MODELLING LOCATION-AWARE BEHAVIOUR IN WEB-GIS USING ASPECTS

Ana Oliveira[1], Matias Urbieta[2], João Araújo[1], Armanda Rodrigues[1]
Ana Moreira[1], Sílvia Gordillo[2] and Gustavo Rossi[2]
[1]*CITI/FCT Universidade Nova de Lisboa, Monte de Caparica, Portugal*

[2]*Lifia, Facultad de Informatica, UNLP, Argentina*

Keywords: Location-awareness, Aspect-oriented software development, Geographical information systems.

Abstract: Web-GIS applications evolve fast as new requirements emerge constantly. Some of these requirements, particularly those related with spatial behaviours, might crosscut previous core application requirements. Conventional modelling techniques, which ignore the effect of crosscutting concerns (such as tangling and scattered behaviours) affect negatively the modularity and thus compromise application maintenance. In this paper we present and aspect-oriented approach to model crosscutting concerns in Web-GIS applications, particularly those related with spatial features. The process introduced in this paper starts with the identification and specification of crosscutting concerns, followed by the composition of these concerns, using the MATA language.

1 INTRODUCTION

Nowadays, web applications are more volatile than ever due to new requirements that are either requested by service providers or even by final users. In particular Geographical Information Systems (*GIS*) also has to deal with the requirements volatility A reasonable way to deal with adding new requirements into an application is to keep in separate modules scattered behaviours by using aspect-oriented techniques (Filman et al., 2005).

Our goal is to use aspect-orientation to deal with GIS concerns in an oblivious fashion, modularizing tangled and scattered behaviour, known as *crosscutting concerns*. Concerns may be functional or non-functional properties that represent needs of the system. Crosscutting concerns are later composed, or weaved, in different points, or *joinpoints*, of the same or other applications. Typical crosscutting concerns arise when dealing with spatial data (e.g., user's location) in Web Software. Web-GIS applications tend to be complex as they combine the volatile nature of Web software with the inherent complexity of dealing with spatial data.

Location-aware behaviour, typical of Web-GIS, usually cuts across other application concerns, since it is likely to have an impact across different application features (Munnelly et al, 2007).

Therefore, this paper introduces an aspect-oriented approach to model common concerns in Web-GIS applications, specifically those related with spatial features. This approach is based on aspect-orientation (Filman et al, 2005) and uses the MATA language (Whittle and Jayaraman, 2007) to specify aspects. We will demonstrate how spatial behaviour can be isolated from other concerns to improve modularity in our application domain.

The rest of the paper is structured as follows. Section 2 presents a motivating example and describes the background of our work. Section 3 introduces our approach for modelling GIS using a running example. Section 7 presents related work. Finally, Section 8 draws some conclusions and describes future work.

2 CROSSCUTTING IN WEB GIS

A typical new requirement which may be added to a Web GIS application is the "indoor representation". Figure 2 shows a web application for a shopping centre that provides Indoor map support for presenting store locations. The application offers a "search function" to provide information about

Oliveira A., Urbieta M., Araújo J., Rodrigues A., Moreira A., Gordillo S. and Rossi G. (2009).
MODELLING LOCATION-AWARE BEHAVIOUR IN WEB-GIS USING ASPECTS.
In *Proceedings of the 11th International Conference on Enterprise Information Systems - Information Systems Analysis and Specification*, pages 416-419
DOI: 10.5220/0002018604160419

stores such as their address, their location inside the shopping centre (Indoor position) – using the map pointed with a dashed ellipse. This Figure also shows an Outdoor map, which indicates the location of the shopping centre in a global map. Both examples (Figure 1 and Figure 2) reveal how the same GIS requirements may be present in applications of different nature, contemplating many occurrences during one execution of the same application.

The inclusion of this new requirement (indoor representation) will create scattered and tangled concerns in the application among its core or base concerns. To make matters worse, adding other concerns increases the application complexity compromising its maintenance. (Section 5 describes how to deal with these new requirements in more detail).

