LNCS 1723

≪UML≫'99 –
The Unified Modeling Language

Beyond the Standard

Second International Conference
Fort Collins CO., USA, October 1999
Proceedings

Robert France and Bernhard Rumpe (Eds.)

Version of October 9, 1999

The rest of this file contains:

– Editor affiliations
– the front matter: preface, toc,
– (a lot of dummy titlepages), and
– the author index

Robert France
Department of Computer Science
Colorado State University
Fort Collins
Colorado 80523, USA
Tel.: ++1-970-491-6356
Fax.: ++1-970-491-2466
Email: france@cs.colostate.edu
St. Vincent
8. October 1996

Bernhard Rumpe
Institut für Informatik
Technische Universität München
Arcisstraße 21
80290 München
Tel.: ++49-89-289-28129
Fax.: ++49-89-289-28183
Email: rump@in.tum.de
Deutsch
22. Juni 1967
Robert France
received his BSc. in Natural Sciences from the University of the West Indies
and his PhD in Computer Science from Massey University, New Zealand. He
is currently an Associate Professor in the Department of Computer Science at
Colorado State University. His primary research interests are in the area of soft-
ware engineering, in particular, rigorous software development techniques. His
current research focuses on formalizing core object-oriented modeling concepts
and developing precise semantics for the UML. His other research interest areas
include domain engineering, formal specification techniques, integrated formal
and informal specification techniques, and systematic software reuse processes.
His work has been partially funded by the National Science Foundation and
Motorola. He was the chair of the First IEEE Workshop on Industrial Strength
Formal Techniques (WIFT'95) and is involved in the organization of workshops
on object-oriented modeling techniques for OOPSLA and ICSE.

Bernhard Rumpe
studied Computer Science and Mathematics at the Technische Universität München. His work aims at narrowing the gap between formal methods and practical modeling techniques. He developed an approach for an integrated formalization of object-oriented modeling techniques that captures structure as well as behavior. He contributed to conferences, was invited to panels focusing on the UML as well as formal methods, and co-organized workshops with related themes at the ECOOP, OOPSLA, and ICSE conferences. His interests include: the rigorous specification of software architectures; use of software specification for the systematic development of object-oriented business systems; diagrammatic high level programming; systematic development methods.
The Unified Modeling Language is described as a language for "specifying, visualizing, constructing, and documenting the artifacts of software systems" and for business modeling (OMG UML V1.x documents). The UML reflects some of the best experiences in object-oriented modeling, thus it has the potential to become a widely-used standard object-oriented modeling language.

As a generally-applicable standard the UML has to be both flexible (extensible, adaptable, modifiable) and precise. Flexibility is needed if the UML is to be used in a variety of application domains. Tailoring of UML syntax and adaptation of UML semantics to system domains is highly desirable. Incorporating domain-specific concepts into the language will yield modeling languages that more effectively support system development in these domains. Tailoring may involve determining a subset of the UML that is applicable to the domain, extending or modifying existing language elements, or defining new language elements. One can envisage UML variants that are tailored to specific domains, for example, UML for real-time systems, multimedia systems, and for internet-based systems. Furthermore, one can also define UML variants that determine levels of sophistication in the use of the UML. For example, one can define a "UML-Light" that utilizes basic UML concepts, a "UML-Advanced" that utilizes more advanced concepts, and a "UML-Expert" that uses concepts that require substantial experiences in the use of the UML. In this respect, one can consider the UML to be a family of languages rather than a single, coherent language.

As in the case of natural languages, one does not need to understand the full language before one can express oneself. Consequently, lightweight versions for different purposes are needed, but extensions of the UML beyond stereotypes and tagged-values wherever necessary should be considered in the future. In the fields of business modeling, timed and analogous systems, as well as architectural descriptions, enhancements will surely come, perhaps bringing new specialized kinds of diagrams into the UML.

