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Managing ubiquitous eco cities: technology, infrastructure and management issues

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Abstract: Literature on Ubiquitous Eco Cities highlights three key issues to be carefully considered while planning, developing and managing such cities: ‘technology, infrastructure and management’. This paper discusses the recent developments in telecommunication networks, trends in technology convergence and both of their implications on the management of Ubiquitous Eco Cities. The paper also introduces recent approaches on urban management, such as intelligent urban management systems, that are potentially suitable for Ubiquitous Eco Cities.

Keywords
Ubiquitous Eco City, technology convergence, telecommunication infrastructure, intelligent urban management systems,

Introduction
In Ubiquitous Eco Cities (U-Eco Cities), like any other cities, urban and infrastructure planning, development and management require advanced technology, 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).

Information and communication technologies (ICTs) form the basis of telecommunications infrastructure that is regarded as the backbone operational channel of a U-Eco City. In the information and knowledge era, 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 and online systems.

Convergence of telecommunication technologies and internet services play a significant role in networking the functions of a city. 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 U-Eco Cities.

The complex nature of U-Eco Cities requires intelligent urban management system, to be employed as decision support systems in managing development, infrastructure and services, that benefits from the state of the art technologies (Yigitcanlar et al, 2008c). 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).

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 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 research reported in this paper also highlights 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**

The U-Eco City concept has taken its roots from the contemporary urban planning as a new technology and ecology model (Han, 2008). The U-Eco City concept enhances 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 organise 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 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. Primary characteristics of a U-Eco City include but not limited to the so called 5Es – five key aspects: Ecological integrity; Economic security; Enhanced quality of life; Empowerment with responsibility, and; Electronic infrastructure (Kline, 2000).

This new, U-Eco City, urban form also has a number of challenges and opportunities. 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, dependency and collapse;
- Urban privileged, and;
- Managing complex and high-tech urban environments.
A 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, and;
- 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 (Kim, 2008; Teriman et al., 2009). 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. 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.

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**

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) “[i]n 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 telecommunications 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”. The telecommunications infrastructure particularly plays a crucial role in the development and management of U-Eco Cities.

Telecommunications is an important ingredient to cities, particularly U-Eco 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, 2003a; 2003b).

Beyond creating the necessary conditions for a robust economic structure and stimulating the growth of productive activity telecommunications infrastructure in U-Eco Cities 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.

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. Especially in U-Eco Cities 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.

**Technology convergence**

Management of ubiquitous urban infrastructure partially depends on intelligent planning support, monitoring and management systems that heavily benefits from ICTs and technologies convergence. U-infrastructure management in the areas of education, transport, power supply, sewerage and waste treatment, and water supply constantly rely on the ICTs convergence to enhance its quality and customer service delivery.

The convergence technologies used in urban infrastructure help local economic growth through u-business, improve local service delivery through u-government, advance connectivity to local and global networks through wireline and wireless devices, and provide access to education through u-education. 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).

Convergence of technology occurs in a number of different areas and ways. For example internet and media convergence provides new opportunities for U-Eco Cities. 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. The integrated activities can be visible in U-Eco city using these converged technologies. For instance the programmable street is provided with multiple functions such as lighting, security monitoring, commercial advertisement, solar energy and audio-visual objects.

Another example is the marketing convergence. Technology convergence in the area of marketing and business is also apparent. The notion of multi-play is often used in a convergence of ICT services and products and often adopted to U-Eco city planning. 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 next level of service used in U-Eco cities 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.

The last convergence example is the telecommunication convergence. It 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, the ‘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).
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).

Intelligent urban management systems
The traditional idea of urban management consists of the good management and planning of a city, entrusted to the institutional actors (UNDP, 1997). Increasing awareness of the complexity of the modern urban setting has led to the questioning of management approaches founded on institutional, administrative and geographical compartmentalisation (Stubbs et al., 2000). The concept of urban management is extensive. Following Borja and Castells (1997), there are five main challenges to managing an urban community: (i) to provide an economic base, (ii) to build urban infrastructure, (iii) to improve the quality of life, (iv) to ensure social integration, and (v) to guarantee governance. The quality of the management depends not only on how well each of these challenges is met, but also on their integration to create coherence in urban development.

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.

Giddens (1984) describes urban environments act as ‘crucibles’ where a multitude of interactions not only take place, but also ‘make place’ for large numbers of individuals. To underline the importance of foresighted in place making and urban management Handy (1994: 18) states that “[l]ife will never be easy, nor perfectible, nor completely predictable”. It will be best understood backwards but we have to live it forwards”. In their research Stubbs et al. (2000) finds that a new conceptualisation of management for responding to complex urban issues that confound bounded problem-solving is necessary.