Figure 1 illustrates how the introduction of new requirements might impact in the application's structure. This Figure shows a UML sequence diagram for "Show Store", showing information about a store. This is taken from the Web-GIS application Maps@Web It contains tangled behaviour as a consequence of composing several GIS requirements such as Indoor Representation, Location Sensing and Points of Interest. We can see that the behaviour of each requirement is scattered along the sequence diagram and crosscuts other behaviour. For example, Location-aware crosscuts Indoor and Outdoor representation, due to the current user position that can be either in a global map or into a specific building. Our goal is to propose an approach for isolating and then modelling these GIS concerns.

The concept of *aspect* was introduced by Aspect-Oriented Programming (AOP) to modularize concerns that could not be modularized using object-orientation (Filman et al, 2005). Concerns may be functional or non-functional properties that represent needs of the system. In other words, a *concern* comprises any coherent set of requirements, e.g., all requirements referring to a particular functionality (Baniassad et al, 2006). *Crosscutting concerns* are concerns that cut across other concerns, creating tangled and scattered representations of the program that are difficult to understand and maintain (Rashid et al, 2003). Aspect-Oriented Software Development (AOSD) (Filman et al, 2005) appeared to handle crosscutting concerns in all stages of the software lifecycle. The MATA aspect-oriented modelling tool is based on UML, allowing aspects composition using class diagrams, sequence diagrams, etc.

To specify an aspectual scenario in MATA, three stereotypes where created to define the composition

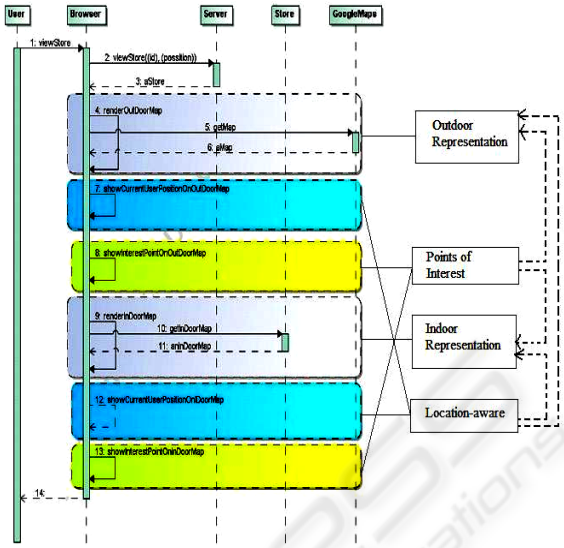

Figure 1: Sequence diagram with tangled behaviour due to crosscutting concerns.

rules: <<create>> (states that the element will be created in the base scenario), <<delete>> (states that the element will be deleted of the base scenario), <<context>> (states that the element will not be affected by the other two stereotypes).Variables in MATA are prefixed by a bar "|", meaning that "|X" will match to any class.

After specifying both kinds of scenarios, base and aspectual, a pattern matching is made between them. This means that the tool tries to establish a connection between elements of each scenario, always respecting the composition rules defined in the aspectual scenario. The resulting composed scenario describes, therefore, the behaviour of both scenarios, according to the rules defined.

GIS applications are usually modelled using simple approaches that are limited to the identification of requirements and system functionalities, ignoring crosscutting concerns modularization, as can be seen in (Longley et al, 2005).

The approach introduced in this paper aims at improving the modularization of GIS Web applications by modularizing typical GIS concerns. The starting point is the identification and specification of crosscutting concerns, which is followed by the composition of the concerns previously identified, using the MATA language.

3 MODELLING GIS CONCERNS WITH ASPECTS

Figure 2 defines a process for modelling spatial con-

cerns using aspects in Web-GIS applications. The process is divided into three main activities: Identification, Specification and Composition.

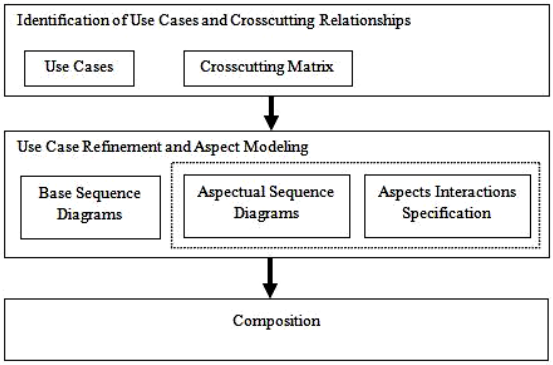

Figure 2: Process for modelling GIS concerns with aspects.

