Flexible Support for Spatial Decision-Making

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Abstract

Decision makers perceive the decision-making processes for solving complex spatial problems as unsatisfactory and lacking in generality. Current Spatial Decision Support Systems (SDSS) fulfil their specific objectives, but fail to address many of the requirements for effective spatial problem solving, as they are inflexible, complex to use and often domain-specific. As technology progresses, there is an increasing opportunity for the use of SDSS in a number of domains. Flexible support for spatial decision-making to solve complex, semi-structured or unstructured spatial problems can offer advantages to individuals and organisations.

This research attempts to overcome problems identified in the fields of spatial decision-making and SDSS. It synthesises ideas, frameworks and architectures from Geographic Information Systems (GIS), Decision Support Systems (DSS) and SDSS. Concepts from spatial modelling, model and scenario life cycle management, knowledge management and Multi-Criteria Decision-Making (MCDM) methodology are explored and leveraged in the implementation of a Flexible Spatial Decision Support System (FSDSS) using object-oriented concepts and technologies.

As part of the research, we proposed a generic spatial decision-making process, developed a domain-independent FSDSS framework and architecture to support this process. We also implemented a prototypical FSDSS that acts as a proof of concept for the spatial decision-making process, FSDSS framework and architecture.

1 Introduction

Spatial Decision-Making (SDM) is an important aspect of our lives and critical for business. SDM focus on the spatial problems that are either dependent or influenced by geographical information. Moloney, Lea, and Kowalchek (1993) observe that about ninety percent of business information is geographically related and covers a wide diverse domains e.g. resource management, environmental modelling, transportation planning and geo-marketing. Spatial problems are normally categorised into allocation, location, routing and layout problems based on their geographical features. To support SDM, a variety of systems have been developed; these include Geographic Information Systems (GIS) and Spatial Decision Support Systems (SDSS). As the extensions of Decision Support Systems (DSS), Peterson (1998) defines SDSS as a interactive and computer-based systems designed to support a user or a group of users in achieving higher effectiveness for solving semi-structured or non-structured spatial decision problems.

Though significant progress has been made in the context of decision-making and decision support systems, there has not been sufficient emphasis on SDM nor on SDSS. Decision makers often perceive the decision-making process adopted to solve complex multi-dimensional spatial problems as unsatisfactory. Decision makers have been using the decision-making frameworks and processes for many years, but the general approaches proposed by Simon (1960) and Mintzberg, Raisinghani and Theoret (1976) were not particularly developed for solving spatial problems, rather they provide a guideline for development of spatial decision-making processes. Though Malczewski (1998) has proposed a multi-criteria decision-making framework, the implementation of the process has not been fully explored in the spatial context. A generic process to guide decision makers to solve spatial problems is lacking. Decision makers have to rely on their own processes and experience for spatial decision-making. On the other hand, existing GIS, DSS and SDSS that support decision makers have their limitations in solving spatial problems. GIS do well in managing spatial data, but lack flexible modelling capacity. DSS are typically used in the non-spatial domain. SDSS encompass spatial analytical techniques inherited from DSS and spatial modelling and various spatial input and output mechanisms provided by GIS to support decision makers to make well-informed decisions based on complex spatial tasks. Densham (1991) argues that SDSS should facilitate a number of functions such as inputting of spatial data, model based analysis and a powerful visual presentation. The investigation on SDSS frameworks and architectures lead us to conclude that current approaches fulfil their specific objectives, but fail to address many of the requirements of a generic, flexible, and easy-to-use SDSS. At this point, SDSS remain a conceptual framework rather than an implemented strategy, as many strategic requirements of SDSS are not implemented properly. Their capability to solve complex multi-dimensional spatial problems is very limited.

To overcome these problems, we first propose a spatial decision-making process, and then develop a Flexible SDSS (FSDSS) framework and architecture to support this process. We also implement a prototypical FSDSS that acts as a proof-of-concept for these proposals. In the following sections, we describe the spatial decision-making process, the FSDSS framework, architecture and implementation.

2 Spatial Decision-Making Process

Malczewski (1997) identifies complexity, alternatives and multi-criteria characteristics as key features of a spatial problem. Spatial problems are complex because they are semi-structured or ill defined in the sense that the goals and objectives are not completely defined. Spatial problems are multi-dimensional and often related to non-spatial information. Each spatial problem can have a large number of decision alternative solutions. These alternative solutions to the spatial decision problems are normally characterised by multiple criteria upon which they are judged.

As non-spatial aspects and spatial aspects can be coexistent in a spatial problem, we need to consider both aspects at the same time. It is difficult to model a complex spatial problem in a single step, but it is possible to model one aspect of a complex problem at a time e.g. create a spatial model to deal with spatial aspects, and a non-spatial model that caters for non-spatial aspects of the problem and then integrate them together.

Spatial modelling technique is used for finding relationships among geographic features and helps decision makers to address the spatial problem clearly and logically. A spatial model contains spatial parameters that refer to the geographical features of a spatial problem. Vector-based spatial data can be categorised into three major groups i.e. spatial objects, spatial layers and spatial themes. A spatial object represents a single spatial item e.g. a point, a line or a polygon. A spatial layer contains a collection of spatial objects similar in nature and every spatial object belongs to a certain layer. A spatial theme comprises a number of spatial objects and/or spatial layers that represent a particular meaning to a particular spatial problem. Every vector data is linked to non-spatial domain data through the spatial reference system. e.g. a point is associated with a business or residential location, a line represents a running path. Each aspect of a spatial problem can be modelled in one layer. These layers are then integrated into a complex model that represents all aspects of the problem.

