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Conceptualizing Smart City with Dimensions of Technology, People, and Institutions

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ABSTRACT

This conceptual paper discusses how we can consider a particular city as a smart one, drawing on recent practices to make cities smart. A set of the common multidimensional components underlying the smart city concept and the core factors for a successful smart city initiative is identified by exploring current working definitions of smart city and a diversity of various conceptual relatives similar to smart city. The paper offers strategic principles aligning to the three main dimensions (technology, people, and institutions) of smart city: integration of infrastructures and technology-mediated services, social learning for strengthening human infrastructure, and governance for institutional improvement and citizen engagement.

Categories and Subject Descriptors

H.4.2 [Information Systems Applications]:

Type of systems – *e-government applications*

General Terms

Management, Performance, Human Factors, Standardization, Theory

Keywords

Smart city, Smart technology, Service integration, Infrastructure integration, Governance

1. MOTIVATION OF RESEARCH

The city, as a government unit, is growing increasingly larger, more complex and more important as the population ranks of urban areas swell with ever increasing speed. According to the United Nations Population Fund (see www.unfpa.org), 2008 marked the year when more than 50 percent of all people, 3.3 billion, lived in urban areas. By 2030 this number is expected to increase to 5 billion. With the rapid increase of the urban population worldwide, cities face a variety of risks, concerns, and problems; for example, physical risks such as deteriorating conditions in air and transportation, and economic risks such as unemployment. **The unprecedented rate of urban growth creates an urgency to finding smarter ways to manage the accompanying**

challenges. Some cities are identified to successfully operate in a smarter way to solve concerns. Recent practices to make cities better for living have become successful cases for new city development strategies. We need to learn from the successfully progressive practices of the cities listed below or more.

Table 1. The List of Smart Cities

Region	Cities
Asia	Bangalore (India); Chongqing (China); Doha (Qatar); Gangnam District, Seoul (Korea); Hong Kong; HwaSeong-DongTan (Korea); Hyderabad (India); Ichikawa (Japan); Jaipur, Rajasthan (India); Jia Ding (China); Kabul (Afghanistan); Mitaka (Japan); Shanghai (China); Seoul (Korea); Singapore; Suwon (Korea); Taipei (Taiwan); Taoyuan County (Taiwan); Tel Aviv (Israel); Tianjin (China); Yokosuka (Japan)
Africa	Cape Town (South Africa); Nelson Mandela Bay (South Africa)
Europe	Besançon (France); Birmingham (UK); Dundee, Scotland (UK); Eindhoven (Netherlands); Glasgow, Scotland (UK); Hammarby Sjostad (Sweden); Issy-les-Moulineaux (France); Karlskrona (Sweden); Malta (Malta); Manchester (UK); Reykjavik (Iceland); Sopron (Hungary); Stockholm (Sweden); Tallinn (Estonia); Sunderland (UK); Trikala (Greece)
North America	US: Albany (New York); Ashland (Oregon); Arlington County (Virginia); Bettendorf (Iowa); Bristol (Virginia); Chattanooga (Tennessee); Cleveland (Ohio); Corpus Christi (Texas); Dakota County (Minnesota); Danville (Virginia); Dublin (Ohio); Florida High Tech Corridor; LaGrange (Georgia); Northeast Ohio; Loma Linda (California); Riverside (California); San Francisco; Spokane (Washington); Westchester County (New York); Winston-Salem (Carolina) Canada: Burlington (Ontario); Calgary (Alberta); Edmonton (Alberta); Fredericton (New Brunswick); Kenora (Ontario); Moncton (New Brunswick); Ottawa (Ontario); Quebec City (Quebec); Stratford (Ontario); Toronto (Ontario); Vancouver (British Columbia); Waterloo (Ontario); Western Valley (Nova Scotia); Windsor-Essex (Ontario); Winnipeg (Manitoba)
Middle/South America	Barceloneta (Puerto Rico); Curitiba, Paraná (Brazil); Pirai (Brazil); Porto Alegre (Brazil)
Oceania	Ballarat (Australia); Gold Coast City (Australia); Ipswich, Queensland (Australia); State of Victoria (Australia); Whittlesea, Victoria (Australia)

Source:

<https://www.intelligentcommunity.org/index.php?submenu=Awards&src=gendocs&ref=Smart21&category=Events&link=Smart21>

Intelligent Community Forum (ICF) annually announces cities awarded as Smart21 Communities, which earns high score in terms of five successful factors to be an intelligent community

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(i.e., broadband connectivity, knowledge workforce, digital inclusion, innovation, and marketing and advocacy). Table 1 describes the cumulative list of cities (in an alphabetical order) awarded by ICF from 2007 to 2011. Practices in the cities listed up deserve attention. Quebec City in Canada was a city highly dependent upon its provincial government because of its weak industrial base until early 1990s. The city government kicked off a public-private partnership to support the growing multimedia sector and high-tech entrepreneurship. For sustainable urban growth, the City of Riverside in California is improving traffic flow and replacing aging water, sewer and electric infrastructure by tech-based transformation. Estonia overcame post-Soviet economic ruin, and its capital city Tallinn played as a center to economic development, harnessing information and communication technologies (ICTs). The city developed a large-scale digital skills training program, extensive e-government, and an award-winning smart ID card. By fostering high-tech parks, Tallinn gains about 80 percent of Estonia's foreign direct investment. Taoyuan County in Taiwan is home to the international airport. It faced powerful competition from other cities. The Aerotropolis initiative makes its economy more robust and improve the quality of living through ICTs. A series of the county government's projects has evolved from *E-Taoyuan* to *M-Taoyuan* to *U-Taoyuan*.

A common fact underlies the practices: that is, those cities are meeting a growing demand for more livable cities. The cities are being labeled with a common phrase: *smart city*. The concept of smart city is not novel, but in the recent years it has taken on a new dimension of using ICTs to build and integrate critical infrastructures and services of a city. The initiatives of making a city smart have recently emerged as a model to mitigate and remedy current urban problems and make cities better as places to live. Hence some view smart city as an icon of a sustainably livable city. Yet, so far we see academics have seldom tackled the practical concept. Considering that, we take an analytic look at the conceptual identity of smart city.

We see commentators confused between visions and basic components of smart city. While a majority of discussions present rosy visions and ideal images of smart city (e.g., smart transportation, smart mobility, smart environment, smart energy, smart safety, and so on), little research has tackled enabling factors of a smart city initiative (what really makes cities smart). Concepts and success factors of smart city have not been discussed with a comprehensive understanding. The discussion of smart city has been made without solid conceptualization.

In this sense, we recognize a research gap in the current literature of smart city. Considering the gap, we raise various conceptual questions. What are main characteristics of smart city? In what aspects do people label some particular cities as smart city? Why is smart city being recognized as a novel concept, making distinction from other similar ones? What leads to the success of a smart city initiative? This paper seeks to answer these inquiries, fill the research gap, and conceptualize smart city for both academics' and practitioners' use of that concept.

