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Perspectives in Conceptual Modeling

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Volume Editors

Jacky Akoka E-mail: Jacky.Akoka@int-evry.fr

Stephen W. Liddle E-mail: liddle@byu.edu

Il-Yeol Song E-mail: songiy@drexel.edu

Michela Bertolotto E-mail: michela.bertolotto@ucd.ie

Isabelle Comyn-Wattiau E-mail: isabelle.wattiau@cnam.fr

Samira Si-Saïd Cherfi E-mail: sisaid@cnam.fr

Willem-Jan van den Heuvel E-mail: W.J.A.M..vdnHeuvel@kub.nl

Bernhard Thalheim Thalheim@is.informatik.uni-kiel.de

Manuel Kolp E-mail: kolp@isys.ucl.ac.be

Paolo Bresciani E-mail: bresciani@itc.it

Juan Trujillo E-mail: jtrujillo@dlsi.ua.es

Christian Kop
Heinrich C. Mayr
E-mail: {christian.kop, heinrich.mayr}@ifit.uni-klu.ac.at

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Preface

We are pleased to present the proceedings of the workshops held in conjunction with ER 2005, the 24th International Conference on Conceptual Modeling.

The objective of these workshops was to extend the spectrum of the main conference by giving participants an opportunity to present and discuss emerging hot topics related to conceptual modeling and to add new perspectives to this key mechanism for understanding and representing organizations, including the new "virtual" e-environments and the information systems that support them.

To meet this objective, we selected 5 workshops:

- AOIS 2005: 7th International Bi-conference Workshop on Agent-Oriented Information Systems
- BP-UML 2005: 1st International Workshop on Best Practices of UML
- CoMoGIS 2005: 2nd International Workshop on Conceptual Modeling for Geographic Information Systems
- eCOMO 2005: 6th International Workshop on Conceptual Modeling Approaches for E-business
- QoIS 2005: 1st International Workshop on Quality of Information Systems

These 5 workshops attracted 18, 27, 31, 9, and 17 papers, respectively. Following the ER workshop philosophy, program committees selected contributions on the basis of strong peer reviews in order to maintain a high standard for accepted papers. The committees accepted 8, 9, 12, 4, and 7 papers, for acceptance rates of 44%, 33%, 39%, 44%, and 41%, respectively. In total, 40 workshop papers were selected out of 102 submissions with a weighted average acceptance rate of 40%.

Together with three invited main-conference and two invited workshop keynote speeches, a demo and poster session, and a concluding panel discussion, ER 2005 featured 14 technical conference sessions, 15 technical workshop sessions and 7 up-to-date tutorials presented by outstanding experts in their fields. We were enthusiastic about the quality of this year's program in all its particulars.

These proceedings contain the selected workshop papers and the tutorial abstracts. Numerous people deserve appreciation and recognition for their contribution to making ER 2005 a success. First of all we have to thank the keynote speakers and the authors for their valuable contributions. Similarly, we thank the workshop chairs and those who organized the various tracks for their effectiveness, and particularly the members of the program committees and the additional reviewers, who spent much time assessing submitted papers and participating in the program discussions on acceptance or rejection. Special appreciation is members of the organization team, who gave their best to make ER 2005 an unforgettable event. Last but not least we thank our sponsors and supporters, in particular the University of Klagenfurt, the Governor of Carinthia, and the Mayor of Klagenfurt, who helped us to organize a high-level event at comparably low cost.

The workshop and tutorial co-chairs also express our deep gratitude and respect for the ER 2005 General Chair, Heinrich C. Mayr, whose leadership and organization were outstanding. The high-quality program is a reflection of the countless hours he spent working so hard for all of us.

October 2005

Jacky Akoka
Stephen W. Liddle
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Preface to BP-UML 2005

Juan Trujillo

The Unified Modeling Language (UML) has been widely accepted as the standard object-oriented (OO) modeling language for modeling various aspects of software and information systems. The UML is an extensible language, in the sense that it provides mechanisms to introduce new elements for specific domains if necessary, such as web applications, database applications, business modeling, software development processes, data warehouses and so on. Furthermore, the latest approach of the Object Management Group (OMG) surrounding the UML even got bigger and more complicated with a more number of diagrams with some good reasons. Although providing different diagrams for modeling specific parts of a software system, not all of them need to be applied in most cases. Therefore, heuristics, design guidelines, lessons learned from experiences are extremely important for the effective use of UML and to avoid unnecessary complication.

