From Online to Ubiquitous Cities: The Technical Transformation of Virtual Communities

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Abstract. Various digital city projects, from the online cases (e.g. the America on Line) to the ubiquitous cities of South Korea, have achieved in creating technically 'physical' areas for the virtual communities, which share knowledge of common interest. Moreover, digital cities can succeed in simplifying citizen access to public information and services. Early digital cities deliver 'smart' and social services to citizens even with no digital skills, closing digital divide and establishing digital areas of trust in local communities. This paper presents the evolution of the digital cities, from the web to the ubiquitous architecture. It uses the latest digital city architecture and the current conditions of the digital city of Trikala (Greece), in order to present the evolution procedure of a digital city.

Keywords: e-Government, digital city, ubiquitous city, e-democracy, virtual communities.

1 Introduction

Multiple approaches have been given to the Digital City: *digital environments collecting official and unofficial information from local communities* [1] *and delivering it to the public via web portals are called information cities* [2],[3],[4]. *Networks of organizations, social groups and enterprises located in a city area* are called digital cities. These definitions were given by major case studies such as the America on Line (AOL), the Kyoto's and the Hull's etc., which are analyzed in this paper in order to present the ubiquitous environment that is generated in many areas all over the world, and to describe the transformation of virtual communities.

Although digital cities were initiated as information based systems (web portals, databases, virtual reality applications etc.), they soon evolved to wide(metro)-area information systems (IS) that deliver different kinds of services to the local communities. Their infrastructures concern network equipment (fiber optic channels and wi-fi networks in the city area), service oriented information systems (e.g. e-Government IS, e-Democracy portals, public Agency web applications etc.), public access points (e.g. wireless hotpots, info kiosks etc.), and social service systems (e.g. intelligent

A.B. Sideridis and Ch. Z. Patrikakis (Eds.): e-Democracy 2009, LNICST 26, pp. 360–372, 2010.
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transport systems, tele-care and tele-health networks etc.). These environments composed a recent digital city definition [5]: *wide(metro)-area infrastructures and applications that focus in covering local needs and in supporting local community's everyday life. This definition has been evolved to the ubiquitous city or U-city [6]: a city or region with ubiquitous information technology. All information systems are linked, and virtually everything is linked to an information system through technologies such as wireless networking and RFID tags*.

Both recent digital city and U-city approaches face multiple challenges: the opportunity for the digital city to become a) a common interface for public transactions in the city area, b) an area-of-trust for virtual communities where opinions can be generated and forwarded to the political leadership. These approaches can develop a "global e-Government environment" in cities, where citizens can access both local and central public services. This global environment can be called "Metropolitan e-Government environment" and its main targets concern: a) the collection of local information, b) the use of local information for the sustainable development of the city and c) the continuous evaluation and improvement of the architecture, and of the quality of the offered services.

In the first section of this paper we present the transformation of the digital city from the web to a technically 'physical' area based on the ubiquitous computing. We propose an extension of the latest architecture of the digital city, in order to include the 'business' layer with standards and rules concerning operation. Finally, we present the evolution case of the digital city of Trikala (Greece), in order to describe successes and failures concerning digital communities' expectations.

2 The Evolution of the Digital City

Since early 90s different digital cities were implemented all over the world (Table 1). These cities vary from the fully virtual cases -where no physical equipment can be accessed by citizens and where no real boundaries limit digital city area-, to the fully physical cases –where digital and real city share common physical space-. Fully virtual cases involve online cities, knowledge bases and virtual communities. On the other hand, fully physical cases involve the latest digital cities such as Beijing, Seoul and Trikala, together with the ubiquitous cities of South Korea and Japan.

2.1 Virtual Cases

The first virtual case was the America on Line cities (AOL cities) [1], where web environments offered digital information and transactions, together with chatting options. AOL simulated a city via grouping services according to civilian logic. The digital city of Kyoto (Japan) [7],[8] and the digital city of Amsterdam [9] were web environments simulating the city and its local life (streets, enterprises, malls etc.). This version of the digital city offered virtual meeting rooms for specific common interests, inviting citizens to participate. These web approaches were evolved to virtual reality environments [10] operating beyond the physical boundaries of a city.