We will explain our approach using the GIS web application Maps@Web, which is a Web application providing a set of varied location-based services, including services related with Cinemas, Hotels, or Universities with the aim of helping users in their daily activities. For instance, if the user wants to go to the university and the cinema on the same evening, this application will calculate an appropriate path to access all these places.

To better demonstrate the contributions of our approach, let's add the new requirement "Indoor Representation". This requirement changes the user's application context, taking him to an indoor representation of space. Next we show how to apply the three activities of our approach.

Identification of Use Cases and Crosscutting Relationships. This designs the use cases and represents the relations among crosscutting use cases using the stereotypes <<include>> and <<extend>>, i.e., a use case that is included by several use cases or a use case that extends several ones is considered as crosscutting. In addition, we adopt a new stereotype, <<trigger>>, to be used when a use case activates one or more use cases. **F**igure 3 shows a partial use case diagram, with the use case "Show Service" and the crosscutting concerns "Change Scale" and "Context Switch". With the introduction of the Indoor Representation requirement, we now have two kinds of maps, Indoor Map and Outdoor Map. In this example, when we want to see any service, it starts with an outdoor representation of the service location. That is why the use case "Show Service" is connected with the concern "View Outdoor Map", with an <<include>> relationship. This last concern will be extended with "Change Scale" every time the map tool bar is changed. When the scale reaches the maximum zoom available, there will be a switch in the user's application context. We represent this relationship between "Change Scale" and "Context Switch" with an <<extend>> stereotype. When the scale reaches the maximum and the context changes, the "View Indoor Map" will be triggered.

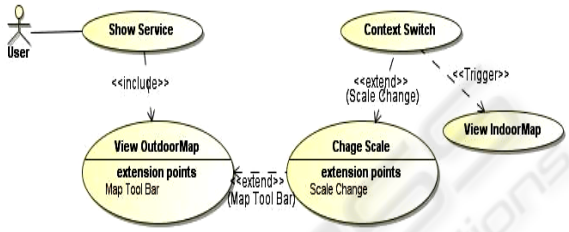

Figure 3: Partial Use Case Diagram for Show Service; use cases are enhanced with possible crosscutting concerns.

"Change Scale" and "Context Switch" are crosscutting concerns and they crosscut other use cases of the system (e.g. Edit Favourite Places, Search by Service) not shown here due to space limitations. They also interact with each other.

Use Case Refinement and Aspect Modelling. The second activity of the approach specifies the base scenarios (Figure 4) and the crosscutting concerns with sequence diagrams (Figure 5 and 6). Figure 4 illustrates the "Show Suggestion" use case, chosen by its importance to this example. Figure 5 shows the crosscutting concern "Change Scale" represented with the MATA sequence diagram. The first message in this sequence diagram matches with the same one in the base scenario. Figure 6 shows the crosscutting concern "Context Switch" that will be activated by the concern "Change Scale". The first message of the sequence diagram in Figure 6 matches with the equivalent one in the base scenario. In this particular case, the base scenario is the aspect "Change Scale". This sequence diagram shows that every time the user performs a change in the scale, the system will verify if a change in the spatial context is required. If this change is needed, the system accesses the information about the new context (in this case it is the indoor location). The "any" fragment allows the base scenario to continue its behaviour, with a sequence of messages.

Composition. It composes the aspectual scenarios with the base scenarios using the MATA language. The composition activity shows that the crosscutting concerns can be isolated in aspects and then composed into one or more base scenarios, without

changing the application execution. By isolating the crosscutting concerns, we promote modularization, reuse, and evolution possibilities of the application.

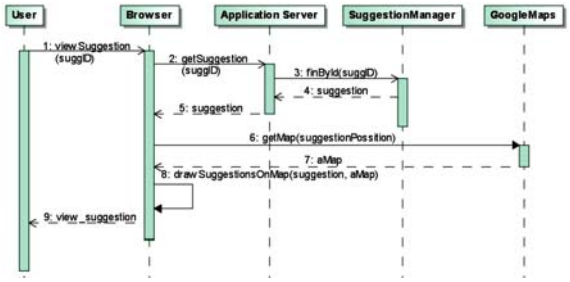

Figure 4: Base Scenario "Show Suggestion".