BP-UML'05 (Best Practices of the UML) is the first edition of this International Workshop held with the 24th International Conference on Conceptual Modeling (ER 2005). This workshop will be an international forum for exchanging ideas on the best and new practices of the UML in modeling and system developments. The workshop will be a forum for users, researchers, analyzers, and designers who use the UML to develop systems and software. To keep the high quality of former workshops held in conjunction with ER, a strong International Program Committee was organized with extensive experience in the UML and also taking into consideration its relevant scientific production in the area.

The workshop attracted papers from 13 different countries distributed over all continents such as The Netherlands, France, Spain, Israel, Korea, USA, Canada and Australia. We received 27 submissions and only 9 papers were selected by the Program Committee, making an acceptance rate of 36%.

The accepted papers were organized in three different sessions. In the first one, two papers will present valuable experience reports and another one will describe how to apply UML for multidimedia modeling. In the second one, one paper will be focused on evaluating the cardinality interpretation by users in a UML class diagram, and the other two papers will be focused on the Use case diagrams of the UML. Finally, in the third session, while one paper will present how to analyze the consistency of a UML diagram, the other two will be focused on the Model Driven Architecture (MDA) and metamodeling.

I would like to express my gratitude to the program committee members and the additional external referees for their hard work in reviewing papers, the authors for submitting their papers and the ER2005 organizing committee for all their support. This workshop was organized within the framework of the following projects: MESSENGER (PCC-03-003-2), METASIGN (TIN2004-00779) and DADASMECA (GV05/220). Thanks to the number of submissions of this first edition together with the high quality of the accepted papers, my intention is to

An Empirical Study of the Nesting Level of Composite States Within UML Statechart Diagrams

José A. Cruz-Lemus[1], Marcela Genero[1], Mario Piattini[1], and Ambrosio Toval[2]

[1] ALARCOS Research Group,
Department of Computer Science, University of Castilla – La Mancha,
Paseo de la Universidad, 4 – 13071 Ciudad Real, Spain
{JoseAntonio.Cruz, Marcela.Genero, Mario.Piattini}@uclm.es
[2] Software Engineering Research Group,
Department of Computer Science and Systems, University of Murcia,
Campus de Espinardo – 30071 Murcia, Spain
atoval@um.es

Abstract. As UML statechart diagrams are the core for modeling the dynamic aspects of software systems, we have been studying their understandability for the last three years. In previous researches, we have already studied the relationship between many of the constructs of the UML statechart diagrams and the effect that they have on the understandability of the diagrams themselves. We have also performed a family of experiments whose results indicated that the use of composite states make UML statechart diagrams easier to understand. This fact motivated us to go a step further and investigate if the Nesting Level of Composites States (NLCS) has an impact on the understanding of the diagrams through a controlled experiment and a replication. In this paper, we present the experimental process and the main findings of them. Unfortunately, the obtained results are not quite conclusive and we have not been able to find an optimal use of nesting within UML statechart diagrams and further empirical research is needed, considering more complex UML statechart diagrams.

1 Introduction

New approaches in software engineering like MDA (Model Driven Architecture) [17] and MDD (Model Driven Development) [1] are enabling a shift in focus from software to models of software. These approaches consider models as end-products rather than just mean to produce software.

In truly 'model-driven' software engineering, the quality of the models used is greatly important. For that reason, models like UML ones are gaining more relevance in the development of software, as the quality of the models used will later determine the quality of the software systems produced.

