Smart Cities: A Socio-Technical Perspective

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Abstract

This research paper elaborates upon the concept of Smart Cities and the evolution of the term itself throughout history in order to outline the emergence of two distinct schools of thought: technocentric and humancentric, which have shaped smart cities. The paper also categorizes smart cities based on these two perspectives and outlines the operational tactics associated with them. After discussing and summarizing the pros and cons of both perspectives, the viewpoint of a socio-technical system-based model for conceptualizing and re-thinking the smart city narrative is presented. This People, Activity, Context and Technology (PACT) based socio-technical ecosystem model and the manner in which it can overcome the shortcomings of the technocentric and the humancentric modes of thinking is thus presented as a way to understand the city and as a laboratory for initiating an ecology of informed smart innovations.

Keywords: Smart cities; Socio-technical system; Architecture; Built Environment; People-centric.

1. Introduction

Cities as agglomerates of quintessential services, cultural mix, job opportunities and prosperity have already attracted 55% of the global population to inhabit them. This figure is expected to touch the 68% mark by 2050 (UN, 2018), equating almost 6.5 billion of the expected 10 billion people in the world to be lured by the future which our cities portray. On a weekly basis, almost 3 million people globally move from rural to urban areas in search of better economic opportunities (UNDP, 2009) (International Organization for Migration, 2015). Statistically speaking, we can categorize the percentage of urbanized areas in the world as follows: Europe - 74%, North America - 82%, Latin America and the Caribbean - 81%, Africa - 43%, Asia - 50%, and Oceania - 68% (UN, 2018). This trait can also be seen if one compares the rise of the mega-city with a population of over 10 million - from 2 Mega-Cities in the 1950's to 30 Mega-Cities today and an expected 43 Mega-Cities to be established by the year 2030 (The Economist, 2015). However, this tendency to pursue a prospective future and the rampant pace of urbanization apart from contributing to 75% of global GDP predominantly by large cities (McKinsey, 2016) are also responsible for consuming 64% of global energy production and the production of 70% of global greenhouse gas emissions in 2013 alone (IEA, 2016). Globally, impacts of our increasing desire to populate, consume and irresponsibly build are becoming apparent more than ever.

According to the United Nations, climate change related disasters have increased by 2.5 times in the last 20 years (World Economic Forum, 2018). Additionally, between 1988 to 2017, 77% of the direct losses of $2.9 trillion is directly associated to extreme weather conditions owing to global warming (UN Office for Disaster Risk Reduction, 2018). At the pollution front, a staggering 4 billion tons of garbage is dumped in the ocean every year with plastic being the major constituent at 8 million tons (National Geographic, 2015), which, alone is responsible for almost 13-billion-dollar worth damage to the marine ecosystem annually (United Nations, 2014). Furthermore, to navigate our cities and owing to the lack of focused investment as well as political will, our increasing reliability on private modes of transportation results in added congestion and pollution, which, alone is responsible for 4.2 million

deaths annually due to exposure to ambient air pollution (World Health Organization, 2016). With over 80% of urban residents exposed to air pollution levels that exceed WHO limits (United Nations, 2016), living healthy is certainly under question. Not surprisingly, *The Economist*, via its Change in Livability score from 2007-2017 has reported that 'Livability' has decreased in some 98 of 140 cities (The Economist, 2017). Attributes of contemporary cities such as air pollution, noise, social isolation, crime and public safety, inactivity, prolonged sitting in work environments, and unhealthy diet owing to an overburdened life style are not only responsible for enhanced mental stress but have physiological ramifications in the form of increasing potential for stroke, heart attack, chronic respiratory diseases, diabetes, as well as cardiovascular diseases. A direct association between urban planning decisions and such drastic health risks can thus be established. For instance, in Europe as opposed to North America, integrated approaches to zoning with respect to accessibility and mixed-use development of housing, schools, clinics, shopping, businesses, etc. results in reduced use of private modes of transportation and increased appetite for active mobility and use of public transport (World Health Organization, 2018).

Cities themselves have evolved overtime and with the rise of technology have started experimenting with fusing the two counterparts of contemporary cities: the physical and the digital. This fusion is essential in order to collect and analyze multitude of pertinent data-sets associated with the city's operation, conduct rigorous analysis in order to find streamlined people-centric solutions to enhance livability, as well as to predict future scenarios of social, spatial, economic and environmental value thus enabling us to make informed urban planning decisions. This transition from purely analogue modes of conceiving and imposing decisions guiding a city's growth is now slowly giving way to adhering modes of digital governance, which thrive on the synthesis of bottom-up heterogeneous datasets in order to understand the city. This transition towards integrating technology within the built environment, in addition to improving city planning processes, has led to rendering focus on aspects of health, livability, wellbeing, ethics, and responsiveness, all characteristics of transitioning towards a smart city.

