Modelling framework for Integration of Geographical Information System and Multi-Agent Models as planning support tools in enhancing Local Authority functions

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SUMMARY

Implementations of information and communication technology in urban planning such as Geographical Information System, Planning Support System and Decision Support System has been widely realised by local authorities to enhance the provision of excellent services to their local citizens and improve urban governance. Information systems technology embedded into spatial planning can be viewed as a solution for a local authority to migrate from their conventional working procedures to a computerized and automated system environment to support decision-making process. This paper will present an overview framework of integrating multi-agent models with geographic information systems technology in understanding and simulating economic growth for enhancing local authority functions. The integration of geographic information systems technology and multi-agent modelling is expected to provide a growth model that will help decision-makers to identify factors that will contribute to growth and sprawl in a region, and assess the impact of particular policies. The usage of geographic information systems in modelling the real situation helps a decision maker with valuable spatial information on the system's behaviour. In addition, the very integration of geographic information systems and multi-agent models will have a great impact on the process. Towards that direction, spatial analysis and complexity modelling will be applied in a detailed case study to simulate changes of land use in the economic region of Klang Valley in Malaysia. It's hoped that this ongoing study will contribute to a better knowledge and may help improving the decision-making process in the future.

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1. Introduction

Information and Communication Technology (ICT) in urban planning such as Geographical Information System (GIS), Planning Support System (PSS) and Decision Support System (DSS) has been increasingly more widely implemented and used by local authorities to enhance their services to local citizens. Currently, the advancement of geo-information technology has affected the nature of decision making, spatial planning and development management. The adoption of GIS in the local authority's planning process, especially in the preparation of development plans, has encourage many local authorities to embark on small scale, multi-faceted GIS-based Decision Support System application to suit their functions and work procedures (Johar et al., 2003).

The main aim of this paper is to provide an overview of ongoing study towards integration of GIS and MAS modelling for planning support in urban economic growth development areas. The remaining part of this paper is structured as follows. Section 2 presents the concept of GIS and Multi-Agents System (MAS) integration. Section 3 explains the study area and data sets. Section 4 present the modelling framework and lastly, section 5 provides some discussion and conclusions.

2. Geographical Information System and Multi-Agents System Integration

In local planning authorities, GIS are used at various points in the planning process, including analytical and synthesis-oriented tasks such as plan development and evaluation. With its powerful capacity for spatial data management, spatial analysis, and visualization, GIS provides planners with new tools to implement their work more efficiently. The use of GIS tools opens up for new possibilities for access of information, more accurate data analysis and help in generating alternative scenarios of development.

GIS is already widely used by local authority to improve their work. Other component should be added and integrating with GIS. Multi-Agent (MA) technology is an important and relevant candidate. MA can serve for two purposes: simulation and problem solving (Ferrard, 1996). Multi-Agent systems, also known as agent-based models, can be defined as a collection of (interacting) autonomous agents, each with their own capacities and goals but related to a common environment that can involve communication, such as passing of information from one agent and environment to another (Cheng, 2003).
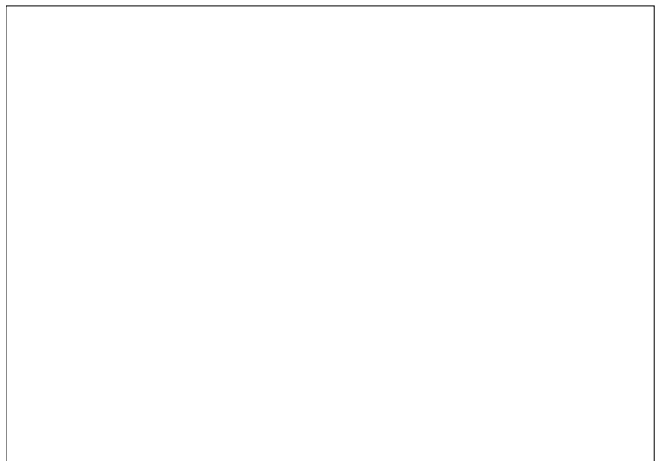
4. The Development and Application of GIS and MAS integration for Spatial Planning

Spatial planning involves the study of the psychology, logistics, economies and sociology that deals with multiple actors and criteria in decision making processes (Ligtenberg, 2006). In the context of regional development and urban dynamics, the agents represent the actors that the researcher distinguishes and are deemed relevant in understanding the dynamics. The agents are depending on the specific purpose of the system ─the urban planning team, individuals and households, firms and organisations, the natural environment, the physical environment, the institutional context and the political environment (Saarloos et al., 2008).

