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MANAGING UBIQUITOUS ECO CITIES: THE ROLE OF URBAN TELECOMMUNICATION INFRASTRUCTURE NETWORKS AND CONVERGENCE TECHNOLOGIES

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Abstract: *A successful urban management system for a Ubiquitous Eco City requires an integrated approach. This integration includes bringing together economic, socio-cultural and urban development with a well orchestrated, transparent and open decision making mechanism and necessary infrastructure and technologies. Rapidly developing information and telecommunication technologies and their platforms in the late 20th Century improves urban management and enhances the quality of life and place. Telecommunication technologies provide an important base for monitoring and managing activities over wired, wireless or fibre-optic networks. Particularly technology convergence creates new ways in which the information and telecommunication technologies are used. The 21st Century is an era where information has converged, in which people are able to access a variety of services, including internet and location based services, through multi-functional devices such as mobile phones and provides opportunities in the management of Ubiquitous Eco Cities. This paper discusses the recent developments in telecommunication networks and trends in convergence technologies and their implications on the management of Ubiquitous Eco Cities and how this technological shift is likely to be beneficial in improving the quality of life and place. The paper also introduces recent approaches on urban management systems, such as intelligent urban management systems, that are suitable for Ubiquitous Eco Cities.*

Keywords:
Ubiquitous Eco City, urban management systems, intelligent urban management systems, technology convergence, information and communication technology, urban telecommunication infrastructure

Introduction

During the last few decades rapid urbanization trends changed urban system and structures across the globe dramatically (Yeung, 2000). Urban systems now have become increasingly complex and large in scale as local urban economies, social and political structures, transportation systems, and infrastructure requirements evolve hastily. Sustainable and efficient usage of scarce resources together with competing economic and social priorities are now parts of everyday decisions required to be made by local governments, which are obliged to hire a sound urban management system that increases the understanding of, and capacity to undertake, the strategic management of urban areas (Teriman et al., 2009). Urban management is basically a process of deliberately directing and facilitating urban development, and also an integration of the traditional ideas of planning, with its physical, economic and social concerns, and recently latched to management with its emphasis on efficiency (Davey, 1993). The application of innovative systems to support urban management and collaborative decision making offers considerably new opportunities particularly for ubiquitous cities, where such cities provide ubiquitous infrastructure and services for their residents and visitors (Galloway, 2003). In Ubiquitous Eco Cities (U-Eco Cities), like any other city, urban and infrastructure planning, development and management require complex information and input from institutions, stakeholders and users to deal with spatial, social, economic, and also multi-dimensional and complex characteristics of urban and environmental phenomena and problems (Lee et al., 2008).

As Warf (1998:255) states "telecommunication is one of the few topics in geography that richly illustrates the plasticity of space, the ways it can be stretched, deformed, or compressed according to changing economic and political imperatives". Over the past few decades, telecommunications networks have become an important infrastructure player, but they are not as readily apparent as other core physical infrastructure such as highways, roads, and water and power grids. Although, the invisible telecommunications infrastructure often follow the same routes of highways and railroads, current communications, whether voice, video, or data, are ultimately dependent on the existence of telecommunications infrastructure (Hackler, 2003a). Recent advancements in telecommunications technologies have had a direct impact on firms, particularly in the service and high-technology related sectors, and the telecommunications infrastructure has become important to their production processes. These developments also have had an indirect effect on the overall economy of cities because of the externalities they generate (Yimaz & Dinc, 2002).

Information and communication technologies (ICTs) form the basis of telecommunications infrastructure. In the information and knowledge era, already upon us, ICTs play an increasingly important role in the planning, provision and management of urban physical infrastructure. Moreover it is evident that ICT networks as urban telecommunication networks are becoming the major urban infrastructure management systems with the rapid development and wide-spread usage of internet. In a recent study, Lee et al. (2008) point out some challenges to apply digital convergence technologies in urban infrastructure particularly in 'Ubiquitous' or 'Augmented' cities where any citizen can access any infrastructure and services via any electronic devices regardless of time and location. This idea of advanced and easy accessibility to amenity and services has been reflected in many science fiction movies such as 'Matrix' and 'Minority Report'. However, although there are some small scale practices, its comprehensive real world applications are yet to be developed.

As an integral part of the urban telecommunication networks, electronic or digital devices such as mobile phones, handheld computers and PCs become the key gadgets of our daily lives. In order to improve their functionality and increase the product sales these digital technologies have been subject to continuous and rapid development. One of the most significant advancements in the field is the ICT convergence that people intend to access needed urban amenity and services through a single device, so called 'black box' (Jenkins, 2006). This technology convergence has been well explored by urban planners, media companies, broadcasters, and information technology enterprises. The trend is found not only in electronic devices but also in business management such as call centres with several help desks that develop consistent customer care services.

Convergence of telecommunication technologies and internet services play a significant role in networking the functions of a city. Early work by Gottman (1983) developed a popular notion of 'transactional city'. In this study he anticipates the modern telecommunication technologies such as fibre optics, global positioning systems and wireless networks accelerate the complexity of spatial transformation known as spatial de-concentration, fragmentation and gentrification (Baum et al., 2006; Chhetri et al., 2009). Accessibility to the internet and the quality of the network service became also a critical need for the infrastructure development, analysis, planning, and design. In the US, information-related investments in urban infrastructure have become an increasingly vital component of national economic activity. In 1995 the annual spending on information systems by far (more than $60 billion) exceeded the total public sector spending on transportation (Wieman, 1998).