We propose a spatial decision-making process (Figure 1) by synthesising ideas of decision-making processes (Simon, 1960; Mintzberg et al., 1976) as well as multi-criteria decision-making (Malczewski, 1998).

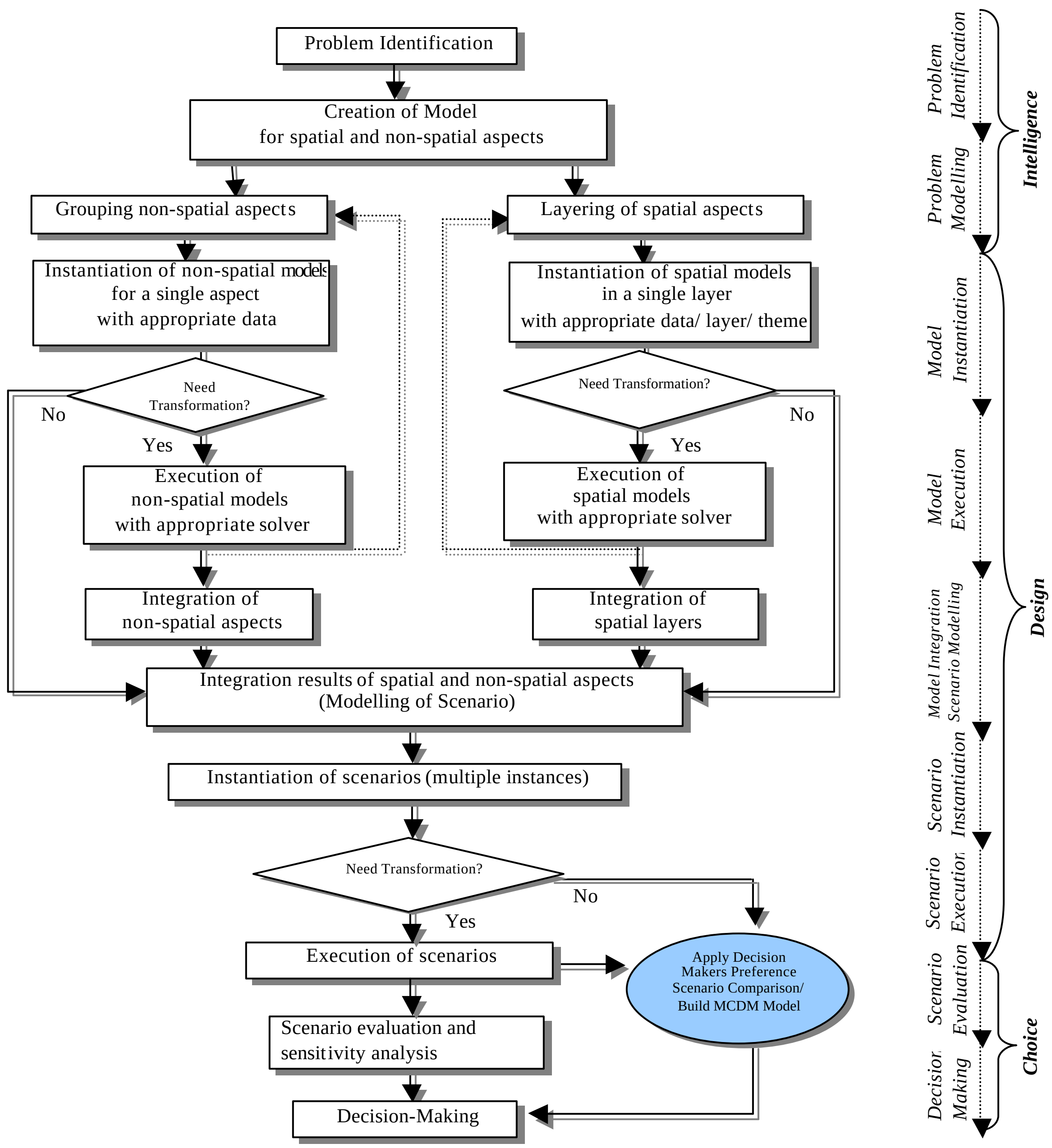


Figure 1. Spatial Decision-Making Process

The process contains nine specific steps, namely, problem identification, problem modelling, model instantiation, model execution, model integration or scenario modelling, scenario instantiation, scenario execution, scenario evaluation and final decision-making.