On the other hand, some major cases that exploit Information and Communication Technologies (ICT) for the social development were implemented: the Copenhagen

Base [11] was a public database containing useful local information. People could initially access the database via the Internet and via text-TV. Today the Copenhagen Base is open to people for data supply and entry. Moreover, the Craigmillar City of Scotland [11] used the ICT to structure groups of citizens who shared knowledge and offered social services to the local community. In Craigmillar –an ex-industrial area-, citizens collaborated in order to handle local needs.

The Smart City [12] refers to a city where the ICT strengthen the freedom of speech and the accessibility to public information and services. In the smart cities the habitants can participate in social events easy and cheap. The smart city approach was initially applied in the case of Brisbane (Australia) and supported the social participation and the close of the digital divide.

The World Foundation of Smart Communities (http://www.smartcommunities.org) is a nonprofit educational organization studying the development of Smart Communities; meaning cities with broadband networks interconnecting their local resources with resources from other geographic areas. The Smart Community uses the ICT in order to improve living and working. Lots of cities from Singapore, Malaysia, Canada, Hong Kong, Spain, German, Ireland, Holland and Saudi Arabia, participate in the Smart Community network.

The Communities of the Future (http://www.communitiesofthefuture.org) is a nonprofit organization defining the digital city as a knowledge democracy. This approach concerns the development of societies, where the novel privileges (privilege to access public information and services), risks (privacy and security) and challenges (social participation) based on the ICT, are analyzed and participation is encouraged. The Knowledge Democracy approach was applied in Blacksbourg (Australia) implementing the Blacksbourg Electronic Village (http://www.bev.net), where habitants with common interests (e.g. citizens, local administration, engineers) are grouped together, composing the neighborhoods entities.

The knowledge based cities [13] is a digital city approach, where the ICT can support local democracy and economy. This approach was applied in Portugal and uses broadband networks developed by telecommunication vendors connecting cities and local economies. Virtual organizations are structured in this network of cities, such as virtual organization for the municipalities, for the enterprises, for the citizens with common interests etc. The interconnected cities structure a regional virtual environment, where cities support each other's progress via the ICT.

The Digital Geography [14] is an approach that extends city physical boundaries and structures teams of interconnected citizens who share knowledge of common interest. The digital geography uses the Internet and the mobile networks to compose digital communities where knowledge is exchanged and where growth is supported. Emphasis is given to the development of Digital States in the same country, which are small-scale digital geographies. Digital geographies are graphically presented with communication zones in the same or in multiple geographic areas.

2.2 Physical Cases

The cases of Hull (UK, www.hullcc.gov.uk) and of Beijing (China) [2] used fiber optic backbones installed in the city, which were called "Metropolitan Area Networks (MAN)". MAN offered broadband access to public information and services from

local agencies, aiming in simplifying everyday life. However, Beijing digital city was implemented for the purposes of the Olympic Games of 2008, and initially offered relating information and services. MAN was used in the case of the Digital Metropolis of Antwerp [11], the first digital city in Belgium. The Antwerp city collaborated with the City of Amsterdam, having a MAN too, in order to interconnect their municipal agencies and offer common information and services to their habitants. This group of digital cities supported the diffusion of the ICT for the decision making by the municipal leadership. Geneva city [11] on the other hand, used its MAN to interconnect the foreign enterprises that were located in the area. It then offered the MAN for public use, and constructed a digital market for all local businesses.

Broadband Metropolis such as the Seoul is an extension of the previous -based on the MAN- approaches. Broadband metropolis [15] contains dense fiber optic networks interconnecting public agencies with the citizens and the enterprises. A main fiber optic backbone is installed in the city, while the last mile connection is established with fiber channels (Fiber-to-the-Home, FTTH). Broadband metropolis comprises an area of healthy competition among telecommunication vendors, while it is attractive for private investments. In these digital city cases, financial wealth is established in the city, which is based on broadband investments.

Mobile Cities such as the New York [16], installed wireless broadband networks in the city, which were accessible (free-of-charge) by the habitants. Both e-learning and e-Government services were offered from local or national organizations in the mobile cities.

