Usability of Knowledge Grid in Smart City Concepts

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Abstract: Knowledge grid (KG) is a promising concept of man-computer global infrastructure aimed at knowledge services, which is being gradually developed. Global infrastructure of modern cities needs to be supported by efficient information and communication technologies considered to be a specific ecosystem. The ultimate goal of this paper is to present ways of implementation KG as some sort of knowledge management in general concepts of smart city (SC). The paper is managed as follows. After short introduction concerning research context the discussed concepts of KG and SC are presented. In the main section real-life examples of SC implementation are investigated in order to identify and describe roles of KG approach in this area. It allows for formulation conclusions on intersection of two approaches investigated.

1 INTRODUCTION

Climate and demographic changes, limited resources, growth of population, urbanisation, increasing importance of information and development of information technologies are forcing large and medium-sized cities to make changes in every area of their operational functioning. Beginning from integrating autonomously functioning ICT platforms through effective energy resources, raw materials and waste managing and ending with developing dialogue with citizens and making physical infrastructure changes. The goal of such upgrade is not only to achieve positive economic impact on a city, region, or a country, but mainly to prepare for meeting future needs of civilisation. Nowadays they are generated by the society which in fact is classified as an information society. Solutions used in cities all over the world (Amsterdam, Copenhagen, Montpellier, New York, Singapore, Wrocław, etc.) are no longer sufficient to provide proper communication between its users - citizens, but has become an integral part of the present civilisation infrastructure. Such a situation forces city governances into using effective management in all different branches of their urban economies. That will lead to the development of higher levels of efficiency, interactivity, flexibility, accountability essential to adapt to the rapid pace of changes which, indeed, is the ideological basis of well-known and used in the world concept of *smart city*.

2 CONCEPTS OF SMART CITY

Although the issue of the smart city concept is not new, it is still in the phase of conceptualisation. This is due to the lack of consistency in the results of research conducted independently by many and various expert groups in different regions of the world where the cities supplied solutions on issues depending on the local economic, social, technological and environmental factors. Therefore, the authors focus on various definitions of different factors as components of smart city. According to DOE Scientific and Technical Information, "*smart city is the city that monitors and integrates elements of infrastructure - roads, bridges, tunnels, subways, airports, sea and river ports, water and sewage, communication, which in turn allows you to optimize urban resources and this translates into maximizing the provision of services to citizens, while reducing costs and improving. The use of the decision-making bodies of modern management safety*" (Hall, 2012). IBM research group claims that "*the smart city is a combination of integrated infrastructures: physical, social, business and IT*" (Harrison et al., 2010). The Innovation Knowledge Foundation pays attention to "*the integration of ICT and Web 2.0*

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technologies, in order to speed up and simplify administrative procedures and office space, which helps to simplify the complexity of the existing decision-making processes" (Toppeta, 2010). Doug Washburn, chief research analyst at Forrester's IT team Infrastructure, believes that "*the basis of smart city is to use intelligent computer technology as a core infrastructure in the city administration, education, health care, public safety, real estate and transportation*" (Washburn, 2012).

As we can see the authors of the above definitions, despite some differences, suggest the need of integration of existing information systems (or more globally knowledge management resources) as the only possible way of achieving a complete, efficient, sustainable and equitable management of business processes taking place inside and outside every city, seeking to achieve smart status. *The use of the decision-making bodies of modern management concepts, approaches, procedures, and technology can enable a new and highly desired order and balance between the requirements of the environmental, social, economic and technological aspects* (Noworól, 2012). Re-establishment of order and consistency in the functioning of cities has become now one of the major problems for the authorities of each agglomeration. Attempts at achieving that goal are determined by the current investment decisions and improvements made. Therefore, it is essential that all changes introduced in cities should include the implementation of Information and Communication Technologies (ICT), which in result should determine sustainable development of a city based on knowledge (see OECD).

