Lecture Notes in Computer Science

The LNCS series reports state-of-the art results in computer science research, development, and education, at a high level and in both printed and electronic form. Enjoying tight cooperation with the R&D community, with numerous individuals, as well as with prestigious organizations and societies, LNCS has grown into the most comprehensive computer science research forum available.

The scope of LNCS, including its subseries LNAI and LNBI, spans the whole range of computer science and information technology including interdisciplinary topics in a variety of application fields. The type of material published traditionally includes

- proceedings (published in time for the respective conference)
- post proceedings (consisting of thoroughly revised final full papers)
- research monographs (which may be based on outstanding PhD work, research projects, technical reports, etc.)

ISBN 3-540-47703-9

9 783540 477037

Lecture Notes in Computer Science

LNCS LNAI LNBI

Roddick et al. (Eds.)

LNCS 4231

ER 2006 Workshops BP-UML, CoMoGIS
COSS, ECDM, OIS, QoIS, SemWAT
Tucson, AZ, USA, November 2006, Proceedings

Springer

Lecture Notes in Computer Science 4231

Commenced Publication in 1973
Founding and Former Series Editors:
Gerhard Goos, Juris Hartmanis, and Jan van Leeuwen

John F. Roddick V. Richard Benjamins
Samira Si-Saïd Cherfi Roger Chiang
Christophe Claramunt Ramez Elmasri
Fabio Grandi Hyoil Han Martin Hepp
Miltiadis Lytras Vojislav B. Mišić
Geert Poels Il-Yeol Song Juan Trujillo
Christelle Vangenot (Eds.)

Advances in Conceptual Modeling – Theory and Practice

ER 2006 Workshops BP-UML, CoMoGIS
COSS, ECDM, OIS, QoIS, SemWAT
Tucson, AZ, USA, November 6-9, 2006
Proceedings

Springer

Volume Editors

John F. Roddick E-mail: roddick@infoeng.flinders.edu.au
V. Richard Benjamins E-mail: rbenjamins@isoco.com
Samira Si-Saïd Cherfi E-mail: sisaid@cnam.fr
Roger Chiang E-mail: roger.chiang@uc.edu
Christophe Claramunt E-mail: claramunt@ecole-navale.fr
Ramez Elmasri E-mail: elmasri@cse.uta.es
Fabio Grandi E-mail: fgrandi@deis.unibo.it
Hyoil Han E-mail: hyoil.han@ischool.drexel.edu
Martin Hepp E-mail: martin.hepp@deri.org
Miltiadis Lytras E-mail: mdl@aueb.gr
Vojislav B. Mišić E-mail: vmisic@cs.umanitoba.ca
Geert Poels E-mail: Geert.Poels@UGent.be
Il-Yeol Song E-mail: songiy@drexel.edu
Juan Trujillo E-mail: jtrujillo@dlsi.ua.es
Christelle Vangenot E-mail: christelle.vangenot@epfl.ch

Library of Congress Control Number: 2006934617

CR Subject Classification (1998): H.2, H.4, H.3, F.4.1, D.2, C.2.4, I.2, J.1

LNCS Sublibrary: SL 3 – Information Systems and Application, incl. Internet/Web and HCI

ISSN 0302-9743
ISBN-10 3-540-47703-9 Springer Berlin Heidelberg New York
ISBN-13 978-3-540-47703-7 Springer Berlin Heidelberg New York

Springer is a part of Springer Science+Business Media

springer.com

Printed in Germany

Typesetting: Camera-ready by author, data conversion by Scientific Publishing Services, Chennai, India
Printed on acid-free paper SPIN: 11908883 06/3142 5 4 3 2 1 0

Foreword to ER 2006 Workshops and Tutorials

Welcome to the workshops and tutorials associated with the 25th International Conference on Conceptual Modeling (ER 2006). As always, the aim of the workshops is to give researchers and participants a forum to discuss cutting-edge research in conceptual modeling, both in theory and, particularly this year, in practice.

The change in the nature of the ER workshops to be a balance between research theory and practice has been apparent for a number of years and shows the continual maturing of conceptual modeling over the past 25 years. Now in its silver anniversary year, the ER series continues to be the premier conference in conceptual modeling and the interest shown in the workshops is testament to this. In all, 39 papers were accepted from a total of 95 submitted, an overall acceptance rate of 41%.

The focus for this year's seven workshops, which were selected competitively following a call for workshop proposals, ranges from practical issues such as industrial standards, UML and the quality of information systems, through to workshops focused on managing change in information systems, geographic systems, service-oriented software systems and the Semantic Web. Four have been run previously at an ER conference, three were new this year.

- Best Practices of UML (BP-UML 2006)
- Conceptual Modeling for Geographic Information Systems (CoMoGIS 2006)
- Conceptual Modeling of Service-Oriented Software Systems (COSS 2006)
- Evolution and Change in Data Management (ECDM 2006)
- Ontologizing Industrial Standards (OIS 2006)
- Quality of Information Systems (QoIS 2006)
- Semantic Web Applications: Theory and Practice (SemWAT 2006)

This volume contains the proceedings from the seven workshops. Also included are the outlines for the three tutorials:

- Conceptual Modeling for Emerging Web Application Technologies - Dirk Draheim and Gerald Weber.
- State of the Art in Modeling and Deployment of Electronic Contracts - Kamalakar Karlapalem and P. Radha Krishna.
- Web Change Management and Delta Mining: Opportunities and Solutions - Sanjay Madria.

Although there was a lot to see, the scheduling of the workshops and the main conference were organized so as to maximize the opportunity for delegates to attend sessions of interest.