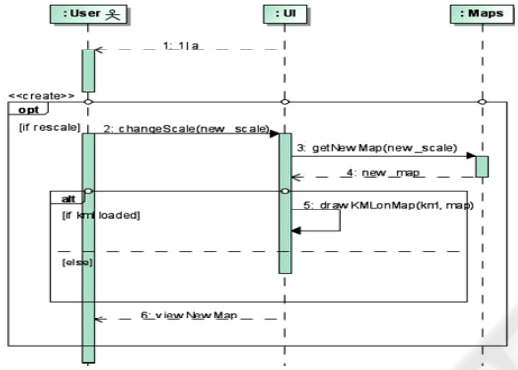

Figure 5: Aspectual Scenario "Change Scale".

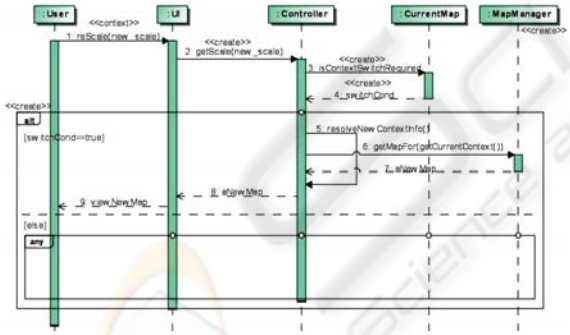

Figure 6: Aspectual Scenario "Context Switch".

4 RELATED WORK

The use of advanced separation of concerns techniques and particularly the use of aspects have been recently proposed for the development of complex Web applications, mainly to provide adaptation behaviours (Baumeister et al 2005).

Munnelly (Munnelly et al, 2007) presents an approach for modularizing context-aware systems by encapsulating different types of context using an aspect-oriented approach. While Munnelly divides the overall context space into eight sub-categories and proposes an aspect-oriented approach for the adaptation of the application to a specific context, our approach presents a process for modelling spatial concerns in a more abstract way.

In (Zipf and Merdes, 2003) the authors discuss the use of aspects in GIS applications. However, they only focus on the programming level, though their analysis of spatial concerns is similar to ours.

5 CONCLUSIONS AND FUTURE WORK

We have shown that in Web-GIS applications, always in constant change, it is crucial to modularize concerns to eliminate crosscutting of these concerns in the application models. Our view represents a step forward with respect to existing approaches in which the spatial concerns are mixed with other crosscutting application concerns.

Currently we are working on the identification and modelling of more typical and recurrent GIS concerns to obtain a catalogue which will let us get new applications by composition following the style shown in the paper. For the near future, we plan to address crosscutting at the user interface level .

REFERENCES

Baniassad, E., Clements, P., Araújo, J., Moreira, A., Rashid, A., Tekinerdogan, B. (2006). Discovering Early Aspects. *IEEE Software 23(1), pp 61 - 70* .

Baumeister, H., Knapp, A., Koch, N. And Zhang, G. (2005). Modelling Adaptivity with Aspects. *ICWE'05. Springer LNCS, Volume* 3579/2005.

Filman, R., Elrad, T., Clarke, S., Aksit, M. (2005). *Aspect-Oriented Software Development.* Addison-Wesley.

Longley, P., Goodchild, M., Maguire, D., Rhind, D. (2005). *Geographical Information Systems and Science.* WILEY.

Munelly, J., Fritsch, S.,Clarke, S. (2007). An Aspect-Oriented Approach to the Modularisation of Context. *5th IEEE International Conference on Pervasive Computing and Communications,USA.*

Rashid, A., Moreira, A.,Araújo, J. (2003). Modularisation and Composition of Aspectual Requirements. *2nd AOSD'03,* ACM.

Whittle, J., Jayaraman, P. (2007). Mata: A Tool for Aspect-Oriented Modelling based on Graph Transformations. *AOM Workshop at MODELS'07.*

Zipf, A., Merdes, M. (2003). Is aspect-orientation a new paradigm for GIS development?. *6th Agile Conference on Geographic Information Science, Lyon, 2003.*