The decision-making process begins with the recognition of a real world problem that involves searching the decision environment and identifying comprehensive objectives that reflect all concerns relevant to a decision problem. The problem is then put into to a model by specifying the relevant attributes and behaviours. The parameters in a model structure are instantiated with appropriate data. Decision makers select a solver for execution of a model instance and generate a complex result i.e. the scenario. The process is iterative in nature so that multiple scenarios instances can be generated using the same scenario structures. The scenario integration process enables the decision maker to combine both spatial and non-spatial scenarios to create a complex multi-criteria spatial scenario that addresses all the requirements of a complex spatial problem. When required, the instantiated scenarios are called for execution using different solvers. The execution of the scenario allows the decision maker to further develop a more desirable solution to a particular problem. Scenario evaluation ranks the many alternative scenarios based on decision makers' preferences. Sensitivity analysis are employed as a means for achieving a deeper understanding of the structure of the problem by changing the inputs e.g. data, solver or evaluation model. This helps to learn how the various decision elements interact and allows the decision makers to determine the best solution. In completing of the above processes, the best-evaluated scenario is selected. As there is no restriction on how the user chooses to solve a problem, decision makers can select the phases to follow based on the nature of the specific problem and their specific purposes.

3 The FSDSS Framework

We propose a flexible spatial decision support system framework (Figure 2) to support the decision-making process and overcome the problems identified earlier. The FSDSS framework is comprised of six major DSS objects or components namely, *data*, *models*, *solvers*, *visualisations*, *scenario* and *knowledge*. These objects are stored in the *object repository* independently, and they communicate through the *kernel*, which is the programmatic engine that makes the system run. The framework accommodates spatial data (spatial objects, layers and themes) and non-spatial data. It contains both spatial and non-spatial models, solvers, scenarios and visualisations. The knowledge is the output of the decision-making process and can be stored in the system for future reference. The decision maker interacts with the system through the *user interface*. Different data, model and solver can be selected from the object repository and mapped together to generate a scenario, or a specific decision support system that is tailored for a particular problem domain. This framework allows generating multiple scenarios at one time and stores them in the scenario pool. The framework supports the integration of several simple scenarios into a complex multi-attribute scenario that contains both spatial and non-spatial aspects through scenario integration process. Similarly, the knowledge can be stored in and retrieved from the knowledge pool.

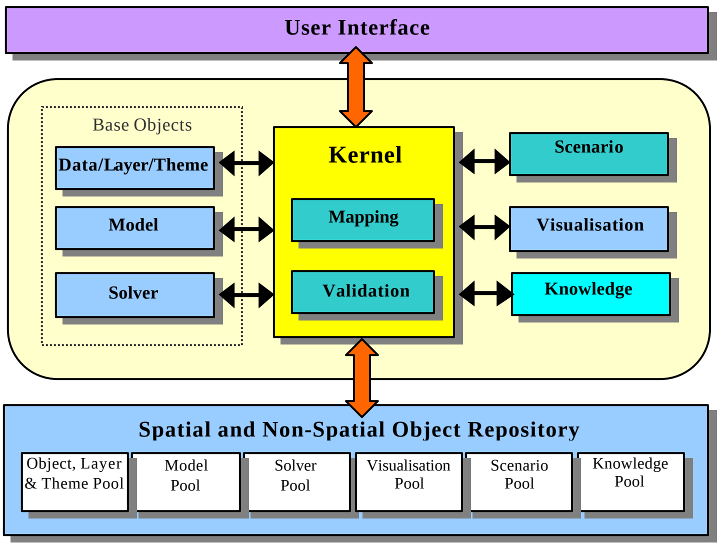


Figure 2. The FSDSS Framework

4 The FSDSS Architecture

We propose the FSDSS architecture that implements the framework and supports the proposed decision-making process, as shown in

Figure 3. The FSDSS architectural components are organised into five distinct layers, these are: *persistence layer*, *object services layer*, *DSS objects layer*, *integration layer*, and *presentation layer*. These layers and their components are briefly described as follows.