Setting up workshops such as these takes a lot of effort. I would like to thank the PC chairs and their Program Committees for their diligence in selecting the papers in this volume. I would also like to thank the main ER 2006 conference committees, particularly the conference Co-chairs Sudha Ram and Mohan Tanniru and the conference Publicity Chair and Webmaster, Huimin Zhao, for their support in putting this programme together.

John F. Roddick
Flinders University
PO Box 2100, Adelaide
South Australia
roddick@infoeng.flinders.edu.au

ER 2006 Conference Organization

Honorary Conference Chair

Peter P. Chen (Louisiana University, USA)

Conference Co-chairs

Sudha Ram (University of Arizona0, USA, ram@eller.arizona.edu)
Mohan R. Tanniru (University of Arizona, USA, mtanniru@eller.arizona.edu)

Program Committee Co-chairs

Dave Embley (Brigham Young University, USA, embley@cs.byu.edu)
Antoni Olive (Universitat Politecnica de Catalunya, Spain, olive@lsi.upc.es)

Workshop and Tutorial Chair

John F. Roddick (Flinders University, Australia, roddick@infoeng.flinders.edu.au)

Panel Co-chairs

Uday Kulkarni (Arizona State University, USA, uday.kulkarni@asu.edu)
Keng Siau (University of Nebraska,Lincoln, USA, ksiau@unlnotes.unl.edu)

Industrial Program Co-chairs

Arnie Rosenthal (Mitre Corporation, arnie@mitre.org)
Len Seligman (Mitre Corporation, seligman@mitre.org)

Demos and Posters Co-chairs

Akhilesh Bajaj (University of Tulsa, USA, akhilesh-bajaj@utulsa.edu)
Ramesh Venkataraman (Indiana University, USA, venkat@indiana.edu)

Publicity Chair and Webmaster

Huimin Zhao (University of Wisconsin, Milwaukee, USA, hzhao@uwm.edu)

Local Arrangements and Registration

Anji Siegel (University of Arizona, USA, asiegel@arizona.edu)

Steering Committee Liaison

Bernhard Thalheim (Christian-Albrechts-Universiät zu Kiel, Germany, thalheim@is.informatik.uni-kiel.de)

ER 2006 Workshop Organization

ER 2006 Workshop and Tutorial Chair

John F. Roddick (Flinders University, Australia, roddick@infoeng.flinders.edu.au)

BP-UML 2006 - Second International Workshop on Best Practices of UML

BP-UML 2006 was organized within the framework of the following projects: METASIGN (TIN2004-00779) from the Spanish Ministry of Education and Science, DADASMECA (GV05/220) from the Valencia Ministry of Enterprise, University and Science (Spain), and DADS (PBC-05-012-2) from the Castilla-La Mancha Ministry of Science and Technology (Spain).

Program Chairs

Juan Trujillo (University of Alicante, Spain)
Il-Yeol Song (Drexel University, USA)

Program Committee

Doo-Hwan Bae (KAIST, South Korea)
Michael Blaha (OMT Associates Inc., USA)
Cristina Cachero (Universidad de Alicante, Spain)
Tharam Dillon (University of Technology Sydney, Australia)
Dirk Draheim (Freie Universität Berlin, Germany)
Gillian Dobbie (University of Auckland, New Zealand)
Jean-Marie Favre (Université Grenoble, France)
Eduardo Fernández (Universidad de Castilla-La Mancha, Spain)
Jaime Gómez (Universidad de Alicante, Spain)
Anneke Kleppe (Universiteit Twente, The Netherlands)
Ludwik Kuzniarz (Blekinge Tekniska Högskola, Sweden)
Jens Lechtenböorger (Universität Münster, Germany)
Tok Wang Ling (National University of Singapore, Singapore)
Pericles Loucopoulos (University of Manchester, UK)
Hui Ma (Massey University, New Zealand)
Andreas L. Opdahl (Universitetet i Bergen, Norway)
Jeffrey Parsons (Memorial University of Newfoundland, Canada)
Óscar Pastor (Universitat Politècnica de València, Spain)
Witold Pedrycz (University of Alberta, Canada)
Mario Piattini (Universidad de Castilla-La Mancha, Spain)

Ivan Porres (Åbo Akademi University, Finland)
Colette Rolland (Université Paris 1-Panthéon Sorbonne, France)
Matti Rossi (Helsingin kauppakorkeakoulu, Finland)
Manuel Serrano (Universidad de Castilla-La Mancha, Spain)
Bernhard Thalheim (Universität zu Kiel, Germany)
A Min Tjoa (Technische Universität Wien, Austria)
Ambrosio Toval (Universidad de Murcia, Spain)
Antonio Vallecillo (Universidad de Málaga, Spain)
Panos Vassiliadis (University of Ioannina, Greece)

Referees

F. Molina	Ki Jung Lee	A. Sidhu
J. Lasheras	S. Schmidt	

CoMoGIS 2006 - Third International Workshop on Conceptual Modeling for Geographic Information Systems

Workshop Chairs

Christelle Vangenot (EPFL, Switzerland)
Christophe Claramunt (Naval Academy Research Institute, France)

Program Committee

Masatoshi Arikawa (University of Tokyo, Japan)
Natalia Andrienko (Fraunhofer Institute AIS, Germany)
Michela Bertolotto (University College, Dublin, Ireland)
Patrice Boursier (University of La Rochelle, France and Open University, Malaysia)
Elena Camossi (IMATI-CNR Genova, Italy)
James Carswell (Dublin Institute of Technology, Ireland)
Maria Luisa Damiani (University of Milan, Italy)
Thomas Devogele (Naval Academy Research Institute, France)
Max Egenhofer (University of Maine, USA)
Andrew Frank (Technical University of Vienna, Austria)
Bo Huang (University of Calgary, Canada)
Zhiyong Huang (National University of Singapore, Singapore)
Christian S. Jensen (Aalborg University, Denmark)
Ki-Joune Li (Pusan National University, South Korea)
Dieter Pfoser (CTI, Greece)
Martin Raubal (University of Münster, Germany)
Andrea Rodriguez (University of Concepcion, Chile)