As UML statechart diagrams are the core for modeling the dynamic aspects of software systems [13], we have been studying their understandability for the last three years. Our main idea was that if diagrams are difficult to understand this will affect their maintainability. In previous researches, we have studied the relationship between

on the understandability of the diagrams themselves. First, we defined and validated a set of metrics [11] for evaluating if the structural properties of UML statechart diagrams, such as size and complexity, influenced the understanding of UML statechart diagrams. In these researches we had found that the usage of composites states had apparently no influence on the understandability of UML statechart diagrams. This fact seemed to be a bit suspicious. For that reason, we decided to run another experiment, and a further replication, for specifically studying if the use of composite states facilitated or not the understanding of UML statechart diagrams [10]. The results of this empirical study indicated that the use of composite states improves the understandability efficiency of UML statechart diagrams, i.e. how accurately the different stakeholders understands the diagrams, if the subjects have a certain level of experience in working with this kind of UML diagrams. These findings motivated us to go a step further and define a new metric named *Nesting Level in Composite States* (NLCS) which indicates the maximum number of nested composite states in an UML statechart diagram. We based on the measure DIT (Depth of Inheritance Tree) defined in [9], as we think that there is a certain similarity between the NLCS within an UML statechart diagram and the depth of a within a generalization hierarchy in an UML class diagram.

In this paper, we will investigate in the NLCS affects the understanding of UML statechart diagram and try to find the optimal nesting level within a diagram through a controlled experiment and a replication of it. For designing the experiment we took several ideas from the different experimental experiences performed related to the DIT metric [3-8, 12, 14, 18, 19, 21].

Not only do we want this paper to be taken under a research point of view, but also to be useful for designers and software engineering teachers at universities.

We will begin defining our research question. The description of the experimental process, covering the design, tasks and performance of the experiment is explained in section 3. Section 4 describes the data analysis and the interpretation of the obtained results. Section 5 tackles all the features related to the replication of the experiment. Finally, conclusions and future work are presented in section 6.

2 Research Question

As we commented in section 1, our research question can be stated as:

> *Does the use of different nesting levels of composite states in UML statechart diagrams affect the understandability of the diagrams?*

In order to answer this question we have defined the previously presented metric NLCS. Based on the guidelines exposed in [18], we have formulated the following experimental hypotheses:

- H_{0-ij}: the understandability of UML statechart diagrams with i and j composite states nesting levels is not significantly different,
- H_{1-ij}: the understandability of UML statechart diagrams with i and j composite states nesting levels is significantly different.

This way, there are three distinct null hypotheses (H_{0-01}, H_{0-02}, H_{0-12}), taking account of symmetries (H_{0-12}=H_{0-21}).

3 Experimental Process

In this section, we describe the controlled experiment that we carried out at the University of Murcia (Spain) in May 2005 for testing the hypotheses stated in the previous section. All the experimental process is based on the guidelines outlined in [23].

3.1 Subjects

38 subjects from the University of Murcia participated in this experiment. 11 of them were on their 4th year of Computer Science whilst the rest had finished their Computer Science studies less than one year before.

The tasks to be performed did not require high levels of industrial experience, so experiments with students could be considered as appropriate [2, 15]. Moreover, students are the next generation of people entering this profession, so they are close to the population under study [16]. Besides, working with students implies a set of advantages [22], such as the fact that the prior knowledge of the students is rather homogeneous. The availability of a large number of subjects is another plus point.

All the subjects had received a short training session before the performance of the experiment, in which the main constructs of UML statechart diagrams were commented on and where some examples of the tasks to be performed by them were explained by the conductor of the experiment.

3.2 Experimental Design

The dependent variable was the understandability of UML statechart diagrams measured by:

- **Effectiveness:** number of correct answers vs. total number of asked questions.
- **Efficiency:** number of correct answers vs. time spent on answering the questions.

The independent variable was the nesting level of the different UML statechart diagrams, measured by the metric NLCS. We used three different diagrams with 0, 1 and 2 nesting levels respectively that modeled exactly the same system (an ATM) and were conceptually equivalent. An example of the experimental material is shown in the Appendix A, at the end of the document. Moreover, for the interested readers, the original experimental material is available at http://alarcos.inf-cr.uclm.es.

3.3 Experimental Task

Each subject received one diagram out of the three possibilities. The universe of dis-

Each diagram had a test which contained 9 questions which were exactly the same (questions and answers) for the three different diagrams. The questions inquired about what state would be reached after the triggering of some events, which state would be reached after a certain sequence of events and guard conditions or what sequence was the minimum possible for going from one given state to another, for instance. The subjects had to note down the answers to the questions and the times at which they started and finished answering the whole questionnaire.

3.4 Experimental Procedure

The experiment started with a twenty-five-minute introductory session in which the conductor briefly explained the main motivation for the experiment as well as the main elements of an UML statechart diagram. After that, the materials for the experiment were randomly distributed to the subjects.

