A planning support system for assessing strategies of local urban planning agencies

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A PLANNING SUPPORT SYSTEM FOR ASSESSING STRATEGIES OF LOCAL URBAN PLANNING AGENCIES

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Abstract:
Here we present our research project, which aims to develop a new kind of planning support system (PSS). The PSS aims to analyse the urban planning process. An important part of the construction of the PSS is the development of a multi-agent simulation model of the urban planning process; the model will be based on the comparison of the planning systems of France, England and the Netherlands.

Keywords:
Planning Support System, Spatial Decision Support System, Multi-Agent System, Urban Planning, Urban Development

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1. INTRODUCTION

Over the years many tools became available to urban planners to aid them in the process of urban planning. These tools provide planners with support in their decisions concerning urban planning. Many of these tools focus on the design and evaluation of possible solutions for spatial planning problems. Very few tools, however, focus on the evaluation and streamlining of the urban planning process itself.
Tools, that focus on the evaluation of the planning process, help create an understanding of the urban planning process. They help predict the outcomes of the planning process, therefore, allow urban planners to better foresee the consequences of their actions. Even so, rather than finding the optimal solution to a spatial planning problem, a focus on the planning process allows planners to find either a set of solutions that are most achievable or the way an optimal solution is best achieved.

In this paper we propose the development of a Planning Support System (PSS), that will help planners to understand, to evaluate and to steer the urban planning process. In section 2 of the paper we discuss the objectives of the research project, which are the development of a PSS, the integration of the planning process in urban development modelling and the adaptation of the PSS to the planning systems of France, England and the Netherlands. Next, section 3 introduces the structure of the proposed PSS and describes the different layers of the PSS. Thereafter, section 4 gives a comparison of the planning systems of France, England and the Netherlands. Finally, the findings of this paper are discussed in the fifth section.

2. RESEARCH OBJECTIVES

In short the objective of the research presented here, which is a PhD project at the University of Franche-Comté, is the development of a PSS that evaluates the functioning of the urban planning process itself rather than evaluating an urban planning solutions that the same planning process might produce.

2.1 Construction of a new type of Planning Support System

Urban planning and design supposes to take into account numerous conflicting phenomena that occur at several interacting scales. Considering such complexity, spatial decision support systems (SDSS) or planning support systems (PPS) can help urban planners and designers to achieve their task. A decision support system (DSS) can be defined as a computer program that assists individuals or groups of individuals in their decision process, supports rather than replaces judgements of individuals, and improves the effectiveness rather than the efficiency of a decision process (Uran and Janssen, 2003) quoting Janssen (1992). A SDSS is used to support decision processes where the spatial aspect of a problem plays a decisive role (Uran and Janssen, 2003). SDSS are close to PSS. But PSS specifically support the whole of or some part of a unique professional planning task whereas SDSS can be regarded as systems designed specifically to support a decision research process for complex spatial problems (Geertman and Stillwell, 2004).
More precisely, Klosterman (2001) defines planning support systems as "*all current and future technologies useful for planning*", but stresses however, that this concerns only the computer hardware, software and related information used specifically for planning tasks. Another definition comes from Geertman and Stillwell (2002), who define PSS as "*a subset of geotechnology-related instruments that incorporate a suite of components (theories, data, information, knowledge, methods, tools) that collectively support all of or some part of a unique planning task*". A planning support system provides integrated environments, which are usually based on multiple technologies, with a common interface. Hence, Geertman and Stillwell tell us that a PSS consist of several components: on the one hand are information and data; on the other hand, are methods, theories and knowledge. A common interface makes these components accessible for urban planners. Moreover, both planning support systems and spatial decision support systems often aim to provide insight into complex spatial information, using geographical information system (GIS).
Finally, the difference between PSS and SDSS lies mainly in the application of these systems, which explains that, for the purpose of this paper, we consider them both interchangeable.