The premise for the term 'Smart City' was already laid back in the early 90s wherein the concept of Digital Cities, Virtual Cities, 2D and 3D cities, etc. was being discussed and experimented upon in various design institutes globally as a result of the advent of ICT (Nicos & Luca, 2018). In this paper, a critical understanding of Smart Cities from the perspective of socio-technical systems will be presented. This sketch of the Smart City shall first elaborate upon what a 'Smart City' is and how the term has been interpreted through time, we shall then categorize smart cities into three generations and will understand the operational trends which activate smart cities, and we shall subsequently speculate on a socio-technical model for developing responsive smart cities.

2. Theoretical Underpinnings

What is a Smart City?

According to 'Bee Smart City', a leading global smart city network and community, the Smart City concept describes the ability for utilizing the capacity of a city/community to create and adopt solutions for overcoming challenges and seizing opportunities that help transform the place we call home to a prosperous and more livable place for all stakeholders (Bee Smart City, 2017). Interestingly, this is one of the few definitions which presents an unbiased view of the terminology, which, is otherwise contesting between two predominant visions of the city: technocentric perspective vs a humancentric perspective. These two perspectives are the key to understanding how top-down as opposed to bottom-up urban planning scenarios as well as the notion of collective intelligence as opposed to data-driven intelligence confront each other, which primarily resulted in the development of a corporate smart city model popularized by IBM as opposed to a holistic smart city model thinking propelled by the European school of thought.

Kominos and Mora (2018), in their article Exploring the Big picture of Smart City Research, have presented a concise outline of the genesis of the Smart Cities. A clear distinction of two periods: late 80's till the late 90s and 2000 till 2010 and ongoing can be traced here. The second half of the 80s was steeped in innovation led development of cities, which popularized the terms 'Intelligent City' and 'Smart City'. Influential authors such as Lipman, Sugarman, & Cushman (1986) and Newstead (1989) in the late 80s followed by Batty (M Batty, 1990) and Masser (Masser, 1990) in the 90s professed about the use of IT and Networked systems for technological growth of cities. This perspective was further altered/augmented by the appearance of the terms 'Digital city' and 'Cyber city' between 1990 and 1995 wherein three-dimensional computer-generated visions of cities and digital metaphors of the city as well as the electronic management of city governance and security and control systems was advocated by authors such as Malina (Malina, 1993); Poggenpohl (Poggenpohl et al., 1995), and Graham (Graham, 2004). The 'Smart and Intelligent' city discourse thus immersed itself into attributes of ICT and innovation while the 'Cyber and Digital' city ventured into virtual representations and electronic governance and surveillance of the city. This era was followed by an explosion in research and experimentations within the domain of smart cities, primarily between 2000 and 2010. This was invariably linked with the advancements in ICT wherein telecommunication networks, sensing systems, knowledge management tools and embedded intelligence (with the rise of ubiquitous computing) during this era were prominent. Developments in software for data management and the miniaturization of technology further made it possible for our cities to be populated with technologies for gathering, communicating, collecting, and analyzing data produced by the city and its embedded services at a much faster pace, which slowly resulted in contradicting and questioning the role of virtual representations and generative logics that were predominant during the Cyber and Digital modes of thinking about the city.

A plethora of authors ranging from Hall et al. (Hall et al., 2000), Komninos (2002), Odendaal (2003), Patridge (2004), Gliffenger et al. (2010), Harrison et al. (2010), Chen et al. (2009), Craglieu et al. (2011), Hernandez-Munoz et al. (Hernández-Muñoz et al., 2011), Batty (Michael Batty et al., 2012), (Bakici et al., 2013) Komninos (Komninos, 2015), Nam and Prado (Nam & Pardo, 2011), (Barrionuevo et al., 2012), Zygiaris (Zygiaris, 2013), and (Marsal-Llacuna et al., 2015) to name a few have presented their definitions of smart cities, which vary significantly from each other, thus deepening the confusion around labelling the city as 'Smart'. Despite ICT remaining the most common element in all these definitions, it becomes evident that post the year 2000, a shift in the mode of thinking from a technocentric vision of smart cities included focusing on 'People' as well as 'Community needs' in a much more integral fashion. This shift in focus also implied a much more holistic focus on improving quality of life by means of using ICT in a manner which improves the way in which every sub-system operates (Batty, 2012). This, in-turn implies that ICT, which is predominantly connected with the term 'intelligent' and in today's context with terms such as 'Artificial Intelligence' needs to adhere to the fundamental quality of being adaptive and responsive to user needs.

