Smart and Intelligent Cities

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Abstract Societal development is increasingly driven by knowledge, or sets of specialized knowledge, accumulated by communities, efficiently and efficaciously disseminated among its members. At the onset of the fourth industrial revolution, the future of local development, including communities such as cities, depends on how intensively they can rely on state-of-the-art technology. Hence the importance of "Smart Cities," and "Learning Cities". The paper taps into the latest developments in the domain and provides conceptual background, definitions, and future insights as driven by key international literature findings. It will demonstrate, by way of achievements/examples/best practices, how key Smart City components in the domain of utilities, transportation, environment, public services and commerce can offer modern solutions to the typical problems encountered by cities. It will also highlight technical solutions such as sensors/actuators and embedded systems, communication networks and protocols, asset/event cataloging and semantics/taxonomies, and finally the use of big data/analysis/mining. The inventory of solutions would not be complete without a description of how citizen involvement and innovations can facilitate progressive city management. Finally, the paper presents a case study that compares typical smart city solutions from Hungary and abroad.

Keywords: • smart city • technical solutions • progressive city management • cloud-based initiatives

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1 Conceptual framework

In the second decade of the twenty-first century, more than half of the global population live in urban areas, and the share of big cities is predominant. The world's largest metropolitan areas are home to more than one-eighth of the global population. Cities are the core of economic growth, demonstrated by the fact that nearly one-third of global economic output is focused here (Gere 2016). Stemming from their roles as drivers of modern economic growth – involving commerce, innovation, talent and infrastructural relations – global cities play a key role in the governance of the global economy.

The growth rate of the population of large cities is spectacular, and ever rising. The share of the global population is also increasing. It is therefore of fundamental interest from a global perspective to manage cities in a way that is sustainable in all aspects.

The rise in the populations of large cities is coupled with the wake of the fourth industrial revolution, resulting in IT being expanded to all areas of life. In the near future, IT will be inevitably governing people's lives, including the environments people live in. Technical innovations are present in both the private and the public sphere; they facilitate the everyday lives of individuals and also assist governments (national, regional or local) to better manage the lives of communities. More and more activities are being optimized or automated so that time management and the exploitation of resources are maintained at ideal levels. The final state of sophistication in the interconnectedness between people and internet-provided management is called the Internet of Things.

Large cities suffer from a number of problems which are inherent to their development, and often inorganic, forced or unplanned. Such problems, among others, include the high cost of living, congested communities, public health crises, and fossil fuel dependency (Czirjak and Gere 2016). IT companies have realized the potential of innovative technological solutions as remedies for tackling urban issues, and today Microsoft, IBM,[1] CISCO,[2] LG,[3] GE[4] and SIEMENS[5] all use the Internet of Things.

A recent report by PwC[6] Russia (PwC 2017) presented survey findings about the tech-readiness of global cities. The term tech-readiness signifies how ready cities are to adopt technology-driven solutions across sectors from education to security and healthcare. This capacity was gauged across several variables, such as the presence of basic infrastructure, the strategies and regulations that support the adoption and use of new infrastructure, the availability of finished prototypes, and the social readiness of citizens to use new technologies.

The report concludes that the ranking and achievement of the "tech-readiness" of cities is spread among the following candidates:

1. Singapore (64%);
2. London (59%);
3. Shanghai (55%);

4. New York (53%);
5. Moscow (53%) (PwC 2017, 2).

The report, among other issues, also highlighted a few areas of innovation as being indicative of tech-readiness. "In terms of embracing new tech in daily life, London (42%) and Toronto (41%) came in at the bottom. When gauging innovation in culture and tourism, Barcelona (78%), Shanghai (78%) and Singapore (72%), took the lead. In readiness to integrate autonomous transportation, London (72%) was at the top. And in terms of digital economy infrastructure, Singapore (75%) came in first—likely due to its adoption and investment of tech in educational settings" (PwC 2017).

City growth, efficient management, and innovative solutions in IT are today interconnected. The application of smart IT solutions for tackling community or urban issues has been gradually adopted across the world, and this process has given rise to the Smart Cities "movement". The denomination Smart Cities can be perceived as a parallel to smartphones, which are versatile, programmable, and whose designers and programmers strive to provide personalized solutions. An expansion of the *smart cities* term is smart urbanization, which is seen as key to building safer, healthier, resilient and sustainable cities of tomorrow by utilizing smart growth principles, effective urban planning models, ICTs, and low-carbon energy systems. Smart urbanization, with smart cities nested within, can help create more habitable and efficient urban centres (Horváth 2016). It may also help alleviate pressure on existing natural habitats, resources and biodiversity, thereby reducing the risk of man-made disasters.