This paper aims to suggest a framework connecting conceptual variants of the smart city label, key elements for being a smart city, and strategic principles for making a city smart. The paper after this introduction is organized into five sections. Section 2 defines smart city by specifying the meanings of smartness in the urban context, exploring current definitions of smart city, and understanding smart city as a broad concept comprising its

conceptual relatives. Section 3 derives prerequisites or central components of smart city from the recent literature. Section 4 discusses what strategic principles contribute to the success of smart city initiatives. The last section addresses concluding remarks.

2. DEFINING SMART CITY

The definitions of smart city are various. As the concept is being known popularly but used all over the world with different names and in different circumstances, there are a range of conceptual variants generated by replacing *smart* with other alternative adjectives. Hollands [41] recognized smart city as an "urban labeling" phenomenon, particularly in terms of what the label ideologically reveals as well as hides. The label smart city is a fuzzy concept and is used in ways that are not always consistent. **There is neither a single template of framing smart city nor a one-size-fits-all definition of smart city.** This section seeks to dismantle "the diversifying terrain of smart cities" [12].

2.1 The Meanings of "Smart" in the Smart City Context

Tracing the genealogy of the word *smart* in the label smart city can contribute to an understanding of how the term *smart* is being loaded. In marketing language, smartness is centered on a *user perspective* [50]. Because of the need for appeal to a broader base of community members, smart serves better than the more elitist term intelligent. Smart is more *user-friendly* than intelligent, which is limited to having a quick mind and being responsive to feedback. Smart city is required to adapt itself to the user needs and to provide customized interfaces [62].

In the urban planning field, the smartness in smart growth is treated as a *normative* claim and *ideological* dimension. Being smarter entails *strategic* directions. Governments and public agencies at all levels are embracing the notion of smartness to distinguish their new policies, strategies, and programs for targeting sustainable development, sound economic growth, and better quality of life for their citizens [19]. They associate smart with achieving policy success in their jurisdictions.

The smartness in smart technologies also merits attention. The technologies had permeated into the commercial application of intelligent-acting products and services, artificial intelligence, and thinking machines [51,66]. Smartness in the technology context implies the automatic computing principle like self-configuration, self-healing, self-protection, and self-optimization [75]. Smart homes, smart buildings, and larger smart ensembles like airports, hospitals or university campuses are equipped with a multitude of mobile terminals and embedded devices as well as connected sensors and actuators [50]. *Smart ecosystem* is a conceptual extension of smart space from the personal context to the larger community and the entire city [88].

2.2 Working Definitions of Smart City

Table 1 presents working definitions of smart city. Washburn *et al.* [80] conceptualizes smart city by laying an explicit emphasis on the use of smart computing technologies. They viewed current urban crises as an imperative of a smart city initiative. Deteriorating conditions of cities in a crisis include scarcity of resources, inadequate and poor infrastructure, energy shortages and price instability, global environmental concerns, and human health concerns. Giffinger *et al.* [35] highlighted the performance of smart city in economy, people, governance, mobility,

environment, and living. The Smarter Cities project of the Natural Resources Defense Council (see <http://smartercities.nrdc.org>) conceptualizes smart city by highlighting positive outcomes made by being smarter.

Some definitions stress technologies. The key part of R. Hall's [39] definition is "city that monitors and integrates conditions of all of its critical infrastructures." One of core mechanisms in smart city is a self-monitoring and self-response system. IBM's view of smart city envisions its three main characteristics: instrumented, interconnected, and intelligent [40]. Instrumentation means sourcing of real-time real-world data from both physical and virtual sensors. Such data may be interconnected across multiple processes, systems, organizations, industries, or value chains. The combination of instrumented and interconnected systems effectively connects the physical world to the virtual world.

Other definitions highlight different aspects. Rios's [73] approach is based on an architectural lens. He sees smart city as a city that gives inspiration, shares culture, knowledge, and life, and motivates its inhabitants to create and flourish in their own lives. Partridge's [69] observation of Brisbane in Australia sheds light on social inclusion and equal participation as enhanced opportunities created by smart city initiatives.

Table 2. Definitions of Smart City

	Definition
[80]	"The use of Smart Computing technologies to make the critical infrastructure components and services of a city—which include city administration, education, healthcare, public safety, real estate, transportation, and utilities—more intelligent, interconnected, and efficient."
[35]	"A city well performing in a forward-looking way in economy, people, governance, mobility, environment, and living, built on the smart combination of endowments and activities of self-decise, independent and aware citizens."
NRDC	A city striving to make itself "smarter" (more efficient, sustainable, equitable, and livable)
[39]	A city that monitors and integrates conditions of all of its critical infrastructures, including roads, bridges, tunnels, rails, subways, airports, seaports, communications, water, power, even major buildings, can better optimize its resources, plan its preventive maintenance activities, and monitor security aspects while maximizing services to its citizens.
[40]	An instrumented, interconnected, and intelligent city. <i>Instrumentation</i> enables the capture and integration of live real-world data through the use of sensors, kiosks, meters, personal devices, appliances, cameras, smart phones, implanted medical devices, the web, and other similar data-acquisition systems, including social networks as networks of human sensors. <i>Interconnected</i> means the integration of those data into an enterprise computing platform and the communication of such information among the various city services. <i>Intelligent</i> refers to the inclusion of complex analytics, modeling, optimization, and visualization in the operational business processes to make better operational decisions.
[73]	"A city that gives inspiration, shares culture, knowledge, and life, a city that motivates its inhabitants to create and flourish in their own lives"
[69]	"A city where the ICT strengthen the freedom of speech and the accessibility to public information and services"

The smart city concept has been expressed with some metaphors. Importantly, smart city has been viewed as a large organic system. Dirks and Keeling [23] stress the organic integration of systems. The interrelationship between a smart city's core systems is taken into account to make *the system of systems* smarter. No system operates in isolation. A smarter city infuses information into its physical infrastructure to improve conveniences, facilitate mobility, add efficiencies, conserve energy, improve the quality of air and water, identify problems and fix them quickly, recover rapidly from disasters, collect data to make better decisions, deploy resources effectively, and share data to enable collaboration across entities and domains. However, infusing intelligence into each subsystem of a city, one by one—transportation, energy, education, health care, buildings, physical infrastructure, food, water, public safety, etc.—is not enough to become a smarter city. A smarter city should be treated as an *organic whole*—as a *network*, as a *linked system* [49].

While systems in industrial cities were mostly skeleton and skin, postindustrial cities are like organisms that develop an *artificial nervous system*, which enables them to behave in intelligently coordinated ways [65]. The new intelligence of cities, then, resides in the increasingly effective combination of digital telecommunication networks (the nerves), ubiquitously embedded intelligence (the brains), sensors and tags (the sensory organs), and software (the knowledge and cognitive competence). There is a growing web of direct connections to the mechanical and electrical systems of buildings, household appliances, production machinery, process plants, transportation systems, electrical grids and other energy supply networks, water supply and waste removal networks, systems that provide life safety and security, and management systems for just about every imaginable human activity.