Sylvie Servigne (INSA, France)
Kathleen Stewart Hornsby (University of Maine, USA)
George Taylor (University of Glamorgan, UK)
Nectaria Tryfona (Talent Information Systems, Greece)
Agnes Voisard, (Fraunhofer ISST and FU Berlin, Germany)
Nico van de Weghe (University of Gent, Belgium)
Nancy Wiegand (University of Wisconsin-Madison, USA)
Stephan Winter (University of Melbourne, Australia)
Ilya Zaslavsky (San Diego Supercomputer Center, USA)
Esteban Zimanyi (Free University of Brussels, Belgium)

CoSS 2006 - International Workshop on Conceptual Modeling of Service-Oriented Software Systems

Workshop Chairs

Roger Chiang, (University of Cincinnati, USA)
Vojislav B. Mišić, (University of Manitoba, Canada)

Advisory Committee

Wil van der Aalst, (Technische Universiteit Eindhoven, The Netherlands)
Akhil Kumar, (Penn State University, USA)
Michael Shaw, (University of Illinois at Urbana-Champaign, USA)
Keng Siau, (University of Nebraska at Lincoln, USA)
Carson Woo, (University of British Columbia, Canada)
Liang-Jie Zhang, (IBM, USA)
J. Leon Zhao, (University of Arizona, USA)

Program Committee

Fabio Casati, (HP Labs, USA)
Dickson K. W. Chiu, (Dickson Computer Systems, Hong Kong)
Cecil Eng Huang Chua, (Nanyang Technological University, Singapore)
Haluk Demirkan, (Arizona State University, USA)
Stephane Gagnon, (New Jersey Institute of Technology, USA)
Patrick Hung, (University of Ontario Institute of Technology, Canada)
Qusay H. Mahmoud, (University of Guelph, Canada)
Hye-young Helen Paik, (University of New South Wales, Australia)
Venkataramanan Shankararaman, (Singapore Management University, Singapore)
Benjamin B. M. Shao, (Arizona State University, USA)
Vladimir Tosic, (Lakehead University, Canada)
Harry J. Wang, (University of Delaware, USA)
Lina Zhou, (University of Maryland at Baltimore County, USA)

ECDM 2006 - Fourth International Workshop on Evolution and Change in Data Management

Workshop Chair

Fabio Grandi (University of Bologna, Italy)

Program Committee

Alessandro Artale (Free University of Bolzano-Bozen, Italy)
Sourav Bhowmick (Nanyang Technical University, Singapore)
Michael Böhlen (Free University of Bolzano-Bozen, Italy)
Carlo Combi (University of Verona, Italy)
Curtis Dyreson (Washington State University, USA)
Shashi Gadia (Iowa State University, USA)
Kathleen Hornsby (University of Maine, USA)
Michel Klein (Vrije Universiteit Amsterdam, The Netherlands)
Richard McClatchey (University of the West of England, UK)
Federica Mandreoli (University of Modena and Reggio Emilia, Italy)
Torben Bach Pedersen (Aalborg University, Denmark)
Erik Proper (University of Nijmegen, The Netherlands)
John Roddick (Flinders University, South Australia)
Nandlal Sarda (IIT Bombay, India)
Myra Spiliopoulou (Otto-von-Guericke-Universität Magdeburg, Germany)
Carlo Zaniolo (UCLA, USA)

Additional Referees

M. Golfarelli
P.S. Jørgensen

OIS 2006 - First International Workshop on Ontologizing Industrial Standards

Workshop Chairs

Martin Hepp (University of Innsbruck, Austria)
Miltiadis Lytras (Athens University of Economics and Business, Greece)
V. Richard Benjamins (iSOCO, Spain)

Program Committee

Chris Bizer (Free University of Berlin, Germany)
Chris Bussler (Cisco Systems, Inc., San Francisco, USA)
Jorge Cardoso (University of Madeira)
Oscar Corcho (University of Manchester, UK)
Jos de Bruijn (DERI Innsbruck, Austria)

Doug Foxvog (DERI Galway, Ireland)
Fausto Giunchiglia (University of Trento, Italy)
Karthik Gomadam (LSDIS Lab, University of Georgia, USA)
Michel Klein (Free University of Amsterdam, The Netherlands)
Paavo Kotinurmi (Helsinki University of Technology, Finland)
York Sure (University of Karlsruhe, Germany)

QoIS 2006 - Second International Workshop on Quality of Information Systems

Workshop Chairs

Samira Si-Saïd Cherfi (CEDRIC-CNAM, France)
Geert Poels (University of Ghent, Belgium)

Steering Committee

Jacky Akoka (CEDRIC - CNAM and INT, France)
Mokrane Bouzeghoub (PRISM, Univ. of Versailles, France)
Isabelle Comyn-Wattiau (CNAM and ESSEC, France)
Marcela Genero (Universidad de Castilla-La Mancha, Spain)
Jeffrey Parsons (Memorial University of Newfoundland, Canada)
Geert Poels (University of Ghent, Belgium)
Keng Siau (University of Nebraska, USA)
Bernhard Thalheim (University of Kiel, Germany)