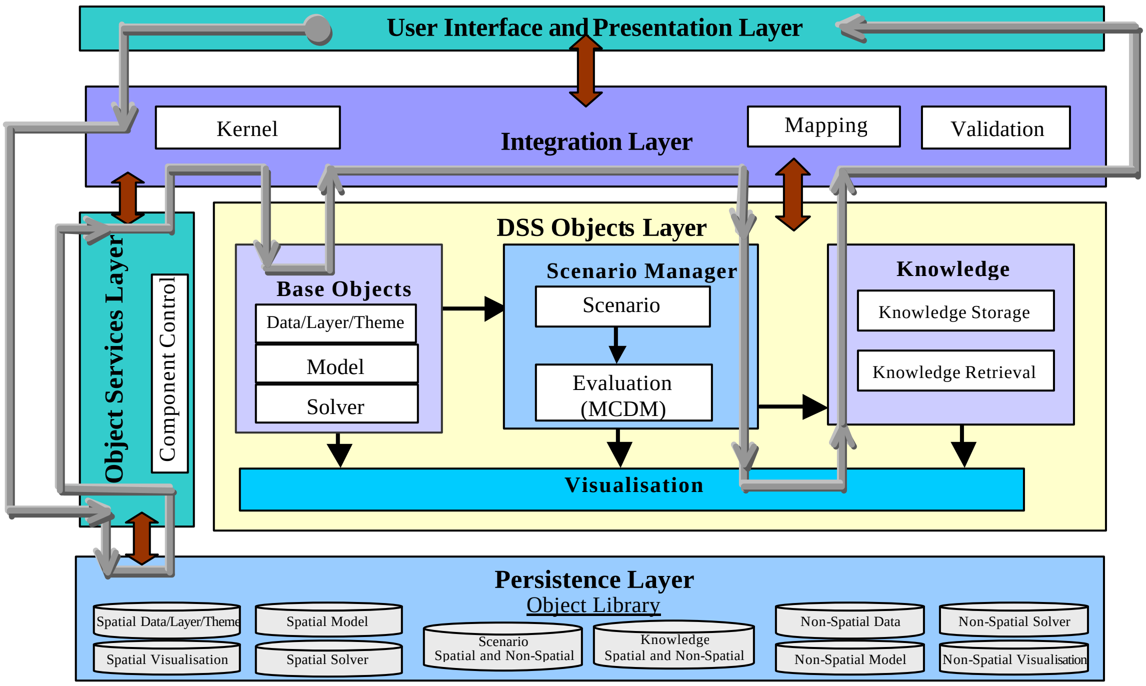


Figure 3. The FSDSS Architecture

Persistence Layer contains the object library used to store the system objects. This includes the storage of non-spatial data and the variety of spatial data (objects, layers, themes and map). It is also responsible for the storage of models, solvers, visualisations, scenarios and knowledge, either spatial or non-spatial in nature, using the object-oriented database management system.

Object services layer manages the system objects through the component control that contains several parameters and methods to coordinate the component pool and the application. It exports objects from the object library to the DSS objects layer, as well as importing the resulting scenarios and knowledge from the DSS objects layer back to the object library. It also facilitates dynamic creation, updating and deleting of the objects.

DSS objects layer supports independent development and use of the decision-support components including both spatial and non-spatial data, models, solvers and visualisations, for generating simple spatial and non-spatial scenarios. It is responsible for integrating scenarios to develop complex spatial scenarios. It supports the evaluation and ranking of multiple scenario instances using the evaluation model. This layer also facilitates the storage and reuse of the result from the decision-making process (the knowledge). It also provides graphical and map-based presentation of data, scenarios or knowledge. The data component includes both non-spatial and spatial data i.e. spatial objects, layers, themes and maps. The model can be of the primitive type or the compound type (Geoffrion, 1987). Primitive type model parameters are directly derived using base data type variables or executed model values of the base models. The compound type parameters inherit and/or aggregate the base models as well as adding some other user-defined parameters. The non-spatial model handles non-spatial problems or non-spatial aspects of a spatial problem. Spatial models cater for spatial problems. The evaluation model is made of different parameters as well as the weights for each of these model parameters. The FSDSS architecture contains the spatial-oriented solvers (contain a parameter of location) and generalised solvers that can be used for both spatial and non-spatial models. The scenario combines data, model, solver and other relevant information. The scenario structure and its multiple instances can be stored in the database. The FSDSS support three types of visualisation i.e. spatial, non-spatial and map-based visualisations. Spatial visualisation is used to represent spatial data, scenarios and knowledge. Non-spatial visualisation e.g. 3D graphs are used to present the output of analytical results. In addition to the general graphical report functions, the FSDSS visualisation is particularly important when used with maps. Different spatial objects, layers or themes are overlaid to generate a new map. The Knowledge component contains the final results of the decision-making process, including information about the decision maker, the rules applied, those alternative scenarios, the final decision as well as the system components used in reach the particular decision.

Integration layer contains the communication components i.e. kernel, mapping and validation components. In addition to activating and using the component functions, the kernel works as a user interface and is responsible for the communicating and integrating of system components. Mapping enables the model component to communicate with data and solver components properly through model-data and model-solver mapping processes. The model parameter or attributes are fixed; the user selects the data attributes for model-data mapping and selects the solver name and solver attributes for model-solver mapping. Validation enables proper communication between system components. It is responsible for checking the input data type to the model and to the solver during the mapping process. The model-data validation tests whether the data type of the model attributes is similar or convertible to the data attributes, while model-solver validation checks whether the data types of the attributes of the model instance are similar or convertible to data type of the solver attributes.

Presentation layer or user interface provides all the interactions between users and the system. It is designed to be technology independent so that this architecture can be implemented using other platforms. It provides a flexible environment where spatial and non-spatial components are used together to create the complex spatial results.

A simple decision-making flow in

Figure 3 illustrates how the FSDSS architecture supports the decision-making process. The decision maker initiates the decision-making process at the interface layer and interacts with the system through the kernel. The component control picks up the relevant components from the persistence layer. The selected data, models and solvers are combined in the integration layer to develop scenarios using the mapping component. The scenario manager manages these scenarios and the evaluated scenarios can be presented using the appropriate visualisation component. The output of the decision-making process can be saved in the persistence layer as knowledge. The interaction between the DSS objects layer and the persistence layer are bi-directional. On the one hand, the architecture allows flexible selection of objects from the object library. On the other hand, the executed result (e.g. scenarios generated) can be stored back to the object library.

5 The FSDSS Implementation

A prototypical FSDSS is implemented to prove the validity of the spatial decision-making processes as well as the FSDSS framework and architecture. Object-oriented concepts, object-oriented database management system and the object-oriented programming language are the tools and technologies used to develop the FSDSS prototype. Jade, as a complete and fully integrated object-oriented system (Post, 2000) is selected for developing the FSDSS prototype. The proposed spatial decision-making process and the implemented FSDSS are evaluated through five scenarios across spatial decision problem domains including location, allocation, routing and/or layout. Table 1 gives details of the type of spatial problems and the specific domains where we tested the prototype.

