Location-awareness and Ubiquitous Cities:

A report to the U-City Research Institute, Yonsei University, S. Korea

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30 June 2011

Executive Summary

The research undertaken for this Report addresses the question:

"Does the convergence of previously discrete strands of information and communications technology (ICT), through the medium of location awareness, offer an integrating framework for the implementation of citizen-friendly ubiquitous cities?

In attempting to answer this question the report examines the different concepts of the ubiquitous city and closely aligned concepts such as the 'digital city', 'intelligent city' and 'ambient society', in order to explore:

(i) how U-Cities are different to earlier technological cities, and

(ii) what challenges and opportunities U-Cities bring.

The report reviews existing city and interoperability case studies and argues that recent developments in the convergence of ICT and location-aware technology are now making the U-City vision a realisable goal.

The U-City concept has been heavily predicated on the development of interoperability standards. These standards are enabling the blending of multiple strands of information and communications technology and e-services to capture and distribute rich, context-related data.

The report also outlines some of the potential limitations experienced by digital, intelligent, and ambient cities that may affect U-Cities. It makes recommendations regarding the future of location-aware ICT in urban planning and management. Finally, it examines the role of 'crowd-sourcing' and public participation in the acquisition and sharing of data and the consequent implications for the role of government in urban governance, planning and management.

The Report's findings and recommendations are:

- **Finding (1):** U-Cities may be viewed as a further evolution of the generic intelligent city concept. As such, lessons can be learned from previous case studies and from the failings of some of the earlier EU digital cities of the 1990s. These lessons include enabling citizens to take part in the management and development of city projects and planning. This helps to ensure that technological services in cities serve the priorities as perceived by the citizens involved as well as the government or city agency priorities.

Recommendation (1): It is recommended that a joint study is pursued, building on this report, that examines in detail the successes and failures of both European and South Korean Intelligent City programmes so as to share experiences, extract more benefit from past programmes and provide the basis of potentially new collaborative research.

- **Finding (2):** The ability to breathe life into the technological concept of the U-City requires advances in the understanding of the dynamics of how virtual, physical and emotional routines of work and leisure are played out in the 'everyday' city. Current mobile location-aware technology and advances in spatial data capture, which encourages both directed and incidental crowd-participation, provides the infrastructure for the research necessary to gain this understanding.

  Recommendation (2): A vigorous programme of research should be progressed using the latest and emerging developments in mobile location aware technology and crowd-sourced data to gain a deeper understanding of the separate and interacting spatial patterns of work, family and social activity in U-Cities.

- **Finding (3):** Data harmonisation and interoperability between data, services and service components is critical for success in the implementation of U-City policies. This harmonisation and interoperability needs to embrace new sources of data from sensor web and crowd-sourced inputs.

  Recommendation (3): The U-Cities programme should build solutions that are compatible with the leading *de jure* and *de facto* standards for geospatial data and services, these being the standards of the International Standards Organisation, Technical Committees 211 and 204 [TC211/TC204] and the Open Geospatial Consortium organisation, respectively. These standards, however, will need to be extended to incorporate new sources of data (e.g. crowd-sourced) and new technological developments (see Recommendation 4).

- **Finding (4):** There is an inevitable tension between the rapid evolution of the location-aware technologies that are central to the U-City vision and the need for standardisation to aid harmonisation and interoperability. South Korean organisations have played a key role in the standards development [e.g. in the evolution of ISO 19157 Data Quality Standard and in Project 19154 on Ubiquitous Public Access) and it will be important that they continue to do so, so that future U-City developments can be built on globally agreed standards.

  Recommendation (4): South Korean organisations should continue to play an active role in the ISO and OGC development of standards and contribute their unique U-City experience towards the widening of the standards to address crowd-sourced data and ubiquitous public access.

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1. Introduction

1.1 Background

In 2008 construction began on Songdo New City in South Korea. With a planned completion date of 2014 (O'Connell, 2005; Duffin, 2008), Songdo is considered to be the world's first *ubiquitous city*, or 'U-City'; a vision of a future urban environment where city-specific information and services can be accessed anywhere, anytime through Information and Communications Technology (ICT). Songdo, the outcome of a partnership between the South Korean Government and the private sector, is being built on reclaimed land in the Incheon Free Economic Zone (IFEZ) near Seoul[1]. Other planned U-City developments will include the Dongtan area of Hwaseong (planned completion date 2010)[2] and Daejeon, but neither will rival the proposed size and complexity of Songdo.

A South Korean stimulated concept, 'U-City', describes a unique urban environment where the city's physical infrastructures are embedded with computing devices across the entire city making them present in the everyday lives of citizens in a way in which they are both omnipresent and invisible. These technological devices are fully integrated through interoperability, connected through wireless networks where everyone, anywhere in the city, will have access to computing power, the Internet and various applications at any time of the day. Residential, medical, government and business computers will all be connected through a series of all encompassing wireless networks, broadband systems and ubiquitous sensory networks. This new way of engaging with the citizenry (traditionally referred to as 'e-government') where functions and services are delivered through the Internet is considered to offer new forms of participation and subsequently increased transparency and democratisation of services. As such, the South Korean Government envisages that ubiquitous computing will provide the residents of Songdo with a convenient, environmentally friendly and secure lifestyle, promising "increased convenience, awareness, transparency and access to information and social opportunities" (Yigitcanlar, 2008: 2). The U-City will also produce economic benefits for existing businesses through the development of new technology whilst at the same time attracting new business to the area thus strengthening the economic competitiveness of the region[3], (Heywood, 2008; Maynard, 2008). The U-City concept has become embedded within the South Korean urban planning framework and legislation has been enacted to support its progression and implementation with the Act of Ubiquitous City Construction, a legal step towards the realisation of the U-City concept in South Korea (Kim *et al*., 2009). Given this previously unseen level of interoperability and due to its scale and comprehensive use of computing technologies embedded within its urban environment, Songdo can be considered as one of the leading technological cities in the world.

Whilst South Korea may have the most advanced technological cities under construction, U-cities represent the present manifestation of what are known generically as 'intelligent cities'. Intelligent cities, designed around comprehensive IT platforms and which utilise intelligent management centres and infrastructures to assist daily management and city planning, exist in various guises within Asia, Europe and North America. Although intelligent cities as a generic concept have a long history, previous manifestations are less technologically advanced. Earlier examples, however, demonstrate how ICT has, in the last two decades, become increasingly incorporated into urban planning and design. This is part of the emergence on a global scale, over the first decade of the twenty-first century, of a concept known as the 'knowledge-based society', an emerging paradigm in urban planning that draws on the knowledge base of cities and in particular innovations in ICT (Yigitcanlar *et al*., 2008b) and is part of a wider strategic planning policy for sustainable and

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[1] See Appendix 1
[2] http://www.udongtan.or.kr/english/cyber/cyb_01_7.aspx (Accessed 18/12/09)
[3] http://news.bbc.co.uk/1/hi/business/7425192.stm (Accessed 15/10/09)

intelligent cities, incorporating ideas of ecological city planning and future urbanism (Kim *et al*. 2009). Knowledge-based urban development is considered the future way forward in urban planning (see for example Yigitcanlar *et al*., 2008a; 2008b): an ideal medium in which to grow more liveable stimulating, cleaner, intelligent, enlightened, tolerant and meaningful communities and cities worldwide (Yigitcanlar, 2007). Central to this idea is the positive exploitation of the talent and creative resources of a city's inhabitants. From an economic perspective, creativity can be considered as the generation of new ideas that form the major source of innovation and new economic activities. In the early twenty-first century, the source of new innovation can overwhelmingly be attributed to the use of increasingly sophisticated and constantly evolving ICT. Given the potential of ICT in shaping the development of urban regions and in particular urban economic opportunity, creativity in respect of ICT has become a key concept on the urban agenda as managers and planners look for new forms of urban and economic development (Yigitcanlar *et al*., 2008a).

Innovation in ICT is central to the development of intelligent cities. Rapid technological advancement of information and telecommunications technology has created new kinds of socio-economic activities which in turn has had profound implications for the future of urban management. Due to the instantaneous reach of information technology and the pressures of change in urban and metropolitan areas that this brings, new strategies of urban planning are required (Heywood, 2008; Yigitcanlar, Saygin and Han, 2008). Over the past decade developments in ICT and urban planning and governance have begun to incorporate geo-referenced data (see Maynard, 2008) as efforts to develop and integrate planning support mechanisms into existing geographic information systems have been made (Yititcanlar, Saygin and Han, 2008). The role of geo-referenced data has been recognised given the relationship between technological advancement and a corresponding "rapidly increasing scale of the physical impacts … on society and the environment [which] is resulting in effects like global warming, irreversible deforestation, polluted and privatised coastlines, acid rain and dying lakes" (*ibid.*). For these reasons alone, Heywood (2008) argues that positive human action is necessary to ensure sustainability, the incorporation of geo-referenced data being an example.

Corresponding technologies such as Web-based GIS, which enables geographic information system functionalities through the Internet, have been developed. Such technologies enable users to view plans and related information on-line often in an easy to assimilate map or multi-media based form, offering greater transparency, participation and democratisation as advocated by commentators such as Yigitcanlar (2008). They also under-pin the concept of *knowledge-based* urban development, as discussed above, which is an emerging paradigm in current and future models of urban planning and development across the competing global urban environment[4] and in which the concept of intelligent cities nestles.

To fully achieve this goal, however, the various information sub-systems and services must be capable of interoperating in a smooth and effortless manner. The parallel and bespoke nature of many of the earlier technological implementations failed to achieve this and only recently has major progress been made here through the standardisation and harmonisation efforts of standards bodies such as the Open Geospatial Consortium, OASIS and ISO TC 211.

[4] See for example Yigitcanlar *et al.*, 2008a; 2008b

1.1.1 Aims of the Report

This report has three key aims.

I. To compare the different terms used to conceptualise the intelligent city. These include closely aligned concepts such as the 'digital city', 'intelligent city' and 'ambient society'. This will enable a clearer understanding of the historical development of the U-City concept and inform, through the examination of European, Asian and North American successes and failures, how future U-cities might be better planned and governed.

II. To understand the relationship between the intelligent city concepts outlined above and the blending of multiple strands of information technology and e-services for the capture and distribution of geo-referenced data. The report reviews existing city and interoperability case studies and shows that recent developments in the convergence of location-aware technology are now making the U-City vision a realisable goal as witnessed in cities in South Korea. The potential limitations experienced by digital, intelligent, and ambient cities that may also affect U-Cities are also examined.

III. To explore new and alternative models that could be used to supplement U-City spatial data management structures. This will include 'Crowdsourcing' by the citizens of U-Cities through consumer devices such as mobile telephones. Such data could be used to complement existing U-City data and assist city officials in decision-making with regard to planning and governance issues.

These aims will be met by answering the following four key research questions:

I. How do ubiquitous cities compare to other types of intelligent cities, in particular European examples?

In order to identify successes and failures that could be used to assist the successful planning and development of U-Cities, the report will explore the extent to which U-Cities are historically similar to earlier developments around the world, where cities were created with IT and technology at the centre of the design.

II. How important is interoperability and what ICT technologies are key to the functioning of ubiquitous and other intelligent cities?

Selected interoperability projects in Europe are examined as a guide to what parallel developments are underway and what is achievable in terms of data and service level interoperability which is integral to the functioning of U-Cities.

III. How might new technologies and concepts shape the future of ubiquitous cities?

The report examines a number of developments which may impact the efficient operation of U-Cities.

IV. What role can 'crowdsourcing' play in the future of U-Cities?

The report discusses the emergence of "bottom-up" citizen-driven developments that have emerged along with the "neo-geography" movement. It considers whether it would be advantageous for new democratic technologies and models to be adopted by U-City authorities in order to provide them with new, rich sources of geo-referenced city data and to assist them in the governance of the U-City.

1.1.2 Report Structure

The remainder of this report is structured as follows:

The second part of this introductory section provides a historical context to the use of ICT in urban planning and the evolution of the intelligent city. It examines the different descriptors of the intelligent city, including ‘smart city’, ‘digital city’, ‘ambient city’ and ‘U-City’. This section also reviews how these terms have evolved over time and outlines the characteristics of these city terms.

Section two reviews examples of these models in Europe, Asia and the United States and outlines how their characteristics and approaches differ. The approaches include centralised, state-driven, technological development models from Asia, commercially-driven technological development models from the US and European hybrid models.

Section three considers what lessons might be learned for future models of ICT and urban planning by exploring how early digital city initiatives were governed and developed in Europe. It highlights implementation issues, limitations and successes. This section also considers critiques surrounding the implementation of ambient and ubiquitous technologies. The effect of non-technological impacts that must be overcome in order to develop a successful U-City are discussed as these factors have impeded the success of other technological cities, such as digital cities, or have subdued the adoption of ubiquitous technologies in other regions of the world outside of Asia. These factors include (i) political issues that shape the development of U-Cities and (ii) social and cultural trends that affect the uptake of new technology, which are related to ethical concerns and have restricted the success of some ubiquitous technology developments.

Section four considers the future of the ubiquitous city (U-City) more specifically. It considers potential technologies and outlines some of the products and services central to the development of location-based services in U-Cities. It points towards an ‘organic’ rather than ‘planned’ approach by introducing new practices in *neo*geography which may materially change the U-City model’s predominantly top-down approach. This may be driven by democratically generated crowdsourced data models which will become more important as geospatial data is collected by citizens and private service providers.

Section five will make recommendations for U-City practitioners based upon the report’s findings.

1.2 (Re)defining the City: a Comparative View of Concepts of the Technological City

This section defines the concept of the ubiquitous city and explores how it is different to other conceptualisations of contemporary global cities that also make innovative uses of new technological infrastructure and devices. It distinguishes the key characteristics of these different types of technological cities and explores what impact they have on the citizens of these innovative urban environments. Some city models are not easily defined and subsequently there is a degree of overlap, especially as cities have continued to change and adopt new technological systems over time.

Three terms are proposed to provide the most appropriate terminology in terms of conceptualising the different types of cities emerging around the globe: the *digital* city, the *ambient* city and the *ubiquitous* city. A brief history of these three city concepts follows. Through comparative analysis, definitions are developed for a comparative typology that is then used in the report to categorise existing city projects.

1.2.1. Looking Inside the 'Intelligent City': Historical Development of Ambient and Ubiquitous Technologies

Between 1850 and 1960 western cities made a general movement to integrate and expand their urban infrastructures. Gas, water, electricity and telecommunication networks were coordinated by central and municipal governments to improve the quality of life for their citizens (Graham and Marvin, 2001). In the US, experiments in and the enhancement of communication networks led to the development of the Advanced Research Projects Agency Network (APRANET) in 1969, forming the US' first information infrastructure, from which the Internet would later emerge (Shin, 2008). Since the early innovations in technology and communications, ICT products and devices have become progressively embedded into the urban fabric of cities.

The installation of CCTV and anticrime systems in London's 'Ring of Steel', private Internet access in New York or 'intelligent' buildings controlling select Japanese office blocks, or residential 'smart homes' controlled by home computers, have led some academics view cities as cyborgs, where cities have become densely networked entities (Graham and Marvin, 2001). The embedding of this technology into urban areas has been widely documented by the media and has spawned a substantial and diverse set of writings, from different academic disciplines. For example, Graham and Marvin (1996) list a selection of the many neologisms used today to describe cities, including: the informational city, wired city, invisible city, the telecity, the intelligent city, the virtual city, the non-place urban realm, teletopia and cyberville.

The wide diversity of these literatures reflects the broad range of individuals and groups writing about these cities, their backgrounds and politics. Stakeholders have, and continue to include, government technocrats, private sector engineers and executives, consortiums of standards producers, computer scientists, GIS practitioners and engineers.

More recently these debates have been accompanied by academic disciplines that view the technological development of cities through a social lens. These disciplines include geography, planning, architecture, urban studies and proponents of sociology and cultural studies. Such a rich pedigree of contributors has the benefit of bringing new insight and ideas to intellectual debates and planning, but is, however, often complicated by the sheer volume of different views and competing terminologies.

A general interpretation of the term ‘intelligent city’ (including ‘smart’ city) might in its crudest form be that which has applied information technologies and virtual spaces to urban functions and activities (Komninos, 2002). However, both Couclelis (2004) and Komninos (2006) have highlighted the problem of a lack of consensus regarding definition. Komninos (2006) identifies at least four different meanings for the term ‘intelligent cities’:

- virtual cities that are created to mirror a real city in cyberspace,

- as used by the World Foundation for Smart Communities which sees digital cities and IT as a strategy to transform and improve life and working arrangements in a region in a significant, non-incremental way.

- territories that use IT and communication technologies to interact with the physical worlds, with the use of sensors.

- territories that use ICT and the creativity of local labour pools to enhance learning and innovation.

The diversity of meaning of the term ‘intelligent city’ by different stakeholders and disciplines limits its value for this report. The terms digital, ambient and ubiquitous cities, are more useful in separating the different characteristics to define different types of cities.

1.2.2. The Digital City

Couclelis (2004: 5) provides a helpful starting point for separating the different types of electronic city by defining the digital city as ‘...a comprehensive web-based representation, or reproduction, of several aspects or functions of a specific real city, open to non-experts’. Digital cities effectively provide an arena where members of local communities can access information from the local government, share knowledge, experiences and mutual interests in an online version of their city, which integrates urban information into public spaces on the Internet, that can also be visited by tourists and business people (Ishida, 2000). The digital city is the intersection between a physical urban area and the communities of people that are associated with that area, which is usually bound by opportunities and constraints emerging from technological and sociological issues. The digital city is different to the ambient city and ubiquitous city, in that the digital city is an electronic metaphor, or reflection, of a physical city, whereas the user’s experience of interactions with technology in ambient and ubiquitous cities is real and embedded within the physical city.

Digital cities have a diverse range of stakeholders, which fall broadly into three categories: private companies, private-public company initiatives and user groups. For example, in the US, the Internet service provider AOL developed many of the early US digital cities, as a private company. On the other hand, Digital Amsterdam was created through a public-private partnership between local authorities and telephone providers. User groups are also key stakeholders that make the digital cities viable by using them, but also by participating in the building of virtual communities. Private and public-private stakeholders have different interests and politics, which is reflected in the rationales that drive the development of different digital cities and the aims and services provided. These differences vary by geography, as European and Asian digital cities seek to provide a public service, whilst North American digital cities tend to focus on profitability for the private companies that operate them. For example, the European digital city Digital City Amsterdam was designed to develop community networks and to allow the municipal government to communicate information to its citizens, whilst Helsinki sought to develop an interactive 3D model of the city (Ishida, 2000). The key aim for these digital cities attempted to provide citizens with access to information on local services. On the other hand, US digital cites have focussed more towards the development of online spaces through the provision of news and shopping and entertainment information. Whilst the outcome is the delivery of information to citizens through development of online communities the driver is the generation of revenue by advertising through the digital city.

