, not only recognizing patterns, but also in the ability to communicate with images through augmented reality and holographic projections. The final decades of the 20th century saw the rise of desktop computing and data analysis tools along with growth in internet usage. Computers became more capable of handling large data sets generated every day at point-of-sale (POS), industrial outputs, manufacturing, mobility and payrolls.

Individual software programs, increasingly becoming relics of this era, also played a major role in proliferating desktop computers.

Advancements in computing and data processing capabilities have allowed large organizations to achieve manufacturing and functional efficiencies (Cambell-Kelly M., 2003) in pursuit of increased capital production. The transformation to web-based technologies and mobile computing has certainly changed the way we traditionally communicate. In a relative measure, the change has been rapid towards the proliferation of handheld devices. Perhaps the most intriguing part of this development is the sensors that each of these devices carry, collecting data about user location and behaviors. The information stored and sent over these devices and websites spurred a Big Data revolution from the beginnings of 21st century. McKinsey report on Big Data projects a 40% growth in data per year compared to a mere 5% growth in IT spending (MGI, 2011). On the other hand, the projected market for 'smart' systems is a staggering $ 57 billion U.S dollars by 2014.

4. Is 'Smart' the New 'Sustainable'?

It is clear from the literature, the discourse of smart cities is centered on information exchanges and ICTs (Hollands R. G., 2011; Komninos N., 2008; Deakin M., Waer H. A., 2012; Mitchell W. J., 1999). A deeper look, however, reveals the discourse's proclivity towards statistical measurability; in other words, data. A clear emphasis is on population data, especially urban population data and the challenge of accommodating the needs of a growing population. Mitchell (1999), first floating the idea of smart cities, proposed the city as the place where the information (byte sized) comes together, transforming the neighborhoods and work places. This transformation of modern cities comes through processing the data produced within these neighborhoods and workplaces. With the increase in data generated per person every day through sensors carried around in the form of mobile phones and data gathered through social media applications, companies like Google, Microsoft and Apple know more about the behavior of users than the users themselves (Lee M., 2010). Getting to work quicker, finding locations of preferred food, finding goods closest to the user etc. have become a common offering in mobile applications. Buildings now don *smart* systems that respond to the users' needs, automobiles communicate with each other and plethora of everyday machines are equipped with electronic sensors to reduce human interference and maximize the efficiency. This transformation to embedded systems especially in consumer electronics is only a logical progression from the previous decade's advancements in software industry.

Just as the emphasis of *smart* systems with embedded electronics that process information is growing through the proliferation of web-based mobile applications, during this decade, the emphasis was on 'sustainability' in every aspect of life (business, economics, environment) throughout the last decade. The more it became main stream and commodified, the more it became confusing as to what constitutes 'sustainability'. Inconsistent ratings systems that measure carbon footprints to material usage have become widespread. However, the notion of sustainability for large corporations that have visible impact on everyday life was something quite different. Reducing the resource usage to manufacture efficient products was the mantra. Every product and service in every sector of the economy is transformed by new parameters such as quiet, healthy, efficient, and environmentally-friendly through increasing expectations by consumers, investors, employees, and other constituents of the business (Laszlo, C., Zhexembayeva, N., 2011). The cheaper the electronics became, the cheaper it is for products to embed them making *smart* the prevalent notion of the decade. The notion of *smart* is commodified just as the notion of *sustainability*, becoming more of a fragmented ideology suffering from the same imperfections.

5. Is Smart Urbanization Possible?

Just as the technological breakthroughs before, mobile computing and web-based applications are indeed a natural progression and allow us to attain higher levels of efficiency in material consumption and work outputs. As before, the dominance of organization and capitalistic forces at governance are quiet obvious. Organizations like Google claim that the future of computing and services are customized around the individual users. Although this is true to a certain degree, the extent of information about personal choices and behavior only fuels the notion of technology translates to power not comfort. The idea of *smart* as it stands today may then only be a fallacy; just another rebranded version of technological determinism. However, the tools at our disposal are more powerful than ever for data analysis and visualizations which Stanley (2008) refers to as “the golden age of statistical graphics” (Friendly M., 2008). We are able to understand shortcomings of policies to services better through information gathering and data analysis. This has arguably contributed towards efficient delivery of services in many cities around the world.