ICT networks are rapidly evolving and in the near future will likely to transform into a network supported by convergence technologies. Wieman (1998) pointed out how localised high-tech economic activity, supported by the early examples of technology convergence, boosts the demand on urban transportation systems. In his recent study Han (2008) investigated the evolution of the ICT development in the Republic of Korea, which rapidly becoming more ubiquitous and getting embedded into physical urban environment and supporting urban infrastructure. He discusses how technology convergence supports rather than diminishes the quality of life in urban spaces. Personal mobile phones, for instance, are integrated with the segments of urban services including public transport, e-government and e-learning. The technology convergence improves the access to urban services and utilities for example by providing mobile phones with new technologies such as SMS, G3, MP3, GPS navigation, digital camera, smart card, and e-payment.

Telecommunication and infrastructure networks are rapidly moving from systems based on wired technology to those that are wireless and seamless digital network systems (Dourish, 2004). However, the question of how the new technology convergence interwoven with the existing physical urban infrastructure such as roads, water and power supply, sewerage, and security system still remains unanswered. Although the ubiquitous computing network system (Weiser, 1991) has become one of the major phases in many contemporary agendas in terms of the design and engineering of computer systems, its economic, social and environmental implications are yet to be explored. Given that significance, there is limited academic research that focuses on the specific implications of telecommunication technology convergence on urban infrastructure development.

This paper aims to investigate the technological paradigm shift by which those urban infrastructures are evolved, how convergence arrangements are provided for current urban infrastructure systems by correct actions over time, and explore intelligent management systems for U-Eco Cities. The paper focuses on how rapid technology convergence brings spatial reconfiguration of activities at different levels such as for homes, neighbourhoods, cities, regions and nations as each different hierarchy of space and place need an appropriate technology and telecommunication infrastructure. This paper also explores a range of technological convergences and discusses the impact of technology convergence on improving telecommunications infrastructure provision and benefits to the economy and broader society in U-Eco Cities. The paper argues the critical role of urban management support systems for ubiquitous cities management and concludes by providing directions for successfully managing U-Eco Cities.

Ubiquitous Eco Cities

As Lee et al. (2008) defines, Ubiquitous Cities (U-Cities) are cities that provide ubiquitous infrastructure (U-infrastructure) and ubiquitous services (U-services) for their residents and visitors by utilizing a range of ubiquitous technologies (U-technologies). Life in an U-City can be exemplified by imagining "public recycling bins that use radio-frequency identification technology to credit recyclers every time they toss in a bottle; pressure-sensitive floors in the homes of older people that can detect the impact of a fall and immediately contact help; cell phones that store health records and can be used to pay for prescriptions" (O'Connell, 2005: 1). Similar to the 'just-in-time' delivery system, which saves time and monetary cost by delivering materials when they are readily needed and by eliminating storage space otherwise needed to stockpile them, urban resources could be conserved in U-Cities by delivering and receiving services right in time with the support of a wired and wireless integrated network equipped with digital home systems and intelligent building systems (Kim, 2008).

In recent years a shift from U-City to U-Eco City has occurred. U-Eco City is defined as a city that provides its residents with high quality of life while using minimal natural resources by making substantive use of ubiquitous information technologies (Yigitcanlar, 2009). The U-Eco City concept creates environments in cities where residents can enjoy access to high-speed networks and enhanced information services at anytime regardless of location through a ubiquitous computing network. Kirkwood (2008) elaborates this definition further by stating:

> "…The significance of the U-Eco City project for the private and public sectors as well as government agencies is in providing the ubiquitous infrastructure itself thus enabling the U-Eco City concept to advance, generating a larger service market for next-generation communication technologies as well as establishing a range of cities of 'good life and happiness' for citizens. A further area of significance would be the establishment of an industry world benchmark in ubiquitous city design and holistic environmental planning of the U-City. This is important to capture the future global market in U-Eco City planning as well as to establish a set of metrics to describe and evaluate the legislative framework, performance activities and capacity for change and evolution of the U-Eco City" (pp. 13-14).

The U-Eco City concept has taken root in contemporary urban planning as a new technology/ecology model. The U-Eco City concept will enhance global competitiveness and connectivity of the public and private sectors through the combination of the hardware construction industry, ICT and their ubiquitous interaction with residents and the natural environment. This ubiquitous interaction and the resulting form of the U-

Eco City are expected to overcome the limitations of current city development approaches and physical city implementation and ongoing management by municipal entities. Current city development approaches to organize the urban fabric use formal spatial patterns for buildings, open space, transportation and infrastructure. The U-Eco city concept uses open technological systems and with an urban management centre (UMC) sitting at its very core, it controls and manages the entire city (Kirkwood, 2008).

In a U-Eco City, urban land, modern technology, industry and people create a mutually supportive and holistic environment for the 21st Century's new urban development. This new urban form also has a number of challenges and opportunities which some are listed below.

