Yigitcanlar, Tan (2008) ***Urban management revolution : intelligent management systems for ubiquitous cities.*** In: The International Symposium on Land, Transport and Marine Technology, 5-6 November 2008, KOFST International Convention Center, Seoul.

URBAN MANAGEMENT REVOLUTION: INTELLIGENT MANAGEMENT SYSTEMS FOR UBIQUITOUS CITIES

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Abstract: A successful urban management support system 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. The paper emphasises the importance of integrated urban management to better tackle the climate change, and to achieve sustainable urban development and sound urban growth management. This paper introduces recent approaches on urban management systems, such as intelligent urban management systems, that are suitable for ubiquitous cities. The paper discusses the essential role of online collaborative decision making in urban and infrastructure planning, development and management, and advocates transparent, fully democratic and participatory mechanisms for an effective urban management system that is particularly suitable for ubiquitous cities. This paper also sheds light on some of the unclear processes of urban management of ubiquitous cities and online collaborative decision making, and reveals the key benefits of integrated and participatory mechanisms in successfully constructing sustainable ubiquitous cities.

1. Introduction

During the last few decades rapid urbanisation 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 oblige a sound urban management system that increases the understanding of, and capacity to undertake, the strategic management of urban areas. 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 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., 2008a).

This paper explores intelligent management systems for ubiquitous cities. It aims to depict the elements for successfully planning for ubiquitous cities. The paper sheds light on the unclear processes of urban management of ubiquitous cities and online collaborative decision making, and reveals the key benefits of integrated and participatory mechanisms in successfully constructing sustainable ubiquitous cities. Following this introduction second section provides background information on ubiquitous cities, infrastructures, services and technologies. Third section reveals the importance of intelligent urban management systems for ubiquitous city formation. The following section argues the critical role of urban management support systems for ubiquitous cities management. Fifth section discusses online urban environmental management systems and E-government platforms for interlinking such systems. Sixth section introduces the Shibuya Community-based Internet GIS project as a good practice example for a ubiquitous urban environmental management support system. Finally paper concludes with directions for successfully managing ubiquitous cities.

2. Towards ubiquitous cities, infrastructures, services and technologies

The rapid growth of cities has been associated with many economic, social and environmental problems. In addition to increasing demands on scarce energy resources, these costs include deterioration in environmental quality, traffic congestion, accidents, misuse of scarce urban land and sprawling greenfield development. Under these circumstances, strategic planning for sustainable and intelligent cities is a crucial challenge for urban policy makers and planners (Kim, 2008).

In reality all urban activities are unsustainable since they consume resources. However, there is an acceptable level of social costs associated with daily activities and the physical movement of people or goods by utilising the emergence of pervasive information and communication technologies (ICTs) to identify ways for existing cities to grow in a more sustainable and intelligent manner. The rapid convergence of ubiquitous technology, ICTs and geographic information systems (GIS), is raising the possibility of dramatically transforming the way people perceive urban environments, and how they interact with each other in urban spaces (Kim, 2008). Endless possibilities for ubiquitous technologies are currently being developed promises increased convenience, awareness, transparency, and access to information and social opportunities that break traditional power structures by receiving and delivering services anywhere and anytime (Townsend, 2005).

As Lee et al. (2008a) define ubiquitous cities (U-cities) are cities that provide ubiquitous infrastructure (U-infrastructure) and ubiquitous services (U-services) for their residents and visitors by utilising 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). Examples of U-services to be provided in U-cities include but not limited to:

- Integrated facility management;
- Concierge-type information technology service;
- Security;
- Education; and
- Healthcare.

Abovementioned services would only be provided by the development of the following systems, where such systems form the backbone of U-cities (Figure 1).

- U-life portal system;
- Facility management system;
- Integrated payment system;
- Digital information system;
- U-healthcare system;
- U-education system;
- Smart card system; and
- Data collection and management centre.

