The Project Management Perspective for a Digital City

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ABSTRACT
Digital cities have been evolved during the last decade and they have installed various information systems and information and communication technology (ICT) based infrastructures across various cities in the world. Most digital cities are ongoing investments, while their outcomes are differentiated from their primary objectives, and many of them are declined although their deliverables have been achieved.
The aim of this paper is to approach the digital city as a unique project instead of a program of projects. In this context, a digital city can be considered a complex and large scale project, while the project management perspective will be applied on two representative forms of digital cities in order to conclude on a common management model, to underline the difficulties of such a project, and to provide with useful instructions that can be used by current and by future project managers who approach a similar initiative.

Keywords: Digital city, smart city, project management, construction management, PMBOK, large scale project, project life cycle.

1. INTRODUCTION
The term digital city was initially grounded by the early 90s from the *America-On-Line cities* (Wang & Wu, 2001; Anthopoulos & Fitsilis, 2009), where web environments offered digital transactions and chatting options. Since then, various terms -such as “smart cities”, “ubiquitous cities”, “broadband cities”, “knowledge spaces”, “smart communities” etc.- are used to describe geographic spaces (cities, states, neighbors, clusters) where information and communication technology (ICT) infrastructures and software applications are combined and offer various e-

services. For the purposes of this paper the term “digital city” will describe all the above notions. The scope and the objectives of the deployed e-services are extensive and many of them are based on Web 2.0 technologies in order to achieve social participation and crowd sourcing. The components of a digital city usually concern “smart people”, “smart environment”, “smart economy”, “smart governance”, and “smart mobility” which generally constitute the notion of “smart living” (Giffinger et al., 2007). On the other hand, according to (Caragliu & Nijkamp, 2009), a “smart” city is established “*when investments in human and social capital in combination with traditional and modern ICT infrastructure support the sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance*”.

Various digital cities faced different challenges and defined alternative priorities such as the improvement of local everyday life; the development of knowledge-based societies; the “close” of the “digital divide”; and the simplification of the public services (Anthopoulos & Fitsilis, 2009). Moreover, some digital cities prioritized e-commerce and public services, others focused on the local quality of life, while current trends concern the environmental protection. The social implications and the diversity of the ICT solutions and of the offered e-services increase the complexity of a digital city, while the transformation of the local community requires a continuous review and reconsideration of a digital city.

The implementation of a digital city is based on the deployment of various projects, which address the predefined priorities and objectives. The aim of this paper is the determination of a proper management method that can support the success of current and of future digital cities, and that can establish their viability. In this context, the digital city is considered as a unique project instead of a set of projects, and the project management perspective is analyzed and delivers useful outcomes. This analysis is critical for such a project due to complexity, scale and viability requirements. It is also important since each similar project is ongoing, and its social adoption is not secured in spite of project success in terms of scope, time, budget and quality.

The project management perspective’s analysis follows the four construction management generic project processes inspired by (Winch, 2009): (a) Defining the Project Mission; (b) Mobilizing the Resource Base; (c) Riding the Project Life Cycle; (d) Leading the Project Coalition. In each process the Project Management Institute (PMI) Body of Knowledge (PMBOK, 2008) areas are considered and a proposed management model for a digital city is structured. Finally, two different representative cases (a) the e-Trikala (Anthopoulos & Tsoukalas, 2006) and the New Songdo (Lee & Oh, 2008) will support the composition of the project management model.

This paper is organized as follows: in the following section of this paper, the context of the Digital City is analyzed and various digital cities are presented in order to define the scope and the complexity of such a project. In section 3, the project management perspective is considered for a digital city with the use of two case studies: the Digital City of Trikala (Greece) and the Ubiquitous City of New Songdo (South Korea). In section 4, the outcomes of the consideration are discussed, and in the final section 5 some results and some future thoughts are presented.

2. THE CONTEXT OF THE DIGITAL CITY

Digital cities have being developed since the early 90s in various forms, facing different challenges and following alternative approaches (Table 1). The *Web or Virtual Cities* such as the America-On-Line cities (Wang and Wu, 2001), the digital city of Kyoto (Japan) (Ishida, 2002;

Ishida, Aurigiri and Yasuoka, 2001) and the digital city of Amsterdam (Lieshout, 2001) were the initial forms. This approach concerns web environments' developments, which offer e-services, online chatting and meeting rooms, and city's virtual simulation (streets, enterprises, malls etc.). The above web environments were evolved to virtual reality ones (Van den Bestelaar and Beckers, 1998) that operate beyond the city's physical borders.

The second approach results in the *Knowledge Bases*, which capitalized crowd sourcing for the social development. Representatives of this approach are the Copenhagen Base and the Craigmillar Community Information Service (Edinburgh, Scotland) (Van Bastelaer, 1998). The first case developed a public database with crowd sourcing options for useful local information, which was accessible via the Internet and via text-TV. The second case 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 unemployment and other local needs.

The Seoul city introduced the *Broadband City/Metropolis*, where fiber optic backbones - called "Metropolitan Area Networks (MAN)"- were installed in the city, and enabled the interconnection of the households and of the local enterprises to ultra-high speed networks (Townsend, 2004). The last mile connection to the MAN was established with fiber optic channels (Fiber-to-the-Home, FTTH), composing a healthy competitive environment for telecommunication vendors, and an attractive field for private investments. Other similar cases can be faced in Beijing (China) (Sairamesh et. al., 2004), in Antwerp (Belgium), in Amsterdam and in Geneva (Switzerland) (Van Bastelaer, 1998). Antwerp and Amsterdam collaborated and interconnected their municipal buildings via their MAN.

Mobile Cities (or *Ambient cities*) such as the New York (New York City Economic Development Corporation, 2005), 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 *Digital City* approach extends the above cases and older ones (Moon, 2002) and describes a "mesh" environment that interconnects virtual and physical spaces in order to deal with local challenges. A definition of the Digital City (Anthopoulos & Tsoukalas, 2006) presents the "*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*". This approach was followed by Hull (UK) and Trikala (Greece).