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 compartmentalisation (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). One of the characteristics of the intelligent urban management is that it improves the communication within and between agencies about the highly connected and emergent nature of problems by benefiting from digital technologies. The most recent view of intelligent urban management is shaped by the principles of ‘real-time’, ‘effective’, ‘efficient’ ‘reliable’ and ‘responding’ to the emerging issues of sustainable development in the urban environment. There are not much comprehensive intelligent urban management systems available at the moment. The big challenge is to make such system work in ambitious U-Eco Cities.

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) summarise the important aspects of shaping the new or intelligent planning and urban management systems.

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.

The literature points out that the complexity of an urban management system could be simplified by using a set of indicators for urban management constitutes an instrument for observation and for decision (Joerin et al., 2001). This simplification gives urban stakeholders a model of city development at a given time and for a definite territorial space (Allen, 2001). The indicators are used as a common base of comparison between the territorial entities. A set of indicators has three strategic purposes in urban management: Monitoring; Controlling, and; Benchmarking (Repetti & Desthieux, 2006).

So far there are a number of intelligent urban management systems are developed in dealing with various urban issues. One of the most common application areas of these management systems is the urban environmental management. Intelligent environmental management systems are broadly defined as computer-based technologies that support environmental management systems. The main benefit of intelligent environmental management system adoption is that it provides a systematic process to address comprehensively all major environmental issues. Tasks that intelligent environmental management systems support include tracking activities, tracking waste, monitoring emissions, scheduling tasks, coordinating permits and documentation, managing material safety data sheets, conducting cost/benefit analysis, and choosing alternative materials, to name a few. An intelligent environmental management system integrates monitoring and simulation for environmental decision support in urban areas. The establishment of clear procedures and responsibilities, environmental management programmes, audits and other tools lead to the effective monitoring of environmental issues and solution of problems in a timely manner. An intelligent environmental management system is a set of interacting processes or elements. Each process or element of the environmental management system takes one or more inputs and creates one or more outputs to be passed onto one or more other processes or elements (DEWHA, 2009).

Another common application area of intelligent management systems is the urban transport management, which is necessary for solving problems caused by traffic congestion through a synergy of new information technology for simulation, real-time control, and communications networks. More specifically, this term refers to the application of advanced information processing, communications, sensing and computer control technologies to the driver-vehicle-road infrastructure system with the aim of improving travel efficiency and mobility, enhancing safety, conserving energy, providing economic benefits and protecting the environment (Regan et al., 2001). Urban transportation planning and management is facing challenges and opportunities in the
rapid developments of intelligent transportation systems. Such systems are characterised by real time information feedback in their operations and management, and by increasing levels of automation of their various components. The challenges to planning and management stem from the increased range and added complexity of the choices available to transportation planners (Kanafani et al., 1993).

The main aim of an intelligent urban transport management system is to strengthen public transport systems to reduce the negative impacts of air pollutants through advanced traffic management, to directly involve citizens in planning their own trips based on environmental friendly routes and finally, to train young citizens and increase the environmental awareness of citizens in general to develop a new urban mobility culture. It also aims is to coordinate transport infrastructure and demand management through the highest possible use and integration of information and its real time processing, based on the principle of environmental protection in the degraded areas. The operation of numerous key components of intelligent urban transport management systems, such as real-time traffic surveillance and management, incident management, traveller information, natural and human hazard evacuation, heavily relies on the support of an effective and efficient communication system (Boxill & Yu, 2000).

**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. But at the same time we are also facing a number challenges. The key challenges for the management of U-Eco Cities can be grouped under several groups.

Firstly, as urban management is becoming more flexible, based on the integration of a strategic global scheme and local management dynamics, the management of highly complex U-Eco Cities are expected to respond both local and global concerns (Carmona & Burgess, 2001; Ingallina, 2001). Urban management generally addresses a number of urban projects (Borja & Castells, 1997) or spatial or territorial planning (von Stokar et al., 2001), which are flexible tools for management and communication established at the conurbation level. The rising sustainability concerns and more and more transparency for public participation are making the management process of U-Eco Cities even more complicated than they already are (Borja & Castells, 1997; le Gal`es, 1998; Shafer et al., 2000).

Secondly, urban management deals more with powerful databases and information systems. To face the considerable volume of data, tools are needed to establish overviews of the goals and provide an appropriate level of synthesis. In a U-Eco City actors (decision makers, technicians, administrators, users, and so on) must be able to access all the relevant data without getting lost in the details, nor swamped with information that does not provide a clear picture and is not directly useful for decision making (Allen, 2001; Joerin et al., 2001).
Lastly, the evolution of management approaches requires new instruments and tools for strategic development, for information update and transmission, and for monitoring the development, and managing the whole planning and delivery process. At this point new generation intelligent urban management systems are needed to be developed particularly to be able to cope with the complexities of U-Eco Cities.

References


