UBIQUITOUS GEOSPATIAL CONCEPT IN EVOLUTION OF THE MACRO AND MICRO SPATIAL PLANNING

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**Abstract.** There are many examples of GIS application in planning such as urban land-use planning, cultural heritage conservation, coastal zone management, and the design of structure plans for sustainable economic development. All these applications are dealing with systems in which natural and human factors are interconnected. But an issue that should be addressed is to what extent the current information technology is able to connect all these parts together? Contemporary improvement in information technology made the computer so imbedded in our everyday practices that we use it without having to think about it. Thus, computing is becoming truly ubiquitous and is available anywhere anytime. Advances in the internet facilities and devices, such as high speed wireless networks, mobile middleware, and smart technologies, has pushed the concept of ubiquitous computing to the forefront of GIS research and development. There are developments in this regards, these are such as GeoWeb 2.0, voluntarily geographic Information (VGI), and Mashups, whereby the application of cloud computing was possible in visualizing urban air pollution and emergency responses to ensure the safety and security. These advancements therefore, have changed the conventional facet of macro and micro spatial planning. Every possible information system such as residential, medical, business, environmental, governmental, and the like can be linked through ubiquitous computing technologies and acts as a virtually one system which works for society. However, the journey to achieve a true ubiquitous GIS is not without challenges. Despite the current potentials there are many issues and obstacles need to be addressed before GIS can to be truly ubiquitous in planning context. Perhaps four criteria as explained by Goodchild et al (1997) can be applied to ubiquitous GIS in planning very well: the system must be distributed (data storage, processing and user interaction can occur at locations that are potentially widely scattered), disaggregated (the monolithic systems are replaced by ‘plug and play’ components designed to interoperate through conformance with industry-wide standards), decoupled (system must be able to access a number of components over many networks required to complete a specific task) and, interoperable (system is based on an "open" system).

1. **Introduction**

The recent advancements of geo-information technology (GIT) have improved formulating and implementation of urban and regional development plans at both macro and micro-levels [1]. For

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instance, at the macro level Geographic Information Systems (GIS) have been used geospatial data modelling, land suitability analysis and evaluating scenarios to generate suitability maps. Urban growth models are other examples that are often developed in regional scales using GIS and information technology capabilities enabling to envisage the future developments based on various scenarios [2-5]. Most of GIS applications have been developed based on particular functionality or purpose at different level and stages of planning. There are many examples of GIS application in planning such as urban land-use planning [6], cultural heritage conservation [7], coastal zone management [8-9], and the design of structure plans for sustainable economic development. All these applications are dealing with complex and interconnected systems of natural and human factors. But the issue of connecting all these parts together is still remained unaddressed.

Contemporary improvements in information technology made the computer so embedded in our everyday practices that we use it without having to think about it. Advances in the internet facilities and devices, such as high speed wireless networks, mobile middleware, and smart technologies, has pushed the concept of ubiquitous computing to the forefront of GIS research and development. Hence, GIS models and analyses moved from desktop computers to the World Wide Web [10]. Accordingly Web mapping technologies, have changed the conventional facet of macro and micro spatial planning. Every possible information system such as residential, medical, business, environmental, governmental, and the like can be linked through ubiquitous computing technologies and acts as a virtually one system which works for society. However, two questions that should be addressed in the journey to achieve a true ubiquitous GIS (u-GIS) are: How new technologies can influence decision making in connecting all planning components at both macro and micro levels? How quality geospatial data can be accessible and useful for planning and decision making processes?

Spatial planning and decision making is a complex and interdisciplinary task with an infinite number of solutions. The new technologies and concepts such as Web 2.0, “Volunteered geographic information” (VGI), GeoRSS, and Mashups provide a foundation for utilizing GIS research results for participatory planning and decision making. However, there is little evidence that practical planning support systems are developed to deliver the efficiency of new technologies into planning and decision making process. Thus, as the first objective the study begins to evaluate the application of new technologies in planning and decision making process at both macro and micro levels.