Precision is needed if the UML is to effectively serve as a standard. A precise language supports effective communication of intent and enables the development of rigorous analysis tools. Work on developing precise semantics for the UML is the main thrust of UML research in academia. The development of a pragmatic and precise semantics for the UML requires both technical and social processes. It is imperative that the semantics support a common-sense usage of the UML in practice. It is not good enough to propose a precise semantics in a formal notation. One must also demonstrate that the proposed semantics
supports commonly held views of how the UML is to be applied and that the
semantics is consistent with widely-perceived successful industrial applications
of the language. Furthermore, the semantics should give tool-developers useful
insight to support the development of semantic analysis tools.

The flexibility and precision qualities may seem at odds with each other.
Regarding UML as a family of languages suggests that there cannot be a single
precise UML semantics. On the other hand, the multiple languages must have
a common language core if they are to be considered UML variants and not new languages. Work on defining a precise semantics for the UML should focus
on (1) identifying this core, (2) developing precise characterizations of the core
concepts, and (3) developing mechanisms that can be used to extend and modify
the core semantics to support the tailoring of the UML to different usages and
domains.

Balancing the demands for UML extensions and adaptations with the need
to consolidate and unify concepts to create a coherent standard will be a major
challenge as the UML evolves. Both forces can contribute significantly to the
development of the UML only if appropriately balanced. Demands for extensions
and adaptations can be analyzed together to identify common concepts that
can be usefully and consistently added to a UML core, but identifying common
concepts and determining the consistency of new concepts with existing standard
UML concepts are challenging activities.

The evolution of the UML can benefit significantly from the best experiences
in other computer science communities. Experiences that can be exploited in the
development of the UML include work on conceptual modeling and knowledge
engineering in the Artificial Intelligence community, work on rigorous/formal
software development in the Software Engineering community, work on data
modeling in the Database community, and work on denotational and operational
semantics, type theories, and higher-level programming languages in the
Programming Language community. For example, it is conceivable that one can
use a sub-language of the UML as a higher-level programming language, thus
paving the way for the use of the UML as a wide-spectrum development
language.

Closely linked to UML issues are questions related to how and where to
use and apply it. Current interest in methodical issues and the definition of
development processes reflects this awareness. Methods-in-the-Large and project
management issues are rather well elaborated, and the “methods in the small”
will receive far more attention in the future. We need more techniques that
allow composing or refining of the various kinds of diagram types, translate
between them, and trace information across diagrams. Proprietary solutions for
some techniques are coded in the tools, and need scientific examination to allow
further improvement.

We are waiting for the day when the (core) UML will be regarded as a
semantically sound and precise language.
The objective of the UML’99 conference is to bring together researchers and developers from academia and industry, and from a variety of computer science communities, to present and discuss works that can potentially contribute to the evolution of the UML. In particular, the UML’99 conference aims to foster closer working relationships between researchers and developers in industry and researchers in academia. As indicated above, the successful evolution of the UML will require theoretical and industry-driven contributions. Past work on the UML provides ample evidence that concepts developed in academia can be effectively interwoven with practical experiences. The intent of the UML conferences is to enhance such interactions by providing an open forum for discussing and analyzing theoretical and practical challenges facing the development of the UML.

In keeping with the scientific orientation of UML’99, the conference is primarily structured around paper presentations and discussion panels. The presentations and panels are targeted to an audience that is at least familiar with the basic elements of the UML, and has a significant interest in the development of the UML as a well-founded standard. In total 166 papers were submitted to the UML’99 conference, of which 44 were selected by the programme committee for presentation. The selected papers touch upon a variety of issues and reflect numerous perspectives on how the UML should evolve. The concerns and issues mentioned above, and more, are addressed in varying degrees in the selected papers.