2.3 Conceptual Relatives

To build the set of common multidimensional components we need to take a close look at many conceptual cousins of smart city and trace the roots of the terms popularly used. A variety of the labels can be largely categorized into three dimensions: technology, people, and community. The conceptual variants are mutually connected with substantial confusion in definitions and complicated usages rather than independent on each other.

Table 3. Conceptual Relatives of Smart City

Dimensions	Concepts	Studies
Technology	Digital city	[6,46,47,81,82,88]
	Intelligent city	[11,52-4,61]
	Ubiquitous city	[4,5,56]
	Wired city	[24]
	Hybrid city	[77]
People	Information city	[18,74,76]
	Creative city	[31,38,55,78]
	Learning city	[16,20,21,71]
	Humane city	[77]
Community	Knowledge city	[23,26,27,49,84-7]
	Smart community	[14,15,19,20,21,28-30,43,44,49,58,66]

2.3.1 Technology Dimension

There are various cousins of the smart city concept that draws from a technology perspective. A *digital city* refers to “a connected community that combines broadband communications infrastructure; a flexible, service-oriented computing infrastructure based on open industry standards; and, innovative services to meet the needs of governments and their employees, citizens and businesses” [88]. Its goal is to create an environment for information sharing, collaboration, interoperability and seamless experiences for all inhabitants anywhere in the city. Williams [82] views it as a sharing of networks. Through digital technologies and wide-area infrastructures/applications, those networks connect organizations, social groups and enterprises located in a city area [5,6]. For example, Widmayer [81] viewed Chicago as a *digital metropolis* consisting of large networks.

The notion of an *intelligent city* emerges at the crossing of the knowledge society (a society in which knowledge and creativity have great emphasis and intangible, human and social capital are considered the most valuable asset) with the digital city [66]. Malek [61] defined an intelligent city as a city that has all the infrastructure and infostructure of information technology, the latest technology in telecommunications, electronic and mechanical technology. According to Komninos and Sefertzi [54], initiatives for intelligent cities make conscious efforts to use information technology to transform life and work within its region in significant and fundamental rather than incremental ways.

There is a conceptual and practical distinction between digital city and intelligent city. The label intelligent city is usually used to characterize a city that has the ability to support learning, technological development, and innovation procedures. In this sense, every digital city is not necessarily intelligent, but every intelligent city has digital components. Both terms are different in the linkage between real city and virtual city. Digital city involves every function of the city such as work, housing, movement, recreation, and environment. Intelligent city primarily involves functions of research, technology transfer, product development, and technological innovation, as a hotbed of innovative industries [54], analogous to knowledge city.

In a *virtual city*, city functions are implemented in a cyberspace [12]. Given the experiential blurring between cyberspace and material space [89], the category of the smart city concept comprises the notion of a *hybrid city* [77], which consists of a reality with its physical entities and real inhabitants and a parallel virtual city of counterparts of real entities and people. Today some cities are experienced as and constituted within virtual and material spaces simultaneously. However, physical distance and location still have importance for consideration [12,63]. Hyperbolic claims that distance will be dead soon belie an important paradox in cyberspace research. The vision of the world without distance still remains unmet in many ways. In practice, ubiquitous cloud of communication is underpinned and enabled by a vast, physical (placed) IT infrastructure of cables, data centers, and exchanges. Place still matters, though virtualization in many cities is accelerating.

A *ubiquitous city* (U-city) is a further extension of digital city concept in terms of ubiquitous accessibility and infrastructure [4,5]. It makes the ubiquitous computing available to the urban elements such as people, building, infrastructure and open space [56]. Its aim is to create a built environment where any citizen can get any services anywhere and anytime through any devices. The

ubiquitous city is quite different from the well-known virtual city. While the virtual city reproduces urban elements by visualizing them within the virtual space, ubiquitous city is created by the computer chips or sensors inserted to those urban elements.

An *information city* refers to digital environments collecting information from local communities and delivering it to the public via web portals [5,74,76,81]. In that city, many info-habitants are able to live and work on the Internet. An information city is an urban center for commerce, social and civic services, and social interactions among people, businesses and government institutions [74,76].

2.3.2 Human Dimension

Creativity is recognized as a key driver to smart city, and thus people, education, learning and knowledge have central importance to smart city. The expansive notion of smart city includes creating a climate suitable for an emerging creative class [12]. A *creative city* is one of smart city visions. Human infrastructure (i.e., creative occupations and workforce, knowledge networks, voluntary organizations, crime-free environments, after-dark entertainment economy) is a crucial axis for city development [31].

Social infrastructure (intellectual capital and social capital) is indispensable endowment to smart cities. That infrastructure is about people and their relationship. Smart people generate and benefit from social capital. Smart city is about a mix of education/training, culture/arts, and business/commerce [7] and a hybrid mix of social enterprise, cultural enterprise, and economic enterprise.

A smart city is a *humane city* that has multiple opportunities to exploit its human potential and lead a creative life. Focusing on education, Winters [83] analyzed why smart cities are growing, who moves, and who stays. In his view, a smart city is a center of higher education and better-educated individuals. Similarly, a smart city is full of skilled workforces [37]. The knowledge worker and the high tech knowledge-sensitive industries migrate into highly livable communities [28]. The smartness of workforce diverges between cities. Smart places are getting smarter while other places getting less smarter because such places act as a magnet for creative people and workers [60]. Along with the inflow of smart people, new creative culture driven by them is a drive to urban development. Švob-Đokić [78] lauded the outcome of creative culture that extends beyond diversity and creativity to economic performance and social tolerance.

A smart city is also a *learning city*, which improves the competitiveness of urban contexts in the global knowledge economy [71]. Learning cities are actively involved in building a skilled information economy workforce [66]. Campbell [16] established a typology of cities that are learning to be smart: individually proactive city, city cluster, one-to-one link between cities, and city network.

A *knowledge city* is analogous to a learning city. It refers to “a city that was purposefully designed to encourage the nurturing of knowledge” [26]. Technopolis and ideapolis, early articulations of a knowledge city, have evolved into digital, intelligent or smart city [85]. The notion of knowledge city is interchangeable to a certain degree with similar evolving concepts such as intelligent city, educating city, or smart city [25,52]. However, a knowledge city is heavily related to knowledge economy, and its distinction is stress on innovation [22]. Knowledge-based urban development has become an important

mechanism for the development of knowledge cities. The buzz concept of being clever, smart, skillful, creative, networked, connected, and competitive has become some of the key ingredients of knowledge-based urban development [84-7].