In response to UN Sustainable Development Goal (SDG) no. 11, stipulating: "Make cities and human settlements inclusive, safe, resilient and sustainable" (UN General Assembly 2015, 14), ITU[7] and UNECE[8] launched the United for Smart Sustainable Cities (U4SSC) initiative. U4SSC primarily advocates for public policy to encourage the use of ICTs to facilitate and ease the transition to smart sustainable cities worldwide. In order to provide a conceptual framework for the initiative, UNECE and ITU, together with other partner organizations, have developed a common definition of a smart and sustainable city:

> *"A smart sustainable city (SSC) is an innovative city that uses information and communication technologies (ICTs) and other means to improve quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social, environmental as well as cultural aspects" (ITU 2017, 45).*

2 Case studies

In the next section, short case studies illustrating the various components or sub-systems of smart city solutions will be discussed, followed by select Key Performance Indicators (KPIs), pertaining to the domain under discussion.

KPIs are taken from the ISO 37120 – the first international standard[9] about city indicators, which lists a totality of 100 indicators (46 core and 54 supporting) which are structured around the following 17 themes: Economy, Education, Energy, Environment, Finance, Fire and Emergency Response, Governance, Health, Recreation, Safety, Shelter, Solid Waste, Telecommunications, Transportation, Urban Planning, Wastewater and Water & Sanitation (ISO 2014).

2.1 Smart economy (Busan, South Korea)

With an economy based on heavy industry, South Korea's second largest city, Busan, confronts challenges similar to those of other large, industrial cities. A primary challenge for Busan is creating job opportunities for its 60,000 annual university graduates and retaining a high-quality workforce. City leaders that face similar issues will be interested in Busan's decision to deploy Cisco's Smart+Connected Communities solution and public cloud infrastructure to stimulate job creation and business growth.

The Busan Metropolitan Government recognized the potential for growing its economic base through the use of information and communication technology (ICT). By connecting citizens, educational institutions, government agencies, and industry, the city has been able to drive sustainable urban development while providing citizens with easy access to city services. A 10GB broadband infrastructure, the Busan Information Highway, has already been deployed and linked to 319 public institutions. This infrastructure gives Busan government a strong foundation for expansion.

Busan Smart+Connected Communities solutions are delivered using a cloud infrastructure based on Cisco UCS™ Unified Computing System™ (UCS®). Today, the cloud connects the Busan Metropolitan Government, the Busan Mobile Application Center (BMAC), and five local universities. Eventually, it will deliver services to citizens through kiosks, citywide digital interactive displays, home-based access, and mobile access (PwC 2017).

One of the first major cloud-based initiatives is designed to create 3500 job opportunities and 300 start-up companies with a focus on mobile application development by 2014. Spearheaded by the Busan IT Industry Promotion Agency (BIPA), the project will create an open innovation ecosystem that fuels the app. economy of Busan. The Busan Metropolitan Government funds ICT development and provides training and education through the BMAC.[10] Software developers, entrepreneurs, and small businesses can register and gain access to tools, training, and testing resources for developing smart

applications and mobile app-based services for citizens. Revenue that is generated is returned to developers through BIPA.[11]

BMAC offers physical workspaces, such as project and meeting rooms, shared application development, cloud platforms for Windows and Mac operating systems, an applications library, a consulting center for start-ups and small office/home office professionals, testing tools, smart devices, application programming interfaces for access to municipal data, an application developer's forum, and marketing resources.

Figure 1: KPI indicators in the Smart Economy domain

THEME	CORE INDICATORS	SUPPORTING INDICATORS
Economy	City's unemployment rate	Percentage of persons in full-time employment
	Assessed value of commercial and industrial properties as a percentage of total assessed values of all properties	Youth unemployment rate
	Percentage of city population living in property	Number of businesses per 100,000 population
		Number of new patents per 100, 000 population per year

Source: Author's construction adopted from ISO (2014).