Technological self-sufficiency and advancement of the U-Eco City concept at the same time must also be dynamic, not static, changing to meet the challenges of each new generation. Major challenges for a U-Eco City include (Yigitcanlar, 2009a: 25):

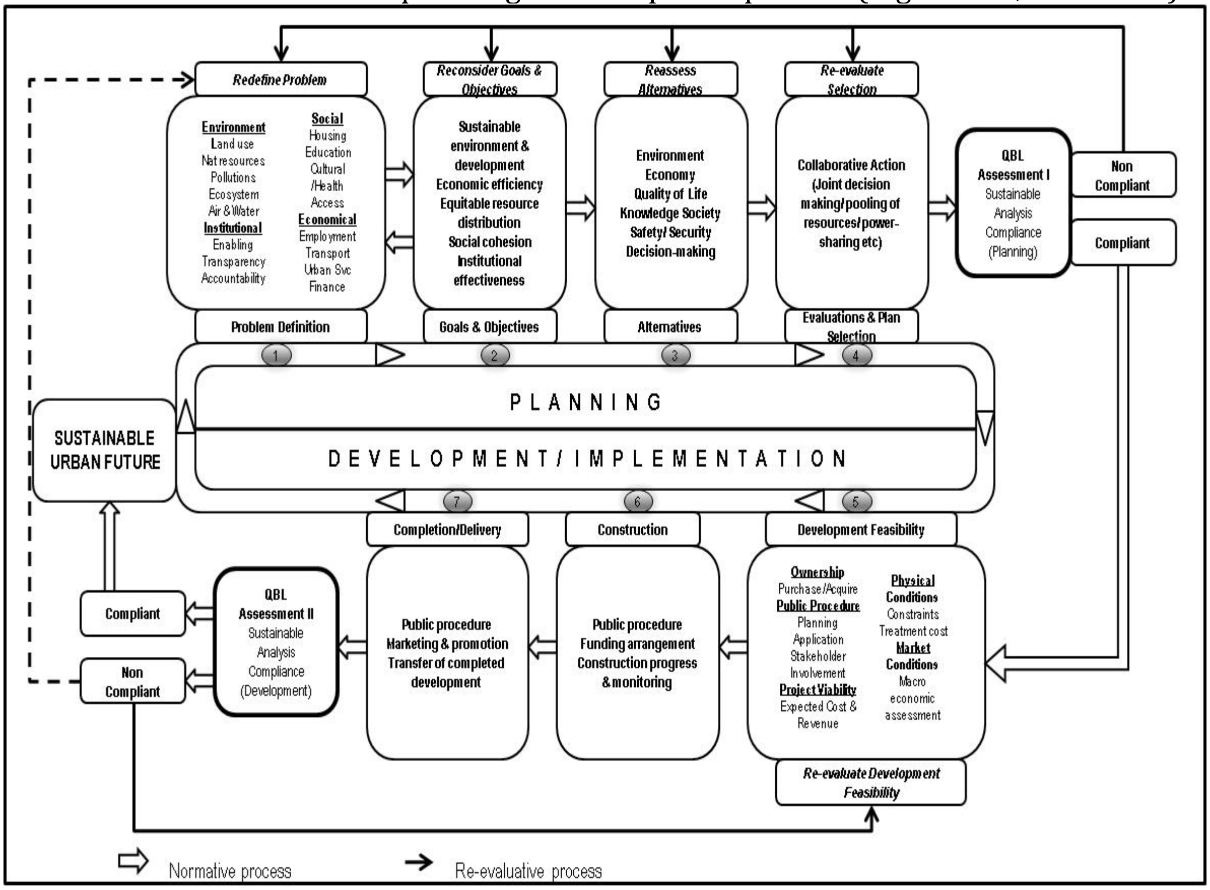
- Development cost,
- Retrofitting,
- More technology and mobility, more energy use,
- Too much transparency, limited privacy,
- Digital security, smart mobs,
- Technology upgrades and dependency/collapse,
- Urban privileged,
- Managing complex/high-tech urban environments.

U-Eco City presents a unique opportunity to foster an alternative model of city and urban development, one that is holistic, environmentally conscious and humane. Some of the major opportunities for a U-Eco City include (Yigitcanlar, 2009a: 25):

- Zero emission, zero car, waste and water are recycled,
- Compact urban development,
- Improved quality of life and services,
- Sustained eco-system, better use of energy and natural resources,
- More legible and accessible built and natural environments,
- Opportunities to build new social spaces,
- New socio-cultural and economic interactions.

To address abovementioned challenges and opportunities planning and development of a U-Eco City require an integrated and sustainable mechanism. Therefore, linking strategy (planning) and practice (development) is crucial for the development of successful U-Eco Cities. Strategic visioning and planning of U-Eco Cities need to consider knowledge-based development in order to establish a strong economic, social and spatial base (Figure 1). Additionally management of a U-Eco City requires an intelligent urban management system which is based on a sound telecommunication infrastructure benefiting from the convergence of ICT and infrastructure networks.

Table 2. Sustainable urban planning & development process (Yigitcanlar, 2009a: 17)



A current research undertaken by Yigitcanlar (2009a) has revealed that "U-Eco City is a new sustainable city form/type, where ubiquitous technologies have the potential to revolutionise planning, development and management of these new cities" (p.26). The U-Eco City concept, along with ubiquitous infrastructure and services, offers new opportunities for pathways towards sustainable urban development. However, integrated and intelligent systems need to be considered for the management of U-Eco Cities as just-in-time delivery of goods and services contribute significantly to the sustainable development by mainly minimising unnecessary resource use.