Every day we are being equipped with new technologies in the field of sensing and data gathering. Very recent inventions of flying insect scale robots (Ma K. Y., et al, 2013) and visual sensors that closely resemble an insect’s eye (Borst A. and Plett J., 2013) further suggest the direction of miniaturization in devices in gathering data. The more we move towards augmented reality through inventions such as Google Glass, Microsoft Kinect and Nokias’ Mixed Reality, the more these devices are able to transmit data to enable ‘customized’ services to the users. This is, however, not a new phenomenon. The symbiotic relationship between map and data has been used for a long time. As early as late 1960’s, IBM has used location based information to address health care through correlating cancer data and locations of poverty in urban areas (Maney K., Hamm S., and O’Brien J. M., 2011). Nevertheless, major challenges remain. Often organizations use themes like is ‘connecting people to data’ and ‘make the world better’ (Maney K., Hamm S., and O’Brien J. M., 2011) for their smart services. However, as with every service, there are equity issues associated with this approach. There will always be questions of what data is being connected to which person, as well as the anonymity in personal data. This deterministic approach has only resulted in exacerbating the urban problems. For example Ceruzzi (2003) points out that Silicon Valley has some of the most real congested highways in the country, as people commute to work with a technology that Henry Ford invented to reduce urban congestion (Ceruzzi P. E., 2003).

Although data is contributing to enterprises that make livelihood and work efficient, the approach is notoriously top down as it is inequitable. Most urban issues pertain to neighborhoods that have deep rooted socio-economic challenges. Availability of solutions that particularly depend on high-tech gadgets and devices to a wider populace, albeit becoming cheaper, is still a question. The reach of e-governance programs is also constantly questioned because of their failure to address some of the most basic needs in urban slums areas where income is from informal sources. Rio de Janeiro, one of the first cities to be fully equipped with *smart* technologies and an IBM’s ‘customer’, still faces issues of urban divide and high percent of crime in its favelas.

In light of Big Data’s role in everyday operations and decision making, the need for understanding its implications are paramount. Although data analytics organizations are impacting many facets of life, especially making city governments their customers, there is still a lot to be desired in terms of how the data is creating better livelihoods for citizens. There is also a need for understanding and integrating biological systems information such as climatic, and biotic; sociological systems of basic human needs, into the Big Data revolution. Underneath the self-designation and investment in *smart* systems by cities, the primary motivation of urban regeneration and economic development is only analogous to previous programs of designated zones and infrastructure developments (Hollands R. G., 2011). Presence of smart systems is not a measure of city’s success in incorporating technology. Therefore, there is an obvious need for flexibility in adapting to the rapidly changing, sophisticated technological systems; and finding ways to understand and improve human capital, as well as environmental conditions. ‘Working’ definitions of *smart* should constitute human-centric and bio-centric approaches rather than techno-centric or capital-centric.

Smart urbanization then becomes an evolutionary framework of cities being intelligent in decision making through advanced tools at their disposal, not at the mercy of large organizations but through a participatory process.

6. Conclusion

The symbiotic relationship between technology and human condition has never been stronger and will continue to grow. Large corporations' contribution to this is a testimony to the prominence of growing interdependence of man and the machine through the complex bridge of Data. As advancements in technology are likely to further the debate of what and how much techno-centric initiatives contribute and address the quintessential human conditions of poverty, social polarization and inequity (Hollands R. G., 2011); and an already tense relationship of modern society to the biological systems. The allowance provided by pervasiveness of powerful computing in everyday life will be able to serve certain political agendas if misused as is seen in the case of many smart city initiatives and the returns are not what they are expected to be in terms of urban regeneration. As modern society reconfigures itself around flows of information, there certainly is a need for better use of emerging tools at our disposal to address the aforemetioned challenges that continue to plague us today. Smart urbanization cannot be achieved only through application of so called *smart* technologies in managing urban systems, but rather being mindful of the complex condition that is ultimately shaping how we understand and manage urbanization. A good starting step would be through a process of supple democratization rather than driven by capital, where innovation serves some of the basic needs smartly far from becoming technologically deterministic and limited.

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