2.2 Smart mobility (Doha, Qatar)

Like many developed areas, there are traffic jams in Qatar that not only aggravate commuters but can also be costly for companies with fleet vehicles that move goods and services around the region.

Smart Fleet combines sensors with Ooredoo's[12] wireless network to help businesses better direct their fleet vehicles to avoid traffic congestion and reduce operating costs (Smart Cities Council 2018). Council member Ooredoo, the telecommunications company based in the Qatar capital of Doha, has developed a cloud- and sensor-based Smart Fleet solution that deploys GPS[13] and GSM[14] technology to centralize and manage transport-related information. The subscription-based service can be used for any kind of fleet, whether in the services sector, transport and logistics, passenger transportation or construction.

When there is a traffic jam, the system can route a driver around it. This not only saves the driver time, but it can save other drivers time too. By reducing the number of vehicles driving into the congestion, the traffic jam can clear faster.

In addition to reducing the amount of gas wasted in traffic, Smart Fleet can also design fuel-efficient routes for drivers which can save companies money and help reduce

pollution. By keeping track of their assets in real-time, the system also helps the companies that use it reduce loss and theft.

Figure 2: Key Performance Indicators in the Smart Mobility domain

THEME	CORE INDICATORS	SUPPORTING INDICATORS
Transportation	Kilometers of high capacity public transportation per 100,000 population	Percentage of commuters using travel mode to work other than a personal vehicle
	Kilometers of light passenger public transportation system per 100,000 population	Number of two-wheel modernized vehicles per capita
	Annual number of public transport trips per capita	Kilometers of bicycle paths and lanes per 100,000 population
		Commercial air connectivity (number of non-stop commercial air destinations)
	Number of personal automobiles per capita	Transportation fatalities per 100,000 population

Source: Author's construction adopted from ISO (2014).

2.3 Smart environment (Triangulum, Eindhoven, the Netherlands; Manchester, UK; Stavanger, Norway[15])

In the Triangulum project, the aim of Lighthouse Cities is to demonstrate that the integration of technologies from the energy, buildings, mobility and ICT sectors within a district can induce significant reductions in energy demand and local GHG[16] emissions and at the same time enhance quality of life and provide a basis for economic growth and development. The project consortium combines the interdisciplinary experience and expertise of twenty-two partners from industry and research and six municipalities which are committed to developing and implementing smart solutions which are planned to be further disseminated and replicated primarily in the three Follower Cities: Leipzig (DE), Prague (CZ), and Sabadell (ES), but also beyond.

As an overarching objective, Triangulum seeks to develop a model for the replication of smart city solutions based on cost and benefit, as well as maximize the dissemination and impact of the knowledge and innovation generated during the project. The replication approach has the following three stages, as shown in the graphic below: demonstration, assessment, and replication. In the demonstration phase, projects such as E-bus lines in public transport are implemented to show how public and private actors can work together to jointly improve the quality of life in cities.

The assessment phase serves to generate robust evidence by describing and quantifying the impacts and benefits. Later, and based on the former, business models that enable

replication in the Follower Cities and beyond are elaborated. To facilitate this process, "on-site assessments" have taken place in the lighthouse cities. These visits took place between late 2015 and early 2016 and were led by researchers from the Institute of Human Factors and Technology Management (IAT) at the University of Stuttgart, the Fraunhofer Institute for Industrial Engineering (IAO),[17] the Fraunhofer Institute for Open Communication Systems (FOKUS),[18] and TÜV Süd.[19] Each of the assessments took place over a period of approximately two weeks and involved 25–40 interviews (political, management and technical), and a creativity workshop. All of this activity was supported by the local Triangulum coordinators in the cities.

Figure 3: KPI indicators in the Smart Environment domain

THEME	CORE INDICATORS	SUPPORTING INDICATORS
Environment	Fine particulate matter (PM2.5) concentration	NO2 (nitrogen dioxide) concentration
	Particulate matter (PM2.5) concentration	SO2 (sulphur dioxide) concentration
	Greenhouse gas emissions measured in tonnes per capita	O3 (ozone) concentration
		Noise pollution
		Percentage change in number of native species

Source: Author's construction adopted from ISO (2014).