The Eurocities (http://www.eurocities.org) is a European network of cities, which focus on the development of an inclusive, prosperous and sustainable ICT environment operating in the area of a city. The participating cities exchange their experiences and they cooperate in the development of an open market and in the treatment of corruption in municipal agencies. The result of the Eurocities initiative is the development of prototype digital city, covering local needs in Europe. A public portal called the Demos has been developed, containing information from all participants. Moreover, pilot projects are being implemented concerning e-democracy and decision making applications.

In Trikala (central Greece) a novel approach to the Digital City was given [5], which extended the above cases and older ones [17]: the digital city is an ICT-based environment whose priorities concern a) the availability of digital means that support local needs and transactions, b) the transformation of the local community to a local information society, c) the direct and indirect, official and unofficial information collection, in order to support the sustainable development of the local community. The Trikala case is analyzed further in the next section, supporting the main focus of this paper.

Broadband cost minimization and the simplification of IS installation and maintenance resulted in further digital city cases. Moreover, the “cloud services” and the “ubiquitous computing” solutions offered by the big international ICT vendors, result in the evolution of the Digital City to the Ubiquitous City (or U-city). The U-city architecture is being implemented in South Korea (e.g. New Songdo [18]) and Japan (e.g. Osaka [19]) and delivers information anytime, to anywhere and to anybody, via interconnected information systems and ubiquitous ICT solutions over the city.

Table 1. Virtual and physical Digital City cases and approaches

City		Digital City	Short Description
1.	American On Line (AOL)	AOL Cities *(virtual)*	Virtual groups exchanging knowledge over the Internet.
2.	Kyoto	Digital City of Kyoto *(virtual)*	City simulation via web and virtual reality interfaces.
3.	Amsterdam	Digital City of Amsterdam *(virtual and physical)*	- City simulation via web and virtual reality interfaces. - Metropolitan Area Network installed in the city - Interconnection with Digital City of Antwerp
4.			
5.	Copenhagen	Copenhagen Base *(virtual)*	Public database covering local needs.
6.	Craigmillar	Digital City of Craigmillar *(virtual)*	Groups of citizens sharing knowledge and social services covering local needs
7.	Brisbane	Smart City of Brisbane *(virtual)*	- Decision making services. - Virtual groups sharing knowledge
8.	Smart Communities	Interconnected cities from even different continents *(virtual)*	Cities interconnected with broadband networks.
9.	Blacksbourg	Knowledge Democracy of Blacksbourg *(virtual)*	Environment with knowledge concerning the ICT.
10.	Knowledge based cities	Knowledge Based Cities in Portugal *(virtual)*	Regional network of interconnected cities
11.	Digital Geographies	*(virtual)*	Virtual teams of users sharing knowledge, who are located in even different countries

Table 1. (*continued*)

12. Hull	Digital City of Hull *(physical)*	- Metropolitan Area Network - Public portals offering local information and services.
13. Beijing	Digital City of Beijing *(physical)*	- Fiber optic and wireless broadband networks in the city. - Public services mainly oriented to the Olympic Games.
14. Antwerp	Digital City of Antwerp *(physical)*	- Metropolitan Area Network - eDemocracy services - Portals offering public information - Interconnection with Digital City of Amsterdam
15. Geneva	Geneva-MAN *(physical)*	- Metropolitan Area Network - Interconnected market
16. Seoul	Seoul Broadband Metropolis *(physical)*	- Fiber optic network all over the city (backbone and FTTH)
17. New York	Mobile City of New York *(physical)*	Wireless broadband network covering the city area.
18. Eurocities	European city network *(virtual and physical)*	ICT usage and experience exchange for: - Social Participation - Local community evolution - Sustainable development

Table 1. (*continued*)

19.	Trikala	Digital City of Trikala *(physical)*	- ICT solutions to cover local needs - Multitier architecture - Global e-Government environment - The Digital City consists a trusted third party for transactions and knowledge exchange
20.	New Sondgo	U-city of New Sondgo *(physical)*	Ubiquitous information systems in city area
21.	Osaka	U-city of Osaka *(physical)*	Ubiquitous information systems in city area

All of the above refer to either digital environments operating in the physical boundaries of a city or to environments that create virtual communities beyond the geographic area of a city. Although different priorities were given on each case, common ICT infrastructures are used (broadband networks and information systems) and virtual teams of citizens are structured. The analysis of the technologies combined in a digital or in a ubiquitous city is beyond the purposes of this paper.