Moreover, national governments shift the planning practices toward localizing decision making by sub-national governments, non-profit agencies, non-government organizations and voluntary associations. Thus, diverse users of geospatial data are growing rapidly [11]. As the second objective this paper addresses the ubiquitous geospatial data infrastructure challenges to foster the planning and decision making agencies to carry out their new responsibilities.

2. Ubiquitous GIS and Spatial Planning

During the last two decades, the growing needs for scientific and technical information to analyze comprehensive planning problems, as well as the use of mathematical models to design spatial optimal solutions have strongly supported the application of information technology in the planning process [1], [12]. Planning and decision support systems are often important features for countries undergoing rapid growth such as Malaysia [13]. GIS have been provided a strong platform to spatial decision making process and considered as main component of Planning Support System (PSS) as well as Spatial Decision Support System (SDSS).

Planners have adapted the GIS tools to meet their particular requirements for the purpose of decision making and often integrated existing analytical techniques with GIS packages to develop user friendly planning tools [13-15]. Furthermore, PSS that is an integration of GIS data, urban model and presentation techniques has highly improved through advances of computers.

The planning departments have also considered the crucial role of GIS in development policies at different levels. For instance, the Malaysian Town and Country Planning Act, 1976 (Act 172) (amended in 2001) necessitates adopting GIS in the formulation of plans at different spatial and
administrative levels to ensure effective planning [1]. In line with this initiative, Yaakup et al., (2005) showed the development of a model for regional planning, called, Application of GIS for Klang Valley Region (AGISwlk) which is an integrated land use assessment (ILA) that dynamically supports the preparation of a Regional Master Plan.

Improvements in computing and current pervasive of trends in high technology generated different types of GIS as well as opportunities to distribute the PSS and SDSS in the Web brought salient tools for communication of public and stakeholders. For instance during 2000-2005, AGISwlk was developed and enhanced to GIS Web for the access and communication of public and stakeholders. Application of new technologies such as Open Geospatial Consortium (OGC) open source codes, Web Map Service (WMS) layers, enabled the developments of planning systems for further quality improvements and reduced costs of data accessibility and spatial decision making process. As an example, AGISwlk has been further developed by generating Integrated Regional database System (SePADU) to establish an online geospatial data network to improve the government’s delivery system in the Federal Territories and Klang Valley Region.

These developments enable data sharing via Internet and establish an integrated, comprehensive and up-to-date GIS application for spatial decision making. However, enhancements were associated with several challenges such as diverse data sources and formats and data publishing methods as well as lack of adequate infrastructure for server performances.

Although the above mentioned developments are unique and innovative steps in different planning and decision making levels, contemporary improvements in GIS industry provides different means to improve the availability of data and more sophisticated tools for application of u-GIS in the spatial planning. These are such as Mobile GIS, 3D GIS, Enterprise GIS, Real Time GIS, and Distributed Global GIS [8].

Perhaps four criteria as explained by Goodchild et al (1997) can be applied to u-GIS very well in order to incorporate the new technologies in the process of spatial planning and decision making: the system must be distributed (data storage, processing and user interaction can occur at locations that are potentially widely scattered), disaggregated (the monolithic systems are replaced by 'plug and play' components designed to interoperate through conformance with industry-wide standards), decoupled (system must be able to access a number of components over many networks required to complete a specific task) and, interoperable (system is based on an "open" system).

The literature suggests that three components ensure implementation of such systems [16,17]: virtual service GIS platform, cross-platform GIS, and 2D/3D integrated GIS. For this reason the network infrastructure must support these technologies, there must be an adequate number of software systems to support applications, and small, inexpensive, low-powered, with convenient displays computers must be available. Currently there are thousands of websites offering services for mapping or geospatial data handling. Launching of online mapping tools such as Google Earth, Microsoft’s Virtual Earth/Bing Maps, NASA’s World Wind and ArcGIS Online validate this articulation [10]. The integration of 2D/3D data is also possible for organizations using time by time improvements by virtual service providers. As an example, using ESRI’s ArcGIS online (http://www.esri.com/) improved and provided opportunity for the authorship and publishing of CityEngine web Scenes is possible. Thus these developments facilitate the integration of u-GIS in spatial planning and decision making.