Large technological corporations such as IBM, Cisco, Siemens, etc. naturally value technical components as the key to conceiving smart cities. Services ranging from waste, water, energy, security, transport, lighting, buildings, etc. are increasingly deploying such technical modes of harnessing data albeit in a siloed fashion. This results in the aggregation of sectorial big-datasets, which does not primarily aid in understanding the city as an ecology of interconnected services. Adam Greenfield, in Against the Smart City (Greenfield, 2013), is one of the many authors who reinforces this opposition for a technocentric vision of Smart Cities and sites various examples of so-called smart cities which have failed to perform because of little to no attention to values vested in mixed use, people centric design, and urban complexity. This technologically propelled perspective of denoting and ranking our cities as 'smart' might not necessarily be the only perspective. On the contrary, this if seen from an ethical perspective could result in issues of social exclusion, inequality,

injustice, and non-resilient modes of urban development rather than promoting a people-centric all-inclusive vision for developing a 'smart and just' city (Vangelis et al., 2017), especially seen from the context of developing nations and their desire to increasingly adhere to the 'Smart City' badge.

In order to extract the essence of these definitions and scope of smart city related discourses, the next section presents a consolidated view on two aspects: Categorization of smart cities and the Trends observed in operating smart cities.

3. Smart City Categories

Based on the confusions, discussions, and debates around the term 'Smart City' presented in the earlier section, the following three categorizations of smart cities can be made:

3.1 The Technology Driven City

This vision is primarily associated with a Technology Centric agenda wherein large-scale multinational ICT providers such as IBM, Siemens, Cisco, etc. encourage and promote the adoption of their proprietary ICT solution to governmental bodies. With its allure of innovation and business opportunities which is highly appealing to urban technology innovators, star-ups and investment firms and the ability to create jobs and impact the economy in a positive fashion, this category of the city can be primarily seen as a city embracing a corporate commercial model. IBM, the primary promotor of this ideology, through its 'Smarter Planet – Smarter Cities' initiative (Palmisano, 2008) has been progressively attracting multiple commissions with various cities globally in order to set up their 'smart' vision. America, in particular, has adhered to this 'corporate smart city model' wherein technology has been advocated as a cure/solution to any and all social, economic, service, and cultural problems. Many criticisms and examples such as PlanIT in Portugal, Songdo in Korea, Masdar in UAE, etc., which are often termed as 'empty cities' are sighted as a bi-product of such models. Researchers such as Anthony Townsend (Townsend, 2013), Soderstrom et al. (2014), Aurigi (Aurigi, 2006), Graham (Graham, 2000) etc. have argued against this model of development.

3.2 The Government Driven – Technology Led City

This category of Smart City is the one wherein the city administration increasingly focuses on deploying technology solutions as enablers to improve the quality of life of people. Authors such as Damieri, (Dameri, 2013), Cocchia (Cocchia, 2014), Kitchin (Kitchin, 2014), to name a few have written and critiqued this approach from the perspective of 'Top-Down' urban planning perspective. This implies that administrators and political class, including municipalities, without the actual or rather limited involvement of the people, deploy their vision of a smart city. This deployment is usually carried forth in consortium with Technology providers and tends to carry an inherent ideology of the all-knowing administrative class whose thinking will genuinely benefit people on-ground. Prominent examples of such cities include the Songdo Business District in Korea, the Incheon Eco-City, South Korea and the Busan Green u-City, South Korea. IBM and its involvement with the Mayor of Rio for deploying IBM's proprietary smart city solutions within the city to monitor landslides, crime detection, central operation centers, etc. is often seen as a prime example of this category of Smart City. However, criticism against this category of smart city is purely based on the decreased potential of understanding, involving, and co-creating the city with people on-ground who are ultimately to benefit from the mega-investments, which smart cities involve. Citizencentric and democratically empowering processes, which would otherwise benefit in the creation of responsible and ethical cities rather than satisfying the demands of major ICT corporates is thus a negative aspect attributed to this category.