Digital cities face common challenges, such as the encouragement of the social participation, and the economic and the sustainable growth of the local community. Today, all digital cities focus on the quality and on the variety of the information that they offer to their habitants (public content and services, private content, video-on-demand and other entertainment services, social networks etc.).

3 Investigating the Performance of a Digital City

In order to investigate how a digital city is implemented and performs, we present the case of Trikala, central Greece (e-Trikala). We use the development experiences and the e-Trikala official publications, in order to investigate how well the digital city performs since its beginning in 2005.

In Trikala, local needs were prioritized following the "bottom-up" procedure [20], and they were grouped into the following axes of precedence [5]:

- Local Economy and employment
- Improvement of everyday life concerning public transactions and transportation
- Education, vocational training and life-long learning
- Tourism and culture

On behalf of the municipality, a team of experts discovered funding and designed the necessary projects that could deal with the above axes of precedence. The set of projects delivered city-wide interconnected information systems and broadband networks, together with important public information and services. The logical architecture of the whole environment follows the multi-tier structure [21], inspired by information cities [2], [3], [4], consisting of following layers [5]:
Users layer, containing potential users of the digital city services: end-users (citizens, businesses, students), groups of end-users (local chamber, teams with common interests), servants who offer public and commercial services via the digital city (civil servants, public agencies, enterprises).

- Service layer, including software applications that deliver public information and services to citizens and enterprises. The applications concern web portals, engines executing e-Government, e-Commerce and social (e.g. telecare) services, web services transacting with other information systems (e.g. central e-Government systems, others located beyond city borders etc.), and geospatial services. This layer structures the interface between the habitants and the public administration (local and central ones). However, today no unique interface collecting all available services from digital city platforms exists, meaning that the digital city has not yet succeeded in its initial objectives. This web distribution of the digital city services can cause troubles to the habitants and can lead to information replication.
- Infrastructure layer, containing the local broadband networks (MAN and a metro Wi-Fi), an intelligent transport system, phone centre for public calls, and public access points in the city hall and in other public buildings. Concerning the broadband connectivity, both a MAN and a metro Wi-Fi are installed in the city today. The Wi-Fi is accessed by more than 2,000 registered users and it is based on more than 10 points of access. However, the MAN was implemented with European funding (under the Information Society Framework Programmes (www.infosoc.gr)), and it interconnects only public agencies today. No private organization can access the MAN, nor can FTTH connections extend it to the households and to the local enterprises.
- Information layer, consisting of information and data that is produced and stored in the infrastructure layer. The information can be public, private or both public/private and the digital city can apply policies for security and privacy, in order to define who can access what resource and to protect sensitive information. Today, there is no common data repository in the digital city of Trikala. Each information system belongs to a unique organization, and the information that it is produced and hosted in each one, belongs to that organization. The digital city cannot apply common security and privacy rules to different information systems and can only observe transactions.

Official publications of e-Trikala (www.e-trikala.gr) return useful findings concerning digital city progress and performance: although the e-Trikala case study was an ambitious approach, aiming to interconnect virtual with physical environments [22], only a few of its primary targets have been achieved while they are all reconsidered. After the completion of projects' design by the team of experts, the municipality structured an office responsible for the procurement and for the management of the projects.

Projects have been procured and implemented since 2005. Today, project deliverables operate under pilot conditions, while the municipal office has been evolved to a municipal company, able to exploit project deliverables and knowledge. The municipal company is also responsible for deliverables operation, and for digital city monitoring, reviewing and evolution.