Program Committee

Jacky Akoka (CEDRIC - CNAM and INT, France)
Laure Berti (IRISA, France)
Mokrane Bouzeghoub (PRISM, University of Versailles, France)
Andrew Burton-Jones (University of British Columbia, Canada)
Tiziana Catarci (Università di Roma "La Sapienza," Italy)
Isabelle Comyn-Wattiau (CNAM and ESSEC, France)
Corinne Cauvet (University of Aix-Marseille 3, France)
Marcela Genero (Universidad de Castilla-La Mancha, Spain)
Paul Johannesson (Stockholm University, Sweden)
Jacques Le Maitre (University of Sud Toulon-Var, France)
Jim Nelson (Southern Illinois University, USA)
Jeffrey Parsons (Memorial University of Newfoundland, Canada)
Óscar Pastor (Valencia University of Technology, Spain)
Houari Sahraoui (Université de Montréal, Canada)
Farida Semmak (Université Paris XII , IUT Sénart Fontainebleau)
Keng Siau (University of Nebraska, USA)
Guttorm Sindre (Norwegian University of Science and Technology, Norway)
Monique Snoeck (Katholieke Universiteit Leuven, Belgium)

Il-Yeol Song (Drexel University, USA)
David Tegarden (Virginia Polytechnic Institute, USA)
Bernhard Thalheim (University of Kiel, Germany)
Dimitri Theodoratos (NJ Institute of Technology, USA)
Juan Trujillo (University of Alicante, Spain)

SemWAT 2006 - First International Workshop on Semantic Web Applications: Theory and Practice

Workshop Chairs

Hyoil Han (Drexel University, USA)
Ramez Elmasri (University of Texas at Arlington, USA)

Program Committee

Palakorn Achananuparp (Drexel University, USA)
Yuan An (University of Toronto, Canada)
Paul Buitelaar (DFKI GmbH, Germany)
Stefania Costache (University of Hannover, Germany)
Vadim Ermolayev (Zaporozhye National University, Ukraine)
Fabien Gandon (INRIA, France)
Raul Garcia-Castro (Universidad Politecnica de Madrid, Spain)
Peter Haase (University of Karlsruhe, Germany)
Kenji Hatano (Doshisha University, Japan)
Stijn Heymans (Vrije Universiteit Brussel, Belgium)
Istvan Jonyer (Oklahoma State University, USA)
Esther Kaufmann (University of Zurich, Switzerland)
Christoph Kiefer (University of Zurich, Switzerland)
Beomjin Kim (Indiana University - Purdue University, USA)
SeungJin Lim (Utah State University, USA)
Jun Miyazaki (Nara Advanced Institute of Science and Technology, Japan)
JungHwan Oh (University of Texas at Arlington, USA)
Byung-Kwon Park (Dogna University, Korea)
Xiaojun Qi (Utah State University, USA)
Lawrence Reeve (Drexel University, USA)
York Sure (University of Karlsruhe, Germany)
Davy Van Nieuwenborgh (Vrije Universiteit Brussel, Belgium)
Mikalai Yatskevich (University of Trento, Italy)

Table of Contents

CoMoGIS 2006 - 3rd International Workshop on Conceptual Modeling for Geographic Information Systems

Keynote

Spatial and Spatio-temporal Data Representation

Optimizing Representation and Access to Spatial Data

Spatio-temporal Data on the Web

CoSS 2006 - International Workshop on Conceptual Modeling of Service-Oriented Software Systems

ECDM 2006 - 4th International Workshop on Evolution and Change in Data Management

Keynote

Accepted Papers

OIS 2006 - 1st International Workshop on Ontologizing Industrial Standards

Accepted Papers

QoIS 2006 - 2nd International Workshop on Quality of Information Systems

Introduction to QoIS06

Information System Quality

Data Quality

SemWAT 2006 - 1st International Workshop on Semantic Web Applications: Theory and Practice

Semantic Web Applications (I)

Semantic Web Applications (II)

Quality-Driven Automatic Transformation of Object-Oriented Navigational Models*

Cristina Cachero[1], Marcela Genero[2], Coral Calero[2], and Santiago Meliá[1]

[1] Web Engineering and Databases Research Group. University of Alicante. Spain
{ccachero, smelia}@dlsi.ua.es
[2] ALARCOS Research Group. University of Castilla La Mancha. Spain
{Marcela.Genero, Coral.Calero}@uclm.es

Abstract. Navigability is a main concern in the design of Web applications. In order to assess such navigability a number of measures has been proposed. From them, measures defined on conceptual models are specially relevant, as it is well known that high quality conceptual models are critical to the success of the deployed system. However, measurement methods associated to such measures, as well as the design modifications that need to be performed on the models in order to improve their values, are usually tightly coupled with particular Web Engineering approaches. This fact compromises their effectiveness and their propagation capacity to different environments and/or methodologies.

Our aim in this paper is to illustrate how navigability measures can be captured in a general manner. In this way, not only is it possible to define a reusable set of relevant measures for a given family of applications, but also such measures can be queried in the context of MDA transformation rules. These rules capture both the measure decision criteria and the design modifications that should take place if the measure value for a given navigational model does not match such criteria.

1 Introduction

The ever increasing complexity of Web applications has caused the Web Engineering field to evolve at an extremely fast pace. This discipline intertwines sound Software Engineering principles with a suitable set of abstractions, particular to the idiosyncrasy of the Web. However, the inclusion in the different Web Engineering proposals of guiding principles that contribute to guarantee that the resulting applications comply with a set of desirable quality characteristics is still a challenge for the field. In fact, up to now no significant relationship has

* This paper has been supported by the Spain Ministry of Science and Technology, project numbers TIN2004-00779, TIN2005-25866-E and TIC2003-07804-C05-03. Also, this research is part of the DADASMECA project (GV05/220), financed by the Valencia Government and the DADS (PBC-05-012-2) and the DIMENSIONS (PBC-05-012-1) projects, financed by the Regional Science and Technology Ministry of Castilla-La Mancha (Spain).