We would like to express our deepest appreciation to the authors of submitted papers, the programme committee members, those committee members who also acted as shepherds for some of the papers, the external referees, Ljiljana Döhring for handling the paper printing process, Adrian Bunk for setting up and handling the electronic submission process, and Matthias Ralff for setting up the Web page for the electronic programme committee meeting. We would also like to thank the numerous people who have been involved in the organisation of UML’99 and, in particular, the organisers of last year’s conference in Mulhouse, Jean Bézivin and Pierre-Alain Muller for their helpful advice, the publicity chairs, in particular, Jean-Michel Bruel for maintaining the mailing list, the poster chair, Jim Bieman, and the conference coordinator, Kathy Krell, who kept all the pieces together and made the organisation a much smoother process. We would also like to thank the IEEE-CS conference support staff for their invaluable help.

September 1999

Robert France, Bernhard Rumpe
VIII

Organisation

“UML’99” was organised by Robert France from the Department of Computer Science at Colorado State University, and by Bernhard Rumpe from the Computer Science Department at the Technische Universität München, under the auspices of IEEE Computer Society Technical Committee on Complexity in Computing, and in cooperation with ACM SIGSOFT and SIGPLAN (Association for Computing Machinery, Special Interest Group for Software Engineering, Special Interest Group on Programming Languages).

Executive Committee

Conference Chair: Robert France (Colorado State University, USA)
Programme Chair: Bernhard Rumpe (Technische Universität München, Munich, Germany)

Organising Team

Conference Coordinator: Kathy Krell
Poster Chair: Jim Bienan
Panel Chair: Bernhard Rumpe
Publicity Chair (Europe, Africa): Jean-Michel Beuel
Publicity Chair (Americas): Jim Bienan
Publicity Chair (Asia, Pacific): Junichi Suzuki

Adrian Bunk, Ilijana Döhring, Emanuel Grant, Matthias Ralff, and all our on-site student volunteers.
Programme Committee

Colin Atkinson (Universität Kaiserslautern, Germany)
Jean Bézivin (Université de Nantes, France)
Jim Biefeld (University of Colorado, USA)
Gregor v. Bochmann (University of Ottawa, Canada)
Ruth Bres (Technische Universität München, Germany)
Jean-Michel Bruel (Université de Pau et des Pays de l’Adour, France)
Frank Buschmann (Siemens AG, Germany)
Betty Cheng (Michigan State University, USA)
Derek Coleman (Hewlett-Packard, USA)
Steve Cook (IBM EMEA Object Technology Practice, UK)
John Daniels (Syntropy Limited, UK)
Desmond D’Souza (Platinum Technology, USA)
Gregor Engels (Universität Paderborn, Germany)
Andy Evans (University of Bradford, UK)
Eduardo B. Fernandez (Florida Atlantic University, USA)
Martin Fowler (Independent Consultant, USA)
Eran Gery (i-Logix, Israel)
Martin Gogolla (Universität Bremen, Germany)
Martin Griss (Hewlett-Packard, USA)
Radu Grosu (University of Pennsylvania, USA)
David Harel (The Weizmann Institute of Science, Israel)
Brian Henderson-Sellers (Swinburne University, Australia)
Pavel Hruby (Navision Software, Denmark)
Peter Hruschka (The Atlantic Systems Guild, Germany)
Heinrich Hussmann (Technische Universität Dresden, Germany)
Ivar Jacobson (Rational Software Corporation, USA)
Gerti Kappel (Johannes Kepler Universität Linz, Austria)
Stuart Kent (University of Kent, Canterbury, UK)
Haim Kilov (Genesis Development Corporation, USA)
Cris Kobryn (EDS, USA)
Philippe Kruchten (Rational Software Corporation, USA)
Kevin Lano (Imperial College, UK)
Gary Leavens (Iowa State University, USA)
Stephen Mellor (Project Technology, USA)
Richard Mitchell (University of Brighton, UK)
Ana Maria Dinis Moreira (Universidade Nova de Lisboa, Portugal)
Pierre-Alain Muller (Objexxon, France)
Linda Northrop (Carnegie Mellon University, USA)
Gunnar Övergaard (The Royal Institute of Technology, Sweden)
Barbara Paech (Fraunhofer Institute for Experimental Software, Germany)
Jim Rumbaugh (Rational Software Corporation, USA)
Andy Schürr (Universität der Bundeswehr München, Germany)
Programme Committee (continued)