The aims underpinning the development of Asian digital cities have mirrored those of the European models. For example, Digital Kyoto seeks to provide information to citizens and to foster the development of communities with residents and tourists, with the intention that communities will have a contribution in city planning, providing a 'bottom-up' mode of governance. Singapore's programme to turn itself into a digital city sought to provide its citizens with access to government services, allowing them to manage their lives online (Arun and Yap, 2000).

Digital cities began to emerge in the early 1990s as the Internet became accessible to the general public. In 1993 the US government, under the Clinton Administration, announced its intention to develop what they called the 'Internet superhighway' (Shin, 2008). The subsequent increase in Internet access to consumers provided the infrastructure that would make digital cities in the US commercially and practically viable. This was soon followed by initiatives in Europe, promoted by the European Union that began to sponsor digital cities conferences in 1994 (Ishida, 2000), to evaluate and promote the development of digital cities in Europe. The result was the emergence of Digital City Amsterdam and Virtual Helsinki, which were sponsored by local authorities (Couclelis, 2004). Similar initiatives began to later develop in Asia, in Japan (Ishida, 2000) and Singapore (Arun and Yap, 2000).

The mediums that underpin digital cities are effectively websites that contain digital maps of a city, information about services or events and online access to government services. Access to these digital cities can be obtained over the Internet through a personal computer, or handheld devices like mobile phones, across standard broadband or telephone networks. The level of interoperability was low, with compatible software accessing a centralised server where the digital city is maintained as a single system. Although digital cities may provide coverage of an entire physical city, enabling citizens to enhance their engagement with public services or access information on entertainment and shopping, those who are computer illiterate, in particular, the elderly are unable to access the city (Arun and Yap, 2000), whilst those who cannot afford a computer or remote access through mobile devices are also excluded (Shiode, 2000; Crang et al, 2006).

1.2.3. The Smart City

The concept of the 'smart' city emerged in the US and Europe in the late 1990s. More than other conceptualisations of the 'intelligent' city, 'smart' cities specifically aimed to include the *human* as well as technological resources of a city: Drawing more explicitly on their 'creative' resources smart cities championed the *creative* and academic industries and information/knowledge-based networks embedded within cities. In the US, the idea of the 'smart' city gained credence from the late 1990s through the *Smart Community* initiative established in California (Komninos, 2002). Although the project identified the potential of incorporating ICT to government and business functionality, the necessity of human interaction and social co-operation for the success of the model was also recognised. Information technologies were utilised to establish digital networks, infrastructures and applications, accessible by the citizen. Like the 'digital' city, despite progress in the implementation of digital services, applications were limited to the dissemination of information via digital networks rather than the provision of advanced services online (Komninos, 2002). Building on the idea of 'smart' communities, similar concepts and models of 'smart' cities, which embraced the value of human knowledge and innovation as an economic commodity, were witnessed in Europe and other global regions from the late 1990s[5]. These are differentiated from 'digital' cities by their inclusion of resources and functionalities other than those associated with ICT. For example, the European *Smart Cities* research project considered 'intelligence' in terms of a city's economy, people, governance and issues of environmental sustainability (see Giffinger, 2007).

In order for 'digital' cities to become 'smart' cities they therefore need to incorporate a new category of applications; that of the real community of people and producers characterised by a high level of knowledge and innovation use. 'Smart' cities combine these aspects with the IT applications and knowledge management tools which make up 'digital' cities. To differentiate the 'digital' city from the 'smart' city, every digital city is not intelligent, but every intelligent or 'smart' city has a digital component (Komninos, 2002).

Komninos (2002) argues however that it is not enough to simply develop an infrastructure for transferring information in order to characterise an area as truly intelligent, or 'smart'. In order for this to be achieved, three basic elements have to become interconnected: the island of innovation, the digital communications environment and the tools/technologies for managing knowledge. The following section deals with a category of 'intelligent' city that has developed this level of ICT 'interconnectedness' to the next level and incorporated the concept of *ambient* technologies.

1.2.4. The Ambient City

The 1990s were characterised as the decade of emerging virtual worlds as academics became interested in the uses and possibilities of the Internet. Despite enthusiastic claims that the Internet gives people access to an informational world without borders virtual worlds are only accessible when there is access to the necessary infrastructure (Graham and Marvin, 2001). Cities are embedded with technological infrastructure, but research has move on from studies of Internet access to the emergence and embedding of so-called ubiquitous technologies into the fabric of cities that entwine people, places and software in complex ways (Crang and Graham, 2007). The concept of the ubiquitous city was circulated in 1991 by Mark Weiser, part of a team of researchers at the Xerox Palo Alto Research Centre in California during the 1980s (Galloway, 2004). Weiser sought to move beyond the paradigm of the time, which focussed on personal computing. Weiser believed that personal computing would be displaced in favour of new computational devices that would enable computing access be obtained anywhere, by anyone: '...computing access will be everywhere: in the walls, on your wrist, and in scrap computers (like scrap paper) lying about to be used as needed. Hence, ubiquitous computing' (Weiser, 1993:71).

Ubiquitous computing, or 'ubicomp', was seen as an idea that would free people from desktop computing and the isolation of virtual reality (Galloway, 2004). The wide scale implementation of ubiquitous computing is challenging and, with a few exceptions discussed in 1.2.5, whilst many cities have adopted some ubiquitous technologies they are not accessible to everyone everywhere. These cities have become known as ambient cities, where Bohn, et al. (2003) uses the definition of ambient intelligence, used by the EU Information Society Technologies Program (1999), to describe how people are surrounded by intelligent and intuitive interfaces that are embedded in everyday objects which respond to individuals in an invisible way. Weiser's original vision was that computers would become built into the urban, physical environment, which is one of the key differences that ambient cities have with digital cities. Digital cities are a virtual representation of a physical city, through online communities, or virtual reality, but the use of ubiquitous computing integrates information and technology into the everyday, physical world (Weiser, 1993). Subsequently, digital cities can be seen as maps that simulate the world, whereas ubiquitous computing is embedded in the territory of the 'real world' with the aim of actually enhancing it.

[5] See http://www.smart-cities.eu; http://www.intelligentcommunity.org/

Ubiquitous computing technology is the central focus of the literature reviewed here. The emphasis in publications has been on specific commercial products or services that are supplied to consumers within specific spaces of the city though development of government systems used for state surveillance and other specialised purposes has also led to advances (Crang and Graham, 2007). As such, the ambient city can be seen as an urban environment which contains different ubiquitous computing technologies, used by commercial companies such as Zipcar, a car sharing scheme that uses RFID ubiquitous technology in the US and UK, (Zipcar, 2009) and in some cases governments (Crang and Graham, 2007). These devices began to become embedded in cities around the globe in the early 2000s as the necessary technology became available to corporations. Ubiquitous computing systems utilise mobile devises to allow people to access information anytime anywhere, so the technology used in ambient cities frequently includes wearable, distributed objects, making use of location-based services, of RFID tags and GPS. According to Cuff (2003), cities now consist of walls with ears, eyes, brains and databanks, and since the computers used in ubiquitous computing are so task-specific, they are small and can blend into the background of cities (Borriello, 2000). Bohn, et al. (2003) suggest that the use of ambient intelligence in cities will continue to grow. For example, guidance devices for the blind, utilising location-based navigational devices in lampposts could help them to navigate unfamiliar routes, whilst sensors in children's clothes or jewellery would make it easy to track them if they got lost. Cook, et al. (2009) have also highlighted how ambient technologies could be used to support elderly and disabled citizens. Semi-intelligent systems could assist the elderly in day-to-day living and 'call for help' by detecting if the individual has had an accident as ambient systems have the capability to observe and detect regular activities, patterns and deviations from them. In addition, sensors in intelligent environments can be used to monitor social groups and predict human activity, which could be useful in monitoring overcrowding and congestion in public areas and transport systems, whilst also maintaining efficient water and power consumption (Cook, et al. 2009).

Ambient cities are unlike digital cities in that they do not often provide coverage across an entire city. In addition, these ubiquitous systems are used commercially and are not interlinked. Although Zipcar uses mobile phones, cars and RFID tags, these devices may be interlinked and interoperable for Zipcar's purposes, but they are not interoperable with other ubiquitous systems. This limits Weiser's vision, as the systems used in ambient cities are not designed to be compatible, because of the ways in which the protocols are designed, or because a company designs a system under the assumption it will only be used by them (Borriello, 2000; Pacyna, 2009). The access to ubiquitous computing technologies within cities can be limited as people may not wish to voluntarily adopt these technologies, especially due to growing privacy concerns, but also because lower socio-economic groups cannot afford computers or mobile devices (Crang, et al, 2006), or the use of the services that use ubicomp, that exist in the ambient city. This creates city divides that Lash (2002) calls 'live and dead zones', which is reinforced by companies that avoid locating new technological infrastructure in poorer areas of cities (Graham and Marvin, 2001).

An important aspect of the transition of digital to ambient technologies is the incorporation of geo-referenced data and their associated technologies (Yigitcanlar, Saygin and Han, 2008). GIS applications such as WebGIS and CommunityViz for ArcGIS have become increasingly embedded in local planning authorities (Yigitcanlar, 2005; 2006) but there is a tendency for these technologies to fail to consider temporal information and therefore to track dynamic changes in complex urban environments. The transition from digital and ambient computing to ubicomp incorporates these temporal aspects being able to provide time-specific data and therefore the ability to revolutionise urban planning remits such as environmental and disaster management as well as the more 'every day' responsibilities of transport management and planning. Since spatial behaviours are dynamic in nature, technologies that are able to model the spatio-temporal, are particularly relevant and critical and hence the criticality of GIS to both urban policy-making and knowledge-based urban development.

Whilst the digital city looks at the city 'as a whole', but also as a virtual world through personal computers, the ambient city is characterised by the prevalence of individual ubicomp systems in the city, that enhance the real city. However, these systems are not necessarily interconnected, universally accessible, or interoperable, as hoped for by Weiser. It is in the concept and development of the ubiquitous, or U-City that we move closer to Weiser's vision.

1.2.5 The Ubiquitous City

Many cities have begun to utilise ubiquitous technology, but since 2005, South Korea has begun to use the term ubiquitous city after adopting the ubiquitous computing concept from the US and deciding to create the world's first U-City (Myung-Je, 2009). Subsequently, the U-City is particular to South Korea, although this will undoubtedly change as the concept is adopted elsewhere: Japan has already begun planning its own U-City. The origins of the U-City are historically linked to South Korea's proactive and enthusiastic adoption of IT and communication system. In 1994, the National Information System initiative was launched, where the government attempted to network the computer systems of government departments. This preceded the more recent launch of the IT839 Plan in 2004 which stimulated the development of new communication networks and mobile devices. Steered by central government but implemented through close relations with the private sector (Shin, 2008) IT839 provided the under-pinning of capabilities necessary to develop U-Cities.

The U-City concept also draws heavily on the visions of Weiser's notion of ubiquitous computing, that embeds computers into our everyday lives in a way in which they are omnipresent, but invisible (Galloway, 2004). Whilst the technologies used in the ambient city are seen to be 'ubiquitous' there is an important distinction between their use in the ambient city and the ubiquitous city. Returning to Weiser's (1993) original vision of the ubiquitous computing, these devices and technologies would be fully integrated through interoperability and connected through cheap wireless networks where everyone, everywhere, will have access to computing power.

This is not the case in ambient cities, but the South Korean U-City projects are far more ambitious and comprehensive with the development of Incheon and Songdo, and the construction of entirely new cities, coordinated and driven by the government. As such, the U-City principle is applied to the entirety of the city, which is equipped with networks linked to a central management centre, where central and local governments can monitor almost everything that is happening (Shin, 2009). This is in stark contrast to the ad hoc ubiquitous systems that have been installed in ambient cities around the world. This provides another contrast with ambient and digital cities through the strong government support for U-City development and further illustrated through the passing of new legislation to facilitate the development of U-Cities (Shin, 2009).

There are three different types of stakeholders involved in the construction of U-Cities:

- Government ministries. The beginning of the U-City project was coordinated and planned by the Ministry for Information & Communication and the Ministry for Construction & Transport.
- Private sector companies. These are working closely with the government and are producing and designing the technologies, in particular Samsung and LG, as well as American firms Gale International and Cisco.
- Consumers. They will use these technologies in day-to-day living as residents of U-Cities such as Songdo.

Unlike ambient cities, the U-City is centrally planned by the government with clearly defined aims and rationales behind their development. The government policy is for U-Cities to help all residents, everywhere, not just private customers, or residents using personal computers at home, with the aim of enriching life, reducing congestion and enhancing environmental sustainability (Korean U-City Association, 2003), which will reshape work, education government leisure and entertainment in both urban and rural settings (Jackson, 2007). According to Don-Hee (2009), the government has the ultimate vision of creating a ubiquitous society where people can connect to the web, television and other digital services anytime, anywhere. South Korea wants to use ubiquitous computing to give its residents a convenient and secure lifestyle, opened up to all citizens, effectively using technological projects to change society. It is also hoped that the domestic industry participants will benefit financially in the creation of a new market, as would the Seoul Metropolitan Government. The financial benefits of South Korea's U-Cities may be maximised if the cities can be used to demonstrate to other governments and developers how truly integrated ubiquitous technology can be successfully used in cities, providing opportunities to export the devices and components of ubiquitous systems overseas (Shin, 2009).

With regard to the technology utilised by U-Cities, extensive use is made of broadband, RFID tags, sensor networks, GIS, wireless broadband, location-based services and smartcard systems (Shin, 2009). The technology used is more heterogeneous and advanced than digital cities and unlike ambient cities, these ubiquitous devices are also used in public places, with, for example, public recycling bins that use radio frequency identification to credit recyclers every time they throw in a bottle. The U-City also integrates healthcare into its mandate, with pressure-sensitive floors in the homes of older people that can detect a fall and contact help automatically and phones that store health records and can be used to pay for prescriptions,' (Shin, 2009). The South Korean U-City concept also sits more closely with Weiser's vision than the ambient city, in that interoperability exists between different devices and networks. Murakami (2003) sees this as a move from Peer-to-Peer (P2P) communication towards Peer-to-Object (P2O) and eventually Object-to-Object (O2O) relationships, where objects will communicate directly with each other, enabled by interoperability.[6] The use of ubiquitous technology in public spaces also enables the city to move beyond mixed or augmented reality environments towards what Falk (1999) calls the 'amplified city', where objects express additional information about themselves to other objects, residents and users.

The ability of the U-City to successfully move beyond ambient cities and to reach the status of a fully ubiquitous city is contingent on the ability of different computing devices to communicate with each other, which will be contingent on wireless communication systems and the accurate production of geographical data (ISO, 1999). People, and their devices, will be mobile within the ubiquitous city environment and will need what the ISO call, ubiquitous public access: access everywhere at all times. This is particularly significant as consumers will no longer be simple consumers of spatial data, but consumers of tailored data and self-organising maps; as well as producers of data, requiring robust standards to generate accurate geo-information. Interoperability standards are also important, because unlike the ambient cities that use ubiquitous technologies in an uncoordinated way, South Korean U-Cities will be mediated through centralised, operational centres that will pool data from these ubiquitous networks, whilst monitoring crime, disaster management, environmental protection and transport (Ministry of Public Administration and Security, 2009). South Korean academics have therefore been at the forefront of discussions in ISO for the development of interoperability standards relevant to ubiquitous cities and Professor Ki-Joune Li of Pusan University has been the lead in ISO Project 19154 (Standardization requirements for Ubiquitous Public Access).

[6] P = person O= object

However, although the U-City is technologically more sophisticated and operates across the entirety, the ability of users to participate within this environment is contingent on their ability to use mobile devices.

1.2.6.Towards a Comparative Typology of 'Intelligent' Cities

Table 1.1 below is based on seven characteristics that vary across the digital, ambient and ubiquitous cities. The differences between the characteristics and each city were prevalent within the literature reviews and can be used to define and categorise cities.

Table 1.1: A Comparative Typology of 'Intelligent Cities'

	Digital City	Smart City	Ambient City	Ubiquitous City
Key stakeholders	**EU/Asia:** Supranational, local governments and private firms **US:** Private firms	National and local governments and private firms	Private firms	National and local governments leading private firms
Technologies	Internet and broadband	Internet and technologies related to research	Broadband, wireless, sensors, handheld devices, LBS, RFID	Broadband, wireless, sensors, handheld devices, LBS, RFID
Time period	Early 1990s -	1990s	Early 2000s -	2004 -
Geographical location	US, Europe, Asia	US, Europe, some in Asia	US, Europe, Asia	Asia
City coverage	City-wide and beyond *-Limited to those with no access: socio-economic, or disability, age, or education*	Focus is on social networks in the city *-vary between citizens*	Limited within city *-Dependent on subscription or use of particular services*	City-wide *-Limited use by individuals due to disability, age, or education*
Interoperability level	Limited outside of 'virtual' city	Limited interoperability, due to experimental systems	Limited between different systems	High interoperability planned though urban management centres and private firms
Development rationale	**EU/Asia:** Supply public service access online, and build communities **US:** Produce private revenue	Transfer knowledge based information between universities and private businesses for economic growth	Produce private revenue	Enrichment of everyday life Enhance economic growth Develop environmental and sustainable cities

2. ICT and urban planning: Examples from Europe, Asia and the United States

2.1 ICT and Urban Planning Europe

A brief overview is provided in this section as to what (as per the typology outlined above) might be considered 'intelligent' city initiatives, implemented across Europe in the past two decades. A summary of current ambient technology initiatives is then given for both city-based projects and cross-border initiatives between countries. Ranging from the first European digital cities to current projects utilising ubiquitous computing technologies, the initiatives outlined reflect both the rapidity of technological development and the European political appetite for technological leadership in the use of information and communication technologies in urban and regional development. This has been expressed through Parliamentary funding on behalf of the European Union which has facilitated and supported a significant volume of research projects, directives and initiatives in relation to digital and ambient technologies towards the specific goal of developing the 'knowledge based society', a key term within European [Union] urban development planning discourse. In terms of planning and functionality, the concept of the 'knowledge based society' signifies a paradigm shift in the way in which urban and regional environments are conceived. Nicos Komninos (2002) states that this approach to urban planning and functionality (which he categorises as the development of *intelligent* cities) is witnessed in: (1) the reorganisation in terms of flexibility and innovation in the sphere of production, (2) the supra-national institutional regulation in the sphere of policy and (3) the new state of knowledge and post-modernist cultural values. Indeed, urban planning in the EU (as well as North America) offers some leading practices for regional reform globally (Heywood, 2008).

2.1.1 European Digital Cities

Reflecting the rapid development of digital computing, digital technologies (then referred to as 'telematics') were included in a series of agendas and programmes across the European region from the early 1990s (Mino, 2000). This development in ICTs reflected the global trend towards 'information societies' witnessed across the metropolitan and regional administrations of Europe, the USA and Japan. A series of pilot projects and applications attempted to employ digital technologies to improve the ability of cities to manage information, transmit knowledge and use information technologies. As an example of global restructuring of western societies such applications promoted the 'informatization' of cities and regions were able to offer better communication capabilities, more complete representations of urban space, more accurate and up-to-date information and useful knowledge and information management engines and tools (Komninos, 2002).

Reflecting this new technological approach to urban planning and management, from 1994, the European Union (EU) sponsored a series of five annual 'European Digital Cities' conferences. In 1996, the EU subsequently launched a four-year European Digital Cities project under the auspices of the Telematics Application Programme for the purposes of supporting European cities and regions in the deployment of new, economically and socially sustainable telematics applications and to identify related future needs and priorities of local authorities (Mino, 2000; Couclelis, 2004). Other strands of the Telematics Application Programme included Telematics for Urban and Rural Areas (TURA) and the Integrated Applications for Digital Sites (IADS) action lines (Mino, 2000). Rather than the dissemination of network programmes via the Internet, the European Digital City programme placed emphasis on the development of telematic services (Komninos, 2002). The European Digital City programme saw a hundred European cities (as part of five discrete networks of cities) implement digital technologies towards a range of municipal and civic initiatives (Ishida, 2002; Komninos, 2002)[7]. The main fields of interest were: telematics and employment, economic development with an emphasis on small enterprises, the quality of life for disadvantaged individuals, information channelling and administration of cities, training and education, the environment, health and tele-democracy (Komninos, 2002). See Section 3.1.1.

Characteristic of European urban planning initiatives involving ICTs, digital city projects in Europe were primarily led by public stakeholders, namely municipal administrations. The specific aim of digital cities was to "build an arena in which people in regional communities can interact and share knowledge, experiences, and mutual interests … [integrating] urban information (both achievable and real-time) and [creating] public spaces in the Internet for people living/visiting in/at the cities [*sic*.]" (Ishida, 2002: 76). A range of discrete projects were initiated under the EDC Programme which contributed to the overall value of digital cities as able to provide services to citizens that aid the functioning of the city (see Komninos, 2002).

Outside of the European Digital Cities programme other initiatives were sponsored in Europe by local authorities and private companies, for example, Digital City Amsterdam, which aimed to widen participation through community e-networks (Couclelis, 2004; van den Besselaar and Beckers, 2005) and the Virtual Helsinki project which aimed to establish digital networks between commercial community users as well as creating 3D online models of the city (Ishida, 2000; Couclelis, 2004).

Despite some moderate successes, evidence suggests that some of these projects ultimately collapsed. An example is, Digital City Amsterdam, which failed to establish online communication and infrastructure successes (van den Besselaar and Beckers, 2005)[8]. The project's website[9], initially created as a communication forum between the municipal authority and its citizens, now serves primarily as an urban social networking and communication engine (Couclelis, 2004). Together with a series of organisational and financial failures, the rapid evolution of ICT technologies during this period meant that new forms of capturing and sharing data quickly superseded their application. Top-down development issues also complicated the success of such projects in addition to poor consumer uptake in the projects. The example of these failed projects provide a series of valuable lessons for local and regional governance for future projects applying ICTs to urban planning and governance around the world and is explored further in section 3.1.1.

The evolution of the digital city also witnessed the development and designation globally of smart cities: those that incorporated a broader set of resources over and above innovations in and applications of ICT, particularly human creativity and knowledge in its various forms. In Europe, the concept of 'smart cities' was most clearly articulated by the European Smart Cities project, a collaborative research programme led by the Centre of Regional Science at the Vienna University of Technology. In this programme, between April and October 2007 researchers measured the performance of 70 medium sized European cities in six distinct development areas (Giffinger,

[7] The five networks of cities were: (1) The Telecities Network (connecting cities with a shared interest in the development of Telematics), (2) The POLIC Network (a union of 55 cities and regions from 17 European countries collaborating on matters of transport and environment), (3) The Car Free Cities Network (60 cities attempting to ensure a healthier environment with less pollution, environmentally sound transport systems and improved safety, (4) The Eurocities Network (representing 90 European metropolises whose mission is to improve urban quality of life and European urban policy as a means of integration) and (5) The TURA Network (cities that implemented the telematics applications via the corresponding EU R&D Programme) (Komninos, 2002).

[8] See van den Besselaar and Koizumi (2005). The Helsinki project was reduced to the creation of a 3D model of the city from its original (broader) remit. See http://www.virtualhelsinki.fi/

[9] www.dds.nl

2007)[10]. 'Smart Cities' measured intelligence not only in terms of developments and applications of ICT but also in terms of more qualitative factors such as citizen education and awareness, business practices and innovation and environmental and sustainability initiatives[11].

2.1.2 Ambient Technologies[12]

This section explores in more detail European city-based and cross-border projects that might be comparable to the Korean U-City concept, determined by their use of ambient or ubiquitous computing technologies (i.e. those which differ to their earlier digital counterparts in their goal towards interoperability of systems, between both cross-city and cross-border data infrastructures).

The past two decades have demonstrated a desire within European urban development spheres to incorporate innovative ICT developments in urban governance and planning for more competitive and sustainable 'intelligent' cities. In the European context the past decade has however witnessed an *evolution* in this concept towards what might be considered the next generation of computing technologies. What initially began as a merely technical interest in bringing communities together through the provision and sharing of information in digital form has subsequently evolved into the concept of the 'Ambient City', through which citizens are informed and mobilised through interaction with ICT technology embedded within the infrastructures of the city.

Such projects in Europe have been facilitated and supported by a series of Parliamentary directives towards the development of ICTs. Initiatives such as the European Union's Framework Programme (aimed at supporting interdisciplinary research across the region) and the INSPIRE spatial data infrastructures directive, have enabled and supported the development of ICT programmes, specifically digital and ambient technologies, to allow European citizens the opportunity to fully benefit from the development of the 'knowledge-based' society, as specifically outlined in the European Union's Sixth Framework Programme[13]. Broadly defined, 'knowledge-based' societies are those that are driven by the knowledge economy, or by opportunities to attract knowledge workers in order to fuel economic growth (Van Wezemael, 2008). 'Knowledge' refers not only to the academic knowledge or 'intelligence' of its citizens but also to creative and cultural knowledge and the ways in which these epistemologies are used. However in the context of the development of urban environments knowledge plays a key role in the form of ICT-based expert systems: 'knowledge-based' in many contexts referring to the incorporation of ICTs in urban functionality with an emphasis on *data* and *information*.

These initiatives have supported a series of research projects both those geographically delimited to specific cities or regions and those involved in developing cross-border spatial data infrastructures (SDIs) (frameworks for co-ordinating the use and implementation of spatial information (Association for Geographic Information, 2007), which aim to achieve the interoperability of administrative, environmental and planning data across national borders (see below). Unlike the Korean U-City concept however, the examples considered here cannot yet be classed as ubiquitous city projects due to the ad-hoc nature of the application of such technologies. Despite these current limitations, goals towards improved interoperability and extending current applications suggest it is only a matter of time before more direct comparisons with the South Korean U-City concept can be made.

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[10] Other research partners were the Research Institute for Housing, Urban and Mobility Studies at the Delft University of Technology and the Department of Geography at University of Ljubljana.

[11] See Appendix 2a

[12] Also see the now completed ODIN project http://www.ist-world.org/ProjectDetails.aspx?ProjectId=f3454df1f1994eaca4c0c9fb62e78f5c

[13] http://cordis.europa.eu/fp6/activities.htm Accessed 22nd October 2009

The projects outlined below are comparable to the U-City concept in their application of ubiquitous computing technologies to city based functions and services. Unlike the ubiquitous city concept these projects are delimited to specific geographical spaces or to the type of service provided and are yet to achieve interoperability on a comprehensive, city- or nation-wide level, to the full gamut of public and private services, anytime, anywhere as envisioned by Weiser (1993).

2.1.3. Citywide Projects

This section considers projects applying ambient technologies to city-based functions and services. At present, those projects employing such technologies for interoperable service provision seem limited to *research* initiatives, leaving a dearth of actual operable examples for review. For a list of projects see Appendix 2.

2.1.4 Cross-Border Initiatives

Projects described, above, are spatially delimited to specific locations in the context of European cities. Developments in ambient computing in Europe also encompass Spatial Data Infrastructure (SDI) technologies that aim to enable interoperability across national borders through the use of digital and ambient technologies towards the development of National and Regional Spatial Data Infrastructures (NSDIs) (Jackson *et al.*, 2009). These SDIs will also be applicable and interoperable at the sub-national, regional and even local perspectives which require an equivalent level of attention (Jackson *et al.*, 2009). The potential of institutional, social and cultural obstacles to seriously impede the realisation of the centralised NSDI vision, given the multitude of stewards of geospatial information for any geographic region and the associated stakeholders whose interests must be protected (Jackson *et al.*, 2009) is significant. These obstacles and proposed ways around them, including the development of 'place-based policies', are discussed in greater detail in section 4.

The development of NSDIs in the European context is largely focused on enhancing the interoperability of data on the environment in general this being the driving force in the INSPIRE Directive[14] although, as demonstrated below, applications also include urban and transport planning and e-administration.

2.1.4.1 The INSPIRE Directive

Europe needs an integrated approach to solve its environmental problems and improve its planning (Craglia, 2009; Klien, 2009). This absence of a networked approach resulted in early work on INSPIRE (Infrastructure for Spatial Information in the European Community) in 2001. The aim of the initiative was to integrate environmental spatial data from different European sources to enable interoperable, seamless, and easy to locate data banks. The framework lays down rules to establish an infrastructure for spatial information across Europe, which is operated by the 27 member states of the European Union (INSPIRE, 2009a). The stakeholders include supra-national EU agencies and units of the member states as well as experts from research backgrounds.

A key objective of INSPIRE is that users from member states will be able to access spatial information from a variety of sources across the EU, providing true interoperability between datasets. INSPIRE also seeks to enhance the interoperability of spatial data and network services that affect how the data is viewed, downloaded and what metadata is generated.

[14] See: http://eur-lex.europa.eu/LexUriServ/site/en/oj/2007/l_108/l_10820070425en00010014.pdf

INSPIRE moves beyond voluntary cooperation as its rules have entered European legal frameworks (Kok, 2007). From 2009, the INSPIRE directive has been integrated into national laws, when the INSPIRE Commission Regulation on Metadata (EC) number 1205/2008 was approved (Klien, 2009). INSPIRE does not aim to not create one central server or service, but to enable the sharing of spatial data between the member states that create and store it (Coote, 2008). To ensure that the spatial data infrastructures of the different member states are compatible across Europe, the INSPIRE Directive requires that common Implementing Rules (IR) are adopted in a number of specific areas (INSPIRE, 2009a), in order to facilitate cross-border interoperability (Coote, 2008). These areas include:

1. Metadata
2. The interoperability and harmonization of spatial data and services for selected themes – known as Annex I, II and III
3. Network services and technologies
4. Measures on sharing spatial data and services
5. Coordinating and monitoring standards

There are 34 thematic categories of data that are covered by the INSPIRE Directive (de Groof, 2009), which are central to environmental policy research and planning. These themes are divided between three categories, known as Annex I, II and III (INSPIRE, 2009b). Annex I includes datasets that comprise of coordinate reference systems, administrative units, names, addresses, transport networks and hydrography. Annex II includes data on elevation, land cover and geometry. Annex III includes geospatial data on statistical units, soil, buildings, risk zones, mineral resources, population and demography. Work on Annex I themes is underway, and work on Annex II and III began in 2010 (INSPIRE, 2009c).

2.1.4.2 GIS4EU

The EU consists of 27 separate countries but its infrastructure systems, government policies, transport and communication networks are interconnected. In order to enable policy-making it is necessary to integrate this data into databases that contain reliable and accurate data relating to the wider EU (GIS4EU, 2009b). Currently, data is stored by individual agencies which collect the data at different scales, using different levels of aggregation, using their own meta-data standards and with many other differences, a situation that makes the integration of data complex. Reference data is also stored using different coordinate systems, using different types of classification for the thematic components and different rules that dictate how to match the edges of data (GIS4EU, 2009b). In addition, there can be a lack of metadata, for compiling datasets, which can be compounded by language differences, whilst legal differences within individual EU states affect how data can be sold and accessed, which further limit the use of data in spatial, environmental research and policy-making (GIS4EU, 2009b).

In order address these interoperability challenges GIS4EU is a project, completed July 2010, that aims to facilitate cross-scale, cross-language and cross-border interoperability and accessibility, according to the standards and requirements of the INSPIRE Directive (GIS4U, 2009a). GIS4EU adopted a common data model, harmonization, aggregation and data exposition rules and guidelines, so that users can access consistent and homogenous reference data, without the need to build a central database, as geospatial data will be accessed from different sites before being integrated (GIS4U, 2009a). The project developed new base cartography datasets through the harmonisation and aggregation process to address the four themes of administrative units, hydrography, transportation networks and elevation.

GIS4EU had six key objectives (GIS4U, 2009a):

1. Create a system approach network through all different classes of subject involved: stakeholders, users, scientists, technicians, data collectors.
2. Overcome the critical aspect linking together all subjects involved in the decision process;
3. Implementing and developing a test side, related to four different basic cartographic layers;
4. Generate a website for free testing, and to share information and methodology;
5. Improve communication and integration among the main actors at different level of producing, using and manipulating base cartography all over EU, in particular related to standard use and common requirements;
6. Generate new opportunities for sharing information and develop common standard compliant to INSPIRE directive and technical aspects.

GIS4EU is an EU funded project through its *e*Content*plus* programme, to develop guidelines and tools to adopt common data models under the INSPIRE directive for the Annex 1 and Annex 2 themes (Hobona et al, 2009). Under the theme of Annex 1, GIS4EU will critically evaluate the INSPIRE common data models relating to administrative units, transport networks, and hydrography, to see how well they integrate data. Under Annex, two, GIS4EU will develop a new common data model to convert elevation data (Hobona et al, 2009). The testing and development of new models is achieved by reverse projecting of data onto new coordinate reference systems, to recode the data, whilst new rules have been created to cope with gaps that emerge in integrated datasets. Integration also involves changing the names of attributes and raster and vector data attributes, such as miles to kilometres for transport networks (Hobona et al, 2009). There are a wide number of participatory stakeholders involved in GIS4EU, including public authorities, data providers, researchers, service providers, software producers, whose standards must all be taken into account. Once the established standards are reused, both money and time in project management for the users of GIS4EU will be saved, and users will benefit from the interoperability of different datasets to integrate cross-border, cross-scale data (GIS4EU, 2009c).

2.1.4.3 U-City Relevance: West to East

Both INSPIRE and GIS4EU have important implications and lessons that could be used in the development of interoperable U-City systems. INSPIRE and GIS 4EU seek to develop frameworks that will enable a user to access multiple databases that are held by different government departments, from across Europe. These datasets include information on elevation, land cover, buildings, population and demography. Carrera and Ferreira (2007) have suggested that municipal governments should develop spatial data infrastructures where government departments stop pooling all their data, and instead task each department with looking after its own data, but where it can be accessed by other departments, with the aim of the developing more detailed and granular sources of geospatial data. U-City designers could use the rules and frameworks developed from the INSPIRE and GIS4EU initiatives to inform their own interoperable frameworks that could enable different government departments within a U-City, and national scale government departments, to obtain data from each other without the need of building common data depositories. These standards could be devised to help homogenise the different sources of data, stored in different locations and managed by diverse government departments. This would remove the need to store data in a centralised silo, saving operational expenses, but this strategy would also enable the relevant authorities and departments to update spatial and city data on a more regular basis than before. This model could also be used to develop an open-architecture infrastructure where crowdsourced data, explored in more detail in section 4, could be directly accessed by city officials, based on information collected and offered by the city's citizens, which could be used to inform the decision-making processes of government officials and planners, to develop and manage the city.

This would enable large and diverse datasets to be accommodated, viewed and processed by officials and citizens as necessary via the U-City's wireless infrastructure, lowering costs, providing more accurate and up-to-date information on the city and its inhabitants. Geospatial data on the movements of crowds, photographs and updates could be used to provide real-time data to the government in emergencies, for example, whilst citizens could also provide ideas and opinions in planning decisions, democratising the U-City and engaging citizens, potentially increasing the sustainability of U-Cities though resident involvement.

2.1.5 Summary: Characterising European Approaches to the 'Knowledge-based' Society

In the European context, the concepts of digital and ambient technologies have been adopted and developed towards several specific objectives. The primary drivers of the incorporation can be summarised as follows:

- **City Administration (*e*-governance) and Urban Infrastructures**: Towards 'integrated service delivery' (information provision, guidance, electronic payments), urban planning and transport, urban regeneration and land-use planning, environmental monitoring and emergency management systems and security;
- **Economic Regeneration/Development**: Attracting new business through infrastructure improvements and accessibility and availability of innovative technologies;
- **Social Inclusion and Quality of Life**: Services for schools, the elderly/disabled, citizen participation (*e*-participation), culture and tourism, health and social affairs, adult education, labour and employment.