2.3.3 Institutional Dimension

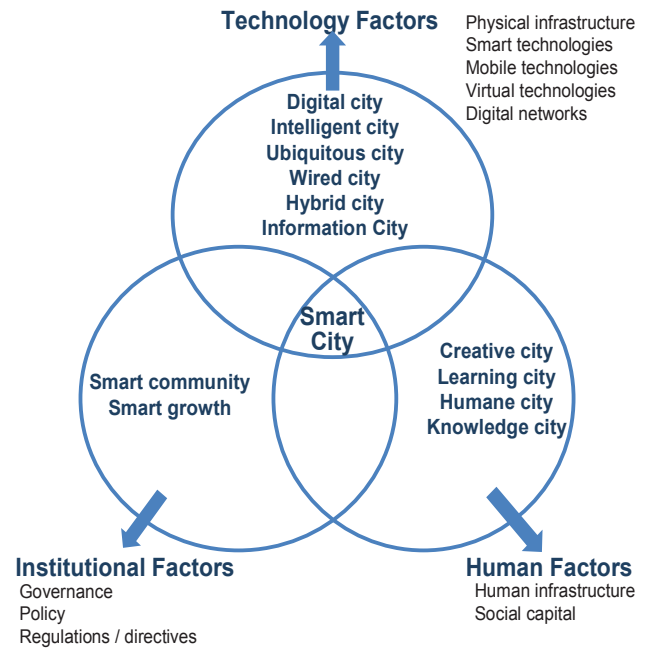
The Smart Communities movement took shape over the 1990s as a strategy to broaden the base of users involved in IT [66]. A smart community should be defined as a community broadly ranging from a small neighborhood to a nation-wide community of common or shared interest, whose members, organizations and governing institutions are working in partnership to use IT to transform their circumstances in significant ways [43]. The concept highlights governance among stakeholders and institutional factors for governance. California Institute for Smart Communities [15] elaborated the concept: “a community in which government, business, and residents understand the potential of information technology, and make a conscious decision to use that technology to transform life and work in their region in significant and positive ways.” With a holistic view, a smarter community is composed of not only a more integrated, collaborative, and inclusive “whole” but also of multiple neighborhoods and communities of interest and of kind [49,58]. A smart community makes a conscious and agreed-upon decision to deploy technology as a catalyst to solving its social and business needs [28,29]. Technological propagation is not an end in itself, but only a means to reinventing cities for a new economy and society. Institutional preparation and community governance are essential to the success of smart community initiatives.

Building and planning a smart community seeks for smart growth [66]. Smart growth was the most use of the term smart in the urban context before the concept of smart city emerges [79]. The smart growth movement had prevailed during the 1990s, as a strong government- and community-driven reaction to worsening trends in traffic congestion, school overcrowding, air pollution, loss of open space, effacement of valued historic places, and skyrocketing public facilities cost [34,45,72]. Smart city resembles some functions of smart growth initiatives as an urban problem solver within or beyond the physical jurisdiction of a community. However, the smart growth concept primarily covers urban growth as the alternative or antidote to spatial sprawl [9,67]. The general implication from smart growth is that the ill-planned, ill-coordinated development provoked the smart growth movement [8]. As urban planning based on governance with multiple stakeholders is pivotal to smart growth, smart city initiatives necessitate governance for their success.

3. CORE COMPONENTS OF SMART CITY

This section discusses a set of fundamental factors which make a city smart according to the literature. From the discussion of conceptual variants of smart city in the preceding section, we identify and clarify key conceptual components of smart city, and re-categorize and simplify them into three categories of core factors: technology (infrastructures of hardware and software), people (creativity, diversity, and education), and institution (governance and policy). Given the connection between the factors, a city is smart when investments in human/social capital and IT infrastructure fuel sustainable growth and enhance a quality of life, through participatory governance [17].

Figure 1. Fundamental Components of Smart City



3.1 Technology Factors

Technology is key to being a smart city because of the use of ICT to transform life and work within a city in significant and fundamental ways [41]. A well-functioning infrastructure is absolutely necessary but not enough to become a smart city. IT infrastructure and applications are prerequisites, but without real engagement and willingness to collaborate and cooperate between public institutions, private sector, voluntary organizations, schools and citizens there is no smart city [58].

Most studies on practices of smart city address issues of technological infrastructure and enabling technologies. The focus on infrastructure and technology stresses accessibility and availability of systems [35,36]. Contrasting with human infrastructure, technological infrastructures have other names such as physical infrastructure [12] and technoware [61]. Washburn *et al.* [80] views smart city as a collection of smart computing technologies applied to critical infrastructure components and services. Smart computing refers to “a new generation of integrated hardware, software, and network technologies that provide IT systems with real-time awareness of the real world and advanced analytics to help people make more intelligent decisions about alternatives and actions that will optimize business processes and business balance sheet results” [80]. Al-Hader *et al.* [1,2] specifies technological components with the framework of smart city development pyramid: smart interface (dash board, common operational platform, integrated web services), smart control systems (automatic control network, local operating network), and smart database resources (database, database server).

Mobile, virtual, and ubiquitous technologies gain importance. Those technologies offer benefits to city dwellers in mobile lifestyle. Smart city application evolves from smart places to networked inhabitants [32]. While the wireless infrastructure is a key element of digital city infrastructure, it is only a first step [1,2]. A set of technological requisites for smart city comprises

network equipments (fiber optic channels and wi-fi networks), public access points (wireless hotspots, kiosks), and service-oriented information systems [5]. A ubiquitous/pervasive computing infrastructure is a key technological component in the build out of a digital city [88]. A smart city provides interoperable, Internet-based government services that enable ubiquitous connectivity to transform key government processes, both internally across departments and employees and externally to citizens and businesses.

3.2 Human Factors

The availability and quality of the IT infrastructure is not the only definition of smart city [17]. Importantly, other definitions stress the role of human infrastructure, human capital and education in urban development [12]. For urban development, Florida [31] suggested 3T (tolerance, technology, and talent), of which two are germane to people and their relationship. Smart people is an important component of smart city [35,36]. The smart people concept comprises various factors like affinity to life long learning, social and ethnic plurality, flexibility, creativity, cosmopolitanism or open-mindedness, and participation in public life. Problems associated with urban agglomerations can be solved by means of creativity, human capital, cooperation among relevant stakeholders, and their bright scientific ideas: in a nutshell, “smart solutions” [17]. The label smart city therefore points to clever solutions by creative people.

The category of human factors highlights creativity, social learning, and education. Smart city is a center of higher education and smart workforce [37,83]. For smart city, Malek [61] emphasizes the importance of humanware, which represents cognitive/creative capability and human skills. Smart city bolsters a creative environment [86]. The category of human factors also includes social inclusion of various urban residents in public services, soft infrastructure (knowledge networks, voluntary organizations, crime-free environments), urban diversity and cultural mix, social/human/relational capital, and knowledge base such as educational institutions and R&D capacities [41,85].

Education is a critical magnet that makes a city attractive. Businesses, organizations, and individuals of all backgrounds gravitate to dynamic learning environments [10]. IT education enabled the vision of Singapore as an intelligent island [59]. Collective intelligence and social learning make a city smarter [20]. The notion of smart community refers to the locus in which networked intelligence is embedded and continuous learning is nurtured. To explain functioning mechanisms of smart community, the hidden portion of the iceberg is collective intelligence and social learning [20]. A smart city initiative becomes an integrated approach to connecting among entire communities (governments, businesses, schools, non-profits, and individual citizens), creating specific services to address city objectives, and advancing collective skills and capacities.