The *Smart City* (or *Intelligent City*) approach is currently the most famous. It was initially applied in Brisbane (Australia) (Partridge, 2004) and in Blacksbourg (Australia) (www.bev.net), where the ICT supported the social participation and the close of the digital divide, and strengthened the freedom of speech 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 first approach provides with ICT infrastructures the city and supports the development of a knowledge-based society and the business growth. The Smart City is fully applicable in Dubai, where it is analyzed into the "media city" (www.dubaimediacity.com) and the "internet city" (www.dubaiinternetcity.com) where broadband and media infrastructures offer cost effective platforms to the enterprises. The second approach is continuously adopted by

various cases (e.g. Helsinki, Barcelona, Austin (USA) and others that can be found at http://smart-cities.eu and at http://www.smartcities.info). This second approach has several dimensions for ICT contribution: economy (Smart Economy), education (Smart People), governance (Smart Governance), transportation (Smart Mobility), sustainability (Smart Environment) and everyday life (Smart Living). A city is measured for its progress in the above dimensions and it gets a rank concerning its overall position. Various ICT vendors (e.g. IBM, Microsoft and Oracle) have implemented and offer commercial solutions for the Smart Cities.

The *Ubiquitous City (or u-City)* came as a result of broadband cost minimization, of the commercialization of complex information systems, of the deployment of cloud services, and of the ubiquitous computing. The U-city architecture is being implemented in South Korea (e.g. New Songdo (Hyang-Sook, Byung-Sun. & Woong-Hee, 2007)), U.S.A. (Manhattan Harbour, Kentucky), Abu Dhabi (Masdar city) and Japan (e.g. Osaka (Osaka ICT Industry, 2008)) and delivers information anytime, anywhere to anybody, via interconnected information systems and ubiquitous ICT over the city. However, this approach is accompanied with the development of new urban spaces where the pervasive computing will be incorporated from the scratch.

The *Eco-cities* capitalize the ICT for sustainable growth and for ecological protection. They apply ICT sensors for environmental measurement and for buildings' energy capacity's evaluation; they provide with smart grids for energy production and delivery in the city; they encourage smart solutions for renewable energy production. This approach has been followed by various cities (e.g. New Songdo (South Korea), Dongtan and Tianjin (China), Masdar (Abu Dhabi) and it is steadily evolving.

Except from the above approaches, various cities joined networks of common interests to provide with intelligence their urban spaces. 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 *World Foundation of Smart Communities* (http://www.smartcommunities.org) is a nonprofit educational organization studying the development of "Smart Communities". This network contains cities from Singapore, Malaysia, Canada, Hong Kong, Spain, German, Ireland, Holland and Saudi Arabia, which use their broadband networks to interconnect their local resources with resources from other geographic areas and study how they can improve living and working. The *Communities of the Future* (http://www.communitiesofthefuture.org) is a nonprofit organization defining the "knowledge democracy". The *Intelligent Communities* (www.intelligentcommunity.org) capitalize the challenges of the broadband economy and take conscious steps to create an economy of prospering in it. Three success factors (collaboration, leadership and sustainability) are measured by the partners (European Regional Information Society Association (ERISA), Eurocities, Global Cities Dialogue etc.) annually and return the best performed cases. *Knowledge Based Cities* (Mountihno & Heitor, 2003) were applied in Portugal, and they use the ICT to support local democracy and local economy with the construction of virtual organizations (e.g. virtual organization for the municipalities, for the enterprises, for the citizens with common interests etc). The *Digital Geographies* (Zook, Dodge, Aoyama & Townsend, 2004) extends city's physical boundaries and structures teams of interconnected citizens who share knowledge of common interest. The *Community Networks* is the evolution of the Free-Nets, they were initially deployed in Cleveland (USA), and they offer free-of-charge services (e.g. the Seattle Community Network (http://www.scn.org)).

Case	Approach	Short Description	Started	Current Condition

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America-On-Line Cities	Virtual City	Virtual groups exchanging knowledge via the Internet	1997	City Guides for U.S. cities (http://www.citysbest.com)
Digital City of Kyoto	Virtual City	City simulation via web and virtual reality interfaces.	1996	Web prototype finished its experiments by September 2001 (http://www.digitalcity.gr.jp)
Bristol	Virtual City	Open community resource	1997	Maintenance of Digital Bristol's site basic content (http://www.digitalbristol.org/)
Amsterdam	Virtual City / Broadband City/ Smart City / Green City	- City simulation via web and virtual reality interfaces. - MAN - Interconnection with digital city of Antwerp	1997	Failed to establish online communications and infrastructure accesses. It has been transformed to the Smart City of Amsterdam, which capitalizes the ICT for environmental protection and energy saving (http://www.amsterdamsmartcity.com)
Copenhagen Base	Knowledge Base	Public database covering local needs.	1989	Updated in 1997 to a friendlier version. Today it operates as a city portal (http://www.kk.dk) and Copenhagen migrated to Sustainable City
Craigmillar Community Information Service	Knowledge Base	Groups of citizens sharing knowledge and social services covering local needs	1994	It operates as a community portal (http://www.s1craigmillar.com)
Blacksburg	Knowledge Democracy of Blacksburg	Environment with knowledge concerning the ICT.	2001	It evolved to a Digital City (http://www.bev.net)
Seoul	Seoul Broadband Metropolis	- Fiber optic network all over the city	1997	Evolves with 84% broadband penetration, it is expected to reach 1GB web connections by 2012, and it provides with Wi-Fi access its public buildings (Engadget, 2009)
Beijing	Broadband City of Beijing	- Fiber optic and wireless broadband networks in the city. - Public services mainly oriented to the Olympic Games.	1999	It is upgraded to Digital Beijing city, which focused on buildings of the Olympic Games 2008 (Rui & Wenfang, 2001; Qi & Shaofu, 2001; Gauggel, 2008)
Helsinki	Broadband city	A city with wireless network and some e-services	1995	New e-services' deployment on WLAN infrastructure (http://www.hel.fi)
Geneva	Geneva-MAN	- MAN - Interconnected	1994	It exists and offers broadband connectivity