As listed above, the initial use of digital technologies has been recognised and adopted for its potential in widening participation through 'e-governance'. Further applications of digital and ambient technologies have also been adopted for improved urban planning towards sustainability, specifically through the application of technologies such as wireless, sensors, handheld devices, LBS and RFID to urban transport systems. Examples of the application of these technologies include clickable maps and 3D iconic visualisations (as witnessed in the case of Virtual Helsinki) as well as participatory decision support in which, due to the prominence of spatial issues in urban decision-making, GIS technologies have been heavily utilised (Couclelis, 2004)[15]. Additional examples include urban simulations based on models of urban change and integrated urban simulation and public decision support which build on this, as well as the development of location-based services which foster a whole range of interactive digital city functions (Couclelis, 2004). This latter example perhaps marks the evolution of digital-city technologies to ambient technologies, signalling the progression of ICT in urban planning in Europe. These have also been employed across the continental region for the benefit of environmental monitoring towards environmental sustainability and management, including risk assessment and hazard response (e.g. EuroGEOSS). Given the goal of the EU towards greater transnationalism, much of the emphasis of e-governance and planning is on developing transnational and national regulatory regimes (Maynard, 2008) witnessed most specifically through the INSPIRE directive. More specific projects are working towards the use of location specific data for a range of applications, which include e-tourism in cities (iTACITUS)[16].

The European model of ICT and urban governance reflects the perceived importance of the role of local or municipal government in the design and implementation of ICT and urban planning policies rather than administration at the state or national level (see Cohen-Blankshtain and Nijkmap, 2003; Maynard, 2008). The European model also reflects recognition on behalf of policymakers of the role of ICT as an essential component in initiatives to improve municipal governance and citizen

[15] See Nyerges and Jankowski (2001)
[16] See Appendix 2c

participation, as well as a key driver behind economic development efforts (Maynard, 2008). Increasing competitiveness and widening participation through 'e-governance', urban planning and environmental monitoring for risk assessment and hazard management are at the heart of the European 'e-Agenda'[17]. At present, despite progression in certain areas (in particular environmental monitoring), with reference to the typologies and examples provided above, European examples currently demonstrate a greater tendency toward digital rather than ambient computing technologies.

2.2 ICT and Urban Planning in Asia

East Asian intelligent cities experience the most comprehensive technological coverage, in comparison to European and US examples, as their municipal governments seek to extend Internet coverage to all city residents, to enhance their standards of living. These city developments are usually characterised as 'top-down' government-led programmes that subsidise the completion of large and ambitious projects. For example, Singapore was one of the first nation-states to develop a comprehensive, national information infrastructure, when the government launched the 'Singapore National IT Plan' in 1986, which sought to connect homes, offices, schools and factories, to the Internet (Arun and Yap, 2000). The government aimed to provide all government services, advice, forms and permits, through an online portal called the 'E-Citizen Service Centre'. Singapore aimed to become the world's first 'intelligent' *country*, predating the digital cities of Europe. Singapore provides an interesting example of an early digital city; unlike the European examples that were formulated by local and supranational governments. Singapore's project was nationally coordinated; a feature it shares with the South Korean model of U-Cities. Although Singapore can be categorised as a digital city, it has begun to slowly change and adopt new technologies and services that are used in ambient cities. Singapore has long used road tolls where transponders in cars are used to automatically bill consumers (Graham, 2002). Again, this reflects more of a U-City model in that it uses ambient technology embedded into the built environment. This has been complemented more recently by new innovations and plans with the launch of Singapore's iN2015 master plan, which seeks to provide new infrastructure, enhanced broadband and a pervasive wireless network, known as the Wireless@SG Programme (IDA, 2009).

Despite earlier categorisations as a digital city (see for example Ishida, 2000), Tokyo has also become a city of ambient technology given developments such as the adoption of real-time ubiquitous technologies for its transport systems. It has also become a test-bed for new ubiquitous technologies as academics, the Tokyo Municipal Government and private sector stakeholders seek to embed ubiquitous technologies into Tokyo with the aim of upgrading the city to a ubiquitous city. Since 2005, feasibility projects have been conducted across Tokyo to assist planners and private companies in meeting the Tokyo Municipal Government's aim of eventually becoming a ubiquitous city, where the new technologies can be showcased to the world (Tokyo Ubiquitous Technology Project, 2009a). This is different to the Korean U-City development in that the City's infrastructure is upgraded retrospectively, whereas the Korean plan is to develop entirely new U-Cities. The Korean government's leading role in the development of new U-Cities seeks to seamlessly integrate ubiquitous technologies within streets, homes and offices, providing coverage across the entire city. The U-City concept can be considered an outcome of the Korean government's proactive stance on the development, implementation and use of IT (Shin, 2008). It is hoped that Songdo will stimulate regional development and improve the quality of life for its citizens focussing on safety, environmental security, and education (Kyung-Min, 2009). While a new city, and the world's first ubiquitous city, Songdo may soon be joined by other evolving digital cities that are beginning to use more ambient technology, driven by comprehensive government programmes, such as Singapore

[17] On a technical note, the use of the 'e' prefix here is deliberate to denote the use of digital rather than ambient technologies through semantic associations to web-based technologies (Internet, broadband etc).

and Tokyo. Songdo has yet to be completed, and as McNeill (2009) has highlighted, previous new build cities, like Brasilia and Islamabad have faced many problems. Subsequently, Songdo's success is not guaranteed, and it will have to compete with more established cities that may also successfully innovate and adopt comprehensive ambient technologies, bringing them closer to towards the U-City status.

2.3 ICT and urban Planning in the US[18]

The US leads the world in terms of computing and communication innovations. The largest IT companies such as Microsoft, Google, Oracle and IBM were founded in the US. The US is also considered to be home of the Internet and also ubiquitous computing, which was coined by Weiser and is central to the concept of the U-City. The widespread implementation of new technologies and their use in intelligent urban environments distinguishes the US approach to intelligent city development from those in Europe and Asia, in that the US model reflects the US's capitalist, market-driven policies in that innovations and developments are fostered through private initiatives. The US utilises public-private sector partnerships to continue to develop and offer access to public and e-governance tools and local content Internet access (Maynard, 2008), although the public authorities play a less active role than witnessed in Asia. The effect of this is frequently that of a digital divide, where poorer communities find it difficult to access the Internet, due to a shortage of IT literacy, or being unable to afford the hardware and infrastructure, excluding them from digital, ambient and ubiquitous cities. On the other hand, wealthier citizens are able to afford IT access and equipment, enabling them to gain access to digital city initiatives.

These issues are highlighted through the example of San Francisco. The city's residents have access to broadband services operated by private, commercial operations, but the municipal government decided that a universal, affordable wireless broadband service should be established to connect all areas and residents of the city to the Internet, especially the urban poor (City of San Francisco, 2005). The City's Department of Telecommunications & Information Services and the San Francisco Public Utilities Commission were tasked with exploring the possibilities of a community-wide wireless broadband network. Benefits and specifications included public safety improvements, construction and IT development. As such, developments in the US that use ambient and ubiquitous technologies are smaller, private developments. There is only one ubiquitous urban environment development in the US, at the time of writing, perhaps, due in part to the issue that real-estate developments in the US are market-driven and there may not yet be a demand for U-Cities in the US. The development is being financed by C&M Investments, a project that entails a 100-acre real-estate project in Dayton, Kentucky, called Manhattan Harbour (Wartman, 2009a). It is hoped that construction will begin in early 2010 when the urban infrastructure is complete with the first phase of homes and commercial properties being placed on the market the following year (Wartman 2009a). The development will include 2,000 homes from apartments to family homes, a Marina, hotel and boardwalk, with proposed ferry services. The project is in its early stages and there is little publicly available information on the technologies envisaged for the development, which will maximise revenues for the local authority and profits for the real estate developer.

2.4 Comparing European, Asian and US Approaches

Despite the application of digital and ambient technologies to particular projects in Europe and North America, it is clear from a comparative examination with their East Asian counterparts, that there is a distinct difference in the way in which such technologies are being embraced across the three regions of the globe. This difference is two-fold: firstly the degree of technological complexity (i.e. the implementation of *ubiquitous* over *ambient* or *digital* technologies), and secondly the extent

[18] More details on these cities can be found in Appendix 5.

of the range of services and tools to which these technologies are applied in any one city or region. Nowhere in Europe or North America is the concept of the U-City, as a fully integrated, fully comprehensive initiative, presently undergoing technological development and construction on a national scale as it is in Korea. This section of the report seeks to highlight and explore these differences between Asian, European and US approaches to intelligent urban environments.

There are different rationales that underlie the development of digital, ambient and ubiquitous cities that affect how these city initiatives are planned and implemented, and which services subsequently emerge. For example, US digital cities are usually developed by private companies to advertise and sell additional services, where the key aim is to generate revenue, whilst digital cities in Europe and Asia are usually developed by governments and municipal authorities to supply public services over the Internet, to build communities and to provide increased Internet access for their citizens. The effect of this is that US digital cities succumb to a digital divide, where those who are financially poor, or computer illiterate, lack access to these services. In the US, ambient services such as ZipCar, where consumers can rent and access a car using RFID and GPS technology, are usually private and generate private revenue. In Europe, however, public services such as iTACITUS (see Appendix 4) are developed experimentally with public-sector backing, to see if ambient technologies can be developed for successful public service usage. In Japan, small public sector projects have also been implemented to explore the use of ambient technologies, in a similar way. The U-City paradigm is driven mainly by Korea, which seeks to enrich everyday life and to enhance economic development and to develop environmentally sustainable cities, which benefit all citizens, who are placed at the centre of the government's plans.

The stakeholders involved in the development and management of intelligent cities typically include both the private and public sector. However, there are significant differences as to the degree of involvement of the different parties involved in city development. For example, in Asia, the Korean, Singaporean and Japanese governments, including academic researchers, have played a central role in shaping the development of technological cities. Both Singapore and Korea have developed units of government and legislation to govern the development of new cities where they have taken an active part in planning new cities and overseeing their development. In these examples, the power-relationships are very much 'top-down' where the government coordinates private companies, smaller municipal bodies and consumers in determining how the city will be designed and the technology and systems that will be provided. On the other hand, the US has consistently maintained a market-approach to city development and although governments seek to enact new projects, the development of new urban areas is pioneered by individual private companies that may or may not include ubiquitous computing devices in their plans for development. European examples sit between these two extremes, where government funding, frequently from the supranational authority of the European Union is used to fund research into new projects that have stimulated research into new programmes through academic partnerships. Whilst funding is made available for the projects, private companies produce the technology and systems, but in the case of European digital city initiatives, the public-private relationships have been more balanced than those in Asia and the US.

The distribution of power between these public-private relationships has generated a particular geography that surrounds the distribution of intelligent cities, in particular the U-City concept, around the globe. The powerful role of government in Asian U-Cities is 'top-down' where the development of new regulation and the placement of U-Cities and digital cities at the forefront of government policy have enabled large technological cities like Songdo to be developed. As these developments are holistic and cover entire cities, the Asian cities are more comprehensively developed, with Internet coverage extending across entire cities. As for the US, its market-driven approach means that the government has a minimal role and market forces mean that companies have only developed ambient services and technologies, and digital cities, if they are profitable, creating a digital divide where some parts of cities have ubiquitous services whilst others do not, reducing city-wide coverage. Europe is similar in this regard, as individual policies have not been developed to introduce new cities, or ambient cities. Unlike the Korean example, the application of digital and ambient technologies in Europe remains significantly ad-hoc, lacking in a joined-up, networked approach to incorporating ambient technologies and driving forward the concept of the new information era or knowledge based society (built on the technological and ideological foundations of ubiquitous computing) across nations and between regions.

That is not to say that European projects have not incorporated ubiquitous computing technologies into future plans. However, unlike the Korean approach, present European examples reflect an 'either/or' approach: for example, the INSPIRE directive has enabled the development of projects such as GIS4EU and EuroGEOSS, fundamentally *environmental* initiatives which aim to work towards connected, networked and interoperable cross-border SDI systems across Europe. Individual city-wide examples demonstrate the use of *ambient* computing but fail to roll this out across a comprehensive city-wide agenda, incorporating technologies to address all aspects of everyday city-life comparable to the application of ubiquitous technologies to urban planning in South Korea. Despite developments in 'digital' and 'ambient' technologies and SDIs and NSDIs, unlike some south-east Asian examples, to date, neither Europe nor the US have yet to embrace the concept of fully integrated, comprehensive 'ubiquitous' computing applications to entire delimited geographical areas.

The technologies incorporated into urban environments vary between the cities in the North American, European and Asian regions - dependent on the different types of city located there. As such, U-Cities based in Asia are more likely to utilise ubiquitous technologies that have a more diverse range of sensors that detect pressure, heat and movement. These technologies also utilise Blue-tooth and wireless networking and devices such as RFID tags and small computers embedded into the environment. These technologies are also used in ambient city services in Europe, but the key difference is that they do not provide comprehensive coverage across the entire city. These variations in the different technologies that form the backbone of these different cities also affect the degree of interoperability between these different types of city and the importance that interoperability plays. The need for interoperability is lowest in the digital cities that are found mostly in the US and Europe, as the access required is through desktop computers or laptops, or handheld devices through standard Internet connections. There is more demand for interoperability in ambient cities in the US, Europe and Asia, where handheld devices require access to data from GPS, RFID tags and the Internet which utilise different devices and need enhanced interoperability. The demand is still lower however, as these networks and ambient services operate across privately designed networks and do not require interoperability with other systems within the city. The greatest demand for interoperability is amongst the U-City systems, as the use of multiple types of technologies through RFID tags and pressure sensors, for example, need to be networked with other systems across the entire city, whilst maintaining constant flows of information between different sensory networks. The need for increased interoperability will potentially occur in the future if U-Cities begin to adopt crowdsourcing technologies, where data can be generated from citizens. The intelligent city developments are unsurprisingly, shaped by the aims and stakeholders of each project, although these do result in stark differences in the technologies and coverage experienced by different city paradigms in different geographical regions. These regional differences in stages of development and application of ICTs to urban planning and management raises a series of more general questions about society, technology and culture between global regions, ideas which are explored in more depth in the following sections of the report.

3. Issues and Critiques: Lessons Learned from European, Asian and US Models

3.1 Governance Issues: European Experiences of Digital City Projects

The European experience of digital cities in the mid-late 1990s, which came out of a range of research and development projects across the region, provides a series of lessons and valuable insights for local and regional governance through the use of ICT. Two projects, 'European Digital Cities' and 'Digital City Amsterdam' are considered here, each providing insights into different aspects of ICT and e-governance.

3.1.1 *European Digital Cities* Project

In 1996, the EU launched a four-year *European Digital Cities* project under the auspices of the Telematics Application Programme for the purposes of supporting European cities and regions in the deployment of new, economically and socially sustainable telematics applications and to identify related future needs and priorities of local authorities (Mino, 2000; Couclelis, 2004). Rather than the dissemination of network programmes via the Internet, the *European Digital Cities* programme placed emphasis on the development of telematic services (Komninos, 2002).

The programme saw 100 European cities (as part of five discrete networks of cities) implement digital technologies towards a range of municipal and civic initiatives (Ishida, 2002; Komninos, 2002). The role of local authorities was recognised in being able to develop partnerships that extended beyond local governments and involved citizens, business, media and community organisations. Local authorities were seen as central to the development of an efficient, effective, equitable, open and accountable Global Information Society (Mino, 2000). Establishing the character of future e-governance in Europe, the main fields of interest were: telematics and employment, economic development with an emphasis on small enterprises, the quality of life for disadvantaged individuals, information channelling and administration of cities, training and education, the environment, health and tele-democracy (Komninos, 2002).

The aim was to apply new and innovative digital technologies (primarily Internet-based including GIS technologies) to bring European cities sharing similar goals and interests together for the development of such technologies in an urban context and to understand the risks and opportunities posed by new ICTs for local authorities and city governments. It recognised the importance of universal access and the diversity of needs.

There were three key applications areas:

1. Economic development and regeneration;
2. Social cohesion and quality and life; and
3. City administration and urban infrastructures.

Sixty cities across the region established pilot projects following strategies that corresponded to these key applications areas dependent on implicit (defined by opportunity) or explicit (defined by priorities set by the municipal authority) objectives. The project ended in 1999 after which several accounts of the project were published detailing the specific experiences, successes and failures of the project (see Mino, 2000; Mino *et al.*, 2000; Komninos, 2002).

Mino's (2000) report highlighted a series of key challenges for government in the implementation and development of ICT applications to e-governance and urban planning. These included: Managing technical and organisational complexity in terms of both integrating a wide range of ICT applications (including ensuring interoperability) as well as managing the collaboration of a diverse group of stakeholders; defining the appropriate policy and regulations to maintain equitable services; and demonstrating the benefits of new applications to relevant actors and stakeholders. This final point bears relevance to the ultimate success of implementing innovative ICT applications to urban planning.

These challenges were accompanied by a range of limitations in the following areas:

1. Rates of penetration at the geographical and social level;
2. Impact analysis and analysis of economic viability (monitoring);
3. Standardisation of technological solutions (interoperability);
4. Sector/service specific applications; and
5. Regulation and Legislation (legal framework).

Any of these could impact on the success of a project attempting to incorporate innovative ICT applications to urban planning and e-governance. Mino (2000) also recognised however, a series of features drawn from a range of successful examples. These included: The development of explicit strategies; the incorporation of technologies into the wider context of organisation, a clear set of overarching goals; technological, financial and administrative support; semi-autonomous institutions able to form effective partnerships with the private sector and learn from involvement with networks of co-operation and the experience of a critical mass of research and development projects on which to build. By maintaining mindfulness of each of these challenges, limitations and features of successful projects, the experience of late twentieth century digital city projects in Europe may offer some valuable lessons for future urban governance in the context of the development of the ubiquitous city in East Asia.

3.1.2 Digital City Amsterdam (or "DDS" from "De Digitale Stad")

Following the model of freenets and community networks in the USA and Canada, a publicly and privately funded initiative, *Digital City Amsterdam* (DDS) aimed to widen participation through community e-networks (Couclelis, 2004; van den Besselaar and Beckers, 2005)[19]. DDS was an experimental virtual public domain launched in 1994 for a 10-week period. After a successful experimental period it became a permanent initiative for six years before its ultimate demise in 2001 (van den Besselaar and Beckers, 2005). The aim of the project was to introduce the Internet and its possibilities to a wider population by providing free access to the Internet as a new cultural domain that could promote creative experimentation.

One specific objective of the project was to link access to the Internet to the upcoming local elections, participation in which had been declining for several years, reflecting an increasing divide between politicians and the electorate. It was hoped that DDS would decrease the widening gap between citizens and politicians and subsequently increase participation. The local administrative authority was convinced by the project organisers that a digital public space could be used by the organisers for the wider dissemination of political information and communication between citizens and politicians. After a successful 3-month trial period, the DDS expanded this service to provide an electronic democratic forum between city inhabitants and local politicians for a 10-week period. The cultural and technological context of the project meant that the DDS was sufficiently successful to raise extra funding to support its continuation. The project however failed to overcome a series of obstacles and implement a long-term strategy, which ultimately led to its demise after six years. These included poor organisational, technological and financial support, failure to remain competitive or technologically innovative, inadequate reciprocal participation and poor perceived

[19] DDS is an abbreviation of *De Digitale Stad*, Dutch for 'The Digital City'.

ownership amongst users. The DDS now serves primarily as an urban social networking and communication engine.