3.3 Citizen Co-Creation Driven City

Citizen co-creation, as the name suggests, is a trend that has now caught the attention of various Governmental bodies. After having understood the pitfalls of the previous categories, this category involves processes wherein governments and citizens collectively operate to co-create solutions and raise concerns, which ultimately lead to transparent governance-based development of the city. One can also term this as a shift towards embracing collective intelligence in conjunction with data-driven intelligence. This implies blending the intelligence of citizens/public, intelligence from city's institutions, infrastructure, buildings, and intelligence gathered via data platforms of crowdsourcing, mobile phones, IoT devices, wireless sensor networks, etc. This enables static as well as dynamic real-time data to be incorporated into decision-making processes while more importantly provides the citizens with a platform to actively engage and be heard within processes of evolving their city. Cities such as Vienna, Vancouver, Medellin, and Barcelona have set examples of ingenious urban regeneration strategies, which engage citizens from even the most vulnerable neighborhoods to produce socially responsive urban inserts and innovation districts. According to Robert Ng Henao, an economist heading the smart city department at the University of Medellin, "Medellín's vision of itself as a smart city broke from the usual paradigms of hyper-modernization and automation". He continues to say that "It replaced them with a more anthropocentric vision of the city's future" (David, 2019). This movement has also seen the rise of the 'Sharing City' culture where bottom-up citizen platforms for sharing resources and services are on the rise. A human centric perspective towards developing the city into a holistic smart and equitable place can thus be seen as an emerging ideology.

After this concise description of the categorizations of Smart Cities, the paper will now provide snapshot of two prominent trends of operation within smart cities.

4. Smart City Trends

Smart city governance and operation trends can be roughly categorized into the following two predominant trends:

4.1 The Urban Operating System Approach: A top-down Perspective

The primary characteristics of this mode of operation can be traced as:

a) The Local Government leads with centralized data collection, information generation and decision making.

b) Information is primarily collected through sensors and IoT systems embedded throughout the city and is assimilated in the so called 'Central brain' or smart city data centers, which are primarily owned and controlled by the government (though the ICT applications are predominantly proprietary of multinational ICT corporates).

c) Cross-sectional or Siloed data is usually put together in these data centers in order to mine for new patterns of social, economic, demographic, infrastructure etc. trends. This in-turn results in the development of new policies and orchestration of daily operations.

The Technology-Driven City as well as the Government-driven Technology-led categories of cities such as Rio de Janeiro, Bandung, Bhopal, and Glasgow to name a few have invested heavily in setting up such integrated control command centers in order to harness big-data and real-time information for improved service offering to the city. Reaction to unusual patterns observed within the collected data, in the form of prediction of environmental calamities, congestion, infrastructural overloads, crime, etc. becomes the primary aim of such control command centers. Typical architecture of such centers

involves the systematic working of the following layers: Application and devices layer (including audio, video, environmental, energy and crowdsourcing hardware), Integration layer (involving application programming interfaces, software development kits, webservices and databases), Analytics layer (including command center platforms, data analytics suites, AI, video and audio analytics packages and predictive learning), and the Integrated Control Centre (including interactive digital wall, operators computer terminals, situation rooms as well as local server rooms). However, points of critique for this trend can be elaborated as follows:

a) Concern over the responsible use of centralized information is considered as a big concern. Sensitive information which can cripple cities as well create social unrest and impact economies thus needs to be scrutinized and managed by responsible people in power.

b) Protection against security breaches is of primary importance in order to protect and safeguard the city's performance engines. Cyber security as well as physical breaches into the servers etc. are of prime importance.

c) Human rights violation and social inequity are a bi-product of this non-transparent form of decision making wherein data collection, analysis and policy making all happen independent of citizen involvement. Situations of imbalanced economic investment and urban growth to benefit certain sectors of vested interests could thus become a dangerous proposition.

4.2 The Self-Organizing System Approach: A bottom-up Perspective

This approach, as the name suggests portrays a bottom-up initiative to understand the city. Some benefits of this approach can be outlined as follows:

a) This approach follows a decentralized model that relies on citizens to generate, share, and make the most of the data to inform decision-making processes.

b) This approach truly harnesses the power of crowd-sourcing and human-in the loop models wherein the role of the citizen and the demands and needs of the citizen gain primary importance.

c) Local authorities are usually responsible for building common platforms guaranteeing the availability of proof of data to citizens, regulating usage and responding to needs of the citizens.