J.F. Roddick et al. (Eds.): ER Workshops 2006, LNCS 4231, pp. 329–338, 2006.

been empirically demonstrated between the quality of the Web application and the fact that the designer has followed or not a given Web methodology.

In fact common practice in the field consists on the use of common-sense practices that are usually aimed at improving the interface usability. Although assessing quality at such a late stage of development can be useful, it is commonly avowed that early detection of problems in the artifacts produced in the initial phases of the life-cycle can save time, cut production costs, and raise the final desired product quality [5]. Aware of such potential benefits, the Web Engineering community has recently started to invest efforts in the inclusion of early measures to guide the construction of the different Web models, with special emphasis on domain and navigational models.

From them, domain models for Web applications hoard the highest number of early measure proposals [4]. Regarding navigational models, which are a distinctive feature of Web Engineering proposals, most efforts have been directed towards the promotion of a good use of the conceptual navigation constructs provided by each approach. For example, WebML defines a WebML Quality Analyzer [6] that is able to automatically check the XML specification of WebML conceptual schemas, and verify and measure some internal attributes, such as the consistency or completeness of the models. Similarly, UWE [3] pays special attention to usability, and recommends the integration of guidelines into both the design process and the CAWE tools that usually accompany Web proposals. Going one step further, the work of Abrahao *et al.* [1] proposes a set of measures that capture some available heuristics [9].

In fact, navigability is at the core of quality aspects such as usability or maintainability [1, 12, 2], as it is widely recognized that a good navigation design let users acquire the information they are seeking quickly and efficiently.

However, much work remains to be done. To our knowledge, all the proposed measures for Web models are tightly coupled with the Web Engineering approach for which they were defined. Unfortunately Web approaches usually greatly differ not only in notation but also in the semantics associated to the constructs, hampering the measure propagation to different environments and/or methodologies. Also, measures are usually defined and calculated in an ad-hoc manner, and the effects of the measure values on the models (that is, the actions the designer could perform in order to improve the model) are usually not specified.

Therefore, in this paper we aim at demonstrating how the definition of a navigational meta-model not only facilitates the understanding of the different Web approaches but also serves as a basis on which early measures for navigational models can be defined and calculated. For this purpose, in Section 2 we present a partial view of the OO-H navigational meta-model, as well as how navigability measures can be formally expressed over this meta-model by means of OCL expressions [14]. Also, we believe that the Web Engineering field can benefit from defining loosely coupled Web measuring models, that is, models that are applicable to a whole family of Web applications regardless of the chosen Web approach. Fortunately, we have at our disposal a Software Measurement Ontology (SMO) [7]. and its corresponding meta-model that allows to derive concrete

measurement models. Our proposal in this sense is to instantiate a subset of this meta-model to express in an independent way a set of navigability measures. In Section 3 we illustrate this approach, and provide as an example a meta-model instantiation that reflects the navigability measure presented in Section 2. Last, we need a way to automate the evaluation/evolution of the navigational model depending on the chosen measures. For this purpose in Section 4 we use a QVT transformation rule [13] that, departing from the OO-H navigational meta-model and the SMO meta-model, generates a new OO-H navigational model that is checked against the quality decision criteria, which are also expressed in the meta-model instantiation. Section 5 concludes this paper with a summary of the main contributions and some future lines of research.

2 The OO-H Navigation Model

As we have stated above, it is well known that the improvement of the early artifacts produced in a development process has a great impact on the final product cost and quality [5]. Also, it is commonly avowed that, when developing Web applications, one of the most important early artifacts that must be produced is the navigational model. The Navigational model reflects the paths the user must follow through the information domain in order to achieve her goals. It is usually organized around navigational packages (also named contexts or targets in different approaches), each one encapsulating views defined over domain objects and paths to connect them. The names of the constructs, as well as their corresponding decorators, usually diverge from proposal to proposal, reflecting their different roots and degree of evolution. Due to this lack of a common Web conceptual ontology, it is highly recommendable for proposals to provide a navigational meta-model that systematically and unambiguously defines the concepts involved and their relationships, and facilitates in this way the communication among researchers and/or practitioners.

Such has been the approach taken by OO-H [8], a well known Web Engineering method whose navigational meta-model is partially presented in Fig. 1. Due to space reasons, we have intentionally left out details concerning service invocation, as well as the existing relationships with UML meta-classes.

In Fig. 1 we can observe how, as in most Web Engineering approaches, the main constructs of the OO-H Navigational Model are *Navigational Targets* (NT), *Navigational Classes* (NC), *Navigational Associations* (NA) and *Navigational Collections* (C). A Navigational Target is a packaging mechanism that serves to structure the navigation through the application subsystems. Navigational Classes are views over conceptual classes, and reflect the information that makes up the current view together with the operations that can be invoked from each view. Navigational Associations reflect navigation steps through the information. Last, Navigational Collections are access mechanisms (menus) that group together navigation paths.

To illustrate their use, let's imagine that we want to model a Ticket Sales system. A Navigation Model corresponding to this system is presented in Fig. 2.