3 KNOWLEDGE GRID APROACHES

Gathering and distributing knowledge (as a result and heritage of past and modern societies) seems to be one of the most demanding challenges not only from ICT point of view but most of all as a storage of civilisation achievements. The concept of offering knowledge resources via computer networks became a main assumption of Knowledge Grid boosters (compare Berman, 2001). At least two approaches should be demonstrated: European and Asian in order to explain an essence of this specific knowledge management "method".

The first European proposal was authored by M. Cannataro and D. Talia (see: Cannataro and Talia, 2003). According to their interpretation "*Knowledge Grid is a software system based on a set of services for knowledge discovery over a grid*". It denotes the following features of this interpretation: knowledge-based stored structures, efficient ways of knowledge management, service oriented knowledge processing, and using multi-purposed knowledge.

The second Asian approach is represented by H. Zhuge (details in: Zhuge 2008; 2012). He declared that "*conceptualized the Knowledge Grid is an intelligent and sustainable Internet application environment that enables people or virtual roles (mechanisms that facilitate interoperation among users, applications, and resources) to effectively capture, publish, share and manage explicit knowledge resources".* He stressed special properties of Knowledge Grid approach: architectural (based on hybrid IC technologies), virtual aspect of grouping requirements, roles and resources, social characteristics of knowledge management, adaptive on demand user expectations and semantic computing model applied in this vision.

The presented approaches can be generalized via integration of common features and considering differences between both perspectives. Concluding, particular features of knowledge grid technology in the demonstrated visions can be summarised by discovering its characteristics including:

- **Architectural (***computer-network grid dimension*),
- **Knowledge-based (***contextual and owner dimensions***),**
- **Service-oriented (***grid dimension***)** and
- **Specific processing Methods (***flexible defined processing ways dimension***).**

All these characteristics of KG have the real impact on its development and implementation processes in many areas.

Considering KG factors essential in broadly defined development processes we would like to stress that there are no research in this area except for some oriented on specific solutions in grids (see: Hwang et al., 2009); (Owoc, 2009); (Owoc, 2010). Broadly speaking, we may take into account determinants typical for any IT products as well as specific for the presented knowledge context.

Technological aspect of Knowledge Grid development in some way is conditioning the whole concept. This is a quest of the adequate computer infrastructure (mostly based on the Internet and modern information technologies) which can serve KG concept (see: Wang et al., 2006). Nowadays hardware parameters as well as available software

packages (especially using artificial intelligence methods) are basically good enough to support KG solutions.

Economical context of KG implementation can be fundamentally identified with knowledge economy and in particular with knowledge network (see: Chattopadhyay et al., 2009 and Cheung and Liu, 2005). In other words KG is approved when actual or future (including long-term) expectations of users are fulfilled at reasonable costs. There are many projects devoted to usability and economics of Knowledge Grid (see: Akogrimo, SGL or CoAKTinG) which lead to elaborating efficient KG applications.

Social determinants of KG development play essential role in the discussed problem. By its nature particular communities or the whole society are creators as well as users of the gathered knowledge. Therefore members of society (individuals or groups) can be stimulators or moderators of the KG development. For sure the consciousness of the KG implementation necessity is growing up which means continuous extensions of the discussed solutions in new areas including smart city concepts.

The last itemised factor of the KG development defined as ***environmental*** expresses human-machine relationships (see: Zhuge, 2008) in more universal context. This environment includes knowledge "actors" (citizens and self-organised communities) that act with computer networks creating a specialized mechanism in order to assure ability to achieve aims defined in KG. Getting into details, specialized architectures with evolving networking mechanisms for the KG environment are built by covering automatic clustering of users and large-scale annotated resources, scalable structures for resource organization and many others.

All the presented factors are crucial in development of applications supporting more complex sectors. In our opinion smart city concepts belong to this area and what is more, some of the defined KG factors can play decisive role in implementation the whole concept especially in more generalized approach of smart city vision.