Lately, multiple applications such as Nextdoor (https://au.nextdoor.com/), Neighbourlytics (https://www.neighbourlytics.com/), etc. which are more focused on the scale of precincts rather than the entire city, are good examples of this approach. Such applications, via the use of citizen participation not only help in understanding neighborhoods from a grass roots level but also are ultimately able to measure quality of life and wellbeing in cities. Data aggregated from local sources such as restaurants, public social media sites, comments by locals, etc. are usually compiled into interactive dashboards in order to be accessed openly in rather intuitive formats. The regular citizen as well as government bodies, town planners, urban developers, etc. are accordingly able to develop and deliver propositions that are based on this ground level understanding of the community and hence are able to benefit local conditions by producing socially and economically viable conditions. Sharing platforms such as Repair Cafes (https://repaircafe.org/en/), as well as platforms such as Gumtree, Marktplaats (The Netherlands), etc. are all new business models wherein people share, exchange, and sell services as well as goods instead of throwing unwanted goods into landfills. Such bottom-up collective effort of citizens presents a new opportunity for re-thinking and evolving the city in a bottom-up perspective.

Issues such as non-scalability of certain platforms as well as non-equitable development of the city primarily based on the demographic, financial and digital literacy rate of the neighborhoods have been seen as limitations to this approach.

From this cursory account of a Smart City, its chronological evolution, categorization and operational structure, outline fragmentation as regards consolidated views on a singular definition as well as operational models. These have also resulted in diverging research directions, which highlight the points of debate between the technical, the social, the collective, the top down, and the bottom up counterparts of thinking about the smart city. It has also become substantially clear that Technology and its growth has had a significant influence on shaping cities and influencing both governmental bodies as well as the citizen wherein the smart city debate again diverts between corporate models of smart cities vs user based participatory means of governance. In order to speculate on a neutral and balanced model, this paper further suggests understanding and conceiving smart cities as socio-technical systems in their own right. A concise discussion on this view including a model for understanding the city as an ecology is thus presented in the following section.

5. A Socio-Technical System (STS) Model for Developing Smart Cities

Socio-technical systems in essence try to embody interactions between people, technology, and environments (Stevens & Salmon, 2017). It is interesting to note that such a system considers hardware, software, personnel as well as community aspects and thus offer a perfect solution to the otherwise technical or human focused attitudes towards developing smart cities. Fusion between social science domains such as social structures, rights, roles, behavior, etc. and technologies and community structures are thus at the crux of such systems. With a basis in 'General Systems Theory', which focus on the common element 'Systems' within all sciences thus creating a situation wherein no one particular science outweighs the other, a democratic platform for integrating multiple facets of a city can be offered via this perspective. Interestingly, a new perspective on technology, "technology being built to social requirements" wherein there is an inherent understanding that participatory rather than top-down technocentric approaches lead to a fulfilling future, can thus be put into practice. A community level-based understanding from a holistic perspective, which the STS model promotes, is thus considered far higher in value than purely Mechanical, Informational or for that matter purely Human level (Whutworth & Adnan, 2013) and can thus benefit in envisioning the smart city.

User participation (all stakeholders), within the process of conceiving smart cities is thus of paramount importance in order to avoid a siloed focus on the development of a city. This can allow for a variety of benefits such as: Greater engagement between stakeholders and associated technologies; democratic ways of gathering, sharing and understanding data (on-ground, which outlines multiple needs, behaviors and traits); understanding of how the city operates in its original form; and extrapolating information from gathered data in a transparent manner and thus developing an informed understanding of what and how to improve the city/system. This crucial human component can prove very critical in developing successful renditions of so called 'Smart' cities, which essentially develop owing to a fusion of collective and responsible data driven perspective. After the Travistock Institute of Human Relations coined the term 'sociotechnical' (Mumford, 2000), authors and thinkers such as Albert Cherns (Cherns, 1976, 1987), Enid Mumford (Effective Technical & Human Implementation of Computer-based Systems (ETHICS) (Mumford & Weir, 1979)) and many others have written extensively on the socio-technical perspective.