In order to increase the motivation and interest of the subjects, the students were explained that the exercises that they were going to perform could be similar to those that would find in their exam at the end of the term.

At this point some examples in shortened version were performed by the conductor, who explained the correct answer to each question and the way of fulfilling the questionnaires properly.

Throughout this time, the subjects were allowed to ask the conductor about any doubt that they might have, and they could make any remarks they wished to.

4 Data Analysis and Interpretation

All the data analysis presented in this section was carried out by means of SPSS [20].

First, we carried out an analysis of the descriptive statistics of the data. The box-plots of the data shown in Figures 1 and 2 illustrate the statistics summarized in Table 1 and Table 2.

In order to check the hypotheses presented in section 2, we performed some t-Tests with α=0.05. The obtained the results for the different dependent variables taking into account all the possible NLCS values are shown in Table 3.

Table 1. Summary statistics for effectiveness

NLCS	Mean	Median	Min.	Max.	St. Dev.	Skew.	Kurtos.
0 (N=13)	0.820513	0.778	0.667	1	0.096635	0.8663	0.3516
1 (N=13)	0.790598	0.778	0.611	0.944	0.096635	-0.1927	-0.5104
2 (N=12)	0.736111	0.750	0.444	1	0.185206	-0.4030	-1.0046

Table 2. Summary statistics for efficiency

NLCS	Mean	Median	Min.	Max.	St. Dev.	Skew.	Kurtos.
0 (N=13)	0.014647	0.014675	0.0090	0.0224	0.003844	0.3130	-0.3562

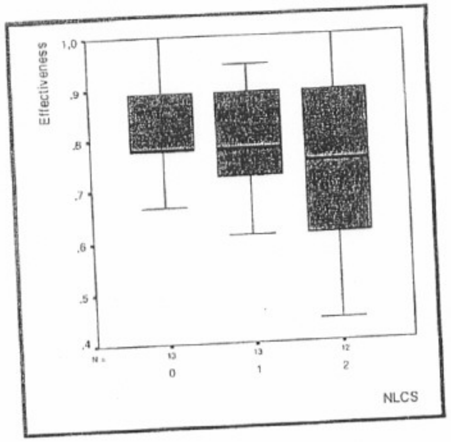

Fig. 1. Effectiveness box-plot

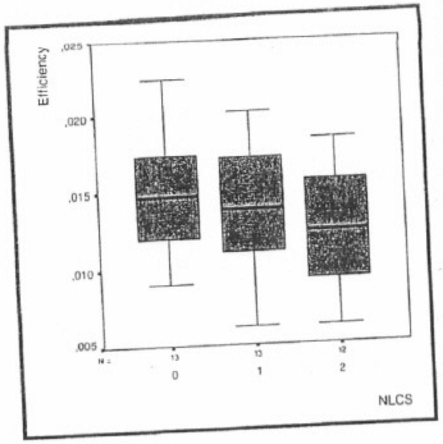

Fig. 2. Efficiency box-plot

Table 3. t-Tests results

Dependent variable	NLCS	df	t Stat.	Sig.
Effectiveness	0 vs 1	24	0.789	0.438
	0 vs 2	16.281	1.411	0.177
	1 vs 2	16.281	0.911	0.376
Efficiency	0 vs 1	24	0.587	0.563
	0 vs 2	23	1.334	0.195
	1 vs 2	23	0.723	0.477

Both for effectiveness and efficiency, the mean values for 0 and 1 nesting levels were quite close, while the mean values for 2 nesting levels were much lower. In our opinion, this means that a flat nesting level (0 or 1 levels) helped the subject to a better understanding of the diagrams than a bigger nesting level.

The results of the t-Tests performed did not allow us to reject any of the null hypotheses that we presented in section 2, as all the significance levels are above 0.05.

Anyway, these results were considered as preliminaries. That is why we performed the replication of the experiment that we present in the following section.

5 Replication

Most of the features of the replication are exactly the same that in the original experiment, so in this section we will only comment the main differences:

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- It was performed by 64 undergraduate students. They all were on their 3rd year of Computer Science and had already received a nearly complete Software Engineering course in which they had been taught the main features of UML. Anyway, these subjects received the same training session by the same experiment supervisor and performed the same examples than in the first experiment.
- The experimental material was also exactly the same than in the original experiment and it was randomly given out to the subjects.