Telecommunications infrastructure

Not so long ago telecommunications infrastructure was not considered in business or household location decisions. Our lifestyles have been changed dramatically during the past few decades, due to rapid technological advances, the convergence to digital forms of computing, media, and communications, and also globalisation. Consequently, telecom has become a complex menu of choices and providers from which business and households choose (Malecki & Bous, 2003). Modern economic productivity benefits from the proliferated use of telecommunications networks and information technologies such as computers and software. This trend has not only altered the business practices of all industries that use these as inputs but also sponsored the growth of new businesses that we now refer to as high-tech industry (Hackler, 2003a). Today firms and also households, many of which rely on constant high-speed, or broadband, connections among far-flung operations, demand not only fast connections, but also redundant links that prevent any downtime or discontinuities, in service. Telecommunications is the leading factor in location decisions of companies today and is accounted as among the top criteria for locating a facility (Lawless & Gore, 1999).

Many cities around the world today highly take advantage of advanced telecommunications infrastructure and such infrastructure has become a growing concern of local government and industry. From computer manufacturing to software development and from biotechnology to aviation industries, many cities seek high-tech growth, where advanced telecommunications infrastructure supports such development, which is associated with prosperous urban regions (Yigitcanlar et al., 2008a). The Silicon Valley in Northern California, Route 128 surrounding Boston, the Silicon Hills in Austin, Texas, and One-North in Singapore are the most prominent examples of advanced telecommunications infrastructure hardwired in high-tech locations (Yigitcanlar et al., 2008b). As mediators of all aspects of the reflexive functioning and development of aforementioned cities, convergent media, telecommunications and computing grids (known collectively as `telematics') are thus basic integrating infrastructures underpinning the shift towards intensely interconnected planetary urban telecommunications networks (Graham, 1999).

Infrastructure networks such as telecommunications support not only cities to develop networks within themselves, but also provide a vehicle to get connected with other cities and join in the 'world city network'. And beyond this telecommunications infrastructure also supports cities in the tough global competition and helps them develop their competitiveness further (Yigitcanlar & Velibeyoglu, 2008). According to Rutherford (2005:2391) "[in] the same way as the supply of producer services in world cities can be seen largely to reflect demand for those services from multinational corporations, in a competitive market environment, the supply of telecommunications infrastructure in and between world cities comes from expressed or anticipated demand for 'high performance' telecommunications network connections to interlink multinational corporate and producer service firm headquarters and offices in cities around the world". Basically without a quality telecommunications infrastructure, a city would become pretty much 'disconnected' from or 'less connected' to the rest of the world city network and, therefore, would lose much of its competitiveness and world city status.

Taylor (2003) sees the connections between offices and cities as the 'skeleton' upon which contemporary economic globalisation has formed, and Rutherford (2005) following up on this analogy argues that measures of intercity relations should include the infrastructural 'backbones' which form the actual basis of the skeleton. Moreover, technological advances play a key role in the provision of telecommunication infrastructure or in other words backbones and skeletons, for example fibre optic network development, which is according to Walcott and Wheeler (2001: 321) "hair-thin threads of glass utilizing laser light pulses in digital computer code, with multiple glass fibres in each cable – some sending messages from A to B and others from B to A – are the standard physical paths for global internet telecommunications for major numeric data and word and graphic information".

For attracting industries, particularly knowledge-based or high-tech ones, being able to meet the telecommunications service requirements is a necessity. Wiemann (1998: 22) argues that "broadband information infrastructure is now as important to a growing array of high-tech firms as railroads were to nineteenth-century steel and textile mills". Similarly, cities that are vying to be '*silicon havens*' are using tactics to enhance their telecommunications assets, from developing smart buildings (i.e. high-bandwidth commercial real estate) to increasing bandwidth available to business. For the latter case, some cities even lobby telecommunications service providers to improve existing telecommunications infrastructure, and some are building their own improved telecommunications infrastructure. These local communities perceive that an improved telecommunications infrastructure is a necessity in the new information economy because telecommunications infrastructure may be both an economic and social advantage. As Dwyre (1998: 47) views "a solid telecom network is key to economic development: building industry and manufacturing, improving agriculture, education, health, social services, transportation, and other crucial elements that make up a nation's economy".

Telecommunications is an important ingredient to cities wanting to have a knowledge economy growth. Basically telecommunications infrastructure is attractive to high-tech industry; locations with large concentrations of high-tech industry are more likely to have greater telecommunications capacity. In many cases the relationship between telecommunications infrastructure and economic development are also mutually reinforcing. This is to say economic growth can spur telecommunications investment because of the increase in demand from new business, and telecommunications investment provides a foundation for further economic growth (Hackler, 2003b).

Beyond creating the necessary conditions for a robust economic structure and stimulating the growth of productive activity telecommunications infrastructure also can produce substantial public benefits (i.e. social welfare, e-democracy, and social development). The impacts of telecommunications infrastructure on household welfare take several forms: impacts on income, access to services, and the consumption value of infrastructure. Below are some of the benefits of advanced telecommunications infrastructure to broader community (Guild, 2000: 280):

- As with firms, households may realise higher incomes through productivity and increased opportunities for employment of their labour through better communications;
- Investment in infrastructure projects also raises incomes through direct employment creation in construction and operations;
- Rural households benefit through better terms of trade for their output and better access to public services, and;
- The most direct impact on social welfare is through actual use of infrastructure services, as they are an important component of household consumption.