4 SMART CITY AS A SYSTEM OF THE SYSTEMS

Main factor of describing city as a kind of smart is intelligent management and the same knowledge management. It means that if the decision-making bodies make decisions regarding the development of the city they must take into consideration contractual six segments, aspects of the agglomeration: smart economy, people, governance, mobility, environment and living (Chourabi et al., 2012).

Figure 1 illustrates the pattern of relations that occur between these elements. This classification describes what are the main aspects of smart city and how strongly it is dependent on real access of citizens to Information and Communication Technologies. The purpose of the existence and operation of ICT infrastructure is therefore necessary to integrate key information generated by its users on each field, which is to provide a complete list of requirements, guidelines for maintenance and improvements in aspects: ecological city life of its citizens, public safety, public services and the operation of any commercial and industrial activities.

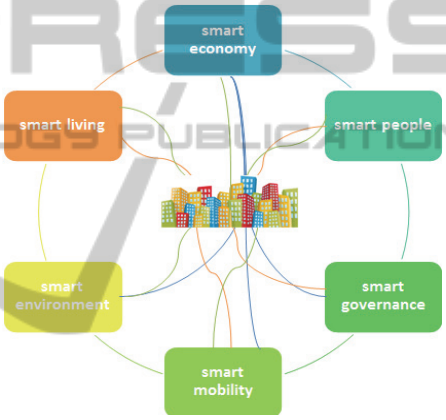

Figure 1: Smart city concept.

To ensure the effectiveness and efficiency of smart city it is crucial to apply all dedicated solutions related to appearing problems concerning each and every area of the city taking advantage of implemented ICT solutions. The existence of individual components, as autonomous entities is impossible. That is why it is important for decision-makers of a city to think of a process of making changes as a holistic investment and development. Looking at the city from the perspective of the whole, complete, living organism allows decision-makers to pay special attention to the integration of urban infrastructures. That mechanism of making changes in one aspect relating results in other aspects make smart city as a "*system of the systems*".

Wherever processes of decision-making are found, through their algorithmisation, it is possible to use information support, using specially dedicated solutions. Strategic vision for the implementation of information systems in urban areas should be

understood primarily through the integration of diverse information systems and customization them for the needs of residents, using all available communication channels and tools.

Many global companies (e.g. IBM, Oracle, Microsoft, CISCIO, Nokia Siemens Network, etc.) and research groups all over the world deliver complex solutions dedicated directly to smart city perfect functioning. All of them are therefore a set of solutions including technologies and applications that integrate multipart IT infrastructures. In this way it is available to optimize the service delivery process through the city to its citizens through the use of a specially created layers of monitoring productivity, improving service delivery and budgeting.

5 PRESENCE OF KNOWLEDGE GRID IN SMART CITY SOLUTIONS

According to the previous considerations of the meaning of knowledge grid in smart city concepts, we have analysed, in our opinion, relationships between knowledge grid solutions factors and demands generated by the smart city vision categorized in first part of article. Results are presented in Figure 2.

To demonstrate strong and direct relationships occurring between the requirements of knowledge grid and elements of smart city we used pie graphs as a content of previously presented model of smart city. Pie charts illustrate crucial elements of knowledge grid which, in our opinion, determines particular aspects of smart city. It is the simplest method of explaining the idea of knowledge grid solutions usability as basics of smart city functioning.

Starting with *technological* aspect of knowledge grid possibly used in smart city, we can see that it covers four of six crucial elements: economy, people, governance and environment directly and completely. The implementation of complex system provides positive effects in a city's economy, facilitates citizens access to the newest ICT products and services, improves decision making processes for authorities and makes natural resources and other cities media management more efficient. The best example of infrastructures integration can be Bornholm, where citizens will be able to manage their energy usage by themselves via mobile devices. (see EcoGrid EU)