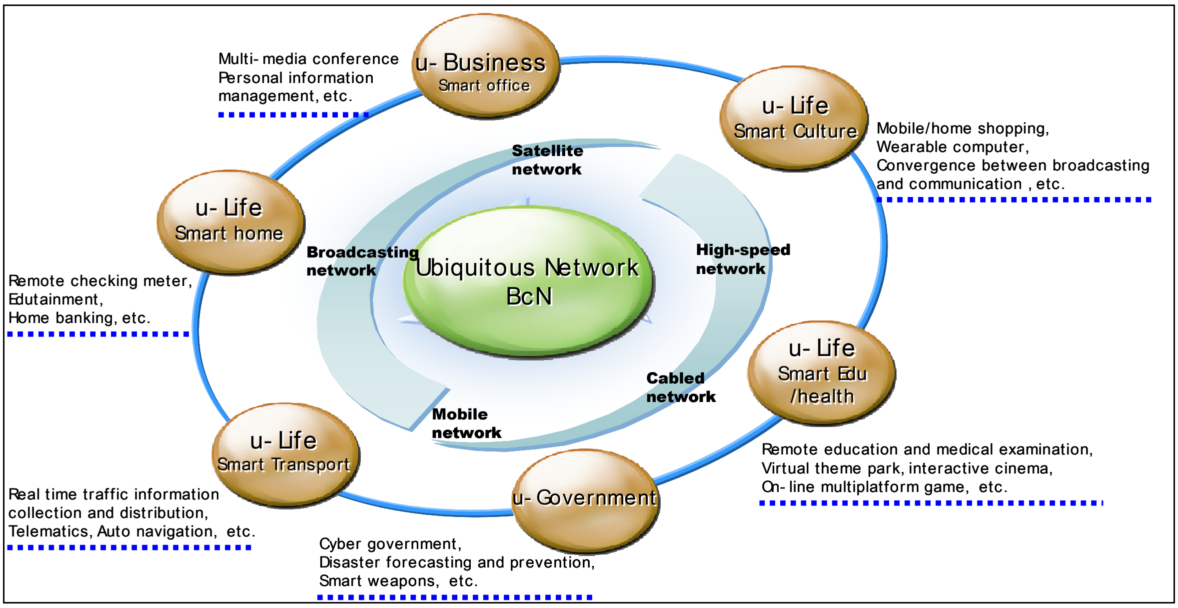


Figure 1. Ubiquitous city framework (Lee et al., 2008a: 156)

As U-technologies ICTs play an increasingly important role in the planning, management and use of urban physical infrastructure in the areas of transport systems, power supply, sewerage and waste treatment and water supply and management. The Republic of Korea, followed by Japan, is a world leader in the use of ICTs in urban infrastructure planning and management (Cohen, 2004). Over the last two decades, Korea has continuously developed local, regional and national strategies for knowledge-based and sustainable urban development by incorporating state of the art ICTs. The country's U-Korea and U-city agendas aim to increase the use of ICTs in the development and management of urban space for prosperous and sustainable development (Lee et al. 2008c).

In the 21st Century, technological developments in the areas of remote sensing, GIS and wireless communications have made huge strides as a result of tremendous changes in mobile networks – mobile phones, vehicle navigation, smart cards and personal tracking systems. In particular, mobile phones have become intelligent devices, used not for only inter-personal communication but also to access information and services provided via the internet (Lee, 1999). These wireless and advanced U-technologies provide opportunities for a person to communicate not only with other people but also with any product or service elements of the existing urban infrastructure, notably transport, water supply, public parks and route directions if the objects contain sensors, processors and software (Lee et al., 2008c). These physical infrastructure items and mobile objects, such as cars on the road, oil running through a pipeline and electricity flows in a power supply line, can be self-monitored, controlled and protected by digital networks (Lee et al., 2008b).

U-infrastructure uses sensors and sensor networks to continually communicate with wired and/or wireless computer devices embedded in personal devices (i.e. mobile phones and personal digital devices), buildings, infrastructure, and any feature or object of the urban space. This allows ubiquitous communication of person-to-person, person-to-object, and object-to-object even though computers or devices are invisible to users. U-infrastructure improves the effectiveness of urban infrastructure planning, management and use in many ways. U-infrastructure also contributes to the creation of an environmentally friendly, sustainable and smart city by making ubiquitous computing available for the public, allowing them to report environmental hazards immediately to the environmental protection agency, for instance, and leads to a significant shift to a new paradigm of urban infrastructure planning and provision in Korea and potentially elsewhere (Lee et al., 2008a). U-infrastructure can make the management of urban facilities more efficient and provision of services less expensive. For instance, people can access information without searching for information via the internet and objects share data with other objects without inputting data from people (Lee et al. 2008c).