3.3 Institutional Factors

The support of government and policy for governance is fundamental to the design and implementation of smart city initiatives. This category comprises a variety of institutional factors drawing from the discussion of smart community or smart growth initiatives: not just supportive policies but also the role of government, the relationship between government agencies and non-government parties, and their governance. It is necessary to establish *administrative environment* (initiatives, structure, and

engagement) supportive for smart city [86]. To enable smart city initiatives, the category should also include integrated and transparent governance, strategic and promotional activities, networking, and partnerships [68].

IBM [42] presented smart government as one key component for smart city. Smarter government will do more than simply regulate the outputs of economic and societal systems. It interconnects dynamically with citizens, communities, and businesses in real time to spark growth, innovation, and progress. The challenges vary from departmental silos to process delays to the lack of transparency and accountability. Smarter government means collaborating across departments and with communities—to become more transparent and accountable, to manage resources more effectively, and to give citizens access to information about decisions that affect their lives. Leading governments are integrating their service delivery, establishing offices that support multiple services, and placing the most needed transactions on the Web. At the most fundamental level, smarter government means making operations and services truly *citizen-centric*.

The transformation to smart city entails interactions of technological components with political, institutional and transitional components [64]. Political components represent endogenous political elements (directions, city council, city government, city mayor), harmonized by exogenous ones (international pressures, agenda, projects, strategies in prevalence) and verified by best practices. Institutional components are prerequisites as well. Institutional readiness such as removing legal and regulatory barriers is important. Transitional components comprise visions, leadership, and organizational transition in structure.

As a cornerstone of smart city, smart governance means various stakeholders’ (especially citizens’) engagement in decision-making and public/social services [36,37]. IT-mediated governance, so called e-governance, is key to enabling smart city by bringing citizens to a smart city initiative and keeping the decision and implementation process transparent [70]. The central spirit of governance is a citizen-centric, citizen-driven approach. The consideration of stakeholders (i.e., end-users, groups of end-users, IT experts, policy/service domain experts, and public managers) is fundamental to architecture of smart city [5,57]. Successful initiatives are the result by a coalition of business, education, government and individual citizens [58]. A successful smart city can be built from top down or bottom up approaches, but active involvement from every sector of the community is essential. United efforts create synergy, which allows individual projects to build upon each other for faster progress, resulting in the involved, informed and trained critical mass necessary for transformation of how the entire community carries out its work.

4. STRATEGIC DIRECTIONS IN KEY DIMENSIONS

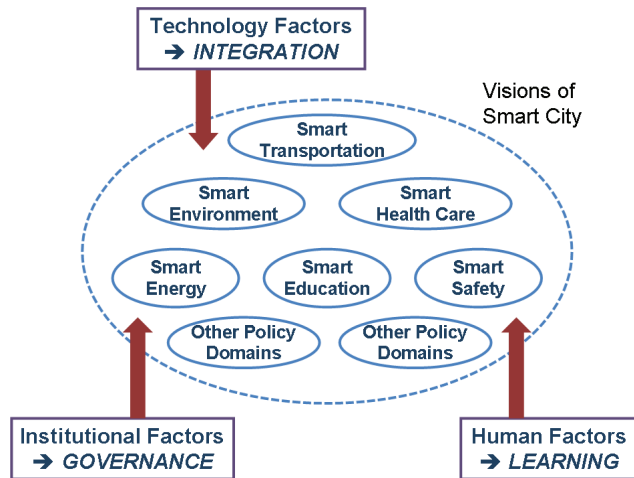
This section offers strategic principles for making a city smart in order to realize the various visions specified for diverse policy domains, aligning to the three categories of core components identified in the preceding section.

4.1 Integration of Technology Factors

A solution to make a city smarter introduces a new level of complexity [48]. The solution should extend beyond technology, but we should still value the indispensable role of technology. Smart city integrates technologies, systems, infrastructures,

services, and capabilities into an organic network that is sufficiently complex for unexpected emergent properties to develop. Integrative service of smart city faces challenges as well as opportunities. The perception of technology in smart city initiatives stresses integration of systems, infrastructures and services mediated through enabling technologies. Technological innovation is a means to smart city, not an ends. IT is just a facilitator for creating a new type of innovative environment, which requires the comprehensive and balanced development of creative skills, innovation-oriented institutions, broadband networks, and virtual collaborative spaces [53].

Figure 2. Strategic Directions of Smart City



4.2 Learning for Human Factors

The emphasis on human infrastructure highlights social learning and education. Towards more progressive smart cities, cities should start with people from the human capital side, rather than blindly believing that IT itself can automatically transform and improve cities [41]. To a substantial extent that is already recognized, the critical factor in any successful city is its people and how they interact. Stronger approaches to awareness, education and leadership offer services that are accessible to all of citizens, get rid of barriers related to language, culture, education, skills development, and disabilities [20]. Social learning soothes the digital divide concern for those who lag behind the prevalent use of the new technologies. Education and training actions should develop IT skills, nurture knowledge workers, facilitate the environment of social learning, and improve IT training in schools, organizations and industries [13].

4.3 Governance of Institutional Factors

Governance encapsulates collaboration, cooperation, partnership, citizen engagement, and participation [20]. Successful cities possess a set of common features [29]. One characteristic is collaboration among different functional sectors and parties (government, business, academics, non-profit and voluntary organizations, and others), and among different jurisdictions within a given geographical region [3,45,58,70]. City government should share concepts (promotional identity and brand), visions, goals, priorities, and even strategic plans of smart city with the public and stakeholders [22,29,68]. Leadership of key leaders and their strong support (championing) of the smart city vision are fundamental to the success of smart city [5,10,14,15,33]. The role

of leadership is pivotal both within government and for its relation with citizens.

5. CONCLUDING REMARKS

We expect that the elaborated conceptualization of smart city in this paper will contribute to future studies. As we explored multiple conceptual dimensions of smart city, the concept is an organic connection among technological, human, and institutional components. Nowadays the usage of “smart” captures innovative and transformative changes driven by new technologies. However, social factors other than smart technologies are central to smart cities. In this sense, a socio-technical view on smart city is needed. Leading a smart city initiative requires a comprehensive understanding of the complexities and interconnections among social and technical factors of services and physical environments in a city. For future research based on a socio-technical view, we must explore both “how do smart technologies change a city?” and “how do traditional institutional and human factors in urban dynamics impact a smart city initiative leveraged by new technologies?”. This research will also explore the practical implications of the conceptual model suggested. To that end, we will continue studying smart city by focusing on exemplar practices of smart city initiatives, considering the dynamics of various stakeholders in those initiatives, and discussing policy innovation in city governments.