Case	Approach	Short Description	Started	Current Condition
		market		
Antwerp	Digital City of Antwerp	- MAN - eDemocracy services - Portals offering public information - Interconnection with digital city of Amsterdam	1995	Smart City interconnected to Brussels and to Amsterdam (Baeyens, 2008).
New York	Mobile City of New York	Wireless broadband network covering the city area.	2004	Exists and decided to be extended (Government Technology, 2011)
Stockholm (Kista)	Mobile city	An innovative cluster-suburb of Stockholm, where researchers and students collaborate for local growth	2002	Kista has become a thriving Science City and a leader in mobile and ICT development (http://en.kista.com/)
Taipei	Smart city	Various e-services based on ICT infrastructure	2004	Exists and evolves to eco-technologies
Dongtan	Eco-city/Smart city	Smart technologies for environmental protection	2005	Under development. It has been delayed
Tianjin	Eco-city/Smart city	Smart technologies for environmental protection	2007	Under development Public housing project in the Eco-city and Keppel District Heating and Cooling System Plant (http://www.tianjinecocity.gov.sg/)
Barcelona	Digital City / Smart City of Barcelona	MAN e-Government services Virtual communities Integrated ICT environment (http://www.bcn.es/digitalcity)	2000	Exists (http://w3.bcn.es) (http://www.bcn.es)
Hull	Digital City of Hull	- MAN - Public portals offering local information and services.	2000	Exists and focused on e-Government, on e-learning and on smart TV (CommuniG8, 2011) (http://www.hullcc.gov.uk)
Trikala	Digital City of Trikala	- ICT addressing local needs - Multitier architecture - Global e-Government environment - The digital city structures a trusted third party for transactions and	2003	Exists and limited its scope to tele-care and to metro-Wi-Fi services (www.e-trikala.gr)

Case	Approach	Short Description	Started	Current Condition
		knowledge exchange		
Austin	"Austin is IT" Digital City / Eco-City	- Digital Media for investment attracting - Metro Wi-Fi network - Clean Energy - Biotechnology and Life Sciences - Early-Stage Technology Commercialization	1995	Exists and emerges to Eco-City (http://www.cityofaustin.org/)
Brisbane	Smart City of Brisbane	- Decision making services. - Virtual groups sharing knowledge	2004	Exists and limited its scope on local e-Government, traffic and parking, and on waste management services (http://www.brisbane.qld.gov.au)
Malta	Smart city	a new hub for ICT applied to environment, infrastructure and residential spaces	2007	Continues to connect ICT companies especially in the field of healthcare and education (http://malta.smartcity.ae/)
Dubai	Smart city	knowledge clusters of Dubai Internet City, Dubai Media City and Dubai Knowledge Village	1999	Exists and continues to integrate top ICT solutions
New Sondgo	U-city of New Sondgo	Ubiquitous information systems in city area	2008	Under development (Jackson et al, 2011)
Osaka	U-city of Osaka	Ubiquitous information systems in city area	2008	It is still a Digital City and it is under development for its u-City form (Jackson et al, 2011)
Manhattan Harbour, Kentucky	U-city	An under development project built from the scratch	2010	Currently, a division of the LG Group, LG CNS, has over 100 ubiquitous concepts to implement in the plan (http://www.themanhattanharbour.com/)
Masdar	Eco-city/u-city	Sustainable communities	2008	Under development. Some components operate (http://www.masdarcity.ae)
Eurocities	European city network	ICT use and experience exchange	1996	It still exists (http:// www.eurocities.eu)
Smart Communities	Interconnected cities from even different continents	Cities that prepare their communities to meet the challenges of a global, knowledge economy	1997	It still exists (http://www.smartcommunities.org)
Knowledge based cities	Knowledge Based Cities in	-MAN installed in each city	1998	Seven (7) digital city projects were initiated in Portugal

Case	Approach	Short Description	Started	Current Condition
	Portugal	- Regional network of interconnected cities - Groups sharing knowledge		(Aveiro, Bragança, Castelo Branco, Guarda, Marinha Grande, Alentejo, Trás-os-Montes) Castelo Branco has failed but others have joined the digital cities' network (http://www.cidadesdigitais.pt) Portals of the digital cities do not meet projects' objectives
Digital Geographies		Virtual teams of users sharing knowledge, who are located in even different countries		Their notion is still evolved, although the initially presented cases cannot be found. Other cross-border initiatives have been observed e.g. National and Regional Spatial Data Infrastructures (NSDIs) (Jackson et al, 2011)

Table 1. Different digital city forms and their evolution

The development of Digital Cities was accompanied by the deployment of an extensive number of e-services, which vary from online city guides to intelligent building management and energy saving (Table 2). On the other hand, the presented cases were either abandoned or updated (some more than once) since 1989 where the above investigation starts. This evolution could define a roadmap for digital cities (Fig.1), which is not common or steady, since local challenges and priorities are differentiated.