Further, U-infrastructure also helps to realise U-democracy by encouraging citizens to participate in the decision making processes using personal devices such as mobile phones, personal digital devices (PDAs), and sometimes by automatic recognition via radio frequency identification or sensors. Policy experiment and simulations through U-infrastructure also provide a fair and transparent participation opportunity for stakeholders (Lee et al. 2008c). Using policy experiment and simulations, a policy maker can test various policy options and evaluate current policies according to the economic and market performance, which diminishes the challenges of policy and market failure (Lee, 2004). However, recent developments in U-technologies and progress towards the development of U-infrastructures and U-services have revealed that without an efficient urban management system it is not possible to form U-cities.

3. 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 utilising 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 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 and 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) summarise 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-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.

4. Urban management support systems

A successful urban management support system requires an integrated approach to governance. This integration includes bringing together economic, socio-cultural and urban development with a well orchestrated transparent and open decision making mechanism. Such decision making mechanism could only be achieved with a broad public and stakeholder participation. In the age of information era, already upon us, to encourage wide participation urban administrations have started to benefit from the opportunities those U-technologies are providing (i.e. computer supported collaborative work environments, web-based platforms). However providing an online platform for public and stakeholder participation and technicians collaboration is not solely enough for coming up with the most suitable decisions. At that point accessing accurate and real-time information plays a big role. As static urban management systems proved in time to be unsuccessful as the last step of the planning or management process, which is monitoring and re-evaluating the decisions, were neglected mostly. This is to say in the 21st Century urban planning, development and management cannot deal with urban ills and problems by continuing its traditional static and slow in action characteristics. Particularly the new trend of U-cities provide an avenue to turn urban planning, development and management into a fully dynamic process by benefiting from real-time information collected through various U-technologies and also benefiting from real-time strategic decision/choice mechanisms (Lee et al., 2008a). Additionally, it is widely accepted that only fully transparent and democratic urban governance can provide such dynamic governance and management system that an intelligent urban management system aims to establish. Therefore, adapting a U-democracy mechanism into online urban management support systems, as well as into the whole decision making process, is crucial. Especially recent online urban environmental management systems practice help in democratising the process and set a good sample for intelligent planning and management systems.

5. Online urban environmental management systems

Environmental information and environmental information systems (EIS) play a major role in urban planning, decision making and management. EIS briefly is a collection of datasets and information that have some relevance for studying, monitoring and exploring the environment. The term EIS is used to describe a collection of socio-economic indicators; a contact list of consultants or a list of chemicals that are used in the production cycle. It can be a set of data files, or a highly integrated information system; a standalone system, running on a personal computer; or a sophisticated system, based on super-computers (Hakay, 1999). EIS relies on technologies – such as a database management system running on a mainframe computer or based on the latest web technology or based on U-technologies (Yigitcanlar et al., 2008a). Its scale can be as wide as global, national, local, or it might not relate to any geographical scale.

Since the early 1990s, a new field of research has been created for EIS research, named 'environmental informatics' which is the field that deals with the development, management and research on EIS (Avouris and Page, 1995). It is an operational combination of remote sensing and GIS technologies. They play a facilitator role in the collection as well as the integration and analysis of the up-to-date spatial and aspatial database with the existing datasets to generate application specific strategic datasets for technological adjustment and social adaptations with future perspective, towards (Chakrabarti and Nag, 2002):

- Environmentally sound land use/land cover practices;
- Minimising the adverse effects of natural hazards, land degradation and so on; and
- Easy to use data format in digital mode to enable E-governance especially in rural poverty alleviation and biodiversity conservation.

Though the term EIS is still widely in use when referring to these systems, they have moved away from being pure information systems. Most of them handle and manipulate datasets. As computing power increases, EIS are used for complex analysis operations and evaluation of possible scenarios (Yigitcanlar et al., 2008a). This transforms EIS into exploration tools where the users evaluate and analyse underlying datasets while constricting their knowledge and meaning of the problem at hand (Checkland and Holwell, 1998).