Leavitt's (1965) Diamond (Fig. 1), also called Leavitt's System model, is a model for understanding the effects of a change strategy on an organization. This research conceptualizes Leavitt's model to a customized socio-technical system model (PACT model) for conceptualizing smart cities. Leavitt's model consisted of four key components, which are all interdependent and exchange information with each other: Structure, Technology, People (actors), and Task. Herein, (a) People are not only looked at from the perspective of their designations but also from the perspective of their skills, efficiency, knowledge, and productivity; (b) Tasks include goals and thus involve a deliberate link between how things are being done currently and what one is trying to achieve; (c) Structure apart

from understanding hierarchies, is also concerned with understanding relationships, communication patterns, and coordination between different subsystems such as management, departments, employees, etc.; and (d) Technology is seen from a faciliatory perspective for enabling people to perform tasks. Understanding the impacts of each of these elements on each other in order to assess the impact of a change and thus taking informed decisions is what is of primary importance within this model.

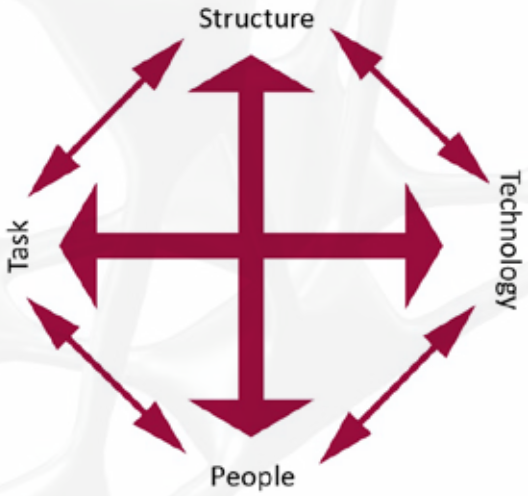

Figure 1: Leavitt's Diamond/Leavitt's System Model (Image source: ACCIPIO, https://www.accipio.com/eleadership/mod/wiki/view.php?id=1837)

The city on the other hand, is a complex socio-technical system, and in the case of this research is considered as an 'Ecology' of four interlinked components in its own right. An adapted model for the informed bottom-up conception of smart cities as shown in Fig. 2 thus introduces these four components as: People, Activity, Context and Technology. Borrowing from the PACT framework proposition, popularized by David Benyon via his book Designing Interactive Systems (Benyon, 2014), the City is seen from the perspective of real-time interactions between these four components, which ultimately shape the idea of an 'Ecology'. Ecology, by definition is a branch in biology, which studies the interactions among organisms and their biophysical environment (both biotic and abiotic components).

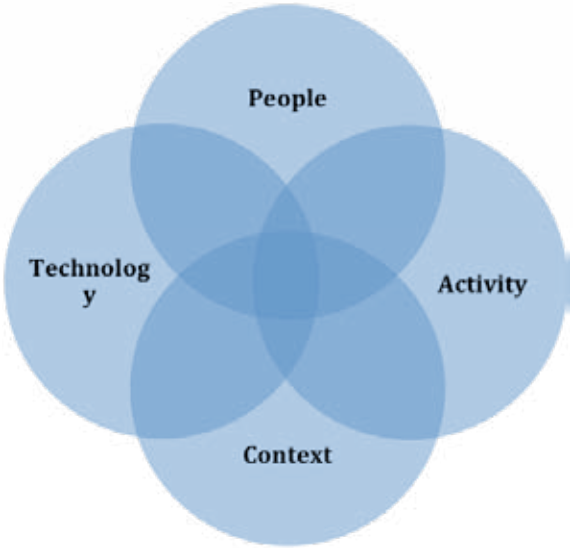

Figure 2: Proposed PACT Model with the city considered as an ecology (Image source: Author)

The proposed model in the case of this research paper is based on the premise that people perform actions as a response to their immediate context with the aid of technologies. A looped logic in the form of activity-based requirements of people which give rise to user-centric technologies, which, in-turn can create opportunities that can change the nature of activities being performed in different situations is thus at play. Acknowledging the fact that people are dynamic actors, who, change their requirements and look for improvements and innovations to impact their wellbeing, and thus acknowledging the city as a dynamic ecology which is in a constant state of flux should lie at the core of developing a smart networked practice for impacting the city. Therefore, solutions sought at the intersection of these four components while keeping in mind the dynamic cyclic nature of evolution and thus the inherent scalability of the solutions (Smart ecologies: SE, as seen in Figure 2) as an ecosystem should constitute the smart city. This ecosystem of implemented solutions is what should ultimately define how smart a city is.