Ed Seidewitz (DHR Technologies, USA)
Bran Selic (ObjecTime Limited, Canada)
Richard Mark Soley (OMG, USA)
Jos Warner (Klaasse Objecten, The Netherlands)
Anthony Wasserman (Software Methods and Tools, USA)
Alan Wills (TriReme International, UK)
Rebecca Wirfs-Brock (Wirfs-Brock Associates, USA)

Additional Referees

Daniel Amyot Joaquim Aparicio
João Araujo Michael Breu
Jean-Michel Bruel Christian Bunse
Luís Caires S. Jerome Carriere
John Cheesman Robert G Clark
Birgit Demuth Ralph Depke
Jawad Drissi Mike Fischer
Falk Fürnstück Emanuel Grant
Reiko Heckel Martin Hitz
James Ivers Erik Kanzties
Elisabeth Kapsammer Ismail Khiriss
Thomas Khülle Frank-Ulrich Künich
Annig Lacayelle Oliver Laitenberger
Katharina Mehner Paul Mukherjee
John O’Hara Gianna Reggio
Aziz Salah Stefan Sauer
Stephane Some Jean Vacher
Annika Wagner Jörg Zettel
Sponsoring Association


Cooperating and Supporting Associations

ACM SIGSOFT (Association for Computing Machinery, Special Interest Group for Software Engineering), http://www.acm.org/sigsoft/

ACM SIGPLAN (Association for Computing Machinery, Special Interest Group for Programming Languages), http://www.acm.org/sigplan/

OMG (The Object Management Group), http://www.omg.org/. UML is a trademark of OMG.

Sponsoring Company

Table of Contents

Invited Talk 1 (Abstract)
Architecting Web-Based Systems with the Unified Modeling Language
   Gayle Booch

Software Architecture
Extending Architectural Representation in UML with View Integration
   Alexander Eyres, Ned Medvidovic
Enabling the Refinement of a Software Architecture into a Design
   Marwan Abi-Antoun, Ned Medvidovic
Using the UML for Architectural Description
   Rich Hilliard

UML and Other Notations
Viewing the OML as a Variant of the UML
   Brian Henderson-Sellers, Colin Atkinson, Don Firesmith
A Comparison of the Business Object Notation and the Unified Modeling Language
   Richard F. Paige, Jonathan S. Ostraff
Formalizing the UML Class Diagram Using Object-Z
   Soon-Kyeong Kim, David Carrington

Formalizing Interactions
A Formal Approach to Collaborations in the Unified Modeling Language
   Gunnar Overgaard
A Formal Semantics for UML Interactions
   Alexander Knapp

Panel 1
UML 2.0 Architectural Crossroads: Sculpting or Mudpacking?
   Moderator: Chris Kobryn
   Michael Jesse Chonoles, Steve Cook, Desmond D’Souza, Sridhar Iyengar, Gius Ramackers
Meta-Modeling

Core Meta-Modelling Semantics of UML: The pUML Approach ............ 140
Andy Evans, Stuart Kent

A Metamodel for OCL .................................................. 156
Mark Richters, Martin Gogolla

Tools

Tool-Supported Compressing of UML Class Diagrams ............ 172
Ferenc Dósa Rákócsy, Kai Koskimies

A Pragmatic Approach for Building a User-Friendly and Flexible UML Model Repository ........................................... 188
Mariano Belaunde

Components

Modeling Dynamic Software Components in UML ................ 204
Axel Wienberg, Florian Matthes, Marko Boiger

Extending UML for Modeling Reflective Software Components ........ 220
Junichi Suzuki, Yoshikazu Yamamoto

UML Extension Mechanisms

Nine Suggestions for Improving UML Extensibility ............ 236
Nathan Dykman, Martin Griss, Robert Kