Considering Future Internet on the Basis of Smart Urban Cities

A Client-City Architecture for Viable Smart Cities

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Abstract **- The Internet has been experienced as the means for deliberation, for free social expression, for knowledge exchange, for enabling entrepreneurship. etc., while it has been capitalized by communities around the world for applications' development and for e-service deployment. In this paper Internet is considered as a supporting tool for communities' growth and wealth, and in this context the local history and experiences are viewed as the basis to focus on the future. Communities grow in organized spaces called cities. Cities did and do not emerge to the same levels, since geographic, financial, political and other variants influence this evolution. However, some cities show significant growth without meeting some of the abovementioned criteria, mainly due to the fact that some civilians present particular intelligence and enthusiasm. Various exemplars of isolated spaces were evolved due to the intelligence of some habitants, which were followed by their future generations. In this paper, this particularity structures a hypothesis, considering that the Future Internet can be based on the Smart Cities, where intelligence and experiences can be created, stored and accessed faster at a metropolitan level, limit data traffic to local areas and free significant resources of the Internet. The novel client-city architecture is proposed to support this hypothesis.**

Keywords - future Internet; smart city; internet challenges; knowledge city; networks of knowledge; smart city viability.

I. INTRODUCTION

The Internet has been dramatically evolved during the last 30 years and its evolution does not concern only technology, but all social activities. Innovative digital products that strengthen entrepreneurship, e-business, e-Government and even Internet Governance were only some of the Internet's implications. Future Internet seeks to capture Internet further evolution in more than technological aspects.

Smart cities on the other hand, appeared in late 80s and visualized urban context, while today they enhance digital content and services in urban areas, they offer sophisticated digital services, they capitalize pervasive computing and they face environmental challenges. The Smart City has an intelligent dimension [5], [7], which concerns "smart people", "smart environment", "smart economy", "smart governance", "smart mobility" and at a total "smart living". In this context, intelligence is the basis for Smart City evolution and it is measured in various ways, while commercial solutions are being offered [6] for its implementation.

This work in progress paper tries to conceptualize an architectural and algorithmic framework for the Internet of the future, which will be based on the Smart Cities for Internet future operation. More specifically, the Smart City is considered as the basis for knowledge engineering processes during e-service execution and during simple Internet processes. The produced knowledge could be captured locally and capitalized with forms similar to historical knowledge cities.

The concept of this paper is based on the following observation: cities used to evolve according to their competitive advantages and variants (e.g., habitants, physical landscape, position, facilities, access to transportation networks etc.). Knowledge cities [4] emerged as the necessity to enable urban space in order to produce and support knowledge in various ways. However, some isolated cities performed significantly in their past, growing and producing knowledge without meeting the above parameters, but due to the enthusiasm, the conceptual ability and the experiences of some habitants. Greek islands -i.e., Aegina, Spetses and Simi- and highland villages -i.e., Ferres- are representative cases, which grew impressively due to some individuals who were followed by their and by future generations.

Since isolated spaces produced knowledge that was accessed by only the local communities and supported local growth, our hypothesis concerns whether "*Smart Cities could generate and store local knowledge being produced by the local digital activities (i.e. the navigation, the discussion and the crawling of habitants) and this knowledge could be accessed at a metropolitan level by the citizens before their Internet navigation goes beyond the urban physical boundaries*". According to this hypothesis, a Smart City becomes a knowledge node –not just a proxy server-, which limits knowledge access to the civilians. Local internet users do not have to access digital resources beyond their Smart City's, and thus Internet traffic could be delimited in some scale. This conceptual model is shortly described in this paper, and this novel architecture is entitled "client-city".

Section II of this paper describes the notions of Knowledge and Smart City and determines our hypothesis. Section III describes the idea about the client-city architecture together with the potential advantages for the

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Internet, while Section IV contains our results and future thoughts.

II. KNOWLEDGE AND SMART CITY

The city contributes to a inhabitant's everyday life in many different ways, concerning facilities and opportunities that enable citizens to live, to educate, to work, to have family, to socialize, and to perform amusing activities etc. The city provides the citizens with experiences and representations, which are influenced by the space and the place offered by the local capacity and perspectives [9]. The city offers opportunities according to its growth, and variants i.e., the position, the landscape, the population, the distance from and the position of the sea and of rivers, the accessibility to transportation networks play significant role in local growth.