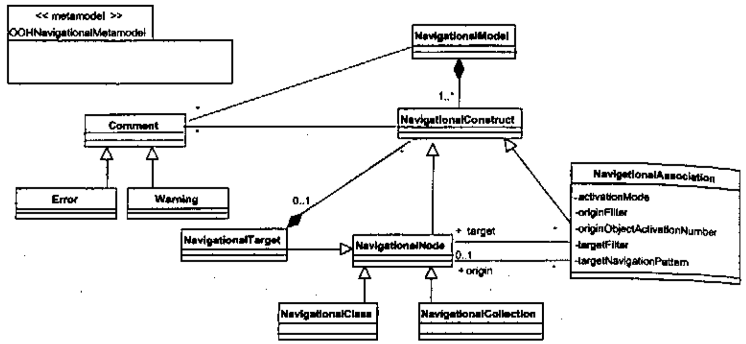

Fig. 1. Partial View of the OO-H navigational meta-model

The partial navigation model of Fig. 2 reflects a system whose navigation is organized around many NT (e.g. *User Registration*, *Shopping Cart*, *Show Details*, and so on), each one encapsulating the navigation paths needed to fulfill a subset of system requirements.

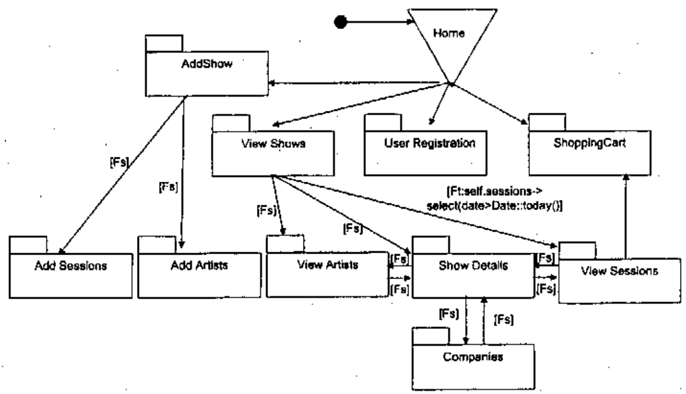

Fig. 2. OO-H Navigational Model corresponding to a Ticket Sales system

The different NT are accessed via a *Home* Collection that, depicted as an inverted triangle, represents the application main menu. The NT and the Home collection are connected by means of NA which may have one or more *Filters* associated. Filters are OCL expressions that constrain navigation. In OO-H, filters can be either user-defined or automatically generated, based on the domain conceptual associations. In our example, the NA between *View Shows* and *View Artists* is an example of NA adorned with a predefined (structural) filter (Fs): the filter extracted from the relationship between shows and their corresponding artists. On the other hand, the filter *self.sessions->select(date>= Date::today())* that adorns the NA between *View Shows* and *View Sessions* is an example of target filter (Ft) that restricts the set of target objects to those sessions that have not yet taken place. In fact Fig. 2 represents one of the most evident mistakes novice web designers make when first designing Web applications using OO-H: they tend to define a new NT for each requirement, instead of performing a previous grouping task. This causes a poorly structured navigational tree and augments the model complexity. In fact, the impact of the number of NT on the model complexity has already been assessed in [1], through the Number of Navigational Contexts measure. For the sake of coherence with OO-H, in the remaining of the paper we have renamed this measure *Number of Navigational Targets* (NNT). Up to now, this measure could be defined in the context of the VisualWADE tool, the Computer Aided Web Engineering (CAWE) tool that supports OO-H, as follows:


```
context NavigationalModel
def NNT:Integer=self.navigationalConstruct->select(oclIsTypeOf
                                    (NavigationalTarget))->size()
```

At this point we face a problem: if little work has been done on validating the impact of measures on navigability, much less has been done on assessing threshold values for such measures. However, for the sake of the example, let's assume that, for this kind of application, the famous Miller's 7+-2 rule [11] is applicable, that is, we do want a navigational model that neither is too scattered (more than nine NT) nor too compressed (less than four NT). This restriction may be expressed as follows:

```
context NavigationalModel
inv notTooManyNT: NNT<10
inv notTooFewNT: NNT>4
```

If we look back to Fig. 2 we can observe that the `notTooManyNT` invariant is not fulfilled, what in VisualWADE would cause a warning to be raised. Although this approach works well for prototypical development, it is tightly coupled with OO-H. This causes that OCL rules associated with the OO-H meta-model may need to be changed whenever we change the kind of application we are modelling (as measures that are relevant for a certain family of applications may not be applicable to others). Therefore we propose to go one step further, and provide a way to define measures that is independent from the chosen methodology and its corresponding meta-model, facilitating reusability.

Next we explain how we can achieve this goal.

3 Adaptation of the SMO to Navigational Models

The homogenization and systematization of the concepts that are relevant for a given domain is a goal that has been achieved through a number of ontologies, defined as formal explicit specifications of a shared conceptualization. Their many advantages have decided us to adhere to the SMO presented in [7] (see Fig. 3) for the description of the navigational measures that are applicable to a given family of Web applications.

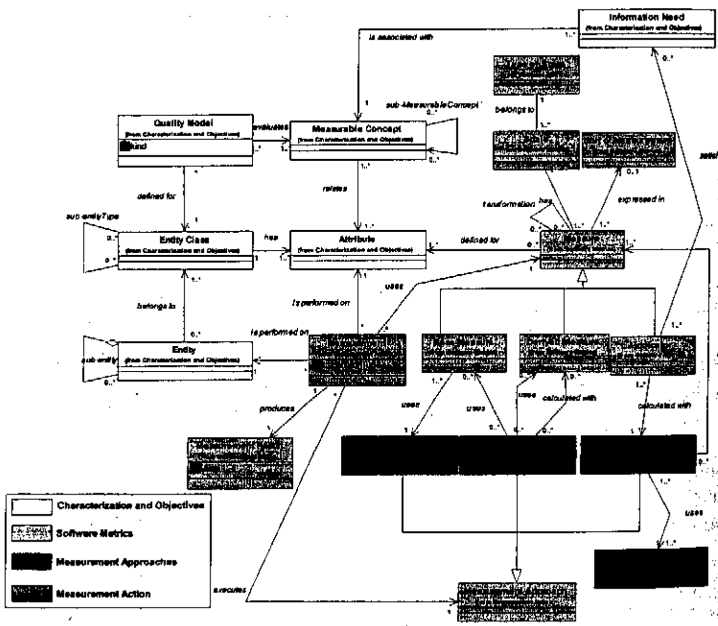

Fig. 3. UML Class Diagram of the Software Measurement Ontology (SMO)