Portfolio	e-Service
Public e-Services	public complaint center
	e-voting
	e-procurement services
	environmental and urban planning services
	e-dialogue and e-democracy
	other local e-government services
e-Business Services	e-marketplace
	e-tourism
	telecommunications services
	e-recruitment
	business installation support

	e-procurement services
	commercial centers
Communications	broadband services
Public safety	amber alert
Energy-Water-Waste Management	environmental and urban planning services
Entertainment and socializing	social media centers
	crowd sourcing
	commercial centers
Education	e-learning services
Transport	intelligent transportation
City promotion	virtual city simulation
	e-tourism
Healthcare	tele-care services
	e- health services

Table 2. The e-Service portfolios structured from the investigated cases

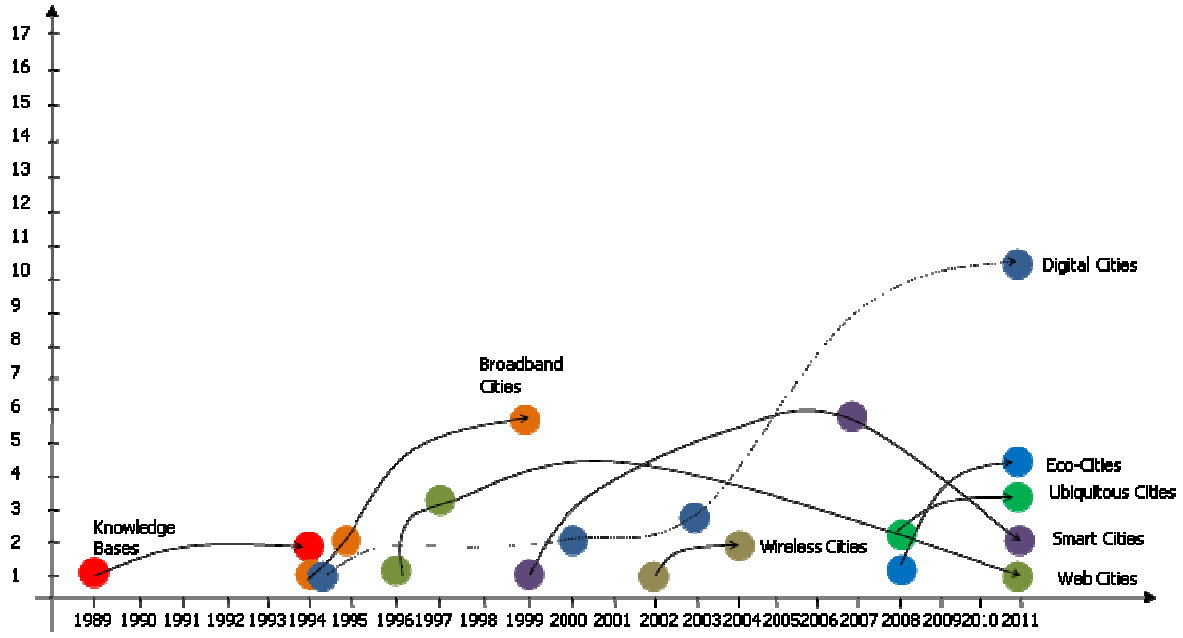

Fig. 1. The evolution roadmap for the digital cities

The above analysis showed that the technological form of a digital city varies and has been evolved mostly to Digital City (as it is explained in this paper), to the novel form of Eco-City – that concerns activities for environmental protection- and to Ubiquitous City. The older

technological forms have been either abandoned or failed, either updated. Moreover, the analysis proves that a digital city is a **large-scale** -in terms of scope, duration and deliverables-, **complex** –in terms of innovative and numerous components that have to be integrated- and **ongoing** project -since most of the examined cases are still under evolution-. Furthermore, although digital cities face different challenges, their e-service portfolio shows many similarities, while similar technologies have to be adopted in different cases (e.g. broadband networks, e-Government information systems etc.). In this context, a digital city requires a number of interventions, which have to be developed in the urban spaces in order to establish any of the above approaches: from neighborhoods' construction from the scratch (ubiquitous cases), to ICT infrastructure's and to broadband networks' deployment, and to e-service provision.

An important finding from the above analysis is that although a digital city is an ambitious and important initiative for any city, and the future of urban living, and although it may succeed in terms of project development (it meets its requirements in scope, time, budget and quality) it can fail in its social adoption –as happened in many cases- (Table 3). Failures can occur due to inappropriate requirements' analysis (Ishida et al., 2009), which provides with a technological form and with ICT solutions that do not by themselves (a) close the digital divide, (b) support the local economic growth, and (c) guarantee digital city's economic viability (New Millennium Research Council, 2005). E-Trikala for instance, defined an overestimated e-service portfolio, which demands extensive maintenance funding that cannot be obtained –especially under the current fiscal Greek environment-, and which has not been adopted by the local community.

Case	Failure reasons
Vejle (Denmark)	Lack in cooperation with the local community's stakeholders
Wiltshire Telecottage Network	Clients' needs were misunderstood.
Craigmillar Community Information Service	Citizens did not feel they contribute. Knowledge base updated to a digital city.
Amsterdam De Digitale Stad	Continuous changes in the technological form. Failed to establish online communications and infrastructure accesses.
Geneva-MAN	Managerial inefficiency, disagreements between stakeholders.
City of Namur (Périclès)	Disagreements between stakeholders, large scale of e-services.
Digital City of Trikala (e-Trikala)	Problems in project's integration, not of public interest, extensive maintenance costs.
Chicago	Contractors introduced e-service charges.
San Francisco	Financial viability plan was mistaken. Inefficient project analysis lead to network's extension, to alternative ICT solutions' selection and to budget's growth.
Dongtan	Political dropdown
Marietta (Georgia), Ashland (Oregon), Lebanon (Ohio)	Underestimated budget, and ineffective cost planning.

Table 3. Cases of failure

The above results suggest a careful requirements' analysis process, which has to consider the deliverables' adoption, while the project managers have to study the after-completion phase. In

the following section, the project management perspective for a digital city is presented, in order to meet the above mentioned findings and to support the success of current and of future cases.

3. THE PROJECT MANAGEMENT PERSPECTIVE FOR A DIGITAL CITY

For the purposes of the project management perspective's analysis the four construction management generic project processes inspired by (Winch, 2009) are used: (a) Defining the Project Mission; (b) Mobilizing the Resource Base; (c) Riding the Project Life Cycle; (d) Leading the Project Coalition. In each process the Project Management Institute (PMI) Body of Knowledge (PMBOK, 2008) areas are considered and a proposed management model for a digital city is structured. Finally, the experiences from the e-Trikala (Anthopoulos & Tsoukalas, 2006) case will support the construction of the project management model.