Some advanced telecommunications can be advantageous, particularly, to remote areas, although not necessarily for use directly by business. The major applications are likely to be for delivering higher quality education and health services. Better education, training, and health services can help upgrade the human resource capacity that is often the greatest problem in remote areas (Fox & Porca, 2001). However, opportunities to use new electronic technologies to extend one's social and economic actions across space are thus being configured highly unevenly within and between the material geographies of contemporary cities. For instance, the `wiring' of cities with the latest fibre optic networks is also extremely uneven. On that point Graham (1999) writes:

> "...It is characterised by a dynamic of dualisation. On the one hand, seamless and powerful global-local connections are being constructed within and between highly valued spaces, based on the physical construction of tailored networks to the doorsteps of institutions. On the other hand, intervening spaces – even those which may geographically be cheek-by-jowel with the favoured zones within the same city – seem, at the same time, to be largely ignored by investment plans for the most sophisticated telecommunications networks. Such spaces threaten to emerge as *`Network ghettos'*, places of low telecommunications access and concentrated social disadvantage" (p.929).

In terms of social implications of telecommunications network Hanafizadeh et al. (2009) highlight the digital divide as one of the key issues to be dealt with in telecommunication infrastructure provision. The digital divide is the differences between individuals, households, companies, or regions related to the access to and use of ICT (Vehovar et al., 2006). The various factors may cause the divide such as historical, socio-economic, geographic, educational, behavioural, generation factors, or the physical incapability of individuals (Curtin, 2001). Whitacre and Mills (2007) argue that as residential internet access shifts toward high-speed connections, a gap emerges in rural high-speed access relative to urban high-speed access, and the potential causes of this high-speed ''digital divide'' include rural–urban differences in people, place, and infrastructure.

Recent developments in both technology and conceptualisation of the needs of the economy and people are providing new opportunities for cities and their administrations to develop new generation telecommunications networks. Particularly *ubiquitous urban infrastructure* developments are among the significant moves in this direction. In the light of global connectivity and increasing communication options available for accessing and exchanging information the vision for future communications is *information anytime, anyplace and in any form*, based on the idea of an open '*electronic'* market of services, where an unlimited spectrum of communication and information services will be offered, ranging from simple communication services up to complex distributed multimedia applications. In this *ubiquitous* context the instant provision of services and the customisation and configuration of existing services become fundamental issues (Magedanz et al., 1996).

Ubiquitous urban infrastructure, particularly in the field of telecommunication, as stated by Arseni et al. (2001), is witnessing the impetuous evolution and expansion of two kinds of systems. The first is the universal *wireline network* that is now able to provide sophisticated multimedia services. The second comprehends the *cellular or wireless network* and is able to satisfy user mobility demand, providing standard telephone services and low-speed data transmission. The new generation telecommunication systems are integrating these wireline and wireless networks in a single, advanced infrastructure. On top of this network integration, the convergence of technology also revolutionises the way telecommunications infrastructure is delivered and accessed. And beyond this it contributes to the formation of the next generation telecommunications infrastructure.

Convergence of ICT and infrastructure

Sustainable urban infrastructure provision and management partially depends on intelligent planning support, monitoring and management systems that heavily benefits from ICTs and telecommunications infrastructure. Infrastructure management in the areas of education, transport, power supply, sewerage and waste treatment, and water supply constantly rely on the ICTs to enhance its quality and customer service delivery. As Britchie et al. (1987) point out:

> "...A shift, from land, material, and energy to knowledge, information, and intellect as key factors of production, increased the interdependence between manufacturing, commerce, and consumption and the new information channels [including] the traditional transport systems" (p.449).

The digital convergence technologies used in urban infrastructure help local economic growth through e-commerce, improve local service delivery through e-government, advance connectivity to local and global networks through wireline and wireless devices, and provide access to education through e-learning. These technologies also minimise unnecessary travels and contribute to reducing greenhouse gas emissions by offsetting material and energy consumption and expediting more efficient use of current form of physical infrastructure. Many local governments have been investing in the latest telecommunication convergence such as wireless internet network technologies (WiMAX) in order to improve the shift from polluting manufacturing industries to clean knowledge industries. Another example is the intelligent streetlights that are being provided with existing streetlights with RFID and wireline and wireless communications technologies in order to minimise the energy consumption (Lee & Leem, 2009). These intelligent streetlights benefits from the convergence technology of construction and information and communications (C-ICT).

Internet and media convergence

Internet is one of the most powerful technologies to access information in the modern society. Internet provides a channel for users to undertake many tasks including doing business, studying online, communicating with others, entertaining such as watching videos, TV shows, listening to music, downloading and uploading pictures, music and videos (Cunningham & Turner, 2005). For instance people can easily access the latest audiovisual data downloaded from youtube.com in anytime if they can access the internet. Jenkins (2006) describes media convergence as a 'black box' which multiple products are integrated with one product taking each of their technical advantages. Convergence leads a technological shift or a new technological process, but it also integrates educational, cultural, and social paradigms. The convergence shows the way in which individuals interact with each other and use various media platforms in order to create new experiences, new forms of media and content (Cunningham & Turner, 2005).

To date technology convergence of the internet media and contents significantly improve our learning activities. For example, a number of primary schools in Australia use *Nintendo DS* with a touch-panel interface for mathematics education. Students of these schools showed higher performance than those who do not use such innovative education tools. Similarly the *Wii* was sold over 50 million units in the world by March 2009. In Australia, the Wii exceeded the record set by the *Xbox 360* to become the fastest selling games, exercise and education console in Australian history (Moses, 2006). This innovative device is based on the technology convergence which integrates a games console, moving sensor and internet browser.

During the last decade, convergence of ICTs also created a new form of urban telecommunication infrastructure. The new generation mobile phones are now equipped with more advanced features such as touch screen, video recording, global positioning system (GPS) navigation, internet and emailing, data storage and security mechanisms. Today it is possible for a mobile phone to access to information on urban utilities and real-time monitoring of the environment (Yigitcanlar, 2009b). These ubiquitous devices can be used in real-time planning and management and can contribute to conservation of urban natural resources, urban growth management and sustainable urban development (Yigitcanlar et al., 2008c).