Moreover, in the knowledge economy the knowledge capacity and the opportunities for knowledge production in a city matter. Various knowledge drivers have been underlined [4] such as the existence of university, the local entrepreneurship, meeting places, diversity, Information and Communications Technologies (ICT) and media. In this context, the Knowledge City could be defined as the ability of a city to enhance knowledge.

On the other hand, according to [5], the Smart City concerns the local intelligence [5], [7], which concern "smart people", "smart environment", "smart economy", "smart governance", "smart mobility" and at a total "smart living".

The term was originally met in Australian cases of Brisbane and Blacksbourg [2] where the ICT supported the social participation, the close of the digital divide, and the accessibility to public information and services. The Smart City was later evolved to (a) an urban space for business opportunities, which was followed by the network of Malta, Dubai and Kochi (India) (www.smartcity.ae); and to (b) ubiquitous technologies installed across the city, which are integrated into everyday objects and activities.

The notion of Smart City has been also approached as part of the broader term of Digital City by [1], where a generic multi-tier common architecture for digital cities was introduced, and assigned Smart City to the software and services layer. This generic architecture (Figure 4) contains the following layers:

- User layer that concerns all e-service end-users and the stakeholders of a Smart City. This layer appears both at the top and at the bottom of the generic architecture because it concerns both the local stakeholders –who supervise the Smart City, and design and offer e-services- and the end-users –who "consume" the Smart City's services and participate in dialoguing and in decision making-.
- Service layer, which incorporates all the particular e-services being offered by the Smart City.
- Infrastructure layer that contains network, information systems and other facilities, which contribute to e-Service deployment.
- Data layer that presents all the information, which is required, produced and collected in the Smart City.

III. THE CLIENT-CITY ARCHITECTURE

It is widely understood that most metropolis can be considered as Knowledge cities, while many important cities [2] are being transformed to Smart Cities. However, many small and isolated urban spaces showed crucial emergence in the past, although they did not meet some of the abovementioned drivers and characteristics of the Knowledge and Smart cities. Instead, the enthusiasm, the personality and the skills of some civilians lead to particular economic and cultural local growth, which was followed by next generations. Some representative cases come from Greece i.e., the small islands of Aegina and Simi and highland villages i.e., the village of Ferres.

This particular behavior of the urban spaces could play significant role in today's trends and in Future Internet. More specifically, the existence of a Smart City is a key driver to transform the urban space to a knowledge city. In this context, an interrelation between Smart City's architecture and knowledge city can be observed:

a) knowledge is produced on the user layer,

b) knoweledge is engineered via users' interraction with the service layer,

c) knowledge and experiences are stored in city's local resources on the data layer,

d) a knowledge mining solution could analyze these knowledge and experiences and provide them to the users in forms of organized knowledge, with a behavior much similar to knowledge cities.

Much knowledge is also produced via simple user processes (i.e. browser navigation, crawling and chatting), which enhance users' experiences. This knowledge could be also "captured" by the Smart City and stored locally, with means similar to a Proxy Server (Muller et al, 2004), but with more sophisticated mechanisms that could be called a "Smart Proxy Server". The architecture of this server is beyond the purposes of this paper.

According to this paper's approach, the entire ICT environment of the Smart City would play the role of a service provider for the local users –located at the users' architecture layer- (citizens, businesses, stakeholders). However, service provision would not be limited to the e-services -contained in the service architecture layer-, but also for trivial internet services such as Internet access, proxy services, security services (i.e., antivirus, anti-spamming, firewalls etc.), cloud services etc. In this context, the Smart City could be seen as a "metropolitan intranet".

A novel architecture can be considered, which capitalizes the Smart City's infrastructure for the execution of the previously presented knowledge management processes and for the provision of trivial Internet services. This novel architecture goes beyond cloud computing, it is entitled **client-city** architecture (Figure 1) and limits local internet activity and Internet traffic inside the city's physical boundaries. The determination of this architecture is beyond

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the purposes of this paper and requires deeper technical analysis.