2.4 Smart governance (G-Cloud framework, New Taipei, Taiwan)

With over 3.9 million citizens and more than 500 administered institutions and schools, New Taipei City Government began constructing and integrating a public cloud and service cloud, not only to strengthen city government operations and those of its subordinate agencies, but also to determine public sentiment regarding government services in order to facilitate a more rapid and effective public service for citizens. The G-Cloud framework is the foundation of the New Taipei City Government and is the cornerstone in terms of operating the public cloud and service cloud (Smart Cities Council 2018).

One of the biggest challenges was that complaints filed by citizens and their subsequent status were processed manually, and saved using various data formats. This meant that it took a lot of time and resources to perform this task. This was a major bottleneck.

Additionally, the user experience left a lot to be desired. The major complaint was the slow response time from the NTPC government regarding their complaints or requests. This was aggravated by the high number of inconsistencies in the responses that the citizens received.

Deputy Director Lin Chunyin at New Taipei City Government Information Center said: "The main objective of the official case is to integrate the two [cloud platforms] more closely and to unify rules, so that both internal colleagues and external users can experience the benefits ... furthermore, we realized it was important to minimize the number of resources required to process their complaints and requests, shorten the response time and finally, strive for 100% accuracy and consistency with regard to replies given to our citizens with regard to their complaints or requests" (Smart Cities Council 2018, 2).

Figure 4: Key Performance Indicators in the Smart Governance domain

THEME	CORE INDICATORS	SUPPORTING INDICATORS
Governance	Voter participation in last municipal election (as a percentage of eligible voters)	Percentage of women employed in city government workforce
	Women as percentage of total elected to city-level office	Number of convictions for corruption and/or bribery by city officials per 100,000 population
		Citizen representation: number of local officials elected to office per 100,000 population

Source: Author's construction adopted from ISO (2014).

This domain measures a city's civic engagement – particularly for women – as well as the honesty and integrity of its elected officials. Increasing transparency in city governments is a critical step in providing and defending basic rights at the city level. "The advantage of the global standard for measuring and reporting on the performance of city governance – including the role of women in city government, can help city leaders worldwide be more responsive, transparent and more responsible to their citizens" (Smart Cities Council 2018).

2.5 Smart education (Cibernàrium, Spain[20])

Barcelona city government founded the whole digital ecosystem of Barcelona Activa, of which Cibernàrium is a network member. The latter organization governs the training and technological dissemination program of Barcelona Activa – Ajuntament de Barcelona. It offers training for professionals and companies, as well as internet initiation activities for all citizens. The Cibernàrium formula involves a wide range of activities of short duration that are very practical and focused on very specific topics – usually a solution, a concept, or a technological tool that helps participants to develop their technological skills and, therefore, helps with their professional training.

Cibernàrium publishes informative materials in different formats: video courses, activity dossiers, and multimedia content. Cibernàrium hosts days for technological diffusion, along with formative and sectoral events directed at professional sectors. Cibernàrium

develops its activity in different spaces of Barcelona and is headquartered in the Media-TIC Building of 22@.

Figure 5: Key Performance Indicators in the Smart Education domain

THEME	CORE INDICATORS	SUPPORTING INDICATORS
Education	Percentage of female school-aged population enrolled in school	Percentage of male school-aged population enrolled in school
	Percentage of students completing primary education	Percentage of school-aged population enrolled in school
	Percentage of students completing secondary education	Number of high-education degrees per 100,000 population
	Primary education student/teacher ratio	

Source: Author's construction adopted from ISO (2014).

3 Conclusion

It is especially important to have a good understanding and insight into solutions as modern cities are expected to witness an increase in the number and complexity of problems that must be tackled. Therefore, this chapter had the aim of presenting a few solutions related to the development of Smart and Intelligent Cities. It offered a conceptual background, definitions, and working realizations of principles, followed by future insights as driven by key findings from international literature. We have sought to demonstrate, by way of presenting achievements/examples/best practices, how key Smart City components in the domain of utilities, transportation, the environment, public services, and commerce can efficiently resolve the typical problems encountered by cities.

Notes:

[1] International Business Machines Corporation, an American multinational information technology company.

[2] Cisco Systems, Inc., an American multinational technology conglomerate.

[3] LG Corporation, formerly Lucky-Goldstar, a South Korean multinational corporation.

[4] General Electric, an American multinational conglomerate.

[5] Siemens AG, a German conglomerate.

[6] PricewaterhouseCoopers, a multinational professional services network.