Spatial Problem	Application Domain	Example Spatial Problems
Allocation	Geo-Marketing	Find geographical distributions
Layout	Running	Design and select best running path
Routing	Delivery	Identify the fast route
Location	Housing	Search the most suitable house

Table 1. Spatial Problems and Implementation Domains

In the following section, we explore the interaction with the FSDSS in the context of the house location problem.

6 Sample Session with FSDSS

This section illustrates the implemented FSDSS to solving a location problem using the proposed spatial decision-making process. Each process step, as shown in Figure 1, is described in detail.

6.1 Step 1: Problem Identification

The problem presented in this session is to identify the optimal location of a property that maximises "return" i.e. the satisfaction level that is measured on the basis of the three criteria: (1) Quality criteria e.g. construction material, built year, size, number of rooms and functions (2) Economic criteria such as market price or rental cost; and (3) Location e.g. property accessibility, vicinity, and environmental conditions.

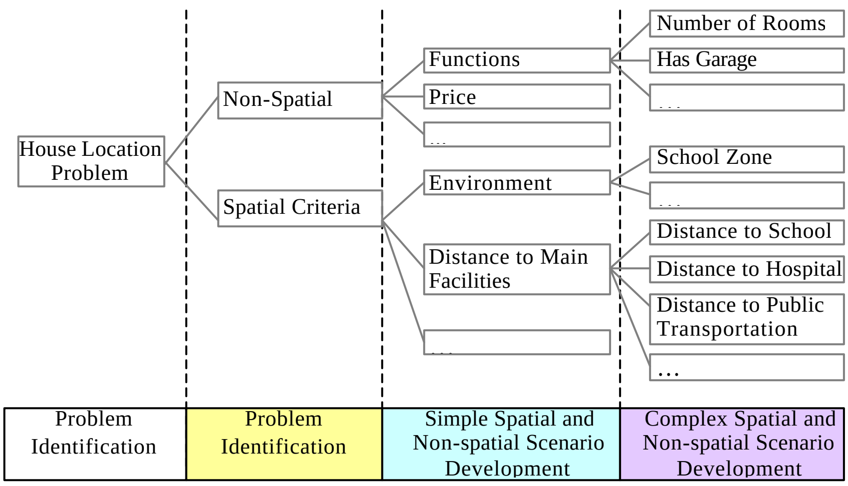


Figure 4. Value Tree of Location Problem

Some of these factors are difficult to evaluate or predict, as relative impacts for some of these factors on return remain unknown. It is hard to structure the problem in its entirety at one time i.e. precisely define and measure the objective for every possible solution. The value tree of the problem analysis is presented in Figure 4. In the next step, the decision maker models this problem using the proposed modelling approach by separating the spatial and non-spatial aspects of a complex spatial problem.

6.2 Step 2: Problem Modelling

The problem modelling involves both spatial and non-spatial aspects. *Quality* and *economic* are non-spatial in nature whereas *accessibility* criteria are of a spatial nature. On the non-spatial side, cost and quality of the property can be analysed using non-spatial models and solvers. The spatial aspect of the problem focuses on the location of the property, as it is an important criterion when people rent or buy a house. Location is a complex criterion that has multiple spatial dimensions e.g. environment and distance to main facilities. These spatial dimensions need to be analysed one by one in order to find a best location. In this illustration, the decision maker first broadly selects a target area then carries out accessibility analysis. The analysis involves both the non-spatial model and spatial model and it uses both non-spatial solvers and spatial solvers. The problem is solved iteratively by firstly, considering spatial and non-spatial data, models, solvers and scenarios; secondly, applying spatial and non-spatial criteria and finally, using the goal- seeking and sensitivity analysis.

6.3 Step 3 and 4: Scenario Development

The decision maker now needs to load relevant decision-making components. These include the property table and relevant map in which the properties are located, the various models, solvers and visualisations to be used for building the different scenarios. A simple non-spatial scenario and a simple spatial scenario are developed separately at first; they are then integrated into a combined scenario. These scenarios are then transformed into a complex multi-criteria scenario through a structural integration process. The scenario development process is illustrated as follows:

Simple Non-Spatial Scenarios The non-spatial scenario is created using the non-spatial *Filtering* model and the *Range* solver. In this example, we have selected the 3-bedroom flat with a price range between $300,000 to $400,000. Several properties are identified through this filtering process as shown in Figure 5. These stored in the database as *Scenario 1* (4 instances).

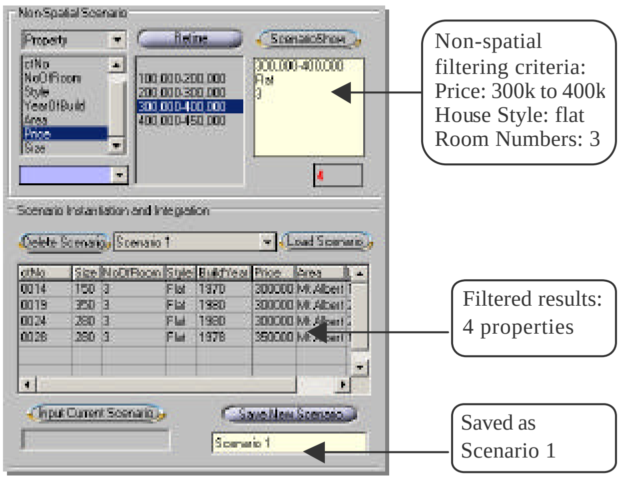


Figure 5. Simple Non-Spatial Scenario Creation

Simple Spatial Scenario The decision maker has selected a buffer zone (a 500-meter radius circle) around a particular location (e.g. x, y coordinates: 200,200). The filtering model is instantiated with the property data and executed using the *Distance* solver to find the properties