Moreover, Smart city's infrastructure could semantically describe and give logical notion to these Internet activities performed by Smart City's users, and store these "digital experiences" being gained by the civilians. For instance, consider a user who crawls for a specific issue about "*where was Alice born?*" Crawlers return various results about Alice, about her CV, about her historic profile etc., which were combined at a logical set of steps by the user, until he reaches the answer to the question. This chain of logical actions/steps that were followed by the user reflects the gained experience, while the outcome represents the gained knowledge i.e. "*Alice is born in Atlanta*" (Figure 2). Of course, alternative paths generate alternative experiences, some of which are useful, while others are meaningless.

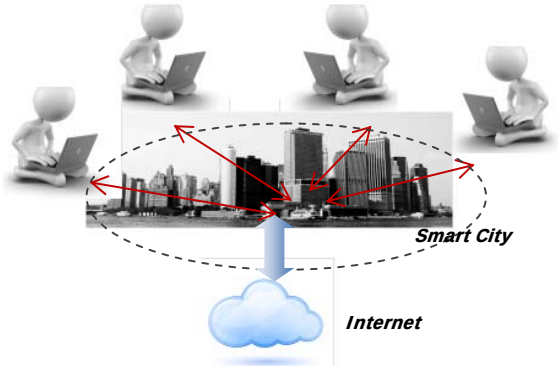

Figure 1. An initial approach to the client-city architecture: simple Internet transactions are performed via the Smart City

The Smart City could assign the successful paths to the gained answer (i.e. where the user stopped the crawling for this question), and create collections of experiences and of knowledge, in similar means such the ones that are discussed in meeting places. Consider the same procedure in a meeting place: the smart person would describe his experiences about Alice like "*Let me tell you about Alice. Alice is born in Atlanta, but … her family lives … etc.*" and a story would be created. These stories concern the local knowledge, and could be stored in the Smart City and displayed to the Smart City users automatically (Chen et al., 1995).

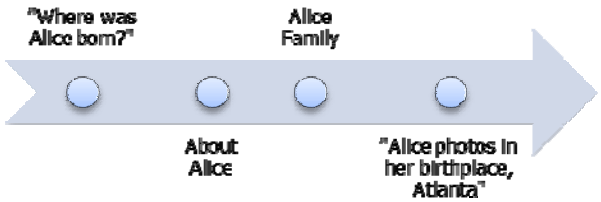

Figure 2. Experience is the path, knowledge is the reached answer

For instance, someone could read on a digital wall daily stories –like the above- created by the civilians. Furthermore, a user that would seek to answer the same question "*where was Alice born?*" would be guided by the Smart City to the locally stored answer and paths, without letting the user leave the physical boundaries of the city and charge Internet's traffic.

So the hypothesis that was defined in the beginning of this paper leads to the following potential answer: *Smart Cities can become nodes of dynamic experience and knowledge creation and storing*. Moreover, *many of local users' activities could be limited inside the Smart City, and lot of traffic can be avoided in the rest Internet*. Finally, *the client-city architecture does not influence Internet's freedom and its opportunities, since the locally stored knowledge in the Smart City can be available to all other Internet users.* According to our hypothesis, Future Internet could be based on connected Smart Cities (Figure 3).

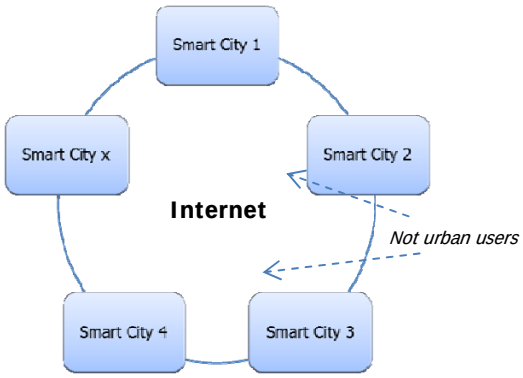

Figure 3. Future Internet can be seen as interconnected Smart Cities

IV. Results and Future Thoughts

Smart cities are being widely emerged around the world, and they enhance everyday life with the contribution of the ICT to the local needs. Various approaches to the Smart City can be faced, but all can follow the generic multi-tier architecture (Figure 4) (Anthopoulos et al., 2006). The Smart City can be seen as a driver of the Knowledge City and supports the production and storage of knowledge by its habitants.