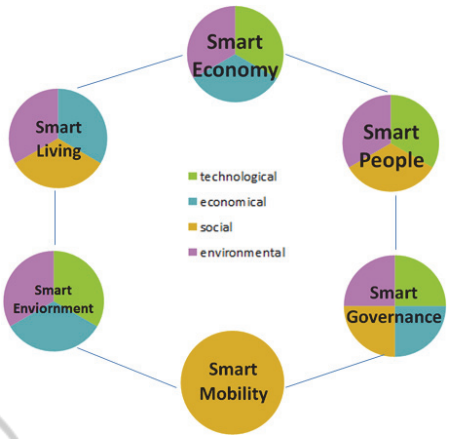

Figure 2: Knowledge grid and smart city intersections.

The *economical* factor of knowledge grid also covers four of six smart city aspects: economy, governance, environment and living. Inventing new technological solutions and improving existing ones which are combined with optimization of producing process has a direct positive influence on economy. When a city makes use of supplied solutions authorities preferably invest in IT sector to ensures improvement of products, services and that specific branch. Complex solutions dedicated to environment management are more efficient than integration of heterogeneous systems. When a city is managed in an efficient way it has a big impact on increasing a level of life quality. Such a solution, called Operations Center of Rio, has already been implemented in Rio do Janeiro, where weather forecasting and public safety module helps the city to avoid very cost-consuming disasters (see The New York Times, 2012).

The *social* factor of knowledge grid is also connected with four elements: people, governance, mobility and living. New channels of communications available, new solutions and fast delivery of new services and products spur citizens to use it and unconsciously to improve technology growth and social life (also including security aspects – see: Shi et al., 2006). Authorities can communicate with citizens in a few seconds, directly and in short time collect all lists of problems generated by specific neighbourhoods (it is a matter of assumed knowledge granularity (see Mach and Owoc, 2010). By using applications dedicated to mobility people can avoid traffics, so it also improves that sector. The fact of being uninterruptedly in touch with others and faster communication between actors/users/citizens improves the quality of life. As a perfect example of such a solution is AmsterdamOpent.nl platform

which allows citizens to support local polices (see AmsterdamOpent.nl).

The *environmental* factor (considered basically as a human-computer relationship) covers five of six smart city aspects: economy, people, governance, environment and living. Investing in proper ICT solutions has a direct impact on city's economy. Modelling and customising human-computer interaction involves and develops citizen skills. Perfectly prepared analytical solution improves and optimises decisions making processes. It has a similar effect on the environment. The existing technology has a positive impact on improving a life quality everywhere. The best proof of such a situation can be Luxemburg, which was placed on the first position in the ranking of European medium size cities, treated as smart. Montpellier reached the highest position among French cities in total ranking, right the first ten. (see Centre of Regional Science, 2007)

6 CONCLUSIONS

To sum up, knowledge grid is a complex system architecture consisting of advanced intelligent solutions based on a grid which is applied to discover existing knowledge. Smart city is a conception which assumes integration of all city infrastructure – physical, social, business and IT. Considering facts and all information presented in the article, we can say that smart city needs intelligent ICT solutions to achieve goals for present cities. It is also known that IT intelligence is thought to be based on knowledge. Nowadays, each city in the world is a big information grid.

The most important fact is the idea of Smart Cities which is one of the key projects for the future of energy in the European Union. It is connected with the implementation of the climate and energy package. All activities undertaken by city authorities are focused on fulfilling the expectations of the European Union. The involvement of cities in building Smart Cities will help to achieve very important goal, which is to reduce climate change by 2020 and reduce CO2 emissions by 20% in 2050 (see Energy 2020).

So, if we as the globe are going to create smart cities, don't we need to firstly focus on existing knowledge grid (which is full of data and information) and then try to develop and schedule other activities? Examples of future research can embrace the following quests: integration of different approaches in formulation of consistent strategy of agglomeration development, survey on factors and determinants influencing applying of knowledge grid methods in cities and monitoring of projects focused on intelligent technologies implementation in modern cities.

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