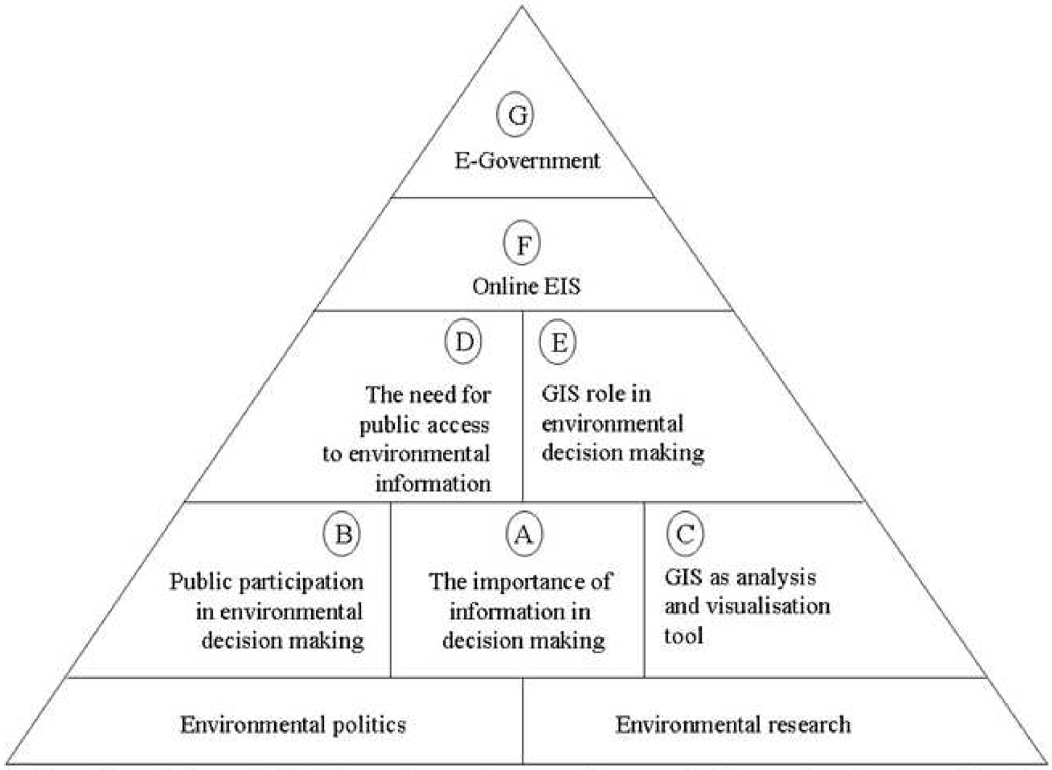
An EIS is comprised of three parts – the input to the system, running and operating EIS, and its outputs. These are the core elements of the environmental information and they form the traditional content of EIS. However, this core is surrounded by a wide range of topics of environmental information (Yigitcanlar et al., 2008a). This includes geographic information about the built and natural environment; information about public transport, traffic and alternative transport means; information about recreational activities; health related information or information about food production and content (Haklay, 2001).

The spatial element of environmental information promotes the use of GIS as a pivotal tool in EIS that serves many roles. Historically, GIS started as a repository for environmental information. It then evolved into a management tool with modelling and analysis capabilities added or connected to it later (Rhind, 1996).

The use of ICT in environmental decision making brings several specific issues. The continual updates and changes in technology combine with the costs of software and hardware to make it expensive and difficult to maintain an operative EIS. There is also a continual need to follow changes in technology, particularly in U-technologies, and to adopt existing systems to these changes. Such changes include the move from central, mainframe computers to distributed computing and from text-based terminals to the multimedia environment of internet (Haklay, 1999), where such move helps in establishing new U-environmental management services.

The involvement of individuals in interest groups in environmental decision making via online EIS enables group members, i.e. stakeholders, technicians and the public, to share information amongst the broader group (Yigitcanlar et al., 2008a). Such groups are usually formed to a specific set of social and political goals. Naturally, there are other social/political/economic entities which such groups are debating and might be in conflict. Each group can collate and use environmental information according to its own filters (Haklay, 2001).

As most of environmental information is stored in computerised information systems, and with accordance to the growing demand for public access to this information, there is a growing need for online EIS for managing the environment effectively (Yigitcanlar et al., 2008a). A review of the latest EIS will reveal a set of seven assertions (Figure 2) that seem to underlie recent initiatives (Haklay, 2000):



A. Sound knowledge, reliable information and accurate data are vital for good environmental decision making.
B. In sustainable development or ecological modernisation all stakeholders should take part in the decision-making processes. A direct result of this is a call for improved public participation in environmental decision making.
C. Environmental information is exceptionally suitable to GIS. GIS development is closely related to development in environmental research, and GIS output is considered superior in understanding and interpreting environmental data.
D. To achieve public participation in environmental decision making, the public must gain access to environmental information, data and knowledge.
E. GIS use and output is essential for good environmental decision making.
F. Public EIS should be based on GIS technologies. Such systems are vital for public participation in environmental decision making.
G. Online EIS should be a service of e-government, so online EIS could be benchmarked and become accessible for all e-government users.

Figure 2: E-government and online EIS assertions (Yigitcanlar et al., 2008a: 695)

Although E-government is a relatively new and expensive application, many countries around the world have shown remarkable ingenuity in creating E-government services. In most of these countries' E-government services also included environmental services such as online EIS (Yigitcanlar et al., 2008a). The following projects (Table 1) can be provided as some of the good practices on the integration of online EIS in an E-government platform, which are also good examples that can be adopted by cities aiming to develop U-infrastructure and services (i.e. U-environmental management service).

Table 1: Good practices in E-government and online EIS (Yigitcanlar et al., 2008a: 695)

Country – State	E-government Portal	Environmental Information Systems Portal
Australia	www.gov.au	www.environment.gov.au
Australia - ACT	www.act.gov.au	www.environment.act.gov.au
Australia - NSW	www.nsw.gov.au	www.nsw.gov.au/environment.asp
Australia - NT	www.nt.gov.au	www.lpe.nt.gov.au
Australia - QLD	www.qld.gov.au	www.qld.gov.au/services_for_queenslanders/environment_and_resources
Australia - SA	www.sa.gov.au	www.environment.sa.gov.au
Australia - TAS	www.tas.gov.au	www.tas.gov.au/tasmaniaonline
Australia - VIC	www.vic.gov.au	www.environment.vic.gov.au
Australia - WA	www.wa.gov.au	www.onlinewa.com.au/enhanced/habitat
Canada	www.gc.ca	www.ec.gc.ca/envhome.html
Hong Kong	www.gov.hk	www.epd.gov.hk
New Zealand	www.govt.nz	www.mfe.govt.nz
Singapore	www.gov.sg	app.mewr.gov.sg
UK	www.direct.gov.uk	www.environment-agency.gov.uk
US	www.firstgov.gov	www.firstgov.gov/citizen/topics/environment_agriculture.shtml

6. The Shibuya Community-based Internet GIS Project

So far, around the world a number of successful online urban planning and management support systems developed, particularly focusing on the urban environmental decision making issues. One of these good practices is a public oriented interactive environmental decision support system developed by the author for the Shibuya City, Japan. Community-based Internet GIS (CIGIS) is a web-based support system to facilitate discussion and collaborative decision making. It enables various users, such as the public, technicians and politicians to interactively obtain and share information on the environment at different levels, scales, aspects and details. Users can access to the platform via any electronic device (i.e. desktop/laptop computers, PDAs, mobile phones). It also facilitates the collaboration of these users in problem solving throughout various decision making stages of the community-based planning process. CIGIS is a mechanism to support sustainable development related thinking, identify community goals, draw up planning guidelines and collect data and store them in a decision support system environment (Yigitcanlar, 2008). Furthermore, the main steps of participatory decision making, collaboration, negotiation and consensus building are integrated into this system (see Figure 3 for the system flow chart of CIGIS).

The CIGIS model is applied to a pilot project in Tokyo, Japan – The Shibuya Community-based Internet GIS project. This project is developed to raise awareness on urban and environmental planning and sustainable urban development issues among the residents of Shibuya, Tokyo. The pilot project aims to provide an easy access to urban and environmental data and to create environmental awareness among the public for achieving sustainable urban development in and around Shibuya. This project develops a comprehensive integrated web-based information sharing platform for the collaborators (i.e. community and stakeholders). Together with U-technology and decision making components, it creates and promotes awareness on sustainable urban development and urban and environmental planning issues, community-government relationships, virtual community and trust online.