Our research focusses on the development of a PSS that is especially equipped to provide urban planners with support on urban development at the regional or agglomeration scale. There exist many examples of similar SDSS and PSS in the literature, although all with very different objectives. A common objective for a planning support system is the generation of one or more solutions to a spatial planning problem. For example, Chang et al. (2008) present an integrated approach to construct a spatial decision support system (SDSS) for the selection of landfill sites for Harlingen, Texas USA. Saarloos et al. (2003, 2005) have developed a multi-agent simulation

model which represented a planning team. The model provides the urban planner with several alternative solutions to a spatial planning problem. Similarly, Zamenopoulos and Alexiou (2003) have designed a system, where agents act as a substitute for the experts who are missing from the planning team.
Other SDSS and PSS are designed to evaluate current and future land-use arrangement. Carsjens and Ligtenberg (2007) have introduced STEPP (Strategic Tool for integrating Environmental aspects in Planning Procedures), which offers an analytical as well as a design component, to enable the design of new spatial arrangements and the assessment of the environmental implications of the designed land use arrangement. Matthews et al. (1999) propose to extend a DSS with a land use planning tool which assists the land manager to explore options, to assess potential impacts, to experiment with alternative land use strategies and ultimately to discover new knowledge. MacDonald (1996) developed a SDSS which enables planners to develop and to evaluate solid waste planning scenarios.
A third type of PSS and SDSS is not only able to find a solution for spatial planning problem but can also facilitate the evaluation of the provided solution. Arentze and Timmermans (2000) have developed *Location Planner* with retail planning problems in mind. The objective of Location Planner is to support both the intuitive mode, the evaluation of planned or anticipated developments, and a goal-seeking mode. *MedAction* addresses the political issues of land degradation and desertification, sustainable farming, and water resources (Van Delden et al., 2007). Among the objective of *MedAction* are the design of solutions to current and future problems and the evaluation of these solutions.

Since there exist already many systems that support urban planners in their decisions regarding the urban development, what is the need for the development of a new spatial decision support system? In other words, what lacks in the existing PSS and SDSS described in the literature?
All the PSS and SDSS described earlier look either at the current and possible future land use configuration, or at one or more solutions for a spatial planning problem. But, none of those systems consider the planning process and, in general, very few PSS and SDSS evaluate the planning process itself. However, an analysis of the planning process can provide useful information.
In particular, an analysis of the planning process can show whether a solution or a plan proposed for a spatial planning problem can be achieved under current circumstances. For example, when a planning agency desires to develop a new housing estate, the analysis of the planning process might show that the parties involved in the plan cannot acquire the necessary terrain.
Similarly, the planning analysis provides additional criteria for the evaluation of solutions to a spatial planning problem. For example, for the development of a new housing estate, a planning agency can propose high quality social housing and abundant public and commercial services. However, if, considering the complete planning process, it appears that developers have little interest in the development of such a housing estate, which eventually leads to a development of a poor quality, a second best solution, more in the interest of developers, might at the end be a better solution than the original optimal solution.
Furthermore, an analysis of the planning process can show that a change in the planning strategies increases the chances of a successful realisation of a proposed development. For example, a proposed renewal of the city centre, or part of it, through brownfield development, appears, after an evaluation of the planning process to have a higher chance of success when the planning agency in question cooperates with neighbouring municipalities, and better coordinate and pace their development proposals.
Finally, the analysis of the planning process can show unexpected effects of proposed alternative developments. For example, in order to meet the demand for cheap houses, a planning agency has two alternatives for the development of a housing estate with houses for first-owners, a brownfield development and a greenfield development. An evaluation of the planning process shows that in the case of the brownfield development developers are only interested in building expensive houses, and that the greenfield development leads to strong opposition of interest groups.
The examples presented here show that the evaluation of the planning process provides additional criteria and helps choose between several optimal solutions. Also, it allows planners to determine which tool is best used to introduce an optimal solution.