5.1 Data Analysis and Interpretation of the Replication

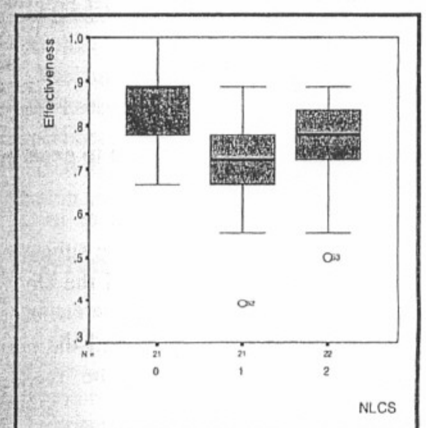
Again, our first step was carrying out an analysis of the descriptive statistics of the data. In this case, we can find that the box-plots of the data in Figures 3 and 4 illustrate the statistics summarized in Table 4 and Table 5.

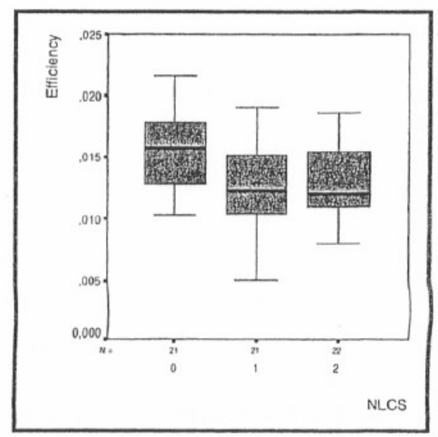
Table 4. Summary statistics for effectiveness (replication)

NLCS	Mean	Median	Min.	Max.	St. Dev.	Skew.	Kurtos.
0 (N=21)	0.830689	0.889	0.667	1	0.083289	-0.304651	-0.07462
1 (N=21)	0.698413	0.722	0.389	0.889	0.113273	-1.072197	1.46562
2 (N=22)	0.739899	0.778	0.5	0.889	0.116769	-0.701001	-0.46467

Table 5. Summary statistics for efficiency (replication)

NLCS	Mean	Median	Min.	Max.	St. Dev.	Skew.	Kurtos.
0 (N=21)	0.015473	0.015801	0.0103	0.0216	0.003071	0.1515	-0.7263
1 (N=21)	0.012659	0.012302	0.0050	0.0190	0.003947	-0.0588	-0.6591
2 (N=22)	0.012927	0.011998	0.0081	0.0186	0.003439	0.2409	-1.0887





Again, we found the best values for both effectiveness and efficiency when the value of NLCS is 0.

We also checked the hypotheses presented in section 2, by performing some t-Tests with α=0.05. Table 6 presents the results for the different dependent variables in function of the NLCS values.

Table 6. t-Tests results (replication)

Dependent variable	NLCS	df	t Stat.	Sig.
Effectiveness	0 vs 1	39	4.300	**0.000**
	0 vs 2	40	2.693	**0.010**
	1 vs 2	39	-1.210	0.233
Efficiency	0 vs 1	40	2.578	**0.014**
	0 vs 2	41	2.556	**0.014**
	1 vs 2	41	-0.238	0.813

In this case there are some statistically significant values, when relating the effectiveness and efficiency obtained for values 0 vs. 1 and 0 vs. 2 of NLCS. This would allow us to reject the hypotheses $H_{0\text{-}01}$ and $H_{0\text{-}02}$.

This would indicate that the optimal nesting level within a UML statechart diagram is 0, that is, not using composite states. An explanation to this finding could be the size of the UML statechart diagrams used in the experiment. In fact, the diagram with a value for NLCS of 0 has only 13 simple states, so it could be more effective and efficient to have no nesting level in the diagram as it can be understood quite immediately. It seems that introducing nesting levels unnecessarily overloads the designer without adding any positive contribution to the understandability of UML statechart diagrams. In order to check this explanation, some more experiments using diagrams with a bigger size and more complexity must be carried out.

5.2 Threats to Validity

We must keep in mind a number of validity issues that are typically related to experiments of this type.