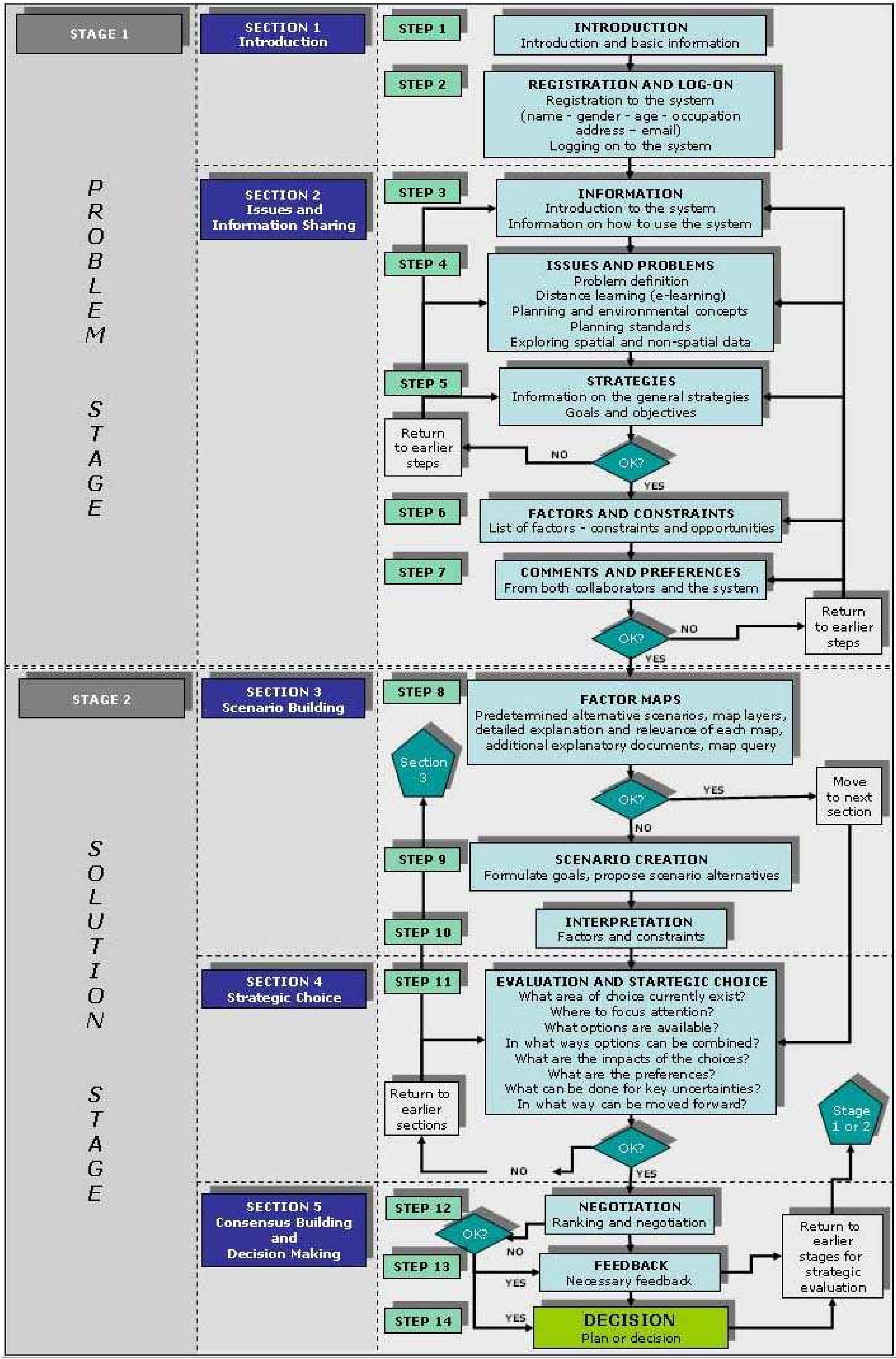


Figure 3. System flow chart of CIGIS (Yigitcanlar, 2008: 356)

As part of this pilot project, U-technologies for accessing information in the database via the internet were set up. The system uses ESRI ArcIMS technology to enable the presentation of the tabular information, interactive maps and videos. The system permits viewing the data anytime from anywhere in the world by using any device that can access to web browsers. Participants can view the map of the city, perform zoom and pan operations to assist in visualisation and navigation, ask questions/queries and then make suggestions about specific features identified from the map. All user input is stored in the web access logs and is then used for future analysis and feedback into the planning and decision making process. In this manner a community database is created, representing a range of views and feelings about environmental and planning issues of the Shibuya City (Yigitcanlar, 2008). A schematic diagram of the system architecture of the CIGIS used for the Shibuya City is illustrated in Figure 4. The system architecture includes 'Computer Supported Collaborative Work Systems (CSCW)' and specific applications to support collaboration. The system constructs a trio of communication, collaboration and coordination among all of the participants and contains forms and common gateway interfaces that the user can interact with to provide information and feedback.