### 4.1 Economic growth and firm demography approach

The success of products and technologies that are created by recently formed and growing companies has a great impact on regional economies (Craymer and Omura, 1996). The special links between firm dynamics and urban dynamics contribute to the firm demography connotation with economic growth. By simulating growth, the spatial requirement of firms may change as well, leading either to expansion or in some cases to moving to another area. In that sense, firm demography can be tied to shifting location requirements and in turn this may lead to changing locational configurations of land uses and firms.

Firm demography or demography of firms is an interesting concept which is similar to micro-simulating the demographic process of individuals or households. This concept has gain interest and attention in several fields of research dealing with spatial planning such as economics and economic geography (van Wissen, 2002), regional science (Van Dijk & Pellenbarg, 2000) and transportation (Moeckel, 2005).

4.2 Modelling Framework

In this study, we develop a model for firm demographic activities using an econometric and GIS analysis approach. The processes involved in building the MAS model are based on different component or activities (Figure 2). The components of the framework are described as follows:

1) Input from Expert/User/Actor involved in the processes will be elicited for information on the various human and non-human processes that occur in the system.

2) The GIS database will contain spatial and attribute data. Spatial data gathered are usually in different scales or different grid systems, so have to be converted and transformed to be accommodated into the GIS.

3) Firm dynamic performance: The analysis of firm dynamic performance covers firm in Kuala Lumpur from between year 1990 and 2007. The evolutions of new firms between these years are shown by sector.
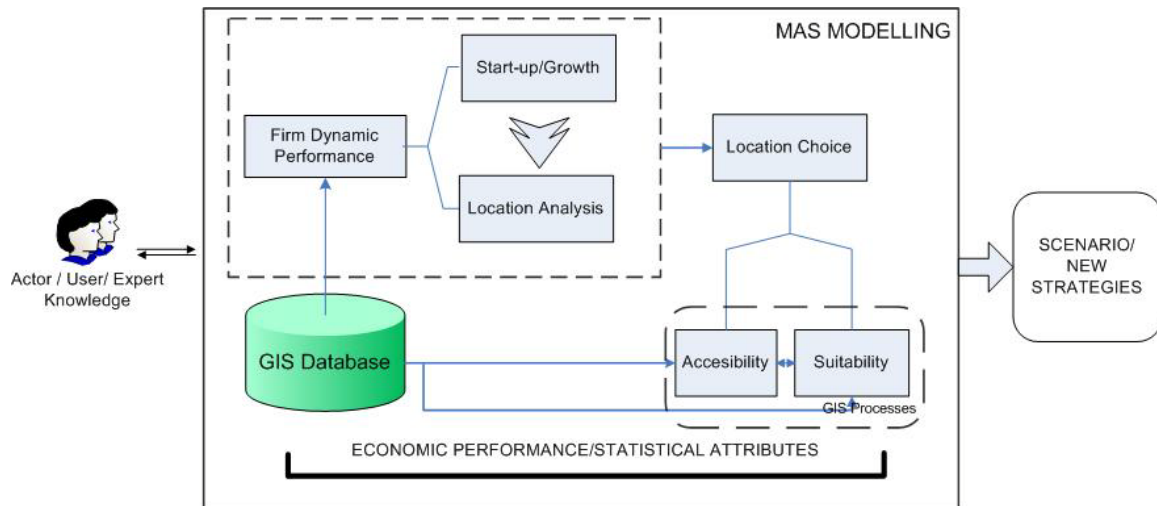
Figure 2 : Modelling Framework

4) Start-up model/Growth model: In firm demographic, birth of a firm is one of the components of its life-cycle. Regression and discrete choice modelling are used to assess this activity.