3.1 Defining the Project Mission

The project's definition is the most critical procedure that preludes project's initiation. Under this process the stakeholders negotiate on project's definition and they determine their scope, requirements, deliverables, duration and budget. This particular process contains two separate activities: (i) understanding client's needs and (ii) stakeholders' management. These activities determine project's scope and organization, they emphasize on information flow and in this context they achieve in PMBOK's project scope management and project communications management knowledge areas.

In most of the examined cases the client was the municipal or the state Government who envisioned the digital city and usually cannot describe its needs from the project. An appropriate method could encourage –as happened in many of the presented cases- the local Government to associate with local universities and telecommunications vendors, and to compose a union of common interests. Then, the union would organize a committee of representatives and managers that would lead project implementation on behalf of the client.

The first question that the client must answer concerns **a generic (not a technological) approach that will be followed** by the municipal environment: a *virtual* or *mesh* environment that *will* or *will not support local needs* has to be chosen; otherwise the project will lead to an *innovative* idea –as happens in the migration of smart cities to the eco-cities- that has to be described. The selection of a virtual environment will limit project's scope to software and to information systems' implementation, with potential crowd sourcing options. A mesh environment on the other hand, extends its scope to construction activities (e.g. fiber and wireless network installation) in combination with ICT projects. In the e-Trikala case, a mesh metropolitan environment was selected, while the New Songdo adopted the mesh idea but with innovational characteristics (ubiquitous and green city).

The next question that the client must answer concerns **the project objectives' definition**. The answer must cover a number of perspectives that face the particularities of the project's location. Anthopoulos & Tsoukalas (2006) introduced an implementation model for a digital city, which recognizes four axes of precedence for the local community's growth (economy, education and training, quality of everyday life, and culture and tourism) and considers five perspectives for project's definition (social, technological, informational, ethical and financial). The implementation model can achieve in PMBOK's project integration management knowledge area, since it performs a detailed analysis of the local particularities, and it identifies the local segments (gap analysis) that the digital city's components will close.

An alternative approach to the implementation's model is the digital city's strategic management (Lysons, Farrington, 2006). The strategic life cycle has to be defined and (a) the strategic analysis (with the use of the IFE/EFE and CPM tables (David, 2011)); (b) the strategic synthesis (with the use Porter's five forces model (1996), Marketing Mix of 7p's (Ivy, 2008; Rafiq & Ahmed, 1996) or the strategy map (Kaplan, Norton, 1996)); (c) the strategic implementation; (d) the strategic evaluation (with ex ante, intermediate and ex post methods); and (e) the strategic review have to be executed and managed.

The third question concerns the **ICT solutions' selection** for the particular case. The examined cases showed the alternative solutions that various cities adopted for their needs and the e-service portfolios that accompanied these selections. This procedure is critical for project success since not all the available solutions are suitable for every city. An effective requirements engineering method will support the decision making by the client. Anthopoulos et al (2011) simulated requirements engineering with a fuzzy based method in e-Trikala case. This method identified suitability indices (extensibility, service availability, citizen satisfaction, and prerequisite systems) and the fuzzy based method returned the following: local e-Government services scores best in extensibility index, intelligent transportation performs best in service availability, e-Health and e-Tourism get the highest rates in prerequisite systems, and e-learning scores best on citizen satisfaction. These outcomes can support the committee to determine the most suitable solutions.

The fourth question concerns **the project design**. Various architectures can support the project determination (Fig. 2). The selected architecture has to secure project's viability in terms of efficiency, extensibility and interoperability. A combination of the Service Oriented Architecture (SOA), multi-tier (n-tier) and modular architectures can support project's technological viability. Moreover, solution's alignment to latest technological standards can encourage users to adopt the offered e-services.

Another critical question concerns **project viability's evaluation**. In this context stakeholders' satisfaction (at least client's, contractor's and end-users') has to be justified. Moreover, case studies show that crowd-sourcing is still a key e-service for digital cities, which delivers digital content and encourages end-users' involvement. Accurate and official digital content by the client has to also be produced, and gives comparative advantages to the digital city. Digital content such as city guides, virtual tours and public service guidelines appear in almost all of the examined cases. The budget has to be calculated according to solutions' selection (solutions' installation, operation and maintenance costs) and secured, and a viability model has to be composed.

The final question returns information about **stakeholders' management**. Stakeholders' determination is very important, as well as their power/interest estimation on the project. The power/interest matrix and the stakeholders' network can provide the committee with valuable utilities to accurately and in-time determination, communication and negotiation with all the key-players of the project. In e-Trikala case (Fig. 3) the stakeholders' determination confirmed a peculiarity in the interested parties in the city. In e-Trikala case, although a bottom-up project's design method was followed (Anthopoulos & Tsoukalas, 2006), the stakeholders' management failed in achieving individual interests and in attracting social participation, due to miscommunication of the project's objectives to the local community, combined with an existing and extensive digital divide in the city, and with political oppositions in the municipality. Today, digital city's e-services have no social interest, and only some tele-care services are used by groups of elderly citizens.