Marketing convergence

Technology convergence in the area of marketing is apparent. The notion of multi-play is often used in a convergence of ICT services and products. The multi-play is needed when an individual accesses different telecommunication services, such as broadband internet access, cable television, telephone, and mobile phone service rather than traditionally only using one or two of these services (Cunningham & Turner, 2005). The multi-play technology convergence consists of dual, triple or quadruple play options depending on the specific application area:

- A dual play service needs to provide two ICT services such as high-speed Internet (ADSL) and telephone service over a single broadband connection. High-speed Internet (cable modem) and TV service provided by a single broadband connection is an example for this type (ANSI, 1998).
- The convergence can be accompanied by the underlying telecommunications infrastructure. An example of this is a triple play service, where communication services are bundled, which allows consumers to access TV, internet and telephone through a single subscription (Flew, 2008).
- A quadruple play service is similar to the triple play service of broadband internet access, television and telephone, but is based on wireless technologies. This service is sometimes referred to as the ‘Fantastic Four’ or ‘Grand Slam’ (Baumgarter, 2005).

The next level of service is the integration of radio-frequency identification (RFID) into the quadruple play, which adds the capability for home equipment to communicate with the outside world and schedule maintenance of its own (Fisher & Monahan, 2008). RFID tags are applied to an object incorporated into a product, an animal or a person for the purpose of identifying, reading and tracking information by using radio waves. Some tags can be read from several meters away and some can far beyond the line of sight of the reader. This technology convergence in marketing helps connect people to other consumers so that they may share their reviews and, at the same time, engaged with the service providers in ways in which they have not been as readily accessible by others in the past.

Telecommunications convergence

Telecommunication convergence is closely related to urban infrastructure such as telecommunications infrastructure and transport system. Convergence is a key concept to coordinate a range of urban network services such as physical networks or components thereof that channel fluxes through conduits or media to their nodes such as *receivers* (Neuman, 2006). Technology convergence required of supporting super ordinate systems connected to the networks. These networks include transportation, pipes, wires and cables in the channels through which their products are sold and serviced. A highly mobile nature of portable technology provides immobile physical networks with convergence incorporating telecommunication devices such as portable video and media devices, GPS navigation devices, portable internet surfing and mobile telecommunications devices into a single device so called 'black box' designed to remove the need to carry multiple devices while away from office or home.

Telecommunication infrastructure network which is interconnected by web of sensors, actuators, wireline and wireless communications networks, and computer systems could benefit from a convergence in a form of combination of different telecommunication media in a single operating platform (O'Brien & Soibelman, 2004). Convergence in fact allows companies no longer confined to their own markets. Fixed, mobile, and internet protocol (IP) service providers can offer content and media services, and hardware and software providers can offer services directly to the end user (Telecom Media Convergence, 2007). These days most of the content or service providers are consistently looking for new digital infrastructure and more effective distribution channels. For instance, the new G3 mobile phone technology uses technology convergence that provides the combination of telecom, data processing and imaging technologies. Previously separate technologies such as voice including telephone features, data including productivity applications, and video including teleconferencing now share resources and interact with each other (Jenkins, 2006). Voice over IP (VoIP) and Bluetooth are merged into a wireless internet network so called WiMAX for seamless mobility between VoWiFi and cellular networks (Telephony Online, 2009). These mobile service provisions give rise to the ability to access to most of the telecommunications channels including voice, internet, video and content without requiring tethering to the network via cables (Williams, 2008). Given the recent advancements in WiMAX and other leading edge technologies, it is fair to say the ability to transfer information over a wireless link at combinations of speed, distance and non line of sight conditions is rapidly improving. Therefore, the whole range of technology conversion becomes increasingly invisible, intangible and pervasive and likely to improve the quality of lives of the users (Firmino et al., 2008).

Implications of convergence technologies

The technology convergence is classified into the following fundamental groups by their common features in implementing and processing specific information: (a) sensing, e.g. data input; (b) network, e.g. data transfer; (c) interface, e.g. data representation; (d) processing, e.g. data processing, and; (e) security, e.g. data safety measures. A recent research by Lee and Leem (2009) take these five broad technology categories and divides them into ten types of specific bundle technologies based on their key implications, and then subdivides them into 25 segment digital devices (Table 2).

Table 2. Structure of technological convergence classification (Lee & Leem, 2009: 13)

Broad Classification	Specific Classification	Faceted Classification
Sensing	Sensing Remote and Surroundings	Sensing Generals
	Context Awareness	Image Based Tag
		Wireless Tag
	Broad Area Information Collection (Topography)	Digital Camera Sensor
		Radar and Laser Sensor
	Location Information Collection	Time of Flight
		Map Matching
		Landmark Navigation
Network	Broadband Convergence Network	Internet Address Standards
		Wired Communication
		Broadband Wireless Communication
		Mobile Telecommunication
		Wireless PAN (Personal Area Network)
		Wired PAN (Personal Area Network)
		Mobile TV
Interface	Codec Technology	Video Codec
		Audio Codec
	Display	Visual Display
Processing	Processing Software	Embedded Software
	Ubiquitous Middleware	USN Middleware
		Control Middleware
Security	Information and Infrastructure Security	Cryptograph and Certification Technology
		Information Management Technology
		Hacking and Virus Prevention Technology
		Security Management Technology

The implementation of convergence technologies on urban infrastructure is already understood clearly and somehow the development is underway in most parts of the developed world. Rapid new economic growth associated with new technology and new infrastructure is clearly now taking its roots in the global knowledge economy (Wieman, 1998). Managing and monitoring the urban infrastructure could be relatively easy by deploying appropriate wireless infrastructure, making it accessible and inexpensive to users, and refining software, portals and so on (Aurigi, 2006). Convergence technology solutions including performance monitoring, distance working and seamless production can be incorporated into broad planning initiatives focusing on improving the efficiency of existing urban infrastructure planning, provision and management.