In this proposed model, the following is the manner that we can break down each component:

6. People

Firstly, it is important to understand that people are diverse in their inherent nature, thinking, liking, and behaviors. Attributes belonging to both physiological and psychological aspects of our operations thus need vital consideration. This is also particularly important that the smart solutions being developed are equitable and ethical and are responsive towards the differently abled and the vulnerable sections of the society. From a wider stakeholder perspective, People, as a terminology covers users/everyday citizen, city administrators and associated government bodies, as well as corporations who have their stake in the development of the city. The requirements of each of these groups with respect to the services that are being developed should be considered. This implies thinking about the everyday user of the developed service (for instance finding a parking spot quickly and easily); about the systems operator (in charge of maintaining local smart solution systems such as parking apps or smart bins); about the systems developer (in charge of conducting predictive analysis on the collected data); and about the managers (managing overall consumption vs production logics of the respective service). It is thus of vital importance that the nature of activities and the context within which these activities are being performed by these diverse set of stakeholders be considered before imposing technologies. On the contrary, technological development should be imbedded within this understanding of relations, needs, and behaviors of the stakeholders. Factors such as user acceptance owing to the perceived ease of use, the benefits and usefulness as well as the careful crafting and introduction of technologies within a given context to promote behavioral change are all critical to the success of any smart city. Administrators as well as corporations should also be equally participative in order to develop more transparent modes of governance as well as communicating outcomes, benefits and failures apart from taking leadership in adopting participatory models (such as the quadruple helix model wherein governments, industry, academia and citizen groups collaborate) for the development of smart cities.

7. Activity

This component concerns understanding the variety of activities and tasks that people perform and thus extract the nature of services that need to be provided and improved upon either with or without the aid of technology. This implies understanding both the purpose of the activity/task as well as the critical features that aid or disrupt the performance of the activity in an optimal fashion. Essentially cities and their operations which impact the wellbeing of the citizens can be categorized via the following service provisions: Transport (accessibility, infrastructure development, etc.), Health (both mental and physical), Environment (including pollution, heat, climate impact, energy usage), Education (educational institutions and associated policies), Real-estate and public spaces

(management and maintenance), Safety (law and order, emergency services, etc.), Economy (business growth, job creation, incentives, etc.), Utilities (water, gas, electricity, waste removal, etc.), and Administration (monitoring, city planning, legislation, etc.). It is critical that before heavily investing in technologies to enhance these essential activities and tasks we analyze, understand, and reason the necessity and the expected impact which is expected by the so-called smartification of these activity segments. Besides this, it is also vital to note that the city can also be seen as a collage, which implies that different suburbs have different needs, demographics, and contexts, which render the careful attribution of development of the aforementioned segments in different proportions. One strategy fitting and solving the needs and requirements of the entire city is thus not necessarily the correct way to approach the city. The role of people/communities and their socio-cultural as well as economic contexts thus becomes key to deploying smart measures. For instance, strategies such as reduction of traffic congestion vs encouraging use of public transport and active mobility means; energy supply vs reduction of waste; increasing better level of education vs maintaining affordability of good education; increasing e-health opportunities vs understanding digital literacy; increasing police presence vs encouraging social policing; deploying smart bins vs understanding the demographic and real-estate based migration patterns, etc. should all be determined after carefully understanding interrelated impacts of the proposed STS components.

8. Context

As is clear from the above expansion on the term Activity, it is important that 'Context' and 'Activity' be interlinked intrinsically while understanding the city. Context in this sense varies from social, economic, as well as geographic phenomenon, which, in themselves are determinants of the nature of activity being performed. These in-turn impact the manner in which nature of communication with governmental bodies and city administrators (deployed using smart technologies) would need to differ in order to receive feedback from the people on-ground. Socially and economically backward locations are often synonymous with high rates of crime, non-unitary community front, hierarchical managements, and often suffer from lack of education and digital literacy. In such circumstance's traditional structures of governance, wherein people (in biased and at times forced or coerced situations) elect governing representatives and thereafter are not engaged in decision-making processes, take precedence. The slow yet participatory modes of engaging with such contexts in order to educate as well as learn about intricacies of social, economic, and powerplay modalities is thus vital instead of imposing an all-knowing smart surveillance system. This is particularly useful if one needs to look at long-term solutions and gradually build up context sensitive smart means of evolving the status of such sensitive contexts. Strategies for engaging citizens by providing them with a transparent and democratic platform for participating in decision-making processes is thus key to developing smart and ethical cities. Besides this, geographic contexts, which present their own challenges in terms of terrain, flooding, over-densification, urban heat gain, excessive consumption of energy as well as hindrance to positioning of economic generators owing to susceptibility of city regions are also vital and should be considered while deriving smart and resilient place making solutions. Precinct level solution sets, which are deeply embedded in understanding local contexts are thus considered key to developing networked smart ecologies.