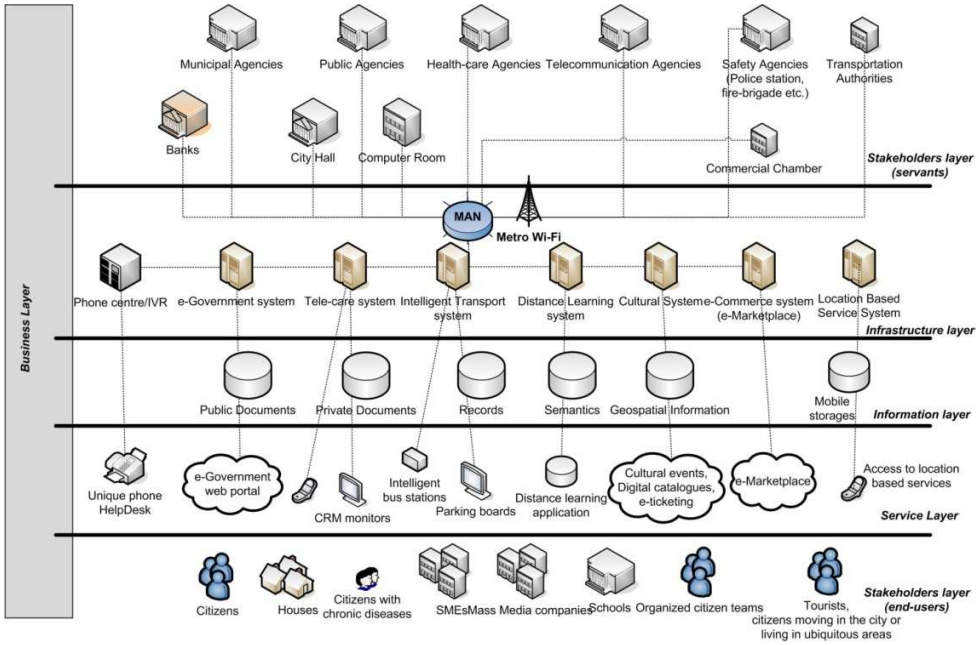

Fig. 2. The n-tier physical architecture of a digital city (Anthopoulos & Tsoukalas, 2006)

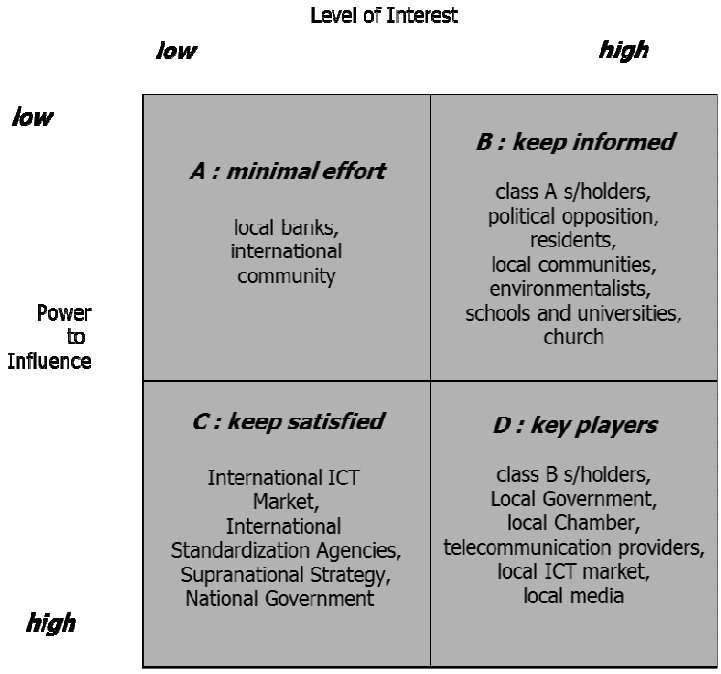

Fig. 3. The power-interest matrix for stakeholders' determination in e-Trikala case

3.2 Mobilizing the Resource Base

Under this process the project manager determines the procurement system, he performs contractors' and the payment methods' selection, while he has to integrate project. This particular process contains three separate activities: (i) forming project coalition, (ii) motivating the project coalition and (iii) managing the dynamics of the supply chain. These activities achieve in PMBOK's project integration management and project procurement management knowledge areas.

The procurement system that has to be followed must be determined. In case of the client is the local Government, the respective legal framework leads tendering procedures and the contractors' selection. In case of a clients' coalition (e.g. local Government, local University, telecommunication vendors), the selection method is complex and has to follow procurement systems according to **(a) who finances the project; (b) who owns the projects' deliverables; (c) which is the coalition's form and the respective procurement legislation**.

In the e-Trikala case the project was running under the responsibility of the Municipality from 2003 to 2006 when a coalition between the Municipality (99%) and the local Commercial Chamber (1%) founded a public-private company who managed the project. This coalition had no particular integration and project implementation was assigned to various contractors. The financiers have been the Greek and the European Information Society Framework Programs, and the project's deliverables belong to the Municipality. The project's committee had to follow the complex and slack Municipal procurement system together with the European tendering framework, which assigned contracts to the most competitive candidates. Contractual uncertainty was attempted to be minimized with the contribution of experts from the Greek Information Society Special Secretary and with fixed price contracts, but managerial inefficiency by the founded manager lead to quality divergences and to contracts with no maintenance periods.

In New Songdo city in contrast (Lee & Oh, 2008), by 2003 a coalition of two private companies (POSCO E&C and Gale International) and financiers (Morgan Stanley, ABN Amro, Bank of Nova Scotia, Woori Bank and Industrial Bank of Korea) funded the project. This coalition was integrated (Winch, 2009) and founded a new private company (NSC) who became the project owner, and various other companies in order to minimize investors' risk. The LLC was one of these new companies under the coalition, who was the general contractor and responsible for all completion guarantees. Recognizing the unique characteristic of Korean industry, the two coalition members decided to fund the equity of commercial projects by the proceeds from the residential unit sales, with the contribution of the financers. Trust was critical for the two members, especially due to the fact that Gale had its chairs in U.S. and was not aware of the national cultural environment. Procurement was mostly based on LLC's negotiations with the resource base of various suppliers. However, the POSCO partner participated in some less-risky residential projects, and when it bid them it increased the construction costs, since it couldn't secure construction contracts with outside investors.

3.3 Riding the Project Life Cycle

This process is used by the project manager to handle the project's implementation in terms of budget, time, quality and risk control. The following activities belong to this process: (i) minimization of client's surprise; (ii) problems' definition and solutions' generation; (iii) budget management; (iv) programme management; (v) conformance or quality management; (vi) uncertainty and risk management; and (vii) information's flow management. PMBOK's project process, integration, scope, time, cost, quality, communications and risk management knowledge areas are enhanced by this process.