According to Jenkins (2006) due to the speedy progress of technology conversion it has been long thought that, eventually, users will access all services and information from urban infrastructure networks and services through one single mobile device, such as a black box tool. The question arises from Jenkins' (2006) claim is that how urban technology practice can identify the next black box tool to invest in and provide necessary urban infrastructure systems and procedures for it. When multiple systems or networks merged together, their intersection points can become quite problematic.

The multi-level technology convergence is indicative of the many technical, institutional, and other services. This complexity is compounded by different disciplines that identify themselves as the responsible players in any given category of infrastructure (Neuman, 2006). The major problems of the implications of black box are grouped under three broad categories.

First of all, black boxes are often in and out of popularity, and the consumers are left with numerous technologies that can perform the same task, rather than a dedicated device for each task. For example, a consumer may own both a smart card and a credit card with a microchip to use public transport, subsequently owning two e-cards. This is for sure does not comply with the streamlined goal or spirit of the 'black box theory', and instead it creates a clutter for the users (Rheingold, 2000).

Secondly, technological convergence tends to be experimental in nature. This leads consumers purchasing technologies with additional functions that are sometimes harder, in some cases even impractical, to use them compare to a device specifically designed for each function (Jenkins, 2006). For instance, Nokia, like iPhone and many other mobile phone brands, has a mobile phone in the market with an in-built GPS navigation. However many users find more practical to use an automobile built-in GPS rather than a mobile phone on a GPS. In some cases technology convergence might be unnecessary or unneeded; however, still an advanced and specialised device for each task might not be affordable for all users. Furthermore, although users primarily make use of a specialised media device for their needs, other black box devices that perform the same task can be used as well under different circumstances, locations or situated contexts. For example, as the Cheskin Research (2002) report underlines:

> "...Your email needs and expectations are different whether you are at home, work, school, commuting, the airport, etc., and different devices are [available] to suit your needs for accessing content depending on where you are – your situated context" (p.8).

Lastly, technology convergence provides a single platform or system to access and use urban infrastructure. However, the physical infrastructure is instead diverging whilst the platforms on the infrastructure are converging. Urban services can offer the same content in a number of forms. An example of this is the underground subways. A subway is a public transport zone, but it is also a space for socialising, shopping, advertising and delivering fluxes such as goods, services, information, energy and people. Branding is important and encourages expansion of one concept, rather than the creation of new ideas (Jekins, 2006). This is totally opposite for physical infrastructure, which is diversified in order to accommodate the convergence of ICTs. The physical built environment needs to be specific to each type of function, otherwise branding would not work effectively. In a black box situation, a user should only need to purchase one form of media and should be able to do everything with it.

Intelligent urban management systems

The changing context, in which our societies are evolving, places new pressures on all the professionals engaged in managing urban and regional development and the built and natural environments. Today, and into the future, planners and managers of urban and regional development face, on the behalf of our governments and communities, the complex demands of (Neilson, 2002: 97):

- The scale of demographic changes underway in our societies and the way these may impact upon our cities and regions;
- An increasing recognition that in modern globalised economies our cities are the 'engines' of economic growth;
- The need to manage urban growth and change to increase our cities' and regions' capacity to compete in globalised markets; and
- The need to create 'learning cities' capable of operating in the rapidly expanding world of knowledge economy and utilizing information and knowledge to advance economic, environmental and social progress.

Around the globe increasing awareness of the complexity of the modern urban setting and abovementioned demands have led to the questioning of management approaches founded on traditional institutional, administrative and geographical compartmentalization (Stubbs et al., 2000). Urban environments act as 'crucibles', where a multitude of interactions not only take place, but also 'make place' for large numbers of individuals (Giddens, 1984) and therefore managing such places plays a critical role in establishing sustainable cities. It has been proved that traditional urban management practices lack of comprehensively tackling urban, economic, social and environmental problems (Jones et al., 2002). Starting from late 1970s it is clearly accepted that automated information systems or intelligent management systems in local governments contribute significantly to the decision process of top policy making and management team by providing them with accurate information and decision directions (Dutton & Kraemer, 1977). In recent years, the growing need for an effective urban management approach led into the development of the notion of 'intelligent urban management'. This new urban management approach rises from improving communication within and between agencies and the public about the highly connected and emergent nature of problems which management responsibility has been assumed (Stubbs et al., 2000).

Regardless of whether intelligent or not a sound urban planning and management system should provide: safe, healthy and cohesive communities; sustainable natural resource management; a supportive environment within which business can develop and which assists in opportunities for economic growth; and appropriate urban structure and form so as to provide equitable access to service and amenities. Jones et al. (2002) summarize the important aspects of shaping the new (or intelligent) planning and urban management systems. These key aspects include (p.190-191):

- Changing attitude and understanding in urban development and economic growth;
- Coordinating and planning the development through a professional and resourced single body;
- Increasing participation in the planning process;
- Providing equal access to services such as education and health;
- Supporting systems for service planning and delivery;
- Strengthening and providing coordinated urban management services between key infrastructure providers;

- Meeting the demands of varying interest groups;
- Operating a regulatory framework for the control, monitoring and assessment of the development;
- Considering all the costs of urban growth such as financial, social and environmental; and
- Bringing transparency and accountability to the management system.