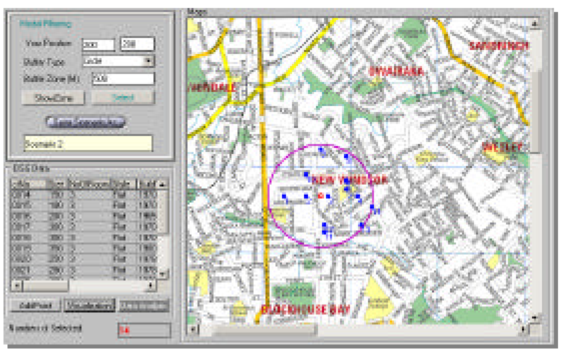


Figure 6.Simple Spatial Scenario Creation

within the defined circle. This process develops many scenario instances (as shown in Figure 6). These scenario instances are then stored in the database as *Scenario 2* (14 instances).

Combined Scenario (Pipelining Integration)

Pipelining integration of spatial and non-spatial scenarios can be done in two ways. The first way is to create non-spatial *Scenario 1* and then execute the geographical filtering model using spatial solvers e.g. *Distance* or *Point-in-Polygon* solver. The process is illustrated in Figure 7. During this integration process, the four non-spatial filtered scenario instances of *Scenario 1* as described earlier are supplied as input to the spatial *Filtering* model. The resulting scenario instances are stored as *Scenario 3* (3 instances).

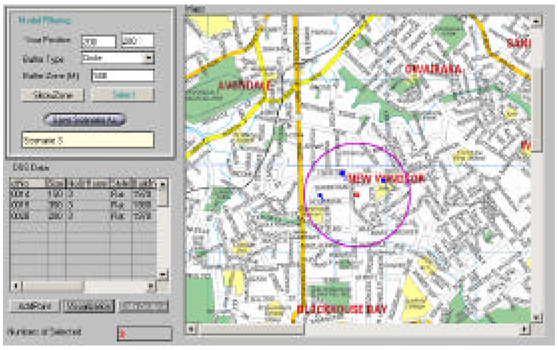
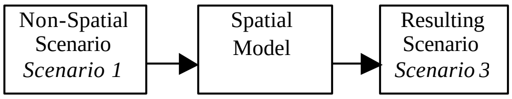


Figure 7. Integration of Non-spatial with Spatial Scenarios



The second way for integration of *Scenario 1* and *Scenario 2* is to supply spatial *Scenario 2* as input into the non-spatial filtering model and then apply the non-spatial *Range* solver for execution. The process develops three instances, as for the previous process, that are stored in the database as *Scenario 3* (3 instances). The second type of integration is illustrated in Figure 8.

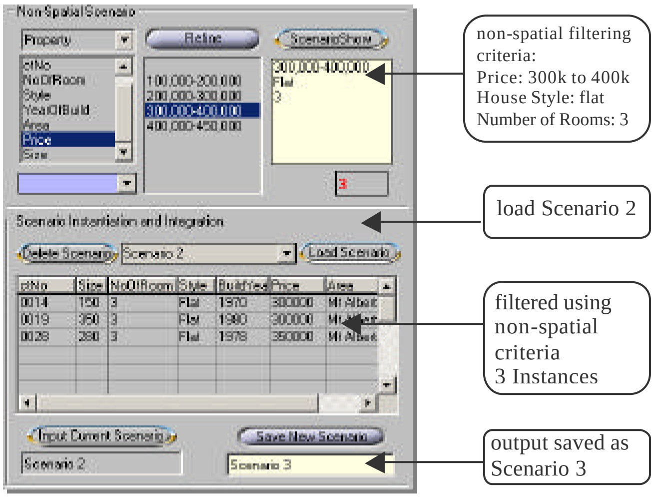
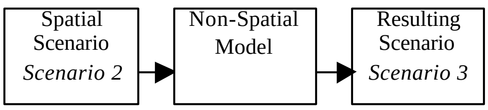


Figure 8. Integration of Spatial with Non-spatial Scenarios



The scenario pipelining integration process can take place bi-directionally, either from non-spatial to spatial or from spatial to non-spatial. The flexible use and integration of spatial and non-spatial models, solvers and scenarios is one of the most important features of FSDSS. The above process helps the decision maker to choose the properties that satisfy the non-spatial criteria e.g. quality, cost and the basic location requirement such as area. The following section illustrates another aspect of the location problem namely, accessibility analysis.

Complex Spatial Scenario (Structural Integration)

The previously created *Scenario 3* and its three instances are loaded from the scenario pool. Now, the decision maker focuses on distance to major facilities for accessibility analysis. The complex spatial scenario is generated using the property data, *Distance* model and *Distance* solver as shown in Figure 9.