The first question that has to be answered concerns **the identification of the project manager, of his efficiency to ride the project and of his power against the project organization**. In the e-Trikala case the coalition was formed by 2005 and it determined the projects' implementation manager: a new public-company with small organization schema (called e-Trikala S.A.), who had enough authorization to procure and manage contracts with external suppliers, but with no particular managerial and technical efficiency. Moreover, the e-Trikala S.A. was responsible for projects' operation and continuation on behalf of the owner. Contractors beyond city's boundaries were selected to develop the projects without any dues that could enhance the efficiency of the owner and could secure projects' viability. No control was applied on the project manager by the coalition during projects' implementation, except from the political opposition in the Municipality, who however had not enough power to intervene in managerial activities. In the New Songdo case, things went different, due to project's scale and since only private companies formed the project coalition, and while the participating criteria concerned extreme capacity to fund and to implement mainly construction projects. The main managerial duties were undertaken by the LLC who was a resulted company of the coalition, and the main contractor of the project.

The second question that has to be replied concerns the **project management method that will be followed by the manager**, in order to enhance control on time, scope, risk, cost, quality, and information flow. In e-Trikala case, client surprise was minimal since all projects kept their initial objectives until their completion. However, today only a few e-services are being offered. The PRINCE2 methodology was followed by the project manager and contractual obligations were secured in terms of scope, time and cost. However, the deliverables' did not meet the expected quality, due to technical inefficiency by the project manager. In New Songdo on the other hand, construction management methodologies were followed and a process of eight (8) Development "Silos" (Vision, Team Assemblage, Business Plan, Design, Permit, Financing, Marketing and Promotion, and Staffing) was adopted, since the project concerns mainly real estate activities. The New Songdo project is large-scale in terms of duration (envisioned by 1979 and it is supposed to run until 2015); budget (over $7 billion); and complexity (landing, constructability, uncertainty and risk, innovation). Only the risk on investment management method was performed with a system of net present value calculations and more than three thousand of Monte Carlo simulations.

The third final question that has to be answered is the identification of the **operation manager of the project**. Although the project life cycle concerns project maintenance, a case of a digital city is more complex than a single and even a set of projects. The digital city is a complex and integrated environment that consists of the deliverables of various innovative projects, and whose continuity is not secured. In e-Trikala the operation manager is the project manager, who has undertaken ICT relative duties (e.g. service provider, helpdesk etc.). The operation manager has an agreement with the coalition of a fee per service. The paradox however is that although the owner had been obliged to the Greek Government to incorporate the projects' deliverables in the organization, he transferred them and their operation duties externally to another organization.

3.4 Leading the Project Coalition

This final process enables the project manager to perform human resource management since he defines and controls the project's organization, to which he is obliged to infuse the project's mission. This process achieves in PMBOK's project human resource management knowledge area.

Two particular questions have to be answered under this process, and concern **the project organization schema** and **the leadership style** that will be adopted and support project's mission infusion. The project organization in e-Trikala case concerned the foundation of a public-private company under the project coalition (e-Trikala S.A.). This company behaved as both as a project organization for the project management on behalf of client, and a project management office (PMO) that operates between the client, the financiers and the contractors. Each of the digital city's individual projects had its own project organization, which had to cooperate with the e-Trikala S.A. The organization schema of the e-Trikala S.A. is complex due to the lack in human resources and in technical skills, while duties' overlapping occur during projects' implementation and operation (Fig. 4). It appears that e-Trikala S.A. follows both function organization model and project organization model. However, a *strong* leadership with *autocratic* style is established in the e-Trikala S.A., as a means of defense against project's failures in objectives and social adoption.

On the other hand, the project organization of the New Songdo city (Fig. 5) focused on successful construction and on risk minimization for the investors. However, conflicts of interest occurred since various partners wanted to both increase their earning and secure their funding. A *less strong* leadership with a *patermalistic* style has been adopted by the project leader, since negotiation processes on project definition, constructability and contracting occur.