6. REFERENCES

- [1] Al-Hader, M., Rodzi, A., Sharif, A. R., & Ahmad, N. (2009a). Smart city components architecture. In *Proceedings of the International Conference on Computational Intelligence, Modelling and Simulation*, (Brno, Czech Republic, Sep 7-9)
- [2] Al-Hader, M., Rodzi, A., Sharif, A. R., & Ahmad, N. (2009b). SOA of smart city geospatial management. In *Proceedings of the 3rd UKSim European Symposium on Computer Modeling and Simulation* (Athens, Greece, Nov 25-27). Available at <http://doi.ieeecomputersociety.org/10.1109/EMS.2009.112>.
- [3] Anderson, G., & Tregoning, H. (1998). Smart growth in our future? In Urban Land Institute (Ed.), *ULI on the Future: Smart Growth* (pp. 4-11). Washington, DC: Urban Land Institute.
- [4] Anthopoulos, L., & Fitsilis, P. (2010a). From digital to ubiquitous cities: Defining a common architecture for urban development. In *Proceedings of the 6th International Conference on Intelligent Environments* (Kuala Lumpur, Malaysia, Jul 19-21).
- [5] Anthopoulos, L., & Fitsilis, P. (2010b). From online to ubiquitous cities: The technical transformation of virtual communities. In A. B. Sideridis & C. Z. Patrikakis (Eds.), *Next Generation Society: Technological and Legal Issues (Proceedings of the Third International Conference, e-Democracy 2009, Athens, Greece, Sep 23-25, 2009)* (Vol. 26, pp. 360-372). Berlin, Germany: Springer. Available at <http://www.springerlink.com/content/g644776482968k36/fulltext.pdf>.
- [6] Anthopoulos, L., & Tsoukalas, I. A. (2005). The implementation model of a digital city. *Journal of E-Government*, 2(2), 91-110.

- [7] Bartlett, L. (2005). Smart city: Social entrepreneurship and community engagement in a rural regional city. In *Proceedings of the International Conference on Engaging Communities*, (Brisbane, Australia, Aug 14-17). Available at <http://www.engagingcommunities2005.org/abstracts/Bartlett-Leo-final.pdf>.
- [8] Beatley, T., & Collins, R. (2000). Smart growth and beyond: Transitioning to a sustainable society. *Virginia Environmental Law Journal*, 19, 287-322.
- [9] Benfield, F. K., Terris, J., & Vorsanger, N. (2001). *Solving Sprawl: Models of Smart Growth in Communities across America*. New York: National Resources Defense Council.
- [10] Boise Smart City Initiative. (2002). *Boise Smart City Initiative Committee Report*. Boise, ID: Capital City Development Corp. Available at http://www.ccdcboise.com/Documents/SC_committee_report_for_screen.pdf.
- [11] Borja, J. (2007). Counterpoint: Intelligent cities and innovative cities. *Universitat Oberta de Catalunya (UOC) Papers: E-Journal on the Knowledge Society*, 5. Available at <http://www.uoc.edu/uocpapers/5/dt/eng/mitchell.pdf>.
- [12] Boulton, A., Brunn, S. D., & Devriendt, L. (Forthcoming). Cyberinfrastructures and "smart" world cities: Physical, human, and soft infrastructures. In P. Taylor, B. Derudder, M. Hoyler & F. Witlox (Eds.), *International Handbook of Globalization and World Cities*. Cheltenham, U.K.: Edward Elgar. Available at http://www.neogeographies.com/documents/cyberinfrastructure_smart_world_cities.pdf.
- [13] Cairney, T., & Speak, G. (2000). *Developing a 'Smart City': Understanding Information Technology Capacity and Establishing an Agenda for Change*. Sydney, Australia: Centre for Regional Research and Innovation, University of Western Sydney. Available at http://trevorcairney.com/file_uploads/cgi-lib.30886.1.IT_Audit.pdf.
- [14] California Institute for Smart Communities. (1997). *Smart Communities Implementation Guide: How California's Communities Can Thrive in the Digital Age*. Available at <http://www.smartcommunities.org/guide/index.html>.
- [15] California Institute for Smart Communities. (2001). *Smart Communities Guide Book*. Available at <http://www.smartcommunities.org/guidebook.html>.
- [16] Campbell, T. (2009). Learning cities: Knowledge, capacity and competitiveness. *Habitat International*, 33(2), 195-201.
- [17] Caragliu, A., Del Bo, C., & Nijkamp, P. (2009). Smart cities in Europe. In *Proceedings of the 3rd Central European Conference in Regional Science* (Košice, Slovak Republic, Oct 7-9). Available at http://www.cers.tuke.sk/cers2009/PDF/01_03_Nijkamp.pdf.
- [18] Castells, M. (1996). *Rise of the Network Society: The Information Age*. Cambridge, MA: Blackwell.
- [19] Center on Governance. (2003). *SmartCapital Evaluation Guidelines Report: Performance Measurement and Assessment of SmartCapital*. Ottawa, Canada: University of Ottawa. Available at http://www.christopherwilson.ca/papers/Guidelines_report_eb2003.pdf.
- [20] Coe, A., Paquet, G., & Roy, J. (2001). E-governance and smart communities: A social learning challenge. *Social Science Computer Review*, 19(1), 80-93.
- [21] Collins, B., Paquet, G., Roy, J., & Wilson, C. (2002). E-governance and smart communities: A social learning challenge. In *Proceedings of the SSHRC Knowledge Based Economy Workshop*, (Newfoundland, Canada, May 10-11). Available at http://www.christopherwilson.ca/papers/Nfld_paper_2002.pdf.
- [22] Dirks, S., Gurdgiev, C., & Keeling, M. (2010). *Smarter Cities for Smarter Growth: How Cities Can Optimize Their Systems for the Talent-Based Economy*. Somers, NY: IBM Global Business Services. Available at <ftp://public.dhe.ibm.com/common/ssi/ecm/en/gbe03348usen/GBE03348USEN.PDF>.
- [23] Dirks, S., & Keeling, M. (2009). *A Vision of Smarter Cities: How Cities Can Lead the Way into a Prosperous and Sustainable Future*. Somers, NY: IBM Global Business Services. Available at <ftp://public.dhe.ibm.com/common/ssi/ecm/en/gbe03227usen/GBE03227USEN.PDF>.
- [24] Dutton, W. H. (1987). *Wired Cities: Shaping the Future of Communications*. London: Macmillan.
- [25] Dvir, R., & Pasher, E. (2004). Innovation engines for knowledge cities: An innovation ecology perspective. *Journal of Knowledge Management*, 8(5), 16-27. Available at <http://www.emeraldinsight.com/journals.htm?issn=1367-3270&volume=8&issue=5&articleid=1506527&show=pdf&PHPSESSID=nhgj3cfuo0c783rinovbv73am1>.
- [26] Edvinsson, L. (2006). Aspects on the city as a knowledge tool. *Journal of Knowledge Management*, 10(5), 6-13. Available at http://www.corporatelongitude.com/download/Aspects_on_city.pdf.
- [27] Edvinsson, L., Dvir, R., Roth, N., & Pasher, E. (2004). Innovations: The new unit of analysis in the knowledge era. *Journal of Intellectual Capital*, 5(1), 40-58.
- [28] Eger, J. M. (2000, Feb 13). Cities: Smart growth and the urban future. The San Diego Union Tribune.
- [29] Eger, J. M. (2009). Smart growth, smart cities, and the crisis at the pump a worldwide phenomenon. *I-Ways*, 32(1), 47-53.
- [30] Eger, J. M., & Maggipinto, A. (2010). Technology as a tool of transformation: e-Cities and the rule of law. In A. D'Atri & D. Saccà (Eds.), *Information Systems: People, Organizations, Institutions, and Technologies* (pp. 23-30). Berlin/Heidelberg, Germany: Physica-Verlag.
- [31] Florida, R. (2002). *The Rise of the Creative Class: And How It's Transforming Work, Leisure, Community and Everyday life*. New York: Basic Books. Available at <http://www.washingtonmonthly.com/features/2001/0205.florida.html>.
- [32] Forest, F., Lavoisy, O., Eurich, M., van Gurp, J., & Wilson, D. (2009). Roadmap for real world Internet applications: Socioeconomic scenarios and design recommendations. In G. Tselentis, J. Domingue, A. Galis, A. Gavras, D. Hausheer, S. Krco, V. Lotz & T. Zahariadis (Eds.), *Towards the Future*