9. Technology

As is evident from the discussions pertaining to the above three interdependent components, Technology should be highly interconnected with supporting and aiding people in improving and enhancing their activities within their respective contexts. Rather than a top-down construct, Technology, specially within the domain of smart cities, should evolve in a bottom-up user and context centric manner for it to be accepted without disrupting ethical boundaries. Technology within the city can take up multiple

forms. If we look at it at a scalar level, then we can essentially categorize it into two levels:

- The city's civic infrastructure scale

This can range from most essential 'network infrastructure' provision in the form of internet connectivity (both fixed and mobile broadband) as a fundamental human right for enabling unbiased communication options; 'IoT and distributed sensing systems' to monitor, capture and relay data pertaining to environmental factors (urban heat, water levels, pollution levels, air quality etc.); civil safety and security (street cameras, integrated panic buttons within smart light poles, adequate lighting etc.); traffic and mobility infrastructure (smart parking, optimized paid parking etc.); services monitoring (energy, water, electricity production vs consumption, smart bins and regulated garbage disposal etc.).

- The context specific governance scale

These are in the form of control centers for data assimilation, storage, and analysis to enable transparent and un-biased decision-making. It is vital though that such data centers also incorporate citizen needs and contextual condition-based datasets as a part and parcel of the decision-making process rather than simply taking a siloed view on the gathered data. A leap from big-data thinking to linked-data thinking is thus of prior value for any smart city initiative. Clever ways of embedding and extracting knowledge from qualitative feedback of users together with the more granular quantitative data sets collected from the city's civic infrastructure scale is thus key for developing associated software and AI and Machine Learning protocols within such control havens. Apart from technologists, the proposed PACT framework encourages decision-making to become a collaborative process wherein citizen, specialists from multiple domains, economists, sociologists, technologists, etc. are given equal opportunity to understand datasets and are thus able to present informed suggestions for the better governance of the city.

- The user/citizen scale

These are quintessential interfaces enabling communication (bi-direction communication should be given preference). Apart from citizen reporting platforms, which make governing bodies aware of the on-ground difficulties that citizens face every day, collaborative platforms in the form of mobile applications such as the Neighbourly app, dedicated citizens forums, community web sites, newsletters, IoT enabled precinct scale reporting tools as well as health and fitness-based applications, etc. are all a part and parcel of such citizen scale initiatives. Community engagement on sensitive issues such as safety for women, children and elderly as well as the state of existing infrastructure which services their own needs daily by the intuitive use of technology is thus crucial to understanding the state of the city. It is this aggregated on-ground reporting wherein people themselves transform into sensors and thus part-take in developing data streams which influence active decision-making, which is much needed for developing healthy and ethical smart cities.

10. Conclusion

This research, while shedding light on the term 'Smart City', elaborates upon the categories and operating trends of smart cities and outlined two prominent yet conflicting ideologies: Techno-centric vs Human-centric, which persist till date. Socio-Technical Systems oriented approach towards understanding the city has been proposed as an ideal approach towards diluting and merging the pros and cons, which emerge from this ideological debate. Herein, a case for an ecological perspective for understanding and re-thinking the smart city in the form of a People, Activity, Context, and Technology

(PACT) model is presented. It is also imperative to understand the city as a dynamic eco-system in its own right and thus the sustained need for understanding the needs, demands, and desires of citizens with respect to the social, economic, geographic, and cultural context within which they perform activities with the help of technologies is presented as paramount. These four components and their equal status (akin to general systems theory perspective) has been projected as a given in order to build resilient smart cities. One can thus project perceiving the 'City as a Laboratory' as an appropriate way to progress towards attaining the goal of developing smart cities via iterative experimentations using the proposed socio-technical system model. Local urban dynamics in conjunction with local needs and the appropriate infusion of technologies while understanding the context within which cities need to evolve is thus the key to developing smart design ecologies which will in turn produce smart and sustainable cities.

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Cite this article as: Biloria N., "Smart Cities: A Socio-Technical Perspective", *International Conference on the 4th Game Set and Match (GSM4Q-2019)*, Doha, Qatar, 6-7 February 2019, https://doi.org/10.29117/gsm4q.2019.0020