This leads us to propose the construction of a SDSS, which enables the testing and evaluation of planning policies or strategies. Rather than creating or evaluating a planning solution, this new SDSS will evaluate planning policies and planning tools for their effectiveness at realising the planning objectives. The research project focuses at the simulation of the relationships between actors in the planning process and the relationships between the same actors and the spatial structure, our interest focuses especially at the influence of planning strategies and the use of planning tools on these relationships. The aim is to be able to investigate how a change in planning strategy or a change in the usage of planning tools changes the relationships between the actors in the planning process and therefore changes the urban development.
We chose to analyse and compare three planning systems: the planning systems of France, England and the

Netherlands. Such a comparison of three different planning systems provides three different planning strategies and usage of planning tools to base the simulation model on and to validate and calibrate the SDSS.

2.2 A multi-agent system for modelling actors behaviours

An important part of the development of the PSS is the simulation of the interaction between the actors, involved in the urban planning processes, using agent-based simulation (ABS) techniques. Here, we present a background on agent-based simulations and the major difference between the proposed simulation model and existing models.

Agent-based simulation (ABS) models emerged in the research of urban development, they, possibly in combination with cellular automata, are well suited for the simulation of urban processes at micro level (Benenson and Torrens, 2004). The design gives these models very useful characteristics (Parker et al., 2003). ABS models are capable of representing complex systems and are yet easily adapted to changing circumstances. They closely mimic the dynamic paths of the system and simulate and help explain emerging phenomena. Brown et al. (2004) indicate that ABS models simulate real world processes rather than produce results that can be fitted to empirical datasets.

ABS models, used in environmental modelling, originate from several disciplines and can be distinguished into two broad concepts (Hare and Deadman, 2004). Firstly, there is agent-based modelling (ABM), which originates from artificial life simulation and individual-based modelling, and refers to the simulation of large populations. Secondly, there is multi-agents simulation (MAS), which originates from multi-agent systems, and refers to distributed intelligence over a small number of agents. The important difference here, besides the size of the agent population, is the communication between agents. In agent-based modelling interactions between agents are modelled as adaptation whereas in multi-agents simulations the interactions between agents are described as cooperation.

Agent-based modelling is often used for the development of simulations of urban processes. ABM allows the researcher to simulate urban development by modelling behaviour of individuals. For example, ABM is used to model the relationship between decisions of individuals or individual households and urban sprawl (Badariotti and Weber, 2002; Brown and Robinson, 2006; Li and Liu, 2007; Loibl and Toetzer, 2003). Another example is the simulation of migration of individuals or households in the urban landscape, which can explain the distribution of social classes (Benenson, 1999; Omer, 1999) or the simulation of rural-urban migration (Espindola et al., 2006; Silveira et al., 2006). ABM is also used to test urban designs and the effect it has on the behaviour of individuals (Dijkstra and Timmermans, 2002).

However, for the development of a simulation of the interactions between the actors in the planning process a MAS seems more suitable. So far, only a few models have been developed that incorporate urban planning or government decision making and can be seen as a multi-agent simulation. Ligtenberg et al. (2001; 2004) built and tested a multi-agent simulation of the urban planning process. Agents represent a local government, an environmental interest group and an agricultural interest group. The agents need to allocate 200 ha for housing through negotiation. Ligtenberg and co-authors tested three scenarios of decision making: voting, weighted voting and consultation. Liu and Andersson (2004) have built a multi-agent model, in which the agents represent residents, urban developers and the government. In the model, residents demand housing to be built at a certain location, developers will build housing on that location if doing so seems profitable and request permission, and the government permits the construction of housing if it fits in the urban development plan or many similar requests are made. Ferrand (1996) simulates spatial negotiations between actors over possible solutions for a spatial planning problem.