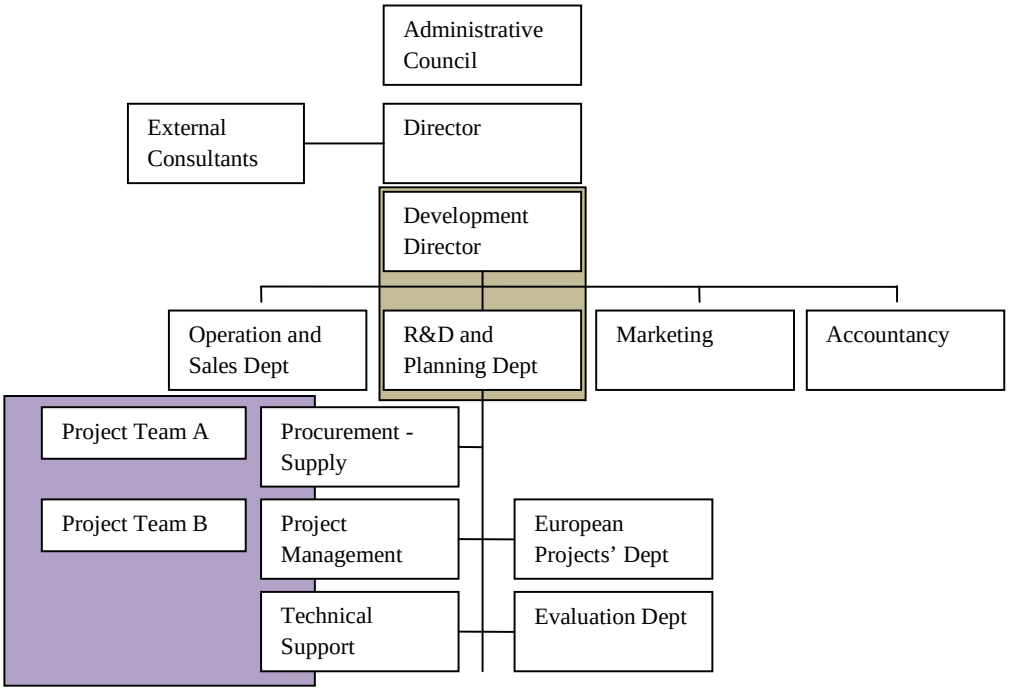

Fig. 4. E-Trikala Project Organization

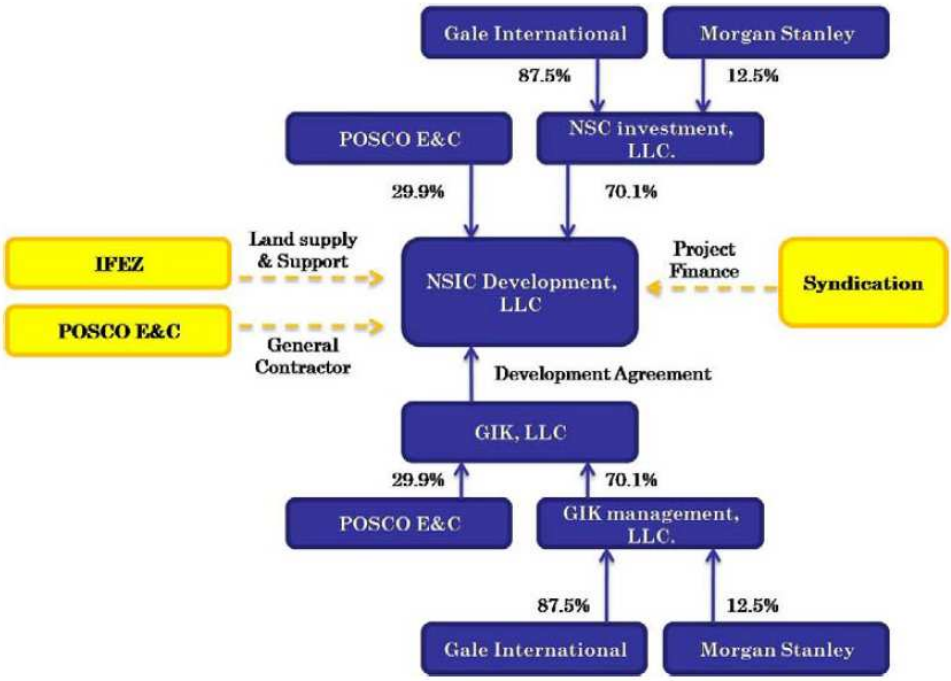

Fig. 5. New Songdo Project Organization (Lee & Oh, 2008)

3.5 The Extracted Project Management Model for Digital Cities

According to the previously presented management processes that were simulated over the two representative digital cities, a common project management model can be described for similar cases. This model (Table 4) follows the generic construction management processes and considers all of the PMBOK knowledge areas. The contribution of this model concerns the primary questions that the project manager has to answer before he undertakes the particular project processes and that will guide project's implementation. The important outcomes from the examined case studies can provide him with representative choices, which lead the examined cases to either success or failure, and to sustainability or to reconsideration.

Question	***Description / Potential Answer***
Process 1: Defining the Project Mission	
Q1. Which generic (not a technological) approach will be followed?	*Virtual, mesh, innovative*
Q2. Which are the project objectives?	*Vision, axes of precedence, milestones*
Q3. Which are the most appropriate ICT solutions for my case?	*Requirements engineering for solution selection according to suitability criteria*
Q4. Which is the architecture of the project? (project design)	*n-tier, SOA, modular*
Q5. How viable is my project?	*Viability model construction*
Q6. Who are the stakeholders and what is their	*Power/Interest matrix definition*

power/interest role in the project?	
Process 2: Mobilizing the Resource Base	
Q7. Which is the procurement system that will be followed?	*Procurement system's identification according to (a) who finances the project; (b) who owns the projects' deliverables; (c) which is the coalition's form and the respective procurement legislation*
Process 3: Riding the Project Life Cycle	
Q8. Who is the project manager, and how efficient and effective he is to ride the project and the project organization?	*Project manager determination. Project organization's orientation.*
Q9. Which is the project management method that will be followed?	*e.g. PRINCE2, construction management methods etc.*
Q10. Who is the operation manager of the project	*Operation manager's identification.*
Process 4: Leading the Project Coalition	
Q11. What schema is followed by the project organization?	*Functional/Project based/Integrated*
Q12. What leadership style is followed by the project manager?	*Autocratic, patermalistic*

Table 4. The project management model for the digital city

4. CONCLUSION

The context of digital city has been evolved during the early 90s and various technological forms appeared around the world. Many digital cities failed due to failures in strategic choices while others changed their technological forms in order to sustain, to attract business investments and to encourage social participation. The domain analysis extracted that the digital cities follow the form of the metropolitan area environments that was described by (Anthopoulos & Tsoukalas, 2006), while the Eco-city model has been also adopted and seems to describe their future.

In this paper the digital city was approached as a unique project –instead of a project portfolio- in terms of scope, owner, client, budget, and implementation timeframe. In this context, the digital city appears to be large-scale, complex and ongoing. The project management perspective was applied on this project, in order to define an appropriate management model for similar cases. The composition of this model followed the four construction management general processes (Winch, 2009), in each of which a set of questions were incorporated. The answer to these questions is not a simple procedure, but it can support future cases in order to find their most "secure" and sustainable implementation. Two representative case studies were approached with this model (the e-Trikala Greek case, and the New Songdo Korean case), in order to determine model's ability and to provide the audience with potential answers. Future thoughts concern the models' further and more detailed analysis, with the contribution of data from other particular cases and project managers.

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