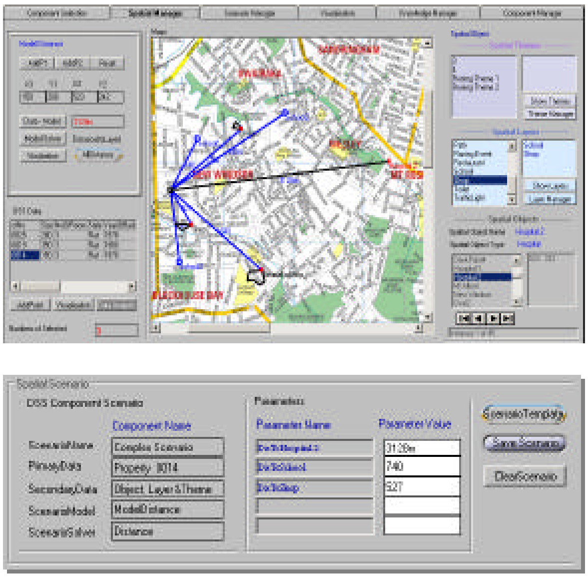


Figure 9. Multi-Attributes Spatial Scenario Development

The distance has multiple dimensions. It includes the distance from a particular spatial object (e.g. property 0014) to another object (e.g. hospital 2). The distance from one object to a spatial layer (e.g. school layer) returns multiple values, in this case the system returns the shortest distance from the target object to a single object (e.g. school 1) in that layer.

6.4 Step 5 and 6: Scenario Integration and Instantiation

The decision maker integrates the simple combined scenario (*Scenario 3*) structure with these newly developed distance parameters to develop a more complex scenario that contains all the criteria for the problem. The structural or permanent integration takes place in two steps. First, a bare scenario template is created as shown in Figure 10.

ctNo	Size	NoOfRoom	Style	BuildYear	Price	Area	Location	DisToHospital 2	DisToSchool	DisToShop

original parameters

new parameters

Figure 10. Scenario Template for Integration of Spatial and Non-Spatial Scenarios

The multiple scenario instances are created then using this template. The decision-making selects a scenario instance from *Scenario 3*, and calculates each of the distance parameters as shown in Figure 10. Once all the relevant distance values have been calculated, a scenario is then instantiated with these values. The process is iterative in nature until all scenario instances have been generated; these scenarios are shown in Figure 11. The scenario template and its multiple instances are stored in the database as *Complex Scenario* and they can be retrieved for further analysis or evaluation.

ctNo	Size	NoOfRoom	Style	BuildYear	Price	Area	Location	DisToHospital 2	DisToSchool	DisToShop
0014	150	3	Flat	1970	300000	Mt Albert	150,200	2860	406	685
0019	350	3	Flat	1980	300000	Mt Albert	235,220	2407	569	663
0014	150	3	Flat	1970	300000	Mt Albert	150,200	3128	740	527

Figure 11. Multi-Criteria Spatial Scenarios

The distance to the schools and shops are calculated on a spatial layer rather than a single spatial object, the system picks up the distance to the closest object in the layer for instantiation of the scenario parameter. The decision maker can select any spatial object, layer or theme for integration of scenarios using the spatial manager as shown in Figure 12.

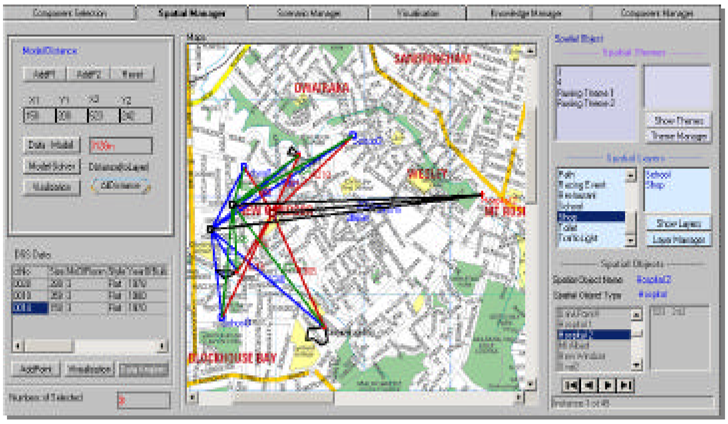


Figure 12. Multiple Spatial Scenario Generation

6.5 Step 7: Scenario Execution

Scenarios can be instantiated with the relevant data; model and a number of solvers can be applied for execution of the scenarios. The scenario can be executed in a simple process or using multiple steps. The integration of executed models (scenarios) is also the process of modelling the scenario itself. During the scenario execution process, one scenario is instantiated and executed using different solvers.

6.6 Step 8: Scenario Evaluation

FSDSS supports MCDM scenario evaluation process. The decision maker needs to build a MCDM evaluation model by specifying parameters and assigning weight to each of these parameters. The evaluation model is instantiated with alternative scenario instances. These scenarios are executed using the solver that is tightly coupled within the evaluation model. The results are then ranked for selection. The sequence of the steps taken in this process is shown in Figure 13.