Although technological development has progressed enormously since the initiation of the DDS project, the experience of the project's apparent failure provides a series of useful insights into issues of ICT and local governance and so may of value for present applications of ICT to local and regional governance in Korea and the wider East Asian context. Peter van den Besselaar and Dennis Beckers (2005) provide a comprehensive account of the life and death of the DDS from which a series of issues are highlighted. From these, lessons for e-governance can be learned, from the importance of socio-cultural context to the necessity of strong organisational structures and robust financial bases.

The decline of the project was attributed in part to poorly or under-developed technological systems, failing systems management and dwindling support for the service, in terms of both technological support, (i.e. the helpdesk was closed) and user demand (i.e. access points were closed) and user numbers decreased. Although the number of 'digital' citizens increased, DDS activity declined: people were spending their time elsewhere in cyberspace. The DDS lacked funding and strategies to compete successfully. In order to survive, external investment was necessary. The life of the DDS subsequently went from a self-supporting non-profit making organisation to a commercial enterprise, focused on profit, a factor the authors assert was key to its ultimate failure and demise. When commercial interests are introduced to the equation there is a conflict of interest and the rationale for the service become skewed and the service ultimately compromised (van den Besselaar and Beckers, 2005).

The experience of one particular user of the DDS (a designer of its Web interface) cited by van den Besselaar and Beckers (1994) provides an insight into the kind of elements that might contribute towards a successful application of ICT for e-governance, particularly one which aims to incorporate a 'bottom-up' approach. After an initially disappointing first impression (largely attributed to the system interface) the user states:

" … then something happened that I had not experienced on any other BBS I knew: The DDS Started to grow very quickly and became very lively. The influence of the thousands of citizens became manifest. The amount and quality of the information increased fast, and interesting discussions took place in the newsgroups and in the web cafes" (van den Besselaar and Beckers, 1994).

What this reveals about consumer uptake of ICT services for e-governance is that the technology must be providing something different, something new and innovative for uptake to be secured. The technology must be sufficiently developed and, critically, *supported*, for user interest to be captured. Perceived *ownership* is also important: in this sense the user must feel that the system is providing a real forum where views and opinions are not only openly accessible and advertised but also where they are attributed *meaning*.

The advantages of ICT systems for widening participation (e-governance) are that they can play a role in providing an 'open' forum for comment and debate, not only for the *provision of information* by the authority to its body politic but also for public consultation; stimulating and retrieving the opinion and views *of* that citizenry. However, as van den Besselaar and Beckers (2005) observe, even if electronic networks foster interaction, such interactions may not lead to a more democratic, participative and inclusive society. What is required is a reciprocal level of input from those with whom users aim to participate. Although discussions took place on the virtual domain of the DDS, the quality was poor and critically, politicians and opinion leaders did not participate. Nor were civic organisations active on the site. Hence, e-participation requires activity on *both* sides of the interface.

The experience of the DDS suggests that other factors to consider are:

- user profile - the accessibility and ICT-literacy of the user and how this contributes to user uptake;
- levels of compliance or user uptake – the level at which ICT supported e-governance systems are viable; and
- socio-cultural and technological contextual – whether success is related to general public interest in ICT and successes of ubiquitous or ambient technologies. Systems must continue to be relevant and innovative. The vulnerability of DDS in a competitive market meant it was unable to survive.

Ultimately the failure of the DDS was due to a lack of ownership by its users. As soon as institutionalisation took place, the rationale of the project changed from one of public domain to "earning revenue to survive" (van den Besselaar and Beckers, 2005: 94). Consequently, the influence of users to shape and develop content declined. What emerges from the DDS experience is that a lively public domain requires active collaboration among individuals and organisations without a hierarchical structure, which discourages participation and creativity.

3.2 Comparative Critiques of Ambient and Ubiquitous Computing

There is a developmental divide in terms of geography between the incorporation of ambient and ubiquitous computing. An insight into the basis of this divide is given by both popular and academic literature where investigations suggest a more critical perspective over the use of pervasive technologies from Western academics who which raise questions regarding the social, economic and ethical implications of ubiquitous computing and pervasive technologies[20]. Ideas of the 'surveillance city' are particularly pertinent. Working from a Western critique of technology and society, Mark Andrejevic (2007), for example, considers how popular comparative portrayals of ubiquitous computing downplay surveillance implications of networked interactivity. Through concerns over increased personal surveillance and the rights to ownership and control of the information captured through networked interactivity, Andrejevic (2007) argues the case for the creation of 'digital enclosure': a model that traces the spatial relationship between the private expropriation of information (also critiqued by Schiller (2007), Boyle (2003) and Lessig (2002) and the construction of networked interactive environments, which Andrejevic argues creates centralised and private data ownership and control. For Andrejevic (2007), much depends on the ownership and control of networks and the subsequent metadata they produce, by whom the terms of entry are set, who gathers and sorts this information, and crucially, for what ends. These concerns, in addition to *who profits* from such activities also constitute a central argument for Crang and Graham (2007). They consider the myriad role of ambient technologies in reconstituting urban space. Rather than creating the vision of what has been allegorised as 'the cloud', where data is ephemeral, information is instead stored by privatised communication networks on which, after becoming purposefully separated from data and resources, users come to rely on for access to, and management of, an array of goods and services (Andrejevic, 2007). Digital enclosure therefore *limits* interactivity by restricting access to those who freely submit to the detailed forms of monitoring that take place within networked interactive spaces: a twenty-first century version perhaps of omnipresence through 'panopticism', articulated by the French theorist Michel Foucault in his text *Discipline and Punish* (Foucault, 1977). Through Andrejevic's model we are presented with the paradox of ubiquitous computing to facilitate both freedom *and* enclosure.

[20] See for example Couclelis, 2004; Bohn *et al*., 2004; Crang *et al*. 2006; Crang and Graham 2007; Wise, 2006

Concerns over the implications for personal agency and empowerment are also raised by cultural theorist J.M. Wise who describes the advent of such technologies as creating a “clickable world where everything is tracked, recorded, compiled and analysed” (2006: 7). For Wise, like Andrejevic (2007), Crang and Graham (2007) and other western commentators, the implications for personal surveillance are fundamental to the development and application of ubiquitous computing technologies, concerns that were raised at the initial reporting of the development of Songdo in 2005 (O’Connell, 2005).

Recognising the potential of ubiquitous technologies to change how we act in the world, Wise (2006) similarly raises questions about social relations and the assumptions about them that become structured into the devices and architectures of ubiquitous computing. Other critiques therefore have focused on the implications of pervasive technologies on social cohesion questioning whether rather than promoting inclusiveness, the digital age promotes social exclusion and marginalisation through the creation of uneven patterns of access (Crang *et al*, 2006) and other problems associated with unequal access (Shiode, 2000).

More than the specific presence or absence of technological actors, different styles and speeds of technologically mediated life come to define urban socio-spatial inequalities. Based on a UK case study, Crang *et al*. (2006) argue that through their more pervasive and continuous use, for more affluent and professional cohorts, new media technologies come to provide the ‘background’ infrastructure to their privileged and increasingly distanciated lifestyles, through which neighbourhood ties are orchestrated. Conversely, more marginalized groups tend to demonstrate more episodic ICT usage which is *facilitated* by the neighbourhood ties that online access *creates* for their affluent and professional counterparts. In addition to its role in reinforcing patterns of social division, differential access to ICT services (in addition to other contextual factors) is also central to determining the ultimate success of the services themselves as found in the case of the Amsterdam Digital City (DDS). The implications of such differential access provide a series of lessons for the application of ICTs to e-governance.

By comparison, those critiquing these ideas from within an Eastern cultural perspective more typically focus on the positive potential of ubiquitous computing technologies. Such technologies are viewed in terms of their future potential for urban everyday life, in terms of urban mobilities, tourism and significantly, with the potential to act as a *cohesive* rather than a *divisive* tool for the promotion of social interaction (see for example Ishida, 2002).

Lee *et al*. (2008) limit their commentary to the improvements u-infrastructures can make to effective urban infrastructure planning and management and the contribution it can make to the creation of environmentally sustainable and ‘smart’ cities. For example the availability of ubiquitous computing to all allows for the immediate reporting of environmental hazards leading to a “significant shift to a new paradigm of urban infrastructure planning and provision in Korea and potentially elsewhere” (Lee *et al*., 2008: 284). Efficiency and economy are also ranked amongst the many benefits perceived by Eastern commentators such as Lee *et al*. (2008) as well as the achievement of u-democracy. Citizens are encouraged and enabled to participate more fully in the decision-making process through the use of personal devices such as mobile phones, personal digital devices (PDAs) or automatic recognition using RFID technologies or wireless sensors. Using such technologies, Lee *et al*. (2008) argue that u-infrastructures are able to provide an efficient system that complies with the planning act and regulations in Korea and achieve transparency and adequacy of services for the public. The focus from this perspective is very much on the benefits u-infrastructure can bring to modern urban planning, although certain challenges of developing u-computing are acknowledged. For example, financing the technological development required, overcoming present and potential digital and knowledge divides (what they describe as the ‘have and have nots’) and ensuring political openness for fully democratic and uncorrupted transparent systems. Other than a sentence in the discussion regarding individual privacy issues, Lee *et al*. (2008) place the emphasis on the improvements to the 'quality of city living' to be made and less so on the social, cultural, ethical and political issues raised by Western commentators.

3.3 Technology, Culture and Society

These differences in attitudes towards pervasive technologies such as ambient or ubiquitous computing were recognised early on in the developmental stages of the U-City at Songdo. In 2005 the *New York Times* reported that despite the origin of such technologies in the US, there was a wider acceptance amongst those working in such technology that due to fewer regulatory and social obstacles this kind of project is more practical to implement in the East (O'Connell, 2005). The report quoted the remarks of a consultant on Seoul's Digital Media City U-City plan: "There is an historical expectation of less privacy. Korea is willing to put off the hard questions to take the early lead and set standards" (*ibid*.). Instead of ubiquitous computing as a tool of surveillance, in Asia the concept is viewed favourably as an opportunity to showcase technological strength and attract foreign investment.

There is at least some evidence to suggest a difference in cultural attitudes towards the use of, and approaches to, ICT technologies that reflects a real divide between the way in which technology is imagined and mediated between global cultures. To gain a deeper understanding of these differences in approaches to the idea of ubiquitous or ambient computing across Europe and the US and South East Asia, however, a deeper examination of respective social and political cultures across distinct global regions is required. How is culture mediated between State and Society? How does Korea conceptualise its national Self (identity) in relation to its Geographical positioning both regionally and globally and how does this inform its ideologies of and relationship to technology and culture, or 'technological culture' as it has recently been *re*-defined by Jennifer Slack and Greg Wise (2005)?

4 The U-City Model: Technologies and Alternative Approaches

4.1 The Location-aware Information and Communications Technologies of U-Cities

The recent pace of change in ICT and location aware technology has been dramatic in contrast to the timescales associated with all forms of intelligent city, which, due to the political processes and the magnitude of the physical infrastructural developments involved, are long. Google was formed in 1998 and had just 8 employees in 1999 and mobile-based location-aware technology such as Google Earth and Google Maps, both launched in 2005, are barely 5 years old. In the last few years we have seen the mass introduction of GPS-enabled mobile phones, broadband mobile connectivity and a wide-range of mobile location-aware and location-based services. Likewise, social networking sites such as Facebook, now with over 400million users worldwide, were formed only in 2006. High-resolution cameras are now standard on mobile phones and there is a general availability of high-resolution image and map data that was previously the domain only of large Government agencies and the defence sector data with much of this data available only on a classified basis.

These technologies have democratised location-based information. For the price of a mobile phone and a modest service contract, or given access to the Internet, a wealth of information on the area we live and work in, the services related to that area and the activities happening in it are now readily available to all. These technologies have had the effect of providing the information network and geographical basis of the services envisaged in the early intelligent city. Rather than an expensive and dedicated infrastructure that might have needed to have been implemented as a centrally funded component of the U-City the wireless infrastructure, positioning and search capabilities and much of the location-based data content will be part of an even more ubiquitous commercial service.

But the positioning, camera and high-bandwidth communication capabilities, of the latest mobile phones have had an even greater impact in potentially facilitating the vision of the U-City architects. They have enabled the citizen to be an integral part of the data collection and communications process. With good quality positioning from GPS, the ability to track the everyday routes that we take and then download these to community-based open databases becomes an easy, near zero-cost transaction. These routes can be enriched with geo-tagged photographs, audio or video clips that we can take and download from the same mobiles. Emerging software, again available at no cost to the user, is available to stitch together clusters of photographs and to generate 3D scene-scapes from them. This data can then be shared, either in an organised manner through services such as Open Street Map which collates volunteered data into an increasingly authoritative free and open-source map data base or with our friends and colleagues through social networks and similar net-based social services.

This development of "citizen-based" or crowd-sourced and volunteered data is generally not a competing source of information to the centrally provided "authoritative" data of the Government and City agencies but should be seen as largely complementary. Government and official agency data tends to have the benefits of high geometric accuracy, spatial completeness and formalised and consistent classification. It will not be influenced by commercial demands and will be considered by most people as the "authoritative" source for the attributes that it covers. At the same time, such data is expensive to capture and impacted by its very virtues of accuracy, completeness, etc. as listed above. The acquisition and quality control can be a slow process leading to significant gaps between the original survey date and the date of use. In contrast, crowd-sourced data whilst usually having the property of relative accuracy (i.e. if a road has a side-road on the left then it would be shown as such) may have poor absolute accuracy because of the limitations of consumer-level position technology. The "crowd" is not overly concerned about completeness of cover in terms of spatial extent but with recording activity where it happens (i.e. there is a human-centric focus to such data). The crowd will also tend not to adhere to standards for the description of features but use the language that they discourse in with friends and colleagues or even use abbreviated "mobile speak". But the benefits they bring to a new, rapidly evolving cityscape is this very human-centric focus. The data will be current and most complete where most people are. The information contributed will often be much richer in descriptive content even if sparser in the recording of the underlying geometry. It will be rapidly communicated through the social networks and communities of the city inhabitants. New developments, changes and especially good or bad services will be rapidly communicated and added to the informal map available to the U-City citizens.

These crowd-related developments are so new (the vast majority of developments are less than 5 years old) that the slower moving and structurally complex government organisations have yet to integrate this "free" source of data into their formal databases[21]. This is partly due to a lack of awareness of the richness of material available and how this can be legally and ethically incorporated whilst avoiding intrusions into individual privacy and partly due to a fear of "contaminating" authoritative data with error-prone content.

[21] The first steps in the integration of crowd-sourced data into authoritative data are now occurring in a number of government-based organisations where such data is used as change intelligence which is then used to prioritise areas for (re-)survey or where further checks are made to confirm the information before incorporation into the authoritative database.

From the “crowd” perspective there has been a similar lack of integration. The ability to incorporate the authoritative data with personally collected and shared open-source data is typically inhibited by licensing restrictions, ease of access to the data and uncertainty associated with the legal basis for doing so. The benefits at the personal level of overcoming these obstacles will usually not justify the investigations and acquisition of knowledge necessary.

The current status is therefore currently one of a hugely enhanced flow of location-tagged information, which is a critical ingredient to making the U-City not only a technological reality but also a social and cultural success. It is also one, however, where the authoritative government-based data, commercial data (often free for personal use but charged for when embedded in other commercial services) and crowd-sourced data remain largely as separate strands of information with full integration still both a research and often legislative challenge.

4.2 The Future of Ubiquitous Computing and Urban Governance

Planning support systems developed over the last few years have the potential to revolutionise the nature of urban planning as acknowledged by Brail (2005) though have been slow to be fully adopted. Yigitcanlar, Saygin and Han (2008) make the important point that planning cannot be disassociated from the societal structure. Assuming this includes the socio-cultural mechanisms that bind that structure together, it can be said that urban planners and governments must keep up with those mechanisms, namely innovations in ICT. Academic commentators have highlighted the emergence and growth of crowdsourcing as a new mode of producing goods and services through distributed networks over the Internet. Such technologies, it is argued here, may find a place in the future of U-Cities as the crowdsourcing model offers benefits to these cities for developing new databases of geospatial data harvested from city residents, but also as a technique for facilitating the participation of citizens in decision-making for both city governance and urban planning.

4.2.1 The Growth of Crowdsourcing and its Potential use in U-Cities of the Future

The term ‘crowdsourcing’, coined by Jeff Howe in 2006, originally described a web-based business model that harnesses the creative solutions of a distributed network of individuals to produce a product or service. Howe (2006) announced that the ‘age of the crowd’ had arrived in the 2000s as the Internet became increasingly used to capture and utilise the combined efforts of crowds of people or resources to meet a set goal. What is particular about crowdsourcing is the use of amateur or ‘non-expert’ captured data to generate new information. Howe (2006) views crowdsourcing as a spin-off from outsourcing, where employing the crowd is cheaper than employing staff using traditional outsourcing models. From this perspective, the crowd can consist of semi-retired experts or amateurs who are given tasks to solve or problems to complete through the medium of the Internet. For example, YourEncore has brought together a crowd of retired scientists who work on small, problem-solving projects for firms that include Boeing and Proctor & Gamble where the expertise and solutions are developed through the collective wisdom of the crowd (Howe 2006)[22]. Again, from this perspective, Crowdsourcing can involve the outsourcing of a company’s design or problems to a collective online group, which Brabham (2008) views as a collective culture where diverse ideas are brought together to solve problems. This view of Crowdsourcing sees the rejection of the traditional client-designer boundary, which has given way to a distributed mode of problem solving and teamwork based around multi-disciplinary research (Brabham, 2008). Previously, product design entailed one solution for one client, in one place, but crowdsourcing in its original guise has seen companies outsource problems and design to a geographically diverse group of experts and amateurs across the Internet, which has been viewed by some as the emergence of an alternative business model (Brabham 2008).