In this paper, the capitalization of the Smart City by the Future Internet challenges is questioned. More specifically, the Smart City is considered as an isolated digital space, where knowledge is produced by the enthusiasm and by the intelligence of its civilians/end-users, with means similar to the ones observed in isolated historical villages and islands which present crucial growth.

It is hypothesized that the Smart City could support Future Internet by limiting digital traffic locally –as a metropolitan intranet-, and by lowering Internet traffic and freeing resources beyond the city area. Moreover, the Smart City can enhance knowledge production via capturing

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citizens' digital activities and by transforming them to digital experiences and knowledge. These experiences and knowledge could be available online –e.g., in a digital wall of the Smart City-, but it could also be provided to local users who seek for similar information via local crawlers, without leaving the Smart City's resources and access the Internet.

In order for the Smart City to perform these operations it must offer typical network services –beyond its e-services-, i.e. proxy, antivirus and anti-spam, and advanced smart-proxy services. These enhanced services could also support the viability of the Smart-City, which is widely questioned and argued [2].

This paper is a work in progress, and a lot of questions need to be answered by future work. The client-city architecture must be determined in detail at a lower level, and the "smart proxy" operation needs to be specified via sophisticated algorithms. A case study would be useful and will be investigated for further research. Moreover, the transformation of the crawling process to experiences is a research challenge for the text-crawling and for the semantic web areas (i.e., the Google Knowledge Graph) and could be achieved and incorporated in a Smart City.

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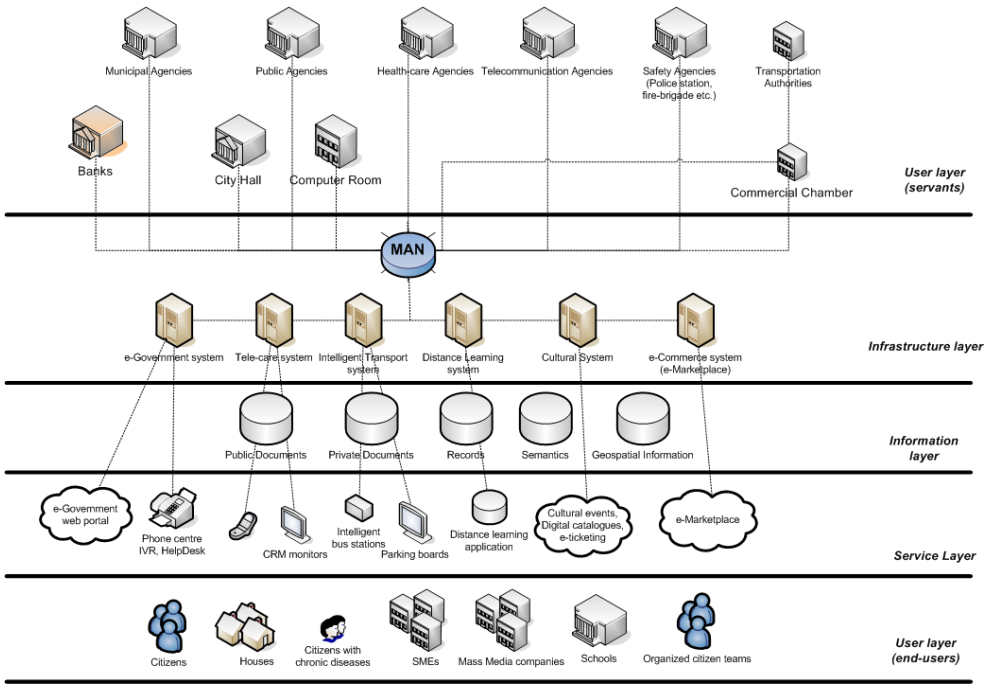

Figure 4. The multi-tier architecture of a digital city [1].