The SMO ontology is divided into four sub-ontologies, as we can observe in Fig. 3. Such sub-ontologies are: (1) the way of measuring (*MeasurementApproaches*), (2) the action of measuring (*Measurement*), (3) the result obtained (*Software Measures*) and (4) the concept and context of measure (*Characterization and Objectives*). Each sub-ontology provides a set of concepts, some of them optional, that may contribute to the definition of the measure. Due to the relevance of deriving concrete measurement models, a meta-model has been defined based on SMO. This meta-model is divided in four packages, one related to each sub-ontology. The fact that our measuring model is based on an ontology-aware meta-model makes it shareable among Web proposals. Next we present the way in which we can instantiate the SMO meta-model to reflect our NNT measure example.

3.1 Ontology-Aware Measuring Meta-model Instantiation

As the reader may have already inferred, the definition of the NNT measure (see Fig. 4) corresponds to the need to *assess the navigability of the Navigational Model*. In order to fulfill this **Information Need**, our measure is part of a *OO-H* **Quality Model** that gathers all the measures, decision criteria etc. that are applicable to any OO-H entity. This model is aimed at evaluating the *navigability* **Measurable Concept.** The *OO-H* **Quality Model** is made up of a set of **Attributes**, among which the *Navigational Complexity* is the one related with the NNT measure. All these concepts correspond to the Characterization and Objectives package that reflects the namesake sub-ontology that we presented in Fig. 3.

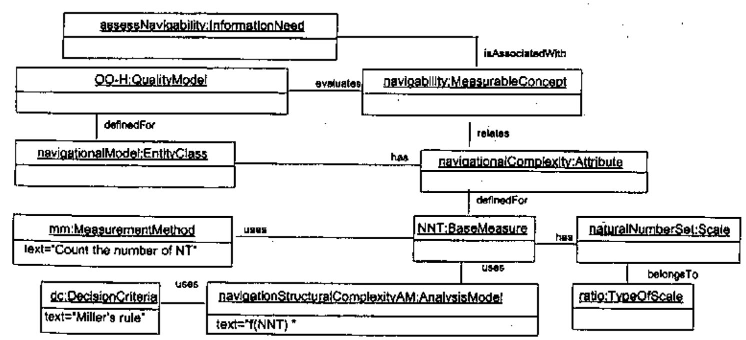

Fig. 4. Ontology-aware measuring model that reflects the NNT measure

Also, we need to express that the afore mentioned *Navigational Complexity* attribute is going to be measured, among others, with the aid of the *NNT* **Base measure**. The fact that the measure is of subtype Base implies that it does not depend on any other measure to calculate its value. Also, we want to express that the value of the NNT measure belongs to a *natural number* **Scale**, of *ratio* **Type of scale.** The **Measurement Unit** would be the *Navigational Target*.

Last, we need to express that the **Measurement Method** used to calculate the NNT measure consists on counting the number of NT that a given navigational view includes.

Also, we need to specify the **Analysis Model**, that includes a set of **Decision Criteria**. In our example, as we have just defined one measure, our Analysis Model assesses navigability just depending on the value of the NNT measure. The Decision Criteria on its turn establishes that a good navigability value has to comply with the Miller's rule, what implies that, in order for the model to be not too trivial nor too complex, the NNT must be between five and nine. Once the NNT measure has been defined, it is time to see how we can apply it to a given navigational model, such as the one presented in Fig. 2.

4 Automation of Measures

One of the main advantages of the measuring model presented in Fig. 4 is its capacity of reuse, as it does not assume any particular Web Engineering navigational meta-model. However, in order to be able to apply a given measure to a concrete navigational model, such connection needs to be established. This can be easily done if we regard a navigational model as a subtype of the concept **Entity Class.** This connection opens the path to the application of a Model-Driven Engineering approach [10] to automate the navigability assessment.

Back to our example, in Fig. 2 we can intuitionally observe how the OO-H navigational model does not fulfill the rule of 7+-2 navigational targets. Therefore an expert designer would manually restructure the application to fulfill such rule. The automation of this process can be achieved by means of a set of transformation rules that, expressed in QVT [13], allows to encapsulate all the knowledge particular to a given Web Engineering approach (in our case OO-H).

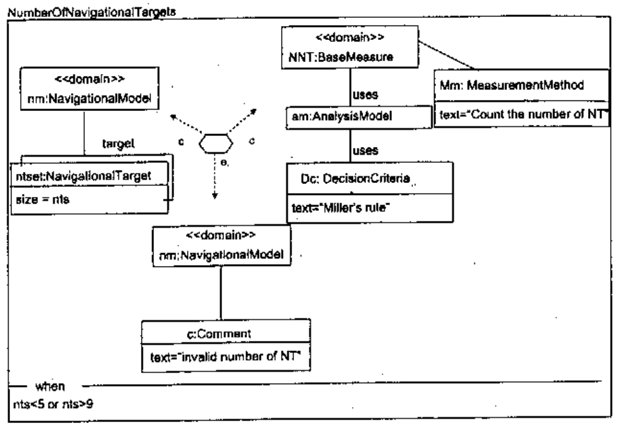

Fig. 5. QVT Transformation rule that checks OO-H navigational models for Miller's rule violations

Let's illustrate this approach by depicting a possible transformation rule that counts the number of NT for the navigational model of Fig. 2 and annotates the model if the decision criteria is not fulfilled (see Fig. 5).