[22] www.yourencore.com

Current examples of the application of crowdsourced data include the University of California's SETI@Home initiative, which taps the unused processing power of computers in homes and businesses through the Internet where they are used to run scientific calculations and process radio telescope data. Other notable examples include Wikipedia, where crowds of users contribute to the generation of a free, online encyclopaedia, where entries are created and edited by the sites own users. Other more commercial examples include iStockphoto, an online member-generated image and design repository, Threadless, an online retail environment for independent designers and InnoCentive, where business problems are outsourced to members (Brabham, 2008b)[23]. In an open source context such organised crowd-based data collection has become particularly relevant to the creation of new user-generated maps; a new trend known as 'neogeographies' (see 4.2.2) and is particularly relevant in the Open Street Maps example http://www.openstreetmap.org/ .

However, the concept of crowdsourced data has evolved and extended from this "managed" approach to become something that is a spontaneous development of social networking and the use of consumer technology to share data between friends and communities. As much of this data is freely added to open web-sites the data can be harvested and collated producing aggregated data that has value much beyond the original intention of the original collectors. Whilst the ethics and legality of collecting data by such web-scraping techniques remains unclear, the value of the data in the social and cultural context of ubiquitous cities is undeniable and is underpinning many web-based initiatives of community and small entrepreneurial entities.

While the idea of the 'crowd' has become pervasive in academic and online ICT publications, Brabham (2008a) argues that crowdsourcing is not to be confused with open source applications, where groups of individuals take part in projects for common goals, such as the Linux operating system, or indeed Wikipedia. Brabham (2008) believes that the key distinction that separates crowdsourcing from opensourcing lies in individual motivation or material incentive – particularly relevant to commercial examples such as Innocentive, and which Brabham (2008b) argues raises questions regarding notions of professionalism and investment in online communities. Through crowdsourcing the individual seeks a profit or reward, whereas in the collection of opensourced data the individual takes part as a way of volunteering or contributing to a project 'for the greater good' such as, for example, participation in Linux.

Crowdsourcing challenges conventional views of 'top-down' decision-making and uses the ideas of a collective group of individuals to develop a series of answers, or solutions. Given some of the critiques of current European, US and Asian models, this principal could be applied to planning and urban governance in U-Cities, where the crowd is constituted by the city's residents who could suggest solutions and take part in decision-making, where the direct benefit is a better urban environment for those helping to manage it through the generation of their own data. This should be categorised as crowdsourcing and not opensourcing, as the residents are all stakeholders seeking a tangible benefit, a better city to live and work in, as opposed to opensourcing where any individual volunteers information.

The data generated by citizens using mobile hand-held devices as well as ideas regarding decision-making could be utilised by the municipal city governments to enhance city planning and governance. This democratisation of information use has already begun with the emergence of 'neogeography', where amateur, user generated geo-referenced data is used in the creation of a range of mapping techniques.

[23] www.istockphoto.com; www.threadless.com; www.innocentive.com

4.2.2 The Rise and Potential Roles of 'Neogeography' in U-Cities

There has recently been an explosion of interest in the use of the Internet to create, assemble and distribute geographic information that is not provided by companies or governments, but volunteered by individuals. Previously, official agencies were responsible for the development of maps, such as the UK's Ordnance Survey unit, but increasingly, private citizens with often, minimal formal qualifications have begun to develop new maps that are personalised for their own use or are providing their own geospatial data to websites that can then be used by others to create maps (Goodchild, 2007). For example, Wikimapia and OpenStreetMap are amassing a global patchwork of geographic information that can be used by individuals, while Google Earth is encouraging volunteers to develop their own applications using their own geospatial data; and Flickr allows users to upload photos of the earth's surface, mapped onto the earth's latitude and longitude. 'Traditional geography' was produced, consumed, communicated and was the subject of academics, who had access to technology and technical expertise, especially with regard to cartography, whereas 'neogeography' has emerged as entry and mapping costs have been dramatically reduced. Low costs and the increase in access to opensourced data and GIS available on the web has enabled amateurs to begin producing their own maps (Goodchild, 2009). This *neo*geography, characterised by the development of maps and generation of data by individuals is hindered by the accuracy of the mapping, but nevertheless, the increased use of user generated content has undoubtedly changed GIS (Goodchild, 2007). This has been viewed as the democratisation of GIS, where the general public can use the simpler features of GIS to create maps, which has in turn popularised the term 'mash-up' where geographic information from across the Internet is superimposed to create new maps.

According to Goodchild (2007), neogeography has seen the emergence of voluntary geographical information (VGI) too where individuals are generating their own spatial data, where photos form cameras are geo-referenced using GPS, or street addresses are used to attach data to maps, generate more precise agricultural mapping (Goodchild, 2007), as well as for example improvements made to global land cover datasets for ecosystems modelling (Fritz *et al*., 2009). This democratisation of mapping is also associated with the term 'citizen science' where amateurs volunteer and become engaged in scientific projects, for example bird surveys, where groups of volunteers observe bird populations in accordance with strict protocols to ensure consistency in data across space and time (Goodchild, 2009). As virtually any information can now be geo-tagged, it is now possible for ordinary citizens to build large datasets, thereby reversing the traditional top-down flow of information to a bottom-up model (Goodchild, 2007; Fritz, *et al*., 2009).

Despite the rise of neogeography, it differs from 'traditional' geography in that as users are concerned predominantly with developing maps as images, not for research or to explore spatial patterns. It is therefore a non-analytical, non-elitist use of mapping: the expertise involved in map–making is embedded in mapping software, not with the map makers themselves (Goodchild, 2009). Subsequently, Goodchild (2009) suggests that neo-geographers should be viewed as neo-explorers, who generate data and maps, but where the expertise is maintained by software developers and professional geographers. As the data of these neo-explorers is shared through social networks where such information is tagged (Hudson-Smith, et al 2008), there is now a mix between centralised data systems and *de*centralised data systems, where data sourced from crowds and official state-generated data can be mixed and used to make maps from the bottom-up through 'mash-ups' (Hudson-Smith *et al*., 2008).

This spatial data has the potential for enormous value to U-City governments as an additional cheap and plentiful source of current data to complement municipal data that could be used in urban planning and mapping. Furthermore, this data could be used to provide city managers with real-time information, where national agencies provide the protocols for interoperability (if interoperability standards could be developed that would make crowd generated data compatible with U-City spatial data infrastructures), which could then be used in urban planning by municipal governments. However, this new approach would necessitate a shift in the role of the both central and municipal government (see 4.2.4)

4.2.3 Urban Planning and Crowdsourcing

As well as the provision of geo-referenced data, the crowdsourcing model can also be used in U-Cities to help manage and plan the built environment. Brabham (2009) argues that public involvement in the operation and planning of cities is important to ensure successful outcomes, although implementing such programmes are problematic and remain a challenge to urban planners and public officials. As such, Brabham (2009) suggests that the web could be used to gather collective intellect from residential populations and that the crowdsourcing model can be utilised by governments as a democratic strategy to involve citizens in public participation processes, in planning the urban environment, and to solve urban problems. It is also the recommendation of this report that the crowdsourcing model could be utilised by municipal city governments to collect additional geospatial information from a crowdsourced environment to complement their own databases and used to manage the city and to supply information. Whilst consulting residents about urban planning is not without its problems, for example, different groups living in an area may have diverse opinions on the future designs of a city, Brabham (2009) argues that on the whole, urban city designs are more successful when local residents are consulted in the planning process – an extension of democracy - where the knowledge of local 'non-experts' can be used to supplement the knowledge and experience of external planning officers and designers.

Crowdsourcing has been used to develop distributed networks of individuals to solve problems and produce services and Brabham (2009) also suggests its use as a governmental problem solving technique, such as in planning to involve participation, as consumers can suggest ways in which the city is designed and governed. Similarly, images and geospatial information developed by residents, in the city through cameras and other hand-held mobile devices could also be used to supplement the data held by a city (Goodchild, 2007). Additional advantages offered by crowdsourcing to urban governance and renewal include the anonymity of participants (enabled by the Internet) which may enhance the objectivity of comments by removing body language that may otherwise dissuade some participants from contributing to a face-to-face meeting. Crowdsourcing also offers flexibility of participation, as it enables the public to sift through ideas without being present at a public meeting held in a single place at one time, thereby facilitating the public participation process.

The subject of public participation (integral to the crowdsourcing model) raises issues of access discussed by Brabham (2008b) in the context of crowdsourcing and Crang and Graham (2007) more widely in relation to ICT and urban planning. One barrier to the use of crowdsourcing in urban planning and the acquisition of geospatial data is the issue of digital divides within cities. It is difficult to develop comprehensive e-planning and geospatial data collection from crowdsourced groups if there is a prominent digital divide, which sees the increased exclusion of the elderly, disabled and low-income citizens, who experience difficulty in accessing the Internet - the key medium, for contributing to geo-spatial data and planning decisions to policy makers and technical departments of the city (Brabham, 2009). However, Korean U-Cities and Asian digital cities are in a unique position to pioneer the use of crowdsourcing in planning and data acquisition, in that many have comprehensive, city-wide ICT infrastructure and inclusive social programmes to maximise and extend access of their citizens to Internet literacy courses that would make these cities key contenders to begin experimenting with city-wide planning debates and the integration of publicly crowdsourced geospatial data held by municipal governments.

The crowdsourcing model may also offer a range of benefits to urban management planning including environmental, disaster and traffic management. South Korean U-Cities are being designed with operational centres that will seek to pool data from around cities to monitor crime and to facilitate disaster management, environmental protection and transport (Ministry of Public Administration and Security, 2009). As such, crowdsourced geospatial data on emergencies, traffic jams and accidents could all be used to provide additional data to the city authorities.

The attributes of crowdsourcing could be modified to provide a new governmental crowdsourcing model, that could become a powerful tool and prominent feature of future intelligent cities, which will see more 'bottom-up' participation informing 'top-down' decision-making'. Such a model would see policy-makers meet in the middle-ground with residents, using crowdsourced data to aid the governance of the city, in addition to the current 'top-down' government influenced policy decision-making processes.

4.2.4 The Future Role of Municipal Government in a Crowdsourced Era

If geospatial data and planning ideas are to be created by a city's own citizens, this raises questions as to the future role of the government in such cities. There is consensus that municipal government is the key administrative level for the design and implementation of ICT policy (rather than state or national government) (Maynard, 2008). However, in recognising the importance of the role of municipalities in urban planning and management, the emergence of crowdsourcing suggests an alternative role. Crowdsourced planning and city government policies could be sourced from the city's own residents, but the implementation of such a scheme would still require the municipal government to fulfil an important role; that of interoperability management. Carrera and Ferreira (2007) have suggested that municipal governments adopt a spatial infrastructure where government departments stop pooling all their data, and instead task each department with looking after its own data, that can be accessed by other departments, with the aim of the development of more detailed and granular geospatial data. A distributed and loosely coupled architecture of this nature require interoperability standards to be at the core of the solution and such standards have been the focus of the Open Geospatial Community. However, the focus has also been on standards in the context of authenticated as distinct from crowdsourced data which introduces new challenges associated with the fusion of geometries from multiple independent and weakly calibrated systems and "free-style" meta-data descriptors.

The use of crowdsourcing to obtain suggestions for city governance and geospatial data acquisitioned from the public would still require the hierarchical power of government planners and technical staff to implement and operate the frameworks, infrastructure, and rules for interoperability, in order for this type of city to work. When designing new urban planning projects, the municipal government would still need to moderate and control the planning process and the crowdsourced opinions. In addition, the municipal and national governments would also be required to design and monitor these spatial data infrastructures to collect and collate crowdsourced data, but also to ensure that people who are not from the city, or a particular neighbourhood, are excluded from the planning process (Brabham 2009). The municipal government would need to decide how much weight to attribute to crowdsourced opinions, but they would also need to coordinate the interoperability standards of crowdsourced data, including: geospatial information, imagery and the information that users tag to space through mobile devices. In this sense, the government would become a regulator of geospatial information, overseeing how it could be brought together with its own U-City data and how private companies, individuals and other government departments could use it.

Top-down government-led approaches to ICT policy in the context of urban planning are not without critique. Although this approach can have the advantage of avoiding overlap and duplicated efforts there are concerns that it may not adequately adjust to the rapidly changing supply and demand of the ICT environment (see Maynard, 2008), a key aspect, of which urban planners in the context of ICT services must remain mindful. Demand is key to ensuring the employment and uptake of services, without which deployment will be slow and there is a risk of peddling an already obsolete ICT service. This will also affect competitiveness by decreasing the gap between themselves and other, better-connected urban regions.

Although a more decentralised approach can ensure a more targeted approach to the needs of citizens, the role of centralised facilitation of ICT policy and urban planning still has a critical role to play. Whilst there is agreement that a more bottom-up approach (through the adoption of the crowdsourcing model) could be beneficial a co-ordinating body in the form of a municipal or central government function is necessary to ensure the smooth running of facilities[24].

[24] It is recognised that certain services and functions are better suited to implementation and management at either the local or national level depending on their functionality (Maynard, 2008). For more on this see Palm and Wihlborg (2006)

5 Recommendations

Based on the findings of this research, the report has four key recommendations, for the future of U-City design and planning:

- **Finding (1):** U-Cities may be viewed as a further evolution of the generic intelligent city concept. As such, lessons can be learned from previous case studies and from the failings of some of the earlier EU digital cities of the 1990s. These lessons include enabling citizens to take part in the management and development of city projects and planning. This helps to ensure that technological services in cities serve the priorities as perceived by the citizens involved as well as the government or city agency priorities.

  Recommendation (1): It is recommended that a joint study is pursued, building on this report, that examines in detail the successes and failures of both European and South Korean Intelligent City programmes so as to share experiences, extract more benefit from past programmes and provide the basis of potentially new collaborative research.

- **Finding (2):** The ability to breathe life into the technological concept of the U-City requires advances in the understanding of the dynamics of how virtual, physical and emotional routines of work and leisure are played out in the 'everyday' city. Current mobile location-aware technology and advances in spatial data capture, which encourages both directed and incidental crowd-participation, provides the infrastructure for the research necessary to gain this understanding.

  Recommendation (2): A vigorous programme of research should be progressed using the latest and emerging developments in mobile location aware technology and crowd-source data to gain a deeper understanding of the separate and interacting spatial patterns of work, family and social activity in U-Cities.

- **Finding (3):** Data harmonisation and interoperability between data, services and service components is critical for success in the implementation of U-City policies. This harmonisation and interoperability needs to embrace new sources of data from sensor web and crowd-sourced inputs.

  Recommendation (3): The U-Cities programme should build solutions that are compatible with the leading *de jure* and *de facto* standards for geospatial data and services, these being the standards of the International Standards Organisation, Technical Committees 211 and 204 [TC211/TC204] and the Open Geospatial Consortium organisation, respectively. These standards, however, will need to be extended to incorporate new sources of data (e.g. crowd-sourced) and new technological developments (see Recommendation 4).

- **Finding (4):** There is an inevitable tension between the rapid evolution of the location-aware technologies that are central to the U-City vision and the need for standardisation to aid harmonisation and interoperability. South Korean organisations have played a key role in the standards development [e.g. in the evolution of ISO 19157 Data Quality Standard and in Project 19154 on Ubiquitous Public Access) and it will be important that they continue to do so, so that future U-City developments can be built on globally agreed standards.

Recommendation (4): South Korean organisations should continue to play an active role in the ISO and OGC development of standards and contribute their unique U-City experience towards the widening of the standards to address crowd-sourced data and ubiquitous public access.

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Appendix 1: East Asian Technology Cities

Digital City Singapore: A Successful, Evolving City

Singapore was one of the first nation-states to develop a comprehensive, national information infrastructure when the government launched the 'Singapore National IT Plan' in 1986. This plan sought to exploit information technology in order to give the country a competitive economic advantage in the Asian marketplace (Arun and Yap, 2000). In 1992 the government issued a report entitled *A Vision of an Intelligent Island*, which outlined the government's plan to construct a nationwide, advanced information infrastructure with the aim of connecting homes, offices, schools and factories to the Internet (NCB 1992). As well as increasing the country's economic prospects, this project also aimed to enhance the wellbeing of its citizens. Singapore ONE was launched in 1996 to provide broadband access across the island (IDA, 2009), all new buildings were to be constructed with Internet connectivity (Arun and Yap, 2000). A key service at the heart of the plan was called 'Singapore Infomap', where all government services, advice, forms and permits could be accessed online through a portal called the 'E-Citizen Service Centre'. One example includes online tax filing, established in 1998 that aimed to streamline the original system, as part of a drive towards e-Government (Tan, et al 2005).

As an island city-state that sought to become the world's first 'intelligent' *country*, predating the digital cities of Europe, Singapore provides an interesting example of an early digital city. The government was instrumental in organising the programme, and has historically had little political competition, which has seen it gain great power and little resistance, enabling it to push through its information technology programme (Arun and Yap, 2000). Singapore's initial development sought to provide its services through the Internet, creating a virtual city, reflecting the available online government services that exist in reality, a characteristic that it shares with the early European digital cities. Following the typology set out in the report (Figure 1.1), Singapore shares features with other global digital cities, for example the fact that it was coordinated by a government body. However, unlike the European examples, which were formulated by local and supranational governments, Singapore's project was nationally coordinated; a feature it shares with the South Korean model of U-Cities.

Although Singapore can be categorised as a digital city, it has begun to slowly change and adopt new technologies and services that are used in ambient cities. Singapore has long used road tolls where transponders in cars are used to automatically bill consumers (Graham, 2002). Again, this reflects more of a U-City model in that it uses ambient technology embedded into the built environment. This has been complemented more recently by new innovations and plans with the launch of Singapore's iN2015 master plan, which seeks to provide new infrastructure, enhanced broadband and a pervasive wireless network, known as the Wireless@SG Programme (IDA, 2009). This wireless programme will provide free, seamless outdoor access at 1Mbps operated by three local wireless operators: the iCELL Network, QMax Communications and SingTel. The iN2015 plan seeks to expand the coverage of the digital city, led by the Infocomm Development Authority of Singapore (IDA), which seeks to enhance Singapore's competitiveness as a global city and to cultivate a vibrant information technology sector (IDA, 2009). This has included the development of an e-Purse application and a national e-Payment infrastructure, designed by IBM, to create an interoperable system, giving consumers the convenience of having a single card for making transit, motoring and retail payments.