The few models, that have been developed to either simulate urban planning or integrate the behaviour of planning agencies, do not suffice for the simulation of the actions and interactions in the urban planning process. The actions and interactions can be split into types. On the one hand there is the plan generation; the creation of plans and policies that describe which land use configuration best solves current and future land use problems and the changes that need to take place. On the other hand there is the process of development control or management, when the planning agency stimulate, initiate and execute the activities that contribute to the development according the plan, and try to avoid activities that are not desired.

None of the models discussed above fully simulate both the planning process and the development control process, as needed in the PSS. Hence, we aim to develop a new MAS for the simulation of urban planning processes.

2.3 Three planning systems considered

An important part of this research is the analysis and comparison of the planning systems of France, England and the Netherlands. The analysis and comparison function as a base for the development of the PSS and the multi-agent simulation model, by providing the necessary detail needed for the PSS to run realistically.

The analysis of three planning systems helps improve the quality of the final PSS. Building a simulation model based on three planning systems enables a more detailed way of thinking. The comparison of the three planning systems creates a focus on the similarities and differences and automatically creates a focus on the necessary details. Furthermore, cities in France, England and the Netherlands have similar problems concerning urban planning and urban development, but the planning agencies respond in a different manner. An analysis of the differences in response by planning agencies enables the creation of a bandwidth for realistic availability and usage of planning instruments.

Urban regions from France, England and the Netherlands will function as case studies for the validation and calibration of the PSS. Picking the urban regions from three different countries gives the possibility to compare three different planning strategies on a more or less similar situation.

The extraction of details and the availability of case studies makes the analysis of the three planning systems an important part of the research objective.

3. STRUCTURE OF THE PROPOSED SDSS

The proposed SDSS is built up in three interacting layers, which are presented in Figure 1. The multi-agent simulation of the action and interactions of the actors in the urban planning and development process has the most interest in our research.