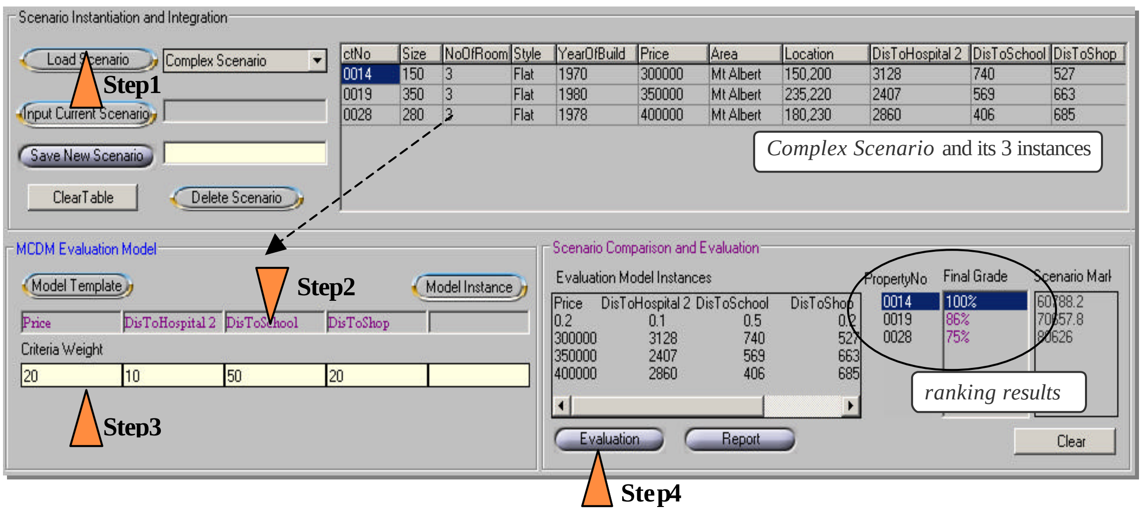


Figure 13. Multi-Criteria Scenario Evaluation

The decision maker selects the scenarios for evaluation to the scenario table as indicated in step 1. Then, an evaluation model is built by selecting the appropriate criteria from the input scenario. In step 3, the decision maker assigns a weight to each of the criteria. Step 4 evaluates the scenarios using the model template created in step 2 and step 3. The built-in solver not only calculates values according to the formula but also ranks these values. The highest value is given as 100% and other scenarios are calculated on a ratio basis by comparing the highest value.

6.7 Step 9: Decision-Making

As we can see from the results *property0014* is ranked highest. Furthermore, the decision maker can apply different evaluation models to explore the alternative scenarios by considering the uncertainty involved in the decision-making process. The uncertainty may be caused by the error in available information to the decision maker, or improper judgement regarding the relative importance of evaluation criteria. Some methods are more suitable in some situations, while others might be more suitable or accurate in other situations. Sensitivity analysis is employed as a means for achieving a deeper understanding of the structure of the problem. Sensitivity analysis is done through changing data, model, solver, scenario, and evaluation models. As we have noticed, *Property 0014* is much cheaper than *property0028,* as the decision maker has given 20% weight on the cost of the property. Therefore, the result might have a big effect on the property cost. The decision maker can change the weight to cost and then re-evaluate these scenarios based on the new created model. This process can be repeated until all the scenarios relevant to the decision maker are explored.

7 Conclusion

Decision makers perceive the decision-making processes for solving complex spatial problems as unsatisfactory and lacking in generality. Current SDSS fulfil their specific objectives, but fail to address many of the requirements for effective spatial problem-solving, as they are inflexible, complex to use, and often domain-specific. This research blends together several relevant disciplines in a unique way and attempts to overcome the problems identified in the fields of spatial decision-making and SDSS.

We proposed a spatial decision-making process. Within the context of spatial decision-making process, we have proposed a modelling approach by addressing the need of differentiating the spatial and non-spatial elements for multi-dimensional complex problem modelling. We then developed a FSDSS framework and architecture of FSDSS to support this process. We also implemented a prototypical FSDSS that acts as a proof-of-concept for the spatial decision-making process, FSDSS framework and architecture. The proposed spatial decision-making process and the implementation of FSDSS have been evaluated through a number of scenarios across diverse domains. The evaluation results indicate that the proposed spatial decision-making process is generic and it is effective in solving complex spatial problems in different domains.

8 References

Densham, P. J. (1991). “Spatial Decision Support Systems” in: Maguire, D.J., Goodchild, M.F. und Rhind, D.W. (Ed.): Geographical Information Systems: Principles and Applications. Longman, Burnt Mill (UK), pp. 403-412.

Geoffrion, A.M. (1987). “An Introduction to Structured Modelling”. Management Science 33(5): 547-588.

Malczewski, J. (1998). “Spatial Multi-Criteria Decision Analysis” in Thill, J-C (Ed.): Spatial Multi-Criteria Decision-making and Analysis: A Geographic Information Sciences Approach. Brookfield, Ashgate: pp 11-48.

Moloney, T., Lea A.C. and Kowalchek, C. (1993). Manufacturing and Packaged Goods in Profiting from a Geographical Information System, GIS World Books Inc, Fort Collins.

Peterson, K. (1998). “Development of Spatial Decision Support Systems for Residential Real Estate”. Journal of Housing Research 9(1): Fannie Mae Foundation.

Post, Elizabeth (2000). Jade for Developers, 2nd Edition. Auckland, NZ, Pearson Education.

Simon, H.A. (1960). The New Science of Management Decision. New York, Harper and Row.