Concerning the broadband access, the initial objectives were that anyone (end-users and groups of end-users) could access the digital city via its broadband networks from everywhere. Today, the metro Wi-Fi covers the 2/3 of city area, and it is open to anyone in its range. Users can access the metro Wi-Fi free-of-charge with the combination of a username and password given to them upon registration. Registration follows the traditional procedure, which demands the physical presence of the user at the municipality, in order to fill-in and to submit an application procedure, meaning that citizens have to obtain and application form document to the municipal authorities. On the other hand, the MAN is accessible only for public organizations, because Greek legislation does not permit private connections yet. It is expected that individuals and the private sector will be able to access the MAN by 2012. Until then, FTTH connections will not be able to extend the MAN, and habitants will access the digital city resources indirectly via the Internet or by phone. The broadband networks' operation is by now a municipal obligation, meaning that monitoring, maintenance and policy application is a difficult procedure that lacks compared to the private sector's competition.

Concerning the offered services no one-stop portal for the digital city exists so far. On the contrary, each project delivered a different but interoperable portal, offering its custom services and information. The municipal company has installed a web portal for the digital city (www.e-trikala.gr), but the web services to the projects portals have not been implemented yet. The reason is that each project deliverable belongs to a different organization of the city, and even hosting on central public infrastructures in the digital city demands legal confirmation.

E-Government progress is weak in e-Trikala case. The digital city has achieved in miniature town hall behavior [23], establishing "vertical connections among municipal agencies", and it offers four (4) services online. The same services are offered to the wider state region, beyond the city boundaries. Moreover, a call center offers helpdesk services to the citizens, concerning public transactions. Other digital public services are offered via the citizen service (KEP) offices (www.kep.gov.gr) and central public agencies, which are executed beyond digital city infrastructures.

However, e-Trikala case performs significantly well regarding social services: tele-care and e-health services are widely accepted by citizens with special needs, who have obtained digital devices from the municipality, in order to be monitored online by the local hospital, doctors and psychologists. Heart diseases are monitored effectively by the local hospital, with the use of an information system installed in the infrastructure layer. Health records are collected and transmitted online, and some privacy issues have to be investigated further. Additionally to tele-care and e-health services, the intelligent transport system performs satisfyingly in e-Trikala: the period of testing has passed and statistical analysis on traffic data has been performed. Today, "smart bus stations" located around the city, inform citizens about the estimated departure times of buses.

On the other hand, no Enterprise Architecture has been composed, either common standards or blueprints have been defined for the future ICT projects that will

be designed and implemented in the city area. Moreover, security and privacy issues have not been analyzed and each information system follows independent policies and rules. The municipal leadership has emphasized in the implementation of the designed projects, and only recently the development of the municipal company is a strategic direction.

The digital city performs similarly in information layer: the infrastructures do not contain common storage repositories for the information created and used in the city, and each project has its own storage capacities. The reasons concern the possession of the data and the proper legal alignment for public data construction, storage, access and use.

All other public services (e.g. tax and other administrating services) are either offered directly via central systems to which citizens are obliged to access or they are executed with the traditional methods. It is expected that by 2012 a central web portal will operate as a one-stop-shop for public services coming from the inside or the outside of the digital city.

The above findings show that the digital city mainly suffers concerning its management and its approach to all kinds of users. Additionally, ownership issues arise in the area concerning the infrastructure and data, which lead to lack of trust among different virtual organizations and virtual teams.

For these reasons, we propose the extension of the digital city architecture via including the Business layer, which contains the policies, the operating rules and the Enterprise Architecture of the Digital City. This layer defines how each system will be designed, installed and interconnected in the Digital City, while it contains the "WHOs and HOWs" for each new system, and for each transaction executed in the Digital City. Additionally, we suggest the renaming of the user layer into the stakeholders layers, in order to describe even the entities that affect a digital city, without transacting with it (e.g. the political leadership, legal authorities etc.). The logical and physical architectures of the digital city will be transformed to those presented in (Table 2) and (Fig. 1) respectively.