Singapore has also been active in addressing some of the previous problems that have plagued other digital cities. One iN2015 initiative, known as the NEU PC Plus programme, offers students, low-income households and disabled people new computers, bundled free broadband access at a subsidised price (IDA, 2009) enhancing coverage of the city. Many initiatives have been devised but require industry partners to aid design and implementation and as yet remain inactive. For example, one scheme that was piloted (but requires a partner for further development) was known as the Digital Concierge Programme, a location-based service that provided residents and tourists with access to information on local services, such as restaurants, with the aim of providing personalised information, whilst allowing them to buy tickets to the cinema over their mobile telephones (IDA, 2009). The digital city-state of Singapore, has continued to evolve, but still relies heavily on the 'virtual city' accessible through the Internet. Although it is set to adopt more ambient technologies, under the iN2015 plan, there is currently little evidence to suggest widespread use of RFID tags or sensors. However, owing to the ongoing implementation of the project, this may be due to a lack of published material. As such, the city's systems continue to make heavy use of the Internet's infrastructure, through broadband and wireless networks, which marks a stark contrast to the ubiquitous technology that is heavily drawn upon by the U-City model. The Singapore example suggests that the concept of the digital city has a specific time frame, from the 1990s, as it is planning to use ubiquitous technology as it moves towards the concept of an ambient city, as mobile technologies become increasingly adopted for practical use.

Smart cities in Japan: Tsukuba and Kansai: Public and private science cities

Regional governments around the world have sought to encourage the development of high-technology development zones, frequently based on California's Silicon Valley, where private companies have innovated and initiated economic growth through successful university-industry relationships (Cooke, 2001). In the 1980s, Japan's Ministry of International Trade and Industry decided to base their regional development plans on the growth of high-technology industries, partially modelled on Silicon Valley (Edgington, 1994). Japanese smart cities, known as technopoles, were built which focussed on bringing together high-technology industry, academia and housing in order to develop and diffuse new technological ideas to SMEs, enhancing regional growth (Cooke, 2001; Edgington, 1994). Two such cities were known as Tsukuba and Kansai.

Tsukuba Science City predates the smart city concept and was established in 1958 when the Japan Housing Corporation and the Ministry of Construction built infrastructure and housing to serve the need of nearly 125,000 people (Cooke, 2001). Tsukuba became a satellite town of Tokyo and a science city where national laboratories and universities were relocated. However, it was not until the 1980s and 1990s when the idea of the smart city became popular that private industry began to show an interest in Tsukuba, turning it into a smart city. Tsukuba's development was a public sector initiative, but even in the early 1990s it had struggled to foster linkages between firms and universities, with limited spin-off firms (Cooke, 2001). The city has become more successful and is now home to more than 300 national and private research institutions and establishments (University of Tsukuba, 2009); 40 per cent of the country's researchers; and is also the site of Japan's national testing and research facilities, which includes research into science, industry, agriculture (Tsukuba City 2009), the Japan Aerospace Exploration Agency (JAXA) and the National Institute of Advanced Industrial Science and Technology (AIST). Tsukuba is a smart city constituted by a planned community with functionally-located government, private research facilities (Lyons and Hamlin, 2001), educational facilities, shops, parks and residential areas (University of Tsukuba, 2009). The University's students are able to gain research experience with the organizations and their facilities (University of Tsukuba, 2009), which links to the ethos of fostering research and knowledge-based transfer to the private sector.

Kansai Science City, was originally proposed in 1978, and by the 1980s a 15000 hectare site was chosen under special legislation by the Japanese National Land Agency (Cooke, 2001). The Kansai Research Institute was established in 1986 to oversee the development of the Kansai Science City

(Edgington, 1994) where 40 public and private research institutions were planned. The Kansai Science city is different to Tsukuba in that it is not a specific site, but a network of the major centres of Kyoto, Kobe, Osaka and Nara, which lie at the core of the network's cultural and scientific district. The initiative was also driven by the private sector too, by firms such as Sumitomo, Matsushito and Kawasaki, although some projects are publically subsidised (Cooke, 2001). There is a high-level of interaction and knowledge exchange between firms and Doshida University and the Hi-Touch research Park (Cooke, 2001) and other state institutions based there including the National Institution of Advanced Studies of the Ministry of International trade, and the Advanced Telecommunications Research Institute along with the engineering faculties of Doshida University (Edgington, 1994). The three aims of Kansai are to create a base for new developments in culture, science and research; contribute to the development of culture science and research in Japan to develop the economy; and to foster the foundation of a creative city (Kansai Science City, 2008). In 2006, a third stage plan was implemented to grow this smart city over the next 10 years, enhancing the social interactions between the 100 companies and organisations involved in the network (Kansai Science Park, 2001).

Ambient City Tokyo: Moving Beyond the Digital City

Despite earlier categorisations as a digital city (see for example Ishida, 2000), Tokyo has since become a city of ambient technology given developments such as the adoption of real-time ubiquitous technologies for its transport systems. It has also become a test-bed for new ubiquitous technologies as academics, the Tokyo Municipal Government and private sector stakeholders seek to embed ubiquitous technologies into Tokyo, with the aim of upgrading the city to a ubiquitous city. Although the concept of ubiquitous technology emerged from California, Japan has been undertaking its own research on networking which has moved into the realm of ubiquitous computing and interoperability through the inception of TRON, 'The Real-Time Operating Nucleus', in 1988. The TRON project, carried out by the TRON Association in Tokyo, has been implemented by academic and industry stakeholders, the latter of which are frequently Japanese companies, where TRON seeks to aid the development of ubiquitous computing by aiding the implementation of standards through specifications around which developers can build new products. The TRON Association is also tasked with spreading the work of TRON both to interested stakeholders and to overseas interests (TRON Association, 2009). The TRON Association believes that its standards have become the benchmark for ubiquitous computing in Japan, of which an additional programme known as The T-Engine Project has emerged, which seeks to provide an open, standardized, real-time operating system for ubiquitous devices. The aim of the T-Engine is to facilitate the quick production of new networkable devices by manufacturers that reduce the time required to design new products (T-Engine, 2009). An additional arm of TRON is the uID Center (2009), which promotes the use and development of u-codes that can be used to automatically locate physical objects and locations within a ubiquitous network, enhancing the possibilities for ubiquitous computing environments. Forums such as TRON have been instrumental in Tokyo, as the city attempts to develop ambient technologies that they hope will eventually form a ubiquitous city.

Research at the University of Tokyo has focussed on experiments using ubiquitous technologies in replica homes using microphones, cameras and touch sensors and RFID sensors (De Silva *et al* (2005). However, the most visible ambient technologies embedded in Tokyo have been temporary experiments conducted by Tokyo's Ubiquitous Computing Technology Center; a joint venture between the Japanese government and some of the country's largest high-tech companies, including Fujitsu, NEC and Hitachi (Williams, 2006). Since 2005, feasibility projects have been conducted across Tokyo to assist planners and private companies in meeting the Tokyo Municipal Government's aim of eventually becoming a ubiquitous city, where the new technologies can be showcased to the world (Tokyo Ubiquitous Technology Project, 2009a). In 2005 the Ueno Zoo experiment gave visitors to the zoo the opportunity to use a ubiquitous communicator, which enabled people to access additional information on the animals from RFID tags, including sounds, video clips and pictures (Ueno Zoo, 2008). The experiment utilised 300 integrated circuit (IC) tags and GPS to provide the extra information and navigation services around the zoo, in order to see how technological standards can be used in the context of commercial and tourist promotion, with the aim of developing a U-City status (Tokyo Ubiquitous Technology Project, 2009b).

In 2006, around 10,000 RFID tags and sensors were installed in Tokyo's Ginza shopping district, providing location-based services to individuals with hand-held readers, which provided users with navigational services and information on shops, bars, clubs and restaurants in Japanese, English, Korean and Chinese, with information on restaurant menus and special offers and the location of train stations. The handset had a touch screen, infrared and Bluetooth for communicating with the beacons and a wireless LAN for access to the Internet with Bluetooth connectivity. In a similar trial, RFID tags have been embedded within pavement slabs to aid blind or partially sighted people, where a RFID reader in the tip of a cane picks up the tag identifications, helping the user to navigate an unfamiliar area, provided with audio information on route hazards (Williams, 2006). A new project was launched in 2009 providing a tour of Ginza, and the Tokyo Government Building, providing visual and audio information to users, through a multilingual interface. This included navigational information, information on shops, and real-time location information on the weather and train services (Tokyo Ubiquitous Technology Project, 2009c). Currently, Tokyo's ambient technologies are largely temporary and experimental with limitations that affect these early prototypes. For example, the handsets used have short battery lives and can require special instruction for users with pacemakers. However, there are some ambient technologies that are currently in use in Tokyo, such as the use of IC cards which can be used to pay for transport by bus, subway and rail journeys, as well as being used as a cashless payment card in shops (Japan Railways Group, 2009).

Ubiquitous City Songdo: The World's First U-City?

The construction of Songdo, South Korea, began in 2008 and has a planned completion date of 2014. This city is entirely new, being built on reclaimed land in the Incheon Free Economic Zone, near Seoul, and is the outcome of a partnership between the South Korean Government and the private sector. Songdo is an important example when defining the concept of a U-City, in that it can be considered to be the city that is closest to matching the vision of a city that is comprehensively embedded with ubiquitous computing technology. In addition, the government's leading role in developing U-Cities means that the term U-City has coevolved with the construction of Songdo as it integrates ubiquitous technologies within streets, homes and offices, providing coverage across the entire city. The city can be considered as an outcome of the South Korean government's aggressive stance on the development, implementation and use of IT, which have become embedded within the concept of the U-City (Shin, 2008).

Although ambient cities use ubiquitous technologies, Songdo is the first city in the world to fully embrace the U-City concept, as residential, medical, government and business computers will all be connected through a series of all encompassing wireless networks, broadband systems and ubiquitous sensory networks (USNs) (IFEZ, 2008). There are several aims that underpin Songdo's development. Songdo seeks to use its free trade zone status to stimulate regional development and to improve the quality of life for its citizens focussing on safety, environmental security, and education, whilst projecting itself to the world as a global city, outgrowing Dubai and Shanghai (Kyung-Min, 2009). Attracting international businesses to the centre is important as is developing the region as a tourist destination. It is seeking to become home to 300 Northeast Asian company headquarters, and 15 foreign university extended campuses (Kyung-Min, 2009), using the U-City technology to attract foreign business. The development of new technologies, it is hoped, will provide additional exports and opportunities for economic growth.

The development of Songdo is managed and coordinated by the South Korean government, which is working with South Korean companies like LG. However, Songdo also has many international links. Foreign companies like Gale, a US real-estate developer, and Cisco, who are designing the ubiquitous network architecture, amongst others, are playing key roles in the development of Songdo's physical and technological infrastructure, on which the city's ubiquitous networks will be reliant (Kyung-Min, 2009). Many of the technological ideas have come from the US, also the original breeding ground of Weiser's concept of ubiquitous computing in the 1990s. However, it is the holistic utilisation of these technologies within an urban environment, which makes Korea the world leader in pioneering the U-City model in the form of Songdo New City. Songdo's planners and government officials are keen to nurture the development of new ubiquitous technologies, including wireless networks and RFID technology through the development of a technology cluster, to promote research and development amongst private firms. Perhaps one of the most important facilities within the U-City is the municipal operations centre. This centre will allow the city to be managed and controlled, as data from USNs, such as RFID and Bluetooth, along with broadband and wireless networks, will feed data to the centre. Information on citizens, transport networks, disaster management, the environment and other systems such as sewage and utilities, will allow the city to be efficiently, safely and economically managed (IFEZ, 2008).

It is planned that the use of ubiquitous technologies will dramatically change daily life for residents in Songdo (Anonymous, 2004). Environmentally, individuals who recycle waste in public spaces, using the appropriate bins will be credited for their actions (O' Connell, 2005), whilst Cisco (2009) is developing 'Green Aware' intelligent buildings that gather and analyse data and display real-time building energy use, CO2 emissions and water usage to enhance sustainability and the environmental consciousness of Songdo's residents. In terms of transport, citizens will be able to borrow a free public bicycle through which are 'recognized' using ubiquitous technology (Futurewire, 2005) and traffic reports and travel plans could be tailored for individuals, whose ubiquitous devices could recommend alternatives routes (Deutsch, 2006). These new technologies would also bring substantial changes to domestic life. Deutsch (2006) discusses how electronic tags on groceries would remove the need for people to queue at counters, as RFID tag scanners at the exit of the supermarket would sense the goods and send a bill directly to the consumer. RFID tags on food would enable you to remotely find out what food is left in the fridge, whilst the fridge would be able to order replacement food itself. Cell phones will be used as a form of payment, reducing the need for cash (O' Connell, 2005), whilst schools and other buildings will have smart-card readers, so parents could find out if their children had arrived at school on time (McNeill, 2009). Whilst a new city, and the world's first ubiquitous city, Songdo may soon be joined by other evolving digital cities that are beginning to use more ambient technology, driven by comprehensive government programmes, such as Singapore. Songdo has yet to be completed, and as McNeill (2009) has highlighted, previous new build cities, like Brasilia and Islamabad have faced many problems. Subsequently, Songdo's success is not guaranteed, and it will have to compete with more established cities that may also successfully innovate and adopt comprehensive ambient technologies towards U-City status.

Appendix 2a: European City-wide Projects

European Smart Cities

Led by the Centre of Regional Science at the Vienna University of Technology, elaborated between April to October 2007, the 'Smart City' project was a privately sponsored collaborative research project in which medium-sized European cities were measured in their performance against six distinct development areas (Giffinger, 2007)[25]. Unlike the European Digital Cities project, 'Smart Cities' measured 'intelligence' not only in terms of developments and applications of ICT but also in terms of more qualitative factors such as citizen education and awareness, business practices and innovation and environmental and sustainability initiatives.

To define the concept, a 'Smart City' is "a city well performing in six characteristics, built on the 'smart' combination of endowments and activities of self-decisive, independent and aware citizens (Mobility, Environment, People, Living, Governance and Economy)"[26]. The ultimate goal of the project was to measure economic competitiveness and sustainable urban development across the 70 cities sampled (against 74 different indicators)[27]. Developments in ICT technologies including communication networks between local government and its citizens, specifically e-governance and e-democracy, as well as the use of ICT, technologies for sustainable urban transport systems and citizen mobility, were measured as well as more qualitative factors such as environmental, social and cultural indicators (Giffinger, 2007). In the final ranking, cities in Scandinavia, the Benelux countries and Austria performed highest overall as well as in areas where the use of digital technologies were measured, i.e. e-governance and urban transport systems. Future research might now consider the evolution of these particular cities and regions in terms of their adoption of ambient or ubiquitous computing technologies for comparison with their global counterparts in East Asia and the US.

The IntelCities Project

Funded by the European Union Sixth Framework Programme in 2004 (to the value of €11.7 million plus €6.8 million IST funding)[28], the collaborative IntelCities project seeks to develop and apply ambient computing technologies towards a primary objective of 'e-governance'. Broadly interpreted the project aims are widening participation and urban and land use planning through the use of ICT. In this respect the project aims to support achievement of the EU policy goal of the "Knowledge Society" by 2010 through advancement of e-Governance at the city scale, focusing on a range of citizens' and business concerns about decision-making over regeneration and management of their local built environment[29].

Pooling advanced knowledge and experience of electronic government and city planning and management in an innovative action research project, the project brings together a critical mass of 20 cities, led by Manchester and Siena with 20 ICT companies including Nokia, Microsoft and CISCO

[25] Other research partners were the Research Institute for Housing, Urban and Mobility Studies at the Delft University of Technology and the Department of Geography at University of Ljubljana.
[26] www.smart-cities.eu
[27] See www.smarrt-cities.eu for a list of cities sampled
[28] http://ec.europa.eu/information_society/activities/egovernment/research/projects/intelcities/index_en.htm; http://cordis.europa.eu/fp6/activities.htm; http://intelcities.iti.gr/intelcities Accessed 22nd October 2009
[29] http://www.feem.it/Feem/Pub/Programmes/Sustainability+Indicators+and+Environmental+Valuation/Activities/200401-INTELCITIES.htm Accessed 20th October 2009

and 35 research groups to undertake prototype studies in a number of EU cities aimed at integrating a wide range of existing IST platforms and information systems[30].

The project aims to achieve these objectives through the development of an Integrated Open System City Platform (IOSCP), a virtual tool dedicated to administrators, firms and citizens in which the potential of ICTs is exploited to assist in the provision of a broad spectrum of city services and to facilitate research activities on the urban environment. The objective of the IOSCP is an integrated citywide information system continuously accessible to all (planners, developers, politicians, designers, engineers, transport and utility service providers and individual citizens) that will enable more inclusive decision-making and support more sustainable life styles. With its use of Open Systems architecture (enabling a wide range of software and hardware products to be managed simultaneously) and multidimensional databases (configured to provide intelligent analysis for users) the project aims to extend beyond the provision of information, to "serve" citizens and city managers with "intelligent environments" that support new, more inclusive, and educational planning processes[31].

The remit of the project extends from widening participation through e-governance to economic regeneration through the implementation of information technologies as well as new forms of electronic services. Such objectives aim to work towards rapid business development whilst enhancing citizens' rights in urban decision-making via advanced visualisation, forecasting, simulation and sustainability evaluation of re-development proposals. It is hoped that through the demonstrator programme a range of problems to be addressed concerning electronic identity and signatures, data integration and security, integration and interoperability of fixed and mobile IT systems, GIS and data handling will be addressed. Once interoperability has been achieved, the foundations for the future 'intelligent information' city will be laid and in turn enable the cities of Europe to support the *eEurope 2005 Action Plan* - leading the race to establish the networked knowledge society[32]. The project also addresses IST strategic objective 2.3.1.9 Networked Business and Governments: "Development of ICTs to support (urban) organisational networking, (urban re-development) process integration, and sharing of resources (through public-private partnerships)" by constructing a demonstration of an Integrated Open System City Platform.

In addition to technical interoperability the project will also address the parallel challenges of ensuring stakeholder inclusion and capacity building within local government organisation transformation so that feasibility, functionality and usability of the IOSCP can be adequately demonstrated. The open systems architecture, relevant standards and underlying multidimensional databases will ensure flexibility and futurity of the "intelligent environments" being developed. It is anticipated that this will provide more agile governance to support rapid business development whilst enhancing citizens' rights in urban decision making[33].