- Internet: A European Research Perspective* (pp. 325-334). Amsterdam, The Netherlands: IOS Press.
- [33] Frece, J. W. (2008). *Sprawl & Politics: The Inside Story of Smart Growth in Maryland*. Albany, NY: State University of New York Press.
- [34] Freilich, R. H. (1999). *From Sprawl to Smart Growth*. Chicago: American Bar Association.
- [35] Giffinger, R., Fertner, C., Kramar, H., Kalasek, R., Pichler-Milanović, N., & Meijers, E. (2007). *Smart Cities: Ranking of European Medium-Sized Cities*. Vienna, Austria: Centre of Regional Science (SRF), Vienna University of Technology. Available at http://www.smart-cities.eu/download/smart_cities_final_report.pdf.
- [36] Giffinger, R., & Gudrun, H. (2010). Smart cities ranking: An effective instrument for the positioning of cities? *ACE: Architecture, City and Environment*, 4(12), 7-25. Available at http://upcommons.upc.edu/revistes/bitstream/2099/8550/7/ACE_12_SA_10.pdf.
- [37] Glaeser, E. L., & Berry, C. R. (2006). Why are smart places getting smarter? *Taubman Center Policy Briefs*, PB-2006-2. Available at http://www.hks.harvard.edu/rappaport/downloads/policybriefs/brief_divergence.pdf.
- [38] Hall, P. (2000). Creative cities and economic development. *Urban Studies*, 37(4), 633-649.
- [39] Hall, R. E. (2000). The vision of a smart city. In *Proceedings of the 2nd International Life Extension Technology Workshop* (Paris, France, Sep 28). Available at <http://www.osti.gov/bridge/servlets/purl/773961-oyxp82/webviewable/773961.pdf>.
- [40] Harrison, C., Eckman, B., Hamilton, R., Hartswick, P., Kalagnanam, J., Paraszczak, J., & Williams, P. (2010). Foundations for Smarter Cities. *IBM Journal of Research and Development*, 54(4). DOI: 10.1147/JRD.2010.2048257.
- [41] Hollands, R. G. (2008). Will the real smart city please stand up? *City*, 12(3), 303-320.
- [42] IBM. (2010). *Smarter Thinking for a Smarter Planet*. Available at http://www.ibm.com/smarterplanet/global/files/us_en_us_1oud_ibmlbn0041_transtasman_book.pdf.
- [43] Industry Canada. (1998). *Report of the Panel on Smart Communities*. Ottawa, Canada: Government of Canada.
- [44] Industry Canada. (1999). *Smart Communities: Program Guide*. Ottawa, Canada: Government of Canada.
- [45] Ingram, G. K., Carbonell, A., Hong, Y.-H., & Flint, A. (Eds.). (2009). *Smart Growth Policies: An Evaluation of Programs and Outcomes*. Cambridge, MA: Lincoln Institute of Land Policy.
- [46] Ishida, T. (2002). Digital city Kyoto. *Communications of the ACM*, 45(7), 78-81.
- [47] Ishida, T., & Isbister, K. (Eds.). (2000). *Digital Cities: Technologies, Experiences, and Future Perspectives* (Vol. 1765). Berlin, Germany: Springer.
- [48] Jennings, P. (2010). Managing the risks of Smarter Planet solutions. *IBM Journal of Research and Development*, 54(4). DOI: 10.1147/JRD.2010.2050540.
- [49] Kanter, R. M., & Litow, S. S. (2009). Informed and interconnected: A manifesto for smarter cities. *Harvard Business School General Management Unit Working Paper*, 09-141. Available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1420236.
- [50] Klein, C., & Kaefer, G. (2008). From smart homes to smart cities: Opportunities and challenges from an industrial perspective. In *Proceedings of the 8th International Conference, NEW2AN and 1st Russian Conference on Smart Spaces, ruSMART 2008* (St. Petersburg, Russia, Sep 3-5). Available at <http://www.springerlink.com/content/d053p7u7g42u573p/>.
- [51] Knight, J., & Weedon, A. (1995). Editorial. *Convergence: The Journal of Research into New Media Technologies*, 1(1), 5-8.
- [52] Komninos, N. (2002). *Intelligent Cities*. London: Spon Press.
- [53] Komninos, N. (2009). Intelligent cities: Towards interactive and global innovation environments. *International Journal of Innovation and Regional Development*, 1(4), 337-355.
- [54] Komninos, N., & Sefertzi, E. (2009). Intelligent cities: R&D offshoring, Web 2.0 product development and globalization of innovation systems. Paper presented at the Second Knowledge Cities Summit 2009. Available at <http://www.urenio.org/wp-content/uploads/2008/11/Intelligent-Cities-Shenzhen-2009-Komninos-Sefertzi.pdf>.
- [55] Landry, C. (2000). *The Creative City: A Toolkit for Urban Innovation*. London: Earthscan.
- [56] Lee, S., Han, J., Leem, Y., & Yigitcanlar, T. (2008). Towards ubiquitous city: Concept, planning, and experiences in the Republic of Korea. In T. Yigitcanlar, K. Velibeyoglu & S. Baum (Eds.), *Knowledge-Based Urban Development: Planning and Applications in the Information Era* (pp. 148-169). Hershey, PA: IGI Global.
- [57] Lepouras, G., Vassilakis, C., Halatsis, C., & Georgiadis, P. (2007). Domain expert user development: The SmartGov approach. *Communications of the ACM*, 50(9), 79-83.
- [58] Lindskog, H. (2004). Smart communities initiatives. In *Proceedings of the 3rd ISONE World Conference* (Las Vegas, NV, Apr 14-16). Available at <http://www.heldag.com/articles/Smart%20communities%20apr1%202004.pdf>.
- [59] Mahizhnan, A. (1999). Smart cities: The Singapore case. *Cities*, 16(1), 13-18.
- [60] Malanga, S. (2004). The curse of the creative class. *City*, 14(1). Available at http://www.city-journal.org/html/14_1_the_curse.html.
- [61] Malek, J. A. (2009). Informative global community development index of informative smart city. In *Proceedings of the 8th WSEAS International Conference on Education and Educational Technology* (Genova, Italy, Oct 17-19).
- [62] Marsa-Maestre, I., Lopez-Carmona, M. A., Velasco, J. R., & Navarro, A. (2008). Mobile agents for service personalization in smart environments. *Journal of Networks*, 3(5), 30-41.