Table 2. The n-tier logical architecture of the Digital City of Trikala

Stakeholders layer *End users, groups of end-users, servants*
Service layer *Web portals, engines, web services, geospatial services*
Business layer *Enterprise Architecture, policies, operating rules*
Infrastructure layer *MAN, metro Wi-Fi, information systems, phone centre, public access points*
Information layer *Public, private, public/private data created and stored*

The digital city environment interconnects all viable and ICT resources in the city and it can deliver information from everywhere to anyone, meaning that it formulates a ubiquitous city. This environment can behave as a global e-Government environment (Metropolitan e-Government environment), with the following characteristics:

- Each citizen has a unique identity in the digital city and he can be authorized once, with the use of the same credentials in order to access different resources.
- Further citizen certificates will not be required for service execution, since any necessary information will be retrieved "transparently" among the digital city systems.
- Authentication tools, local content and services can be available via a common web portal. Habitants use the digital city portal to access local commercial, public or social services.
- Each transaction is executed and monitored by the digital city infrastructures.
- The digital city can be evolved to an "intelligent e-Government environment", since it will be able to "predict" the execution of some public services by monitoring citizen needs (with the consent of the involved parties). For instance, a citizen application for residence movement could be accompanied by records update in tax-systems, by a new service triggering concerning the power Supply Company etc.
- The Digital City is a virtual organization, consisting of various virtual teams [24]. This virtual organization is used for knowledge sharing and exchange, and for decision making.

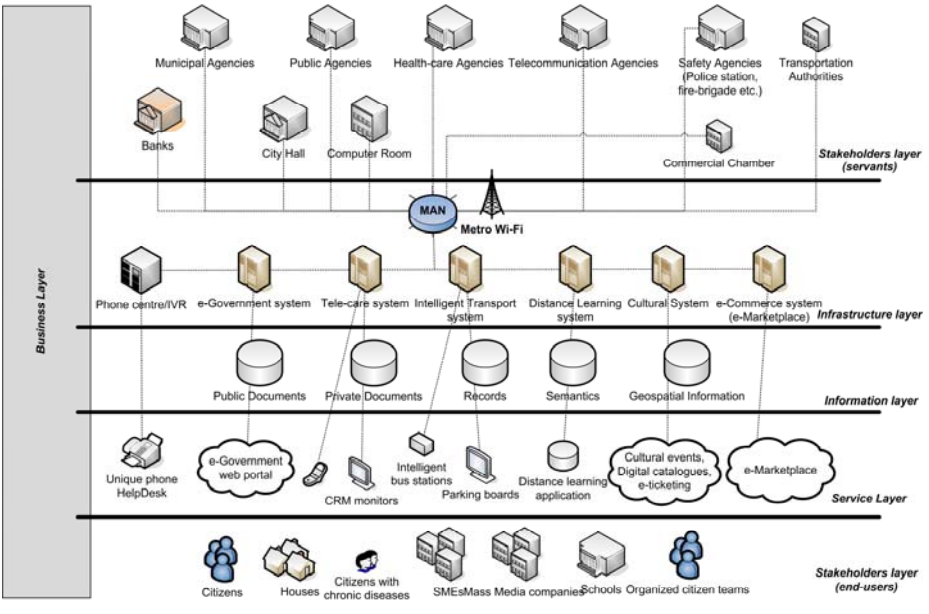

Fig. 1. The physical architecture of the Digital City of Trikala

4 Conclusions

Digital City environments have evolved since the early 90s when they first entered the digital era. Web sites and virtual reality applications transformed to smart and knowledge repositories, which began interacting with groups of citizens inside city boundaries. Then broadband networks and other intelligent technologies were applied over the city, resulting in current digital cities. However, South Korea shows digital city future, with the application of ubiquitous computing in metropolitan environments. In this paper we presented how digital cities have been evolved, and how they can simplify e-Government transactions: we called this environment "Metropolitan e-Government environment", where new challenges concerning e-Government arise. Policies and rules guiding metropolitan transactions will be investigated in future research.

We analyzed the e-Trikala digital city case study: we used its official resources in order to evaluate its performance since 2005; we mentioned the wide acceptance of the social services, as well as with organization and ownership problems in the city. Finally, we proposed extensions for the logical and physical architectures of the digital city, in order to define solutions and to obtain trust among the virtual organizations structured in the digital city. The e-Trikala case can be used as a typical example of the local authorities' success in introducing e-government systems to the benefit of citizens and of local communities.

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