Additionally, much like in the case of U-Eco Cities an intelligent urban management system as support systems highly benefits from the state of the art technologies in planning, decision making and management. These advanced technologies include U-technologies, ICTs, decision support systems, digital information systems, strategic choice tools, and E-service technologies (i.e. for E-commerce, E-government and E-education). In recent years such technologies made online and web-based platforms and decision support systems accessible for technicians, policy makers and the public for urban planning, development and management purposes.

Conclusion

In the 21st Century global and local forces, such as climate change, resource consumption and depletion, energy security, oil vulnerability, globalisation, knowledge economy, global financial crisis, and technological developments, are rapidly re-shaping our cities. In this reshaping process developing pathways towards sustainable urban development has been one of the most crucial topics in recent years (see Newton, 2008). In this regard U-Eco City, infrastructure, service and technology developments offer new opportunities. Such developments revolutionise the urban planning, development and management by providing a new direction for intelligent urban management. For example intelligent management of urban infrastructure and services provide just-in-time delivery of goods and services and contribute significantly to the sustainable development of our cities by mainly minimising unnecessary resource use. Similarly U-infrastructure and services supported by convergence telecommunications technology and infrastructure by improving community and environmental health contribute to the formation of healthy cities.

On the one hand, along with these opportunities, and many more, intelligent management systems for U-Eco Cities also present a number of challenges. These challenges include: strategically planning every stage of the U-Eco City development process; significant financial commitment to invest on developing, equipping and retrofitting new U-technologies to urban environments; developing a system that is resilient to adopt new technological changes quickly; and securing and safe guarding the whole system from external and internal security treats. Beyond technology revolutionising urban management for U-Eco Cities also requires several key instruments. These instruments include: a strong administration and will to plan and develop sound policies; legislations and regulations to legitimize and empower the process; a fiscal system based on 'user pays' principle rather than tax payers funding of all services; strong financial and institutional structure to realise and coordinate U-infrastructure and services; capability to manage both assets and knowledge that is key for the knowledge-based and sustainable development of cities (Yigitcanlar et al., 2008b; 2008c); and embracing an advocating, transparent and participatory approach for development. For a successful urban management strategic visioning and planning, as Neilson (2002) highlights, linking strategy and practice play a key role.

On the other hand, decisions regarding to telecommunications infrastructure investments in U-Eco City policy making could have a noteworthy impact on sustainable urban development by minimising environmental impacts and improving the quality of lives of residents. Around the world, local governments have been developing planning strategies focusing on long term telecommunications infrastructure development. However, the rapid changes in the technology and telecommunications infrastructure, including technology convergence, do not make their work any easier in having a concrete long term development plan that contributes to the formation of sustainable urban futures.

Technology convergence develops new standards for performance and accessibility for urban infrastructure, and helps lifecycle planning and management. Besides, this convergence process also has its downside. Particularly in their initial forms, converged devices are frequently less functional and reliable (e.g. a mobile phone camera may not perform better than a digital camera). As the array of functions in a single device escalates the ability of that device to serve its original function decreases (Jenkins, 2006). For example, an iPhone (which, by name implies that its' primary function is that of a mobile phone) can perform many different tasks, but does not feature a traditional numerical pad to make phone calls. Instead, the phone features a touchpad, which some users find it troublesome compared to a conventional phone keyboard. In fact technological convergence in some ways holds immense potential for the improvement of the quality of life and liberty, but also degrades it in others (Rheingold, 2000). Regardless, thanks to convergence and nano-technologies, in recent years an ever-wider range of technologies are being converted into single multipurpose devices.

The recent telecommunications infrastructure planning strategies are aiming to reduce labour, administrative and material costs to manage the urban infrastructure and utilities across cities and towns. Many countries around the world, particularly in Korea and Japan, technology convergence is now focusing more on enhancing efficiency of urban services by providing a higher quality of life such as one-stop services for a number of urban networks and platforms. The telecommunications infrastructure policies are also targeting to increase the public recognition and business opportunities through the evolution of convergence over time.

Technological convergence helps people access more features in a short amount of time through a single device. This means more cutting edge R&D investment for service providers to remain competitive in the market. With the advancements in technology comes the ability for technological convergence, which Rheingold (2000) believes that it alters the 'social-side effects' in virtual, social and physical worlds as they are being collided, merged and integrated. Therefore, further studies are needed to scrutinise the impacts of technology convergence upon the production of sustainable urban space and policies within the structure of a socio-spatially sustainability approach. Additionally, the following questions are worthwhile to further investigate on: How wireline, wireless and seamless technologies can be integrated into a sustainable urban environment model? How ICTs can be converged effectively in order to monitor and manage energy consumption? And, how can we measure ICTs efficiency in the construction and daily operation of urban infrastructure?

Lastly, the key importance of telecommunications infrastructure and convergence technologies in economic and social development of cities, particularly U-Eco Cities, should not be ignored, as Beaverstock et al. (2000: 126) writes "cities accumulate and retain wealth, control, and power because of what *flows through* them, rather than what they statically contain".

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