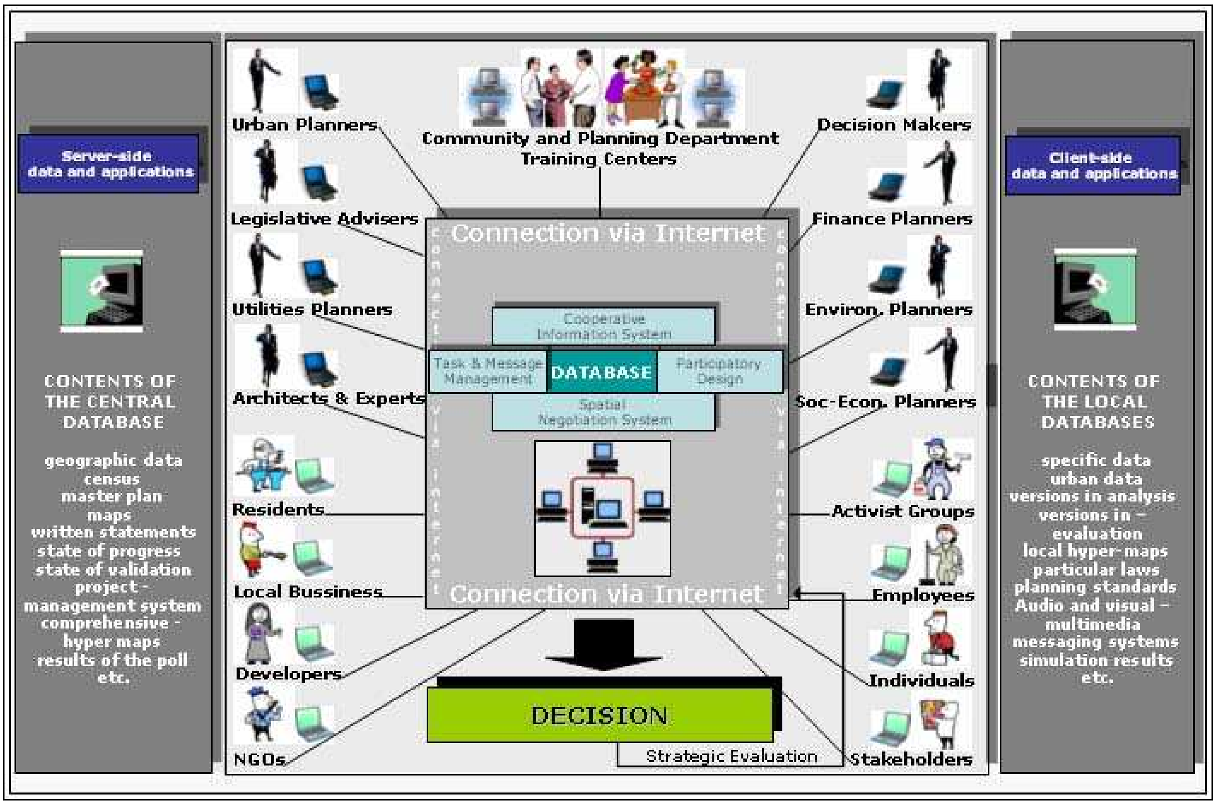


Figure 4. System architecture of CIGIS (Yigitcanlar, 2008: 353)

The Shibuya Community-based Internet GIS pilot project has shown that online urban environmental management support systems could be developed and accessed by the wider community to strengthening of cities sustainability bases. Additionally further development of such or similar projects lead into the development of U-environmental management services.

7. Conclusion

In the 21st Century global and local forces, such as climate change, resource consumption and depletion, energy security and oil vulnerability, globalisation and knowledge economy, 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 ubiquitous city, infrastructure, service and technology developments offer new opportunities. Such developments will 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 will provide just-in-time delivery of goods and services and will contribute significantly to the sustainable development of our cities by mainly minimising unnecessary resource use. Similarly U-infrastructure and services by improving community and environmental health will contribute to the formation of healthy cities.

Along with these opportunities, and many more, intelligent management systems for U-cities also presents a number of challenges. These challenges include: strategically planning every stage of the U-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-cities also requires several key instruments. These instruments include: a strong administration and will to plan and develop sound policies; legislations and regulations to legitimise 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. Lastly, for a successful urban management strategic visioning and planning, as Neilson (2002) highlights, linking strategy and practice play a key role.

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