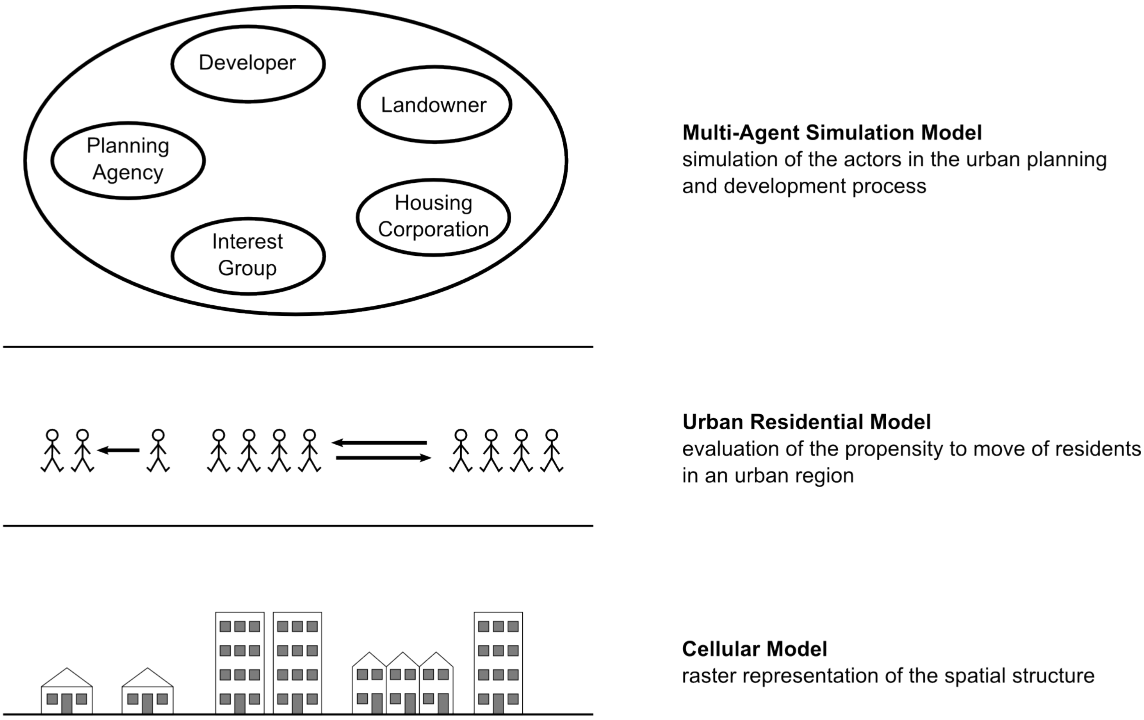

Figure 1: *Layer structure of the proposed Planning Support System.*

3.1 Layers of the SDSS

The structure of the SDSS is based on the processes that lead from the need for a government to plan and manage urban development and the actual urban development. The three layers in the proposed PSS each group a distinct set of actors or elements who play a key role in the urban planning and development.

In the first layer, a cellular model represents the spatial structure. From this model the spatial quality of an urban region is extracted by parameters like, building density, housing quality and economic values of the parcels. The cellular model simulates the change of the spatial structure caused by autonomic processes and the actions of actors like developers and housing corporations. Furthermore, the cellular model simulates the effect of residential occupation on the spatial structure and the spatial quality.

The second layer, the urban residential layer, represents some aspects of the urban dynamics that have a major influence on the urban planning and the urban development. Here we use an urban residential model, which evaluates the propensity to move of the urban residents in a search for a residence with the desired quality. As the migration of residents depends on the spatial structure and the spatial quality, the outcome of the urban residential model depends on the outcome received from the cellular model.

The third layer simulates the behaviour of actors who are responsible for the urban planning and development. For this layer we will develop a multi-agent simulation model that represents those actors and their actions and interactions. The aim is to create a model that accurately simulates the process of urban planning and development. The model simulates the creation of planning policies by planning agencies and the related interactions between planning agencies and actors, like interest groups, who have an interest in the planning process. Furthermore, the model simulates the urban development initiated by actors, most importantly developers and corporations and the development control conducted by planning agencies. The MAS model can change the cellular model, simulating the change of the spatial structure, and the simulations within the model are influenced by the outcomes it receives from the cellular model and the residential model.

3.2 Multi-Agent Simulation Model

The agents from the MAS model represent the actors involved in the urban planning and development process. Therefore, the decision rules and interaction rules of the agents are derived from the behaviour of their real-world counterparts. In the urban planning process and the urban development control process, four types of actors are relevant: planning agencies, developers and corporations, landowners, and interest groups.

The main activities of planning agencies are the definition of a spatial plan or spatial policy for the urban development, and the management of the urban development. These will also be the main activities of the agents representing the planning agencies. The agents decisions and actions are guided by the utility function, which the agent bases on information it receives from other agents, the residential model and the cellular model.
Developers and housing corporations initiate and conduct most of the urban developments. The agents, that represent these actors, will be able to change parameters in the cellular model, representing change of the spatial structure. Developers and housing corporations need authorisation by a planning agency, before they can construct new housing or any other change of the spatial structure. Similarly, the developer agent needs authorisation from the planning agency agent.
In principle, every actor in the urban planning and development process can own land and therefore be a landowner. The role of the landowner is quite important in the urban planning and development, since the landowner of a terrain determines the development of that terrain. In the model, developer agents aim to buy cells of the cellular model the agents want to develop. Other agents can use landownership as a means to influence spatial development.
Interest groups scrutinise and criticise the urban developments. They are participants in the urban planning process; they attempt to influence the final outcome, hence the spatial plan or policy, of that process through consultations, lobby and protest. In the MAS model, interest group agents negotiate with planning agency agents over the content of the spatial policy.