5) Location Analysis: Geocoding tools, proximity and area analysis used to examine the location of firms in the study area. The result is used as input for the location choice model.

6) Location choice model: There are many factors influencing the location of firms or businesses. Leitham et al. (2000) among others identified business characteristics, the locality and the type of production as the factors. Other researchers suggested that firm location choice is based on (1) labour cost and quality; (2) market and transportation access; (3) interest of pro-business community (Dipasqualea and Wheaton, 1996); (4) the economies of scale and the economies of agglomeration (Li, 2007). Although these are not the only factors that influence the location choice, the importance of these factors seems to vary by business sector and city. This model is one of the most important steps in firm location decisions. For this model, we apply a discrete choice model.

7) Accessibility and suitability model: These models will be performed using GIS tools such as Spatial Analyst and Network Analyst. The models are design and create using Model Builder facilities for showing the structural arrangement of the analysis.

8) Scenarios or new strategies: The model may contribute to generate scenarios or new development strategies. The spatial information from the modelling process could be used to support the decision.

Based on Figure 2, the MAS modelling process used economic performance and statistical attributes as its input. To a certain extent, other inputs such as socio-economic and government's policies data also will be taken into consideration depending on the model that will be developed.

4.3 Methodology

Following the modelling framework, the modelling methodology is design to meet the objectives of the GIS and MAS integration process. Summary of the process is given in Figure 3.
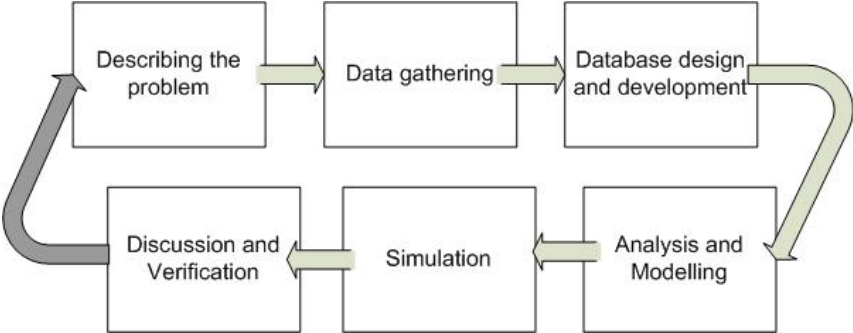
Figure 3 : GIS and MAS Modelling Process Activities

In the modelling process, the first and most important part that has to be considered is to defining the problem (Campo, 2003). In this research, the problem should be defined based on applying the modelling method of regional growth with specific reference to an economic region in Malaysia. The second stage is the data-gathering process. Data's gathering involves the process of collection of spatial and non-spatial or attribute data for the model. Afterwards, the data will be stored and structured in GIS format. For this purpose, the database design and development will be carried out to ensure all the data for this study is ready and available in the database. The next activities are the analysis and modelling. In these processes, spatial analysis and complexity modelling will be applied in a detailed case study to simulate the land-use changes in the region. Lastly, discussion and verification of the model will be performed to validate the model and ensure it is applicable to this study.

5. Discussion and Conclusion

This paper presented a modelling framework of the development of a multi-agent model of urban dynamics in the context of economic growth. One of the challenges in this research is the lack of data, especially the firm data. Part of the data is available such as a date of start-up, firm address, firm status and type of firm but no information is available about migration, closure date or employment status. Thus, model opportunities are limited to data availability.

The modelling framework of GIS and MAS integration gives additional knowledge for local authority to deal with spatial data for the decision making activities. As one of the fastest

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growing region in Malaysia, Klang Valley's local authority needs essential 'tools' for the decision-making process that involve continuing monitoring, evaluating and analysis of current environment for their current and future development. It's hoped that this ongoing study will contribute to better knowledge and practice and helps improving the decision-making process in the future.

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BIOGRAPHICAL NOTES

Noordini is currently a PhD candidate at Urban Planning Group, Eindhoven University of Technology. Her interest is on Geographical Information System in Urban and Regional Planning. Her PhD research is focus on Development and application of Multi-Agent Models in Planning for regional Economic Growth. This paper is a part of her ongoing PhD research.

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