The objectives of the project will be achieved through the creation and the evaluation of six different prototypes in a number of cities; Manchester (*e*-regeneration), Marseille (*e*-city administration),

[30] http://www.ist-world.org/ProjectDetails.aspx?ProjectId=a36115c06bc84565ae18d34d0edfdd66 Accessed 20th October 2009

[31] http://www.ist-world.org/ProjectDetails.aspx?ProjectId=a36115c06bc84565ae18d34d0edfdd66

[32] Towards providing the opportunity for the European community to participate in the global information society, the Action Plan aimed to stimulate secure services, applications and content based on a widely available broadband infrastructure. See http://ec.europa.eu/information_society/eeurope/2002/news_library/documents/eeurope2005/eeurope2005_en.pdf

[33] http://www.ist-world.org/ProjectDetails.aspx?ProjectId=a36115c06bc84565ae18d34d0edfdd66 Accessed 20th October 2009

Siena and Helsinki (*e*-participation), Rome and Leicester (*e*-transport information), Dresden (*e*-land use planning). Current progress includes the creation of the Intelligent Cities Alliance and new website to help implement the suite of services Europe-wide as well as plans to create a (virtual) 'European Intelligent Cities Research Centre' to pass on valuable e-government knowledge and expertise[34].

Intelligent City Programme Birmingham[35]

The Digital Birmingham initiative aims to widen participation, promote social inclusion and economic growth through harnessing digital technologies towards innovation and improvement in transport, education, communication, media, healthcare and the environment with the ultimate goal of national leadership in digital technology.

A component of this initiative, the Intelligent City Programme is a public-private stakeholder-led project between Coventry University, Microsoft and Birmingham City Council. The Programme is a £multi-million demonstrator programme able to address key urban issues relating to transport, tourism, security and climate change through the exploitation of information technology. The intention is to build an interoperable intelligent technology platform within a three week Proof of Concept focusing on Intelligent Transport, to build out a demonstrator application layer platform to be integrated with existing data/services. The programme expects to deliver location-based services that provide real-time data on public transport networks, and automated payment systems, which could also route CCTV footage directly to law enforcement agencies on the ground through mobile devices.

Focusing on bringing together digital media and transport technologies the Intelligent Transport aspect of the Programme aims to provide real-time data on traffic congestion, car parking availability and bus scheduling to provide real time geo-referenced tracking information through one platform to the individual user through GPS technology accessible via mobile phones. In addition to improved urban transport planning, objectives include the reduction of traffic congestion and carbon emissions. Discussions towards a demonstrator project along the A38 are currently at an advanced stage[36].

With aims towards the use of ubiquitous computing technologies and interoperability of data inputs and outputs, the Intelligent Transport programme is working towards establishing Birmingham as an ambient city. Specifically dealing with distinct services and technologies, despite a citywide agenda, the Intelligent City Programme in Birmingham is at present a technological 'vision' still very much in its development and testing stages.

[34] See http://ec.europa.eu/information_society/activities/egovernment/research/projects/intelcities/index_en.htm. that it will provide more current information on the status of the project once accessible.

[35] http://www.digitalbirmingham.co.uk/projects/intelligent-cities Accessed 13th October 2009

[36] http://www.digitalbirmingham.co.uk/projects/intelligent-transport Accessed 26th October 2009

Appendix 2b: European Cross-Border Initiatives

GIGAS

The aim of GIGAS is to facilitate the interoperability and harmonisation of online environmental resources in Europe so that they can be accessed, distributed and shared by different users and agencies through interoperable architectures in Europe, contributing to the development of a single information space in Europe for environmental data (GIGAS, 2009b). The project (incorporating GEOSS, INSPIRE and GMES and Action in Support) was established in mid-2008, to identify gaps in the interoperability frameworks between these three environmental projects, operated in Europe. GIGAS aims to seek opportunities where elements of the projects involved could be bridged so that geo-referenced environmental data can be shared (Klien et al, 2009). The European environment is not constrained by national borders, so it is important for timely, accurate information on the environment, climate, pollution, water and land use to be accessible to European agencies, to enable sound policy decisions to be made - a key aim of GIGAS. As such, there has been a move towards a Shared Environmental Information System (SEIS) initiative, where policy makers can access existing geo-referenced data across Europe in an open and transparent way (Klien et al, 2009).

Currently, the aforementioned European environmental initiatives share similar characteristics, but their independent development makes it difficult for users to adopt the different standards, which creates barriers to interoperability (GIGAS, 2009a). The GIGAS Forum seeks to surmount this problem as it aims to be an authoritative platform that monitors and provides advice to Environmental Monitoring and Environmental Information Management initiatives in Europe, including GMES, GEOSS, INSPIRE and SEIS. The GIGAS Forum and its events provide an opportunity for practitioners to meet, discuss and develop geospatial standards in order to overcome interoperability problems that face cross-initiative scenarios (GIGAS, 2009a). The development of interoperability standards is achieved by analysing the requirements and barriers to interoperability between projects, so that the architectures of the projects can be integrated for GMES, INSPIRE and GEOSS, by influencing new standards in development and adoption. The sharing of data also enables agencies to avoid the duplicating of data thereby reducing project costs.

Large numbers of stakeholders are involved in the three European initiatives so in order to facilitate the adoption of standards, protocols and architectures, GIGAS seeks to bring together the key organizations behind Europe's leading environmental projects. These include the Joint Research Centre that coordinates INSPIRE, the European Space Agency that is responsible for the GMES project, and the Open Geospatial Consortium that is steering the development of the GEOSS architecture (GIGAS, 2009b). These groups are joined by the three main standardization bodies, the ISO, OGC and CEN, with groups of SME stakeholders and research institutes (Klien et al, 2009). The project has attracted EU funding for a two-year period after which, and once the project is complete, the stakeholders aim to use the platform to continue to foster interoperability and the harmonization of data after June 2010 (Klien, 2009).

EuroGEOSS

The Earth's dynamic environment is changing, which requires understanding at a global scale to calculate the potential impacts on society and to plan for disaster management (Diaz-Sànchez et al, 2009). This has resulted in the development of a Global Earth Observation System of Systems, named GEOSS (EuroGEOSS, 2009a) and the EU funded related project, EuroGEOSS. EuroGEOSS is part of the Seventh Framework programme of the EU and includes 22 public and academic partners from 10 different countries, which is coordinated by the Bureau de Recherches Gèologigues et

Minières of France and the European Commission Joint Research Centre (EuroGEOSS, 2009a). The aim of EuroGEOSS is to integrate European geospatial data on forests, droughts and biodiversity, so that scientists around the world will be able to access this data, which will subsequently promote interdisciplinary research to uncover how the changing environment will impact society. Crowd sourcing is an important element of EuroGEOSS where social networks and volunteers will be able to contribute information on their local environment, through sites such as www.geo-wiki.org, which can be used to improve the quality of data on land cover maps. EuroGEOSS seeks to integrate these new sources of data, in line with Web 2.0 principles, with official sources to improve the data used to monitor the environment (EuroGEOSS, 2009a).

EuroGEOSS seeks to provide interoperability between different datasets in accordance with the INSPIRE framework, but in addition to providing interoperable data, the project seeks to devise analytical models that can be used by scientists from different disciplines to inform their research (EuroGEOSS, 2009b). In terms of forestry, EuroGEOSS will contribute to interoperable, local, regional and global systems such as the Global Forest Information Services, based on the existing systems of the European Forest Data Centre and the Observatory for Central African Forests. EuroGEOSS will develop greater interoperability between the available sources of geospatial and tabular data. The project will also look at the African Protected Areas Assessment Tool (APAAT), an online information system with data on protected areas, used by decision-makers, which will be reengineered to produce a Digital Observatory for Protected Areas (DOPA). This new service orientated architecture, will provide increased interoperability, providing access to additional data sources through the development of new models, to forecast the impact of climate change on habitats (EuroGEOSS, 2009c).

An additional aim is to develop a European Drought Observatory which complies with INSPIRE frameworks that will be used to provide a European Early Warning Drought System by integrating data from existing European drought monitoring programmes which are currently limited to particular spatial scales (EuroGEOSS, 2009c). This will also include the integration of localized groundwater flow data from across Europe. Although processing to be completed by the user, data will be stored with the original sourcing agency with the added interoperability to enable the user to move up and down particular scales of information on droughts. A metadata catalogue will also be created to provide users with information on what data is available (EuroGEOSS, 2009d).

Appendix 2c: Other Applications of Ambient Technologies

ODIN

The ODIN project aims at developing innovative paradigms for the design of open, distributed, and networked tools to boost the integration of an entire new class of just-in-time, interactive, value-added, map-based and personalised services for the mobile citizen (tourist, entrepreneur, commuter, farmer). ODIN will provide citizen/tourist/SMEs in rural areas with easy mobile access to just-in-time, geo-spatial Web applications (intelligently integrating administrative, business, environment, transport, weather, culture & leisure information with e-commerce purchasing, booking and payment) to improve quality of life and raise business in the regions targeted by the project. The industrial strength of ODIN lies in the collaborative work of a complementary set of medium-sized IST System Integrators, Mobile Telecommunication Operators and major IST Developers in digital information and Geographic Information Systems. ODIN also includes committed Regional Service Providers (Public administrations and local authorities) with a deep interest in the rationalisation and cost-effectiveness of their operations through the use of the ODIN platforms and services. With the cellular market in Europe reaching its maturity, the growing competitive pressure is causing mobile telecom operators to increasingly target the mass market, while also paying particular attention to the needs of their high-value business subscribers, by launching tailor-made services to suit the needs of differing market segments. Innovative offerings and the launch of new ranges of voice, data and value-added (Internet) services targeting the growing market of handheld digital wireless devices, are issued at high-speed.

In parallel, the development of new map-based web-service paradigms, based on high degree of integration information (resulting from different, networked information), interactivity, and personalisation (while delivered on conventional fixed network and devices) such as those issued by the IA 1011 TITAN project (4th Framework Programme), have been proven successful in large European rural areas. Within the long-medium term future, we envisage a situation where a growing demand of just-in-time, map-based, integrated and tailored web-based information services will be adopted by mobile citizens, for example, employees tourists and entrepreneurs. The project undertakes the definition of a global system architecture for the delivering platform and services compliant to the guidelines ISO/ODP (Open Distributed Processing) 10746, and, specifically contributes to the work of the ISO TC-211/OpenGIS Consortium which was set up to define standards on spatial data interoperability (some of the ODIN participants are active partners within this Consortium). ODIN is based on projects that will be completed in four European regions, and the expected main results include:

1) Specifications and the implementation of the Information Connector, Information Manager and Information Visualisation networked and interoperable tools;

2) Specifications and the implementation and validation of advanced services to improve citizens' quality of life through the provision of applications that serve the mobile user.

3) Extensive demonstration (6 months) of the services being provided, establishing project benefits (covering the assessment of technical results, usability, and cost-effectiveness, and impact) and

4) An assessment of the innovation's transferability to other places[37].

[37] http://www.ist-world.org/ProjectDetails.aspx?A=1&DataSelectionDataType=Project&DataSelectionSelectionType=advanced&FindSelectedEntityEntity=Project&FindSelectedEntitySelectedIndex=-1&ProjectId=f3454df1f1994eaca4c0c9fb62e78f5c%3b&GeneralSearchTerm=

Intelligent Tourism and Cultural Information Through Ubiquitous Services - iTACITUS

Completed in 2009 by the Fraunhofer Institute for Computer Graphics Research in Darmstadt, Germany, the iTACITUS project has built on developments in mobile computing over the past decade which have resulted in ever-more complex and capable mobile computing devices such as mobile phones, PDAs and smartphones. Such devices are able to provide the user with concepts such as *context* and *location awareness*[38]. The value of the project lies in the potential of such technologies to change the nature of cultural or historical tourism, cultural and historical resources often being at the centre of urban and rural development in European countries where these resources are particularly relevant such as Greece, Italy and Spain (Ancona *et al*., 2008). iTACITUS is one of several projects that have worked to apply developments in mobile and wireless technologies to cultural and historical tourism beyond the portable guide medium, a device now commonplace in museums and other tourist attractions. The use of augmented reality is cheaper than developing 3D models and representations of cultural artefacts and can be used to enhance historical sites for visitors and tourists (Zollner 2009). An additional project is Agamemnon, funded under the 6th European Union Framework Programme (see Ancona *et al*., 2006a; 2006b), which is similar to iTACITUS, but enables visitors to experience augmented reality on their own mobile devices and telephones. Data on archaeological sites and structures, under the Agamemnon programme, can be accessed by users' mobile devices at tourist and heritage attractions. Visitors are also able to access tailored information on their mobile devices to develop personalised tours.

Classified by Ancona *et al.* (2008) as an example of 'augmented reality' technology[39], iTACITUS aims to provide a bespoke experience for the individual, based upon a dispersed repository of cultural (e.g. historical, scientific and archaeological) resources, enabling both location-based and context-based interface paired with location-independent services. The services provided will include audio-visual, mixed reality and virtual reality organisational components, to be delivered in a flexible and timely fashion. The system is based on an advanced user interface on mobile devices supporting image recognition, voice interface and the capability of using any available hardware interface: WiFi, Bluetooth, UMTS/GPRS and infrared interfacing. Through a virtual context supporting knowledge conceptualisation, iTACITUS aims to enable the user to locate, without direct access to search engines, and find information that is likely to be useful in his present cultural context especially where mobility is fundamental[40].

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[38] *Context awareness* refers to a device's ability to sense parameters such as a users geographic location and time, device characteristics, clime and weather and user's identity. *Location awareness* refers to the representation of context mainly defined by location (Ancona *et al.*, 2008). Additional parameters include *attention awareness* (recognising the object under scrutiny) and *device awareness* (the ability to detect peripheral hardware devices). A further important dimension is the *communication paradigm* of the user-device which denotes the ability to communicate with a given or unlimited number of additional clients interconnected over wired network communicating wirelessly.

[39] An augmented reality system generates a composite view of the world, using both real and virtual views of a given scene which provide virtual reconstructions of monuments and other objects of interests. Additional examples include ArcheoGuide and CINeSPACE (Ancona *et al*., 2008).

[40] http://www.ist-world.org/ProjectDetails.aspx?ProjectId=f3454df1f1994eaca4c0c9fb62e78f5c 15th October 2009

Appendix 3: North American Case Studies

Digital San Francisco: A Failed Digital City?

The residents of San Francisco have access to the infrastructure of broadband services operated by commercial operations, but the municipal government decided that a universal, affordable wireless broadband service should be established to connect all areas and residents of the city to the Internet (City of San Francisco, 2005). There was concern that between 2001 and 2005 the US fell from 3rd to 16th in the global rankings for broadband penetration, and policy makers believed that the US was lagging behind in broadband access that is important to connect residents to social, educational and economic services and opportunities (City of San Francisco, 2005). The City's Department of Telecommunications & Information Services and the San Francisco Public Utilities Commission were tasked with exploring the possibilities of a community-wide wireless broadband network. Benefits and specifications included public safety improvements through enhanced communications and interoperability, improved healthcare via telemedicine and the capacity to provide information to tourists and visitors to the city, but most importantly was the provision of affordable access to all (City of San Francisco, 2005). Wi-Fi technology was to be part of the solution, enabling ubiquity and interoperability with different devices through an open-access platform too. San Francisco lacked the funds to develop its own system so it invited commercial organisations to fulfil the City's needs, the winner of which was a consortium of EarthLink and Google, where the former would develop the network infrastructure and the latter would provide the web access (Hudson, 2006). There were criticisms that wireless broadband was not ideal for residents in tower blocks, although the project collapsed when EarthLink pulled out of the project in August 2007 following a corporate restructuring (City of San Francisco, 2009).

San Francisco has also launched a series of initiatives aimed at widening participation in the digital economy, including the refurbishment of computers for low-income families, and non-profit organisations, as well as computer training as part of its Digital Inclusion programme. This programme also targets limited–English speaking groups and disabled residents to increase their access to local community and city information (San Francisco, 2009b). The Network of Community Networks that have been developed by San Francisco, in place of the initially city-wide planned network provides 3750 low income housing units and their residents with free access to the Internet (City of San Francisco, 2009c).

San Francisco has a reputation for being a city of technological innovation, but it also has a deep digital divide where citizens are excluded from Internet access dependent on race, gender, education, disabilities and income. As access to the Internet improves IT literacy and enhances job prospects, as well as providing access to healthcare, access to hardware and the Internet for such marginalised sections of San Francisco's communities is imperative, as are the skills to use the technology. With this in mind, the City has begun to provide free broadband Internet access to San Francisco's public housing sites and programmes to promote computer ownership and access (City of San Francisco, 2009d).

San Francisco is a digital city whose citizens are provided with access to the Internet predominantly through private services providers. Despite the digital divide, San Francisco has sought to develop a system to cover the entire city that would subsidise the cost of access to those on low incomes. Despite this failure, access has been provided to the poor, with Internet access improved despite the failure of the large project, which provided them with access to local information and e-government services, enhancing the cities access to services.

Manhattan Harbour: America's First U-City?

A development company called C&M investments is developing a 100-acre real-estate project in Dayton, Kentucky called Manhattan Harbour (Wartman, 2009a). An Internet search reveals that it is the closest type of development in North America to mirror the ubiquitous city, although this project is smaller than the U-Cities that are being designed in Korea. Whilst the construction of Manhattan Harbour is private development, organised and initiated by a private company, it is utilising municipal government tax incentives to fund the development of its public infrastructure (Wartman, 2009a). It is hoped that construction will begin in early 2010 when the urban infrastructure is complete with the first phase of homes and commercial properties being placed on the market the following year (Wartman 2009a). The development will include 2,000 homes from apartments to family homes, a Marina, hotel and boardwalk, with proposed ferry services

The project is in its early stages and there is little publicly available information on the technologies envisaged for the development. However, the developers are working with LG CNS, one of the Korean companies supplying and designing the ubiquitous technology that is to be used in South Korea's Songdo project, with which they have signed a memorandum of understanding (Wartman, 2009b). The developer hopes that embedding LG's technology into the Manhattan Harbour project will make it the US's first ubiquitous city (Wartman, 2009b). The development is aiming to implement state-of-the-art technology, including wireless Internet, interactive screens on refrigerators that broadcast community events and personal digital assistants that communicate information to residents (Business Courier of Cincinnati, 2009). LG CNS' involvement is also said to be attracting other international firms and investors (Business Courier of Cincinnati, 2009).

As this is a private project, Manhattan Harbour is being developed to maximise revenue for the local authority and to maximise profit from the real estate developer. According to Shin (2008) the US has a market-led approach to city construction and IT development in contrast to Asian government approaches, like South Korea's centralised organisation, which explains this project's small size. It is unknown how much ubiquitous technology will be included in the completed project, but it may initiate further technological city projects in the US.