Actors depend on each other to achieve their objectives. Here are some examples of the relationships that need to be modelled in the MAS model: planning agencies and interest groups have preferences towards the urban development, but can take no or limited initiative in the urban development; developers and corporations can initiate urban development, but need approval by one or more planning agencies; and the rules of democracy forces planning agencies to listen to interest groups. The relationships between the agents need to be adapted to the simulated planning system, the same goes for the agents' utility functions and decision rules.

4. COMPARING THREE PLANNING SYSTEMS

The previous sections briefly mentioned the differences between the planning systems of France, England and the Netherlands and how these differences influence model design. We choose to compare the planning systems of these countries for our research, since they are all European countries with similar objectives concerning urban development. Although the objectives are the same, however, the means and the policies to achieve these objectives are very different.

In all three countries local planning agencies create some sort of plan or policy, that sets out the objectives for the urban development, however the format of this plan differs much.
The English planning system is a discretionary system, here the content of urban plans is defined globally. For the decision to issue a building permit planners can use many different arguments, and their decision can differ

from the original plan. On the contrary, France and the Netherlands both have regulatory planning systems, where planners have to issue building permits solely based on the land use plan (Booth, 1996).
As a consequence,the creation of the plan is a more important process in France and the Netherlands than the definition of spatial policies in England. Furthermore, for British planning agencies it is much easier to consider recently changed objectives in building permit applications as opposed to France and the Netherlands, where it takes much longer to adapt plans to changed demands and objectives.
The flexibility, at which a planning agency can consider new demands and objectives at the application of a building permit, effects how quick new objectives can lead to a given urban development.

For the urban development, planning agencies depend on market forces. Developers often initiate urban development but the extent of the influence of market forces may vary considerably.
In the Netherlands, the planning agencies determine the details of the physical plan in extensive consultation with private bodies. In England, on the contrary, the planning agencies only determine a broad framework and the developers and landowners fill in the details, under firm control by the planning agencies (Larsson, 2006). Consequently, a Dutch planning agency has more influence on the change of the spatial structure, but also the risks that Dutch planning agencies need to take are much higher. As a result the choice for a certain planning policy effects the final details of the change of the spatial structure.

The French, English and Dutch planning agencies not all have the same tools available for the urban planning an development control. For example there is a difference in how planning agencies finance works of public interest. In both France and England, planning agencies have an instrument to retrieve the money or other means from developers to finance constructions of public interests: In England the dedicated planning tool is the Section 106 (Cullingworth and Nadin, 2006) and in France the planning tool is the *Zone d'Aménagement Concerté* (ZAC) (Merlin, 2007). Planning agencies in the Netherlands do not have such an instrument (Needham, 2007).
Therefore, Dutch planning agencies need to find other means to actively generate money to finance constructions of public interest. This changes the role of Dutch planning agencies in the urban development in comparison to the role of French and English planning agencies.

Differences in the availability or usage of planning tools influences the extent to which a planning agency can realise its objectives. When a planning agency chooses not to use a planning tool or the tool is simply not available, the planning agency looses influence on the urban development or needs to find other ways to influence the development, often implying a higher risk for the planning agency.

5. DISCUSSION

In this paper we described a research project that aims to develop a planning support system. The objective of the proposed PSS is to aid urban planners in their planning decision by analysing and evaluating the planning process. The analysis of the planning process provides additional criteria for the evaluation of possible solutions for a spatial planning problem or indicates how a possible solution is better realised with a change in planning policy.
The PSS will consist of three layers: a cellular model representing the spatial structure; a residential model, and multi-agent simulation model of the urban planning and development process. The latter will be developed as part of the research project and will integrate both the plan generation process and the development control process. The proposed MAS model simulates the behaviour of actors in the urban planning process, like planning agencies, developers and housing corporations, landowners, and interest groups. The basis for the development of the MAS model is a comparison of the planning systems of France, England and the Netherlands, which provides examples of different planning strategies and different usage of planning tools.
With the development of a new PSS, we aim to provide a tool that leads to new insights in the field of urban planning and urban development.

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