In Fig. 5 the QVT graphical notation for the *NumberOfNavigationalTargets* relation is presented. This transformation rule involves two checkonly (c) domains: the *NavigationalModel* domain (root for the OO-H meta-model) and the *BaseMeasure* domain (defined in the context of the measuring meta-model). First, the transformation rule checks whether the NNT measure is relevant for our navigational model, and whether Miller's decision criteria is applicable. This will be evaluated to true if the corresponding objects are present in the measurement model (meta-model instantiation) that we have previously defined (see Fig. 4). Then we must calculate the actual number of NT included in the navigational model under consideration. In OO-H this value can be established by simply counting the number of NT associated to our Navigational Model. The transformation rule stores this value in the *nts* variable. The adaptation of Miller's rule to the OO-H meta-model is established in the *when* clause of the transformation. This clause indicates, also in OCL-like syntax, that the transformation rule must be activated only if the number of NT is erroneous. In this case, the desired action is to enrich the OO-H model with a comment, associated with the whole model, that warns the designer about the violation of the rule. We specify such action on a third enforceable (e) domain (again the OO-H *NavigationalModel*). More transformation rules can be defined in this general way, making up a repository of measuring transformation rules.

We would like to stress the fact that the decision whether or not a particular rule is relevant for a given application will be taken once the measuring metamodel has been instantiated for such application. If the measuring structure reflected in the transformation rule is present in the meta-model instantiation, the rule will check whether the decision criteria is met, and will take any desired action if this is not the case. Although in our example the action has consisted on simply annotating the model, more sophisticated transformation rules could be defined to automatically generate a new model that does comply with the measuring criteria.

5 Conclusions and Further Work

This paper has presented a way to define a reusable measuring model that, based on the SMO meta-model, can be integrated into any particular Web Engineering approach. Also, it has demonstrated how the instantiation of this meta-model can participate in the quality assessment of particular navigational models, becoming a discriminator to decide whether or not a given QVT transformation rule, defined as part of a transformation rule repository, is applicable. Such transformation rules are the only elements that are aware of the specific Web Engineering meta-model that is being used, encapsulating in this way the specific knowledge. Besides, these transformation rules automate the measurement process, as well as the annotation/modification of the corresponding navigational models (if necessary) depending on the established measuring decision criteria. We would also like to stress the fact that the explicit consideration of ontologies (SMO) and standards (UML, OCL, QVT) whenever possible improves understandability and reusability of the approach. At this moment efforts are being made towards the definition of transformation rules that not only annotate but also modify in a sound way the OO-H navigational models. Also, intensive work is being performed on the OO-H CAWE tool to provide full support to this proposal.

Last, we would like to stress how, as soon as the Web Engineering community reaches an agreement regarding a common meta-model for Web application development, not only the meta-model instantiation but also the set of defined transformation rules will be able to be seamlessly reused among approaches.

References

[1] S. Abrahao, N. Condory-Fernandez, L. Olsina, and O. Pastor. A Defining and Validating Metrics for Navigation Models. In *Proceedings of the 9th International Software Metrics Symposium*, pages 200–210, 2003.

[2] J. Almer. Designing for Web Site Usability. *IEEE Computer*, 35(7):102–103, 2002.

[3] R. Atterer, A. Schmidt, and H. Hussmann. Extending Web Engineering Models and Tools for Automatic Usability Validation. *Journal of Web Engineering*, 2005.

[4] L. Baresi, S. Morasca, and P. Paolini. Estimating the Design Effort of Web Applications. In *Proceedings of the 9th International Software Metrics Symposium (METRICS'03)*. Springer, 2003.

[5] L. Briand, S. Morasca, and V. R. Basili. Defining and Validating Measures for Object-Based High-Level Design. *IEEE Transactionson Software Engineering*, 25(5):722–743, 10 1999.

[6] S. Comai, M. Matera, and A. Maurino. A Model and an XSL Framework for Analyzing the Quality of WebML Conceptual Schemas. In *Proceedings of the ER'02 International Workshop on Conceptual Modeling Quality*, pages 339 – 350. Springer, 10 2002.

[7] F. García, M.F. Bertoa, C. Calero, A. Vallecillo, F. Ruiz, M. Piattini, and M. Genero. Towards a consistent terminology for software measurement. *Information and Software Technology*, pages 1–14, 07 2005.

[8] J. Gómez, C. Cachero, and O. Pastor. Conceptual Modelling of Device-Independent Web Applications. *IEEE Multimedia Special Issue on Web Engineering*, 8(2):20–32, 04 2001.

[9] M. Ivory. *Automated Web Site Evaluation*. Kluwer Academic Publishers, 2004.

[10] S. Kent. The Expressive Power of UML-based Engineering. In *Proceedings of the 3nd International Conference on Integrated Formal Methods*, volume 2335, page 286. Springer, 06 2002.

[11] G. Miller. The magical number seven, plus or minus two: Some limits on our capacity for processing information. In *The Psychological Review*, volume 63, pages 81–97, 1956.

[12] J. Nielsen. *Designing Web Usability: The Practice of Simplicity*. New Riders, 2000.

[13] Mof query/views/transformations final adopted specification. omg doc. ptc/05-11-01. www.omg.org/docs/ptc/05-11-01.pdf.

[14] J. Warmer and A. Kleppe. *The Object Constraint Language. 2nd Edition. Getting your models ready for MDA*. Addison Wesley, 2003.