First, the subjects were not professional modelers in the experiment or in the replication. Obviously, we would expect much more accurate results if the subjects were more experienced. However, the limited difficulty of the tasks and the UoD used make the students become suitable experimental subjects, as they are much easier to work with than some others. Nevertheless, further replications of the experiment using people already working in this profession would be really interesting.

Secondly, as we have already remarked, the diagrams that have been used repre-

6 Conclusions and Future Work

Worried about how UML constructs impact on the understandability of UML statechart diagrams we carried out several empirical studies. The results obtained in a previous empirical research [10] had revealed that the use of composite states improved the understandability efficiency of UML statechart diagrams, i.e. how accurately the different stakeholders understands the diagrams, if the subjects have a certain level of experience in working with this kind of UML diagrams.

Going a step further, in this research we have investigated if the Nesting Level in Composite States (NLCS), which indicates the maximum number of nested composite states in an UML statechart diagram, affects the understanding of UML statechart diagrams.

The findings obtained through a controlled experiment and a replication of it have not been really conclusive. We have not been able to find an optimal use of nesting within UML statechart diagrams, and we can only partially conclude that a flat nesting level (0 or 1) within a relatively simple UML statechart diagram makes it more understandable.

As a future work, we must perform some new experiments with more complex diagrams in order to obtain more conclusive results which would allow us to establish some useful guidelines for designers. Moreover, we think that our research can have educational repercussions. The findings obtained until now give justify as special emphasis on the use of composite states when teaching UML statechart diagrams in software engineering courses at universities.

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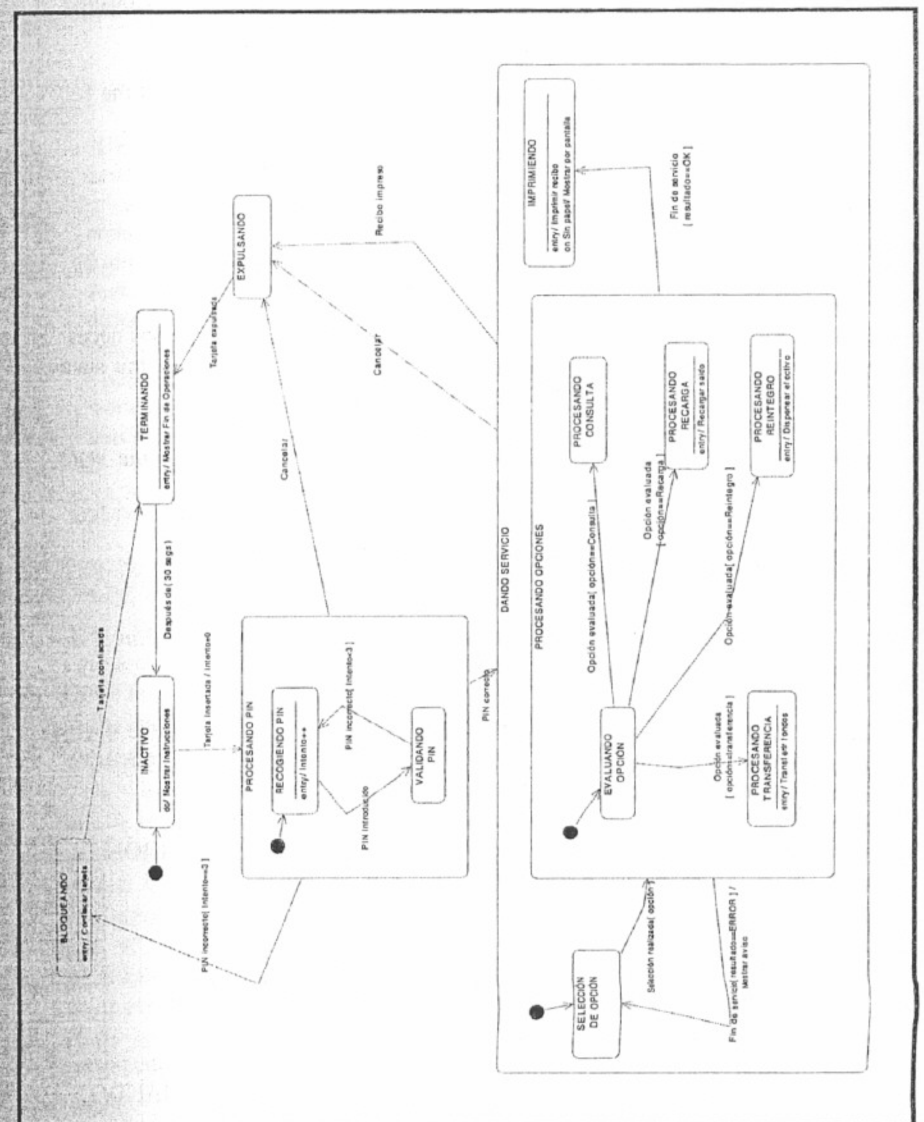
Appendix A: Experimental Material