In addition, the considerable number of GeoWeb and geographic information contributed by users through various application programming interfaces (APIs) has made GIS powerful tools for participatory planning [10,18]. Bugs et al., (2010) assessed the public participation GIS (PPGIS) and Web 2.0 technologies in urban planning practice in Canela, Brazil. They showed a valuable approach for engaging the public in the spatial planning process through a straightforward communication among users and decision makers. This is known as Planning 2.0.

Despite all these improvements, there are challenges that should be considered in future developments of u-GIS application in planning and decision making process. Part of these issues is related to the planning policies and integrating the new technologies in planning strategies and
implementations. Organizational capacity and lack of expert human resources in organizations is one example. Other issues are related to geospatial data availability and accessibility, national, state, and local governments have to revise their existing policy on data accessibility and avoid parallel working. Furthermore, inconsistency in the production of geographic information and different standardizations reduces interoperability of data and tools. More detail about geospatial data challenges and u-GIS is explained in the next section.

3. Ubiquitous Geospatial Data Challenges
The new challenges for data development, dissemination, and administration are emerged due to the needs and applications of diverse and growing users of geospatial data [11]. National spatial data infrastructure (NSDI) in any country is the dominant framework for fostering access to distributed geospatial data developed and administered by government. However, NSDI implementation that requires the local government participation in national context is often a problematic[19].

Rajabifard et al., (2006) indicated the role of sub-national government and the private sector in contemporary SDI and suggested new roles for its future generation SDI. They found that, the contemporary trends and developments have shown a shift in roles of three major players in SDI (national government, state/local government, private sector) mostly in developed countries. While traditionally, the national government influenced on both strategic and operational levels, currently the operational levels are moved to the sub-national government level. Thus, land use planning, day-to-day decision making, and infrastructure development is achieving a more sustainable development objective. Accordingly, the flow of information is changed to bottom-up level from private sector to sub-national and ultimately national levels.

Despite the argument of Rajabifard et al., (2006) that sub-national governments will play the most important role in future SDI’s, Budhathoki et al., (2008) believe that web 2.0 and volunteered geographic information (VGI) initiatives are most important components. Thus, the third generation of SDI is user-oriented rather than production-oriented of first generation and process-oriented of second [20-21].

Today the digital spatial data that are created by citizens using cell phones, digital cameras, and other devices use GPS technology to provide others with information based on their location [22]. Accordingly, every content in the web is associated with the location through ‘Geotagging’ technology. This is the basis for explaining VGI as a new phenomenon that is receiving growing attention in public participation in development process. As an example, Sui and Goodchild (2011) indicated how participants of OpenStreetMap (OSM) in both North America and Europe have been organizing mapping parties to work together to map their road networks for their communities.

While the ubiquitous geospatial data is increasingly attracted a great deal of attention in the world, developing countries like Malaysia have yet to be prepared for incorporating this information into their planning process. It is inevitable that contemporary and ever growing technology should be considered in the process of spatial planning in order to achieve a more sustainable development.

4. Conclusion
This paper was set out to review and evaluate the application contemporary developments of ubiquitous GIS in both macro and micro level spatial planning and decision making process. The paper raised two questions about the application of new technologies and geospatial data in the process of decision making. The review of current developments in Geoweb and the bottom-up flow of geospatial data invites the planning departments and other agencies to revise and up-date their policies and infrastructure. The National government could play a strategic role in providing the framework and allow state/local governments as well as private agencies to perform the local decision making process.

Moreover, standard geospatial database design considering the global and regional SDI guidelines enables to enhance current PSS developments. Further research should focus on exploiting the user-generated information and utilizing available easy-to-use systems that provide planners with tools to
interact directly to other agencies and citizens. At last the success or failure in adopting u-GIS for spatial planning and decision making depends on variety of human, organizational, and technical factors.

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