[7] International Telecommunication Union (ITU), a specialized agency of the United Nations.

[8] "United Nations Economic Commission for Europe (ECE) is one of the five regional commissions under the jurisdiction of the United Nations Economic and Social Council". (Wikipedia. Available at: https://en.wikipedia.org/wiki/United_Nations_Economic_Commission_for_Europe (15 March, 2019)).

[9] The International Organization for Standardization (ISO) is an international standard-setting body composed of representatives from various national standards organizations.
[10] Busan Mobile Application Center, an innovative center to host a variety of services for its citizens, operating like an app store for developers.
[11] Busan IT Industry Promotion Agency, an establishment to foster and support information and cultural industries.
[12] Ooredoo QSC: an international telecommunications company headquartered in Doha, Qatar.
[13] Global Positioning System (GPS): a satellite-based radionavigation system.
[14] GSM (Global System for Mobile communications): a standard developed by the European Telecommunications Standards Institute (ETSI).
[15] For further information, please check the website of the Triangulum project: http://triangulum-project.eu/ (15 March, 2019).
[16] Greenhouse gas.
[17] The IAO offers research services to companies and public-sector bodies and institutions.
[18] FOKUS is a non-profit organization, helps the conception and implementation of research and development projects of any size.
[19] A technical service corporation catering to the industry, mobility and certification Segments.
[20] For further information, please check the website of the Cibernàrium programme: https://cibernarium.barcelonactiva.cat/ (15 March, 2019).

References:

Accenture (2014) *Technology Vision 2014. Building Cities for the Digital Citizen*, available at: https://www.accenture.com/id-en (March 15, 2019).

Cibernàrium programme (2019) available at: https://cibernarium.barcelonactiva.cat/ (March 15, 2019).

Czirjak, R. & Gere, L. (2016) Smart Cities – Addressing Social Challenges?, *Hungarian Geopolitics*, 4, pp. 16–31.

ESRC (2017) *European Urban Living Labs as experimental city-to-city learning platforms*, available at: http://www.urbantransformations.ox.ac.uk/blog/2017/european-urban-living-labs-as-experimental-city-to-city-learning-platforms/ (March 15, 2019).

Gere, L. (2016) Global Cities Redefined, *Hungarian Geopolitics*, 4, pp. 6–15.

Horváth, Z. (2016) Assessing regional impact based on destination image, *Regional Statistics*, 6(1), pp. 164–192.

ISO (2014) *Sustainable development of communities — Indicators for city services and quality of life*, available at: https://www.iso.org/obp/ui/#iso:std:iso:37120:ed-1:v1:en (March 15, 2019).

ITU (2017) *Key performance indicators for smart sustainable cities to assess the achievement of sustainable development goals*. Recommendation ITU-T Y.4903/L. 1603, available at: https://www.itu.int/rec/T-REC-Y.4903-201610-I (March 15, 2019).

PwC (2017) *The Future is Coming: Index of Cities' Readiness*, available at: https://www.pwc.ru/ru/assets/the-future-is-coming-eng.pdf (March 15, 2019).

Rab, J., Riedel, M. & Steiner, B. M. (eds.) (2015) *Smart City Példatár* (Budapest: Lechner Nonprofit Kft.).

SETIS (Strategic Energies Information System) (2018) *European Initiative for Smart Cities*, available at: https://setis.ec.europa.eu/about-setis (March 7, 2019).

Smart Cities Council (2018) *New Taipei City Government Constructs G-Cloud Framework*, available at: https://na.smartcitiescouncil.com/system/tdf/public_resources/New%20Taipei%20constructs%20G-cloud%20framework.pdf?file=1&type=node&id=2067&force= (March 15, 2019).

SmartUrbanation (2017) available at: http://www.smarturbanation.com/smart-urbanation-2017/ (March 15, 2019).

Triangulum project (2019) Available at: http://triangulum-project.eu/ (March 15, 2019).

UN General Assembly (2015) *Transforming our world: the 2030 Agenda for Sustainable Development*. 21 October, A/RES/70/1, available at: http://www.refworld.org/docid/57b6e3e44.html (March 15, 2019).

Wikipedia (2019) *United Nations Economic Commission for Europe (ECE)*, available at: https://en.wikipedia.org/wiki/United_Nations_Economic_Commission_for_Europe (March 15, 2019).