In this appendix we present an example of the original (Spanish) experimental material handed out to the subjects in the experiment and a translated version of the questionnaire attached to the diagrams.

The complete experimental material can be found at http://alarcos.inf-cr.uclm.es



CHECK TIME (HH : MM : SS) __ : __ : __

1. If we are in the state IMPRIMIENDO and the event *Recibo impreso* occurs, which state do we reach?

2. If while being in the state SELECCIÓN DE OPCIÓN the event *Selección realizada* occurs and the variable opción has the velue Consulta, which state do we reach?

3. Which state do we reach if while being in the state INACTIVO the following sequence of events occurs?
   a. Tarjeta insertada
   b. Pin introducido
   c. Pin incorrecto
   d. Pin introducido
   e. Pin correcto

4. Which is the **minimum** sequence of events and guard conditions necessary for going from the state SELECCIÓN DE OPCIÓN to the state INACTIVO?

5. Which is the value of the variable Intento if starting from the state INACTIVO the following sequence of events occurs?
   a. Tarjeta insertada
   b. Pin incorrecto
   c. Pin correcto

6. If we are in the state SELECCIÓN DE OPCIÓN and the event *Cancelar* occurs, which state do we reach?

7. If while being in the state PROCESANDO REINTERGRO the event *Fin de servicio* occurs and the variable resultado has the value ERROR, which state do we reach?

8. Which state do we reach if while being in the state SELECCIÓN DE OPCIÓN the following sequence of events occurs?
   a. Selección realizada
   b. Opción evaluada
   c. Fin de servicio
   d. Recibo impreso

9. Which is the **minimum** sequence of events and guard conditions necessary for going from the state INACTIVO to the state TERMINANDO?

Utilizing a Multimedia UML Framework for an Image Database Application

Temenushka Ignatova and Ilvio Bruder

Database Research Group, Computer Science Department,
University of Rostock, Germany
{temi, ilr}@informatik.uni-rostock.de

Abstract. To support the design of data models for multimedia applications, we employ the concept of a framework introduced in object-oriented design. We define a UML framework, which can be used for deriving application-specific multimedia database models. With the UML framework, we define the core elements of a multimedia database model, such as mediatype- and application-independent structure, content, relationships and operations. Thereby, the advantages of using UML for representing multimedia data as well as shortcomings of this approach are discussed. Furthermore, we describe the utilization of the UML framework for the instantiation of a model for an image database of scanned handwritten music scores.

1 Introduction

Multimedia databases have to provide support not only for representing the data itself, but also for the application-specific behavior and characteristics of this data. Therefore, the latter have to be considered in the design of conceptual data models for building multimedia database applications.

There are a number of proposals for multimedia data models originating from a database, an information retrieval, as well as from a media-specific points of view [1]. Inside [2], Subrahmanian sets the theoretical fundamentals of multimedia database systems as well as the requirements towards the underlying data models. A model for multimedia documents, which implements the information retrieval aspect is proposed by Chiaramella, Mulhem, and Fourel in [3]. A logical model for multimedia documents based on the description logic ACL has been enhanced with fuzzy logic based functionality by Meghini, Sebastiani, and Straccia [4]. In chapter 2 of [5], Wu, Kankanhalli, Lim, and Hong have represented content-based definitions for multimedia documents and systems from the computer vision point of view.

These models propose concepts with a strong theoretical background. However, they concentrate more on the multimedia data itselfs rather than on the design of multimedia applications. Therefore, we study the possibilities to build application-specific conceptual models for multimedia databases. The