- [63] Martin, J. L., Varilly, H., Cohn, J., & Wightwick, G. R. (2010). Preface: Technologies for a smarter planet. *IBM Journal of Research and Development*, 54(4). DOI: 10.1147/JRD.2010.2051498.
- [64] Mauher, M., & Smokvina, V. (2006). Digital to intelligent local government transition framework. In *Proceedings of the 29th International Convention of MIPRO* (Opatija, Croatia, May 22-26). Available at http://www.mmc-consulting.hr/Download/2008/03/07/Mauher_M_Digital_to_Intelligent_City_Transition_Framework.pdf.
- [65] Mitchell, W. J. (2006). Smart City 2020. *Metropolis*, April. Available at <http://www.metropolismag.com/story/20060320/smart-city-2020>.
- [66] Moser, M. A. (2001). What is smart about the smart communities movement? *EJournal*, 10/11(1). Available at <http://www.ucalgary.ca/ejournal/archive/v10-11/v10-11n1Moser-print.html>.
- [67] O'Toole, R. (2001). *The Vanishing Automobile and Other Urban Myths: How Smart Growth Will Harm American Cities*. Bandon, OR: The Thoreau Institute.
- [68] Odendaal, N. (2003). Information and communication technology and local governance: Understanding the difference between cities in developed and emerging economies. *Computers, Environment and Urban Systems*, 27(6), 585-607.
- [69] Partridge, H. (2004). Developing a human perspective to the digital divide in the smart city. In *Proceedings of the Biennial Conference of Australian Library and information Association* (Queensland, Australia, Sep 21-24). Available at <http://eprints.qut.edu.au/1299/1/partridge.h.2.paper.pdf>.
- [70] Paskaleva, K. A. (2009). Enabling the smart city: The progress of city e-governance in Europe. *International Journal of Innovation and Regional Development*, 1(4), 405-422.
- [71] Plumb, D., Leverman, A., & McGray, R. (2007). The learning city in a 'planet of slums'. *Studies in Continuing Education*, 29(1), 37-50.
- [72] Porter, D. R. (2002). *Making Smart Growth Work*. Washington, DC: Urban Land Institute.
- [73] Rios, P. (2008). Creating "the smart city". Available at http://dspace.udmercy.edu:8080/dspace/bitstream/10429/20/1/2008_rios_smart.pdf.
- [74] Sairamesh, J., Lee, A., & Anania, L. (2004). Information cities. *Communications of the ACM*, 47(2), 28-31.
- [75] Spangler, W. S., Kreulen, J. T., Chen, Y., Proctor, L., Alba, A., Lelescu, A., & Behal, A. (2010). A smarter process for sensing the information space. *IBM Journal of Research and Development*, 54(4). DOI: 10.1147/JRD.2010.2050541.
- [76] Sproull, L., & Patterson, J. F. (2004). Making information cities livable. *Communications of the ACM*, 47(2), 33-37.
- [77] Streitz, N. (2009). Ambient intelligence landscapes for realizing the cities of the future: Introduction and overview. In *Proceedings of the 3rd European Conference on Ambient Intelligence* (Salzburg, Austria, Nov 18-21). Available at <http://www.smart-future.net/14.html>.
- [78] Švob-Đokić, N. (Ed.). (2007). *The Creative City: Crossing Visions and New Realities in the Region*. Zagreb, Croatia: Institute for International Relations, Available at http://www.culturelink.org/publics/joint/cultid08/Svob-Djokic_Creative_City.pdf.
- [79] Urban Land Institute. (1998). *ULI on the Future: Smart Growth*. Washington, DC: Urban Land Institute.
- [80] Washburn, D., Sindhu, U., Balaouras, S., Dines, R. A., Hayes, N. M., & Nelson, L. E. (2010). *Helping CIOs Understand "Smart City" Initiatives: Defining the Smart City, Its Drivers, and the Role of the CIO*. Cambridge, MA: Forrester Research, Inc. Available at http://public.dhe.ibm.com/partnerworld/pub/smb/smarterplanet/forr_help_cios_and_smart_city_initiatives.pdf.
- [81] Widmayer, P. (1999). Building digital metropolis: Chicago's future networks. *IT Professional*, 1(4), 40-46.
- [82] Williams, M. (2010, Nov 18). 2010 digital cities survey winners announced. *Government Technology*. Available at <http://www.govtech.com/e-government/2010-Digital-Cities-Survey-Winners-Announced.html>.
- [83] Winters, J. V. (2010). Why are smart cities growing? Who moves and who stays. *Journal of Regional Science*, 20(10), 1-18.
- [84] Yigitcanlar, T., & McCartney, R. (2010). Strategising knowledge-based urban development: Knowledge city transformations of Brisbane, Australia. In *Proceedings of the 14th International Planning History Society (IPHS) Conference*, (Istanbul, Turkey, Jul 12-15).
- [85] Yigitcanlar, T., O'Connor, K., & Westerman, C. (2008a). The making of knowledge cities: Melbourne's knowledge-based urban development experience. *Cities*, 25(2), 63-72.
- [86] Yigitcanlar, T., & Velibeyoglu, K. (2008). Knowledge-based urban development: The local economic development path of Brisbane, Australia. *Local Economy*, 23(3), 195-207.
- [87] Yigitcanlar, T., Velibeyoglu, K., & Martinez-Fernandez, C. (2008b). Rising knowledge cities: The role of urban knowledge precincts. *Journal of Knowledge Management*, 12(5), 8-20.
- [88] Yovanof, G. S., & Hazapis, G. N. (2009). An architectural framework and enabling wireless technologies for digital cities & intelligent urban environments. *Wireless Personal Communications*, 49(3), 445-463. Available at <http://www.springerlink.com/content/g1v63025217mt8x0/>.
- [89] Zook, M. A., & Graham, M. (2007). Mapping digiplace: Geocoded Internet data and the representation of place. *Environment and Planning B: Planning and Design*, 34(3), 466-482. Available at <http://www.envplan.com/epb/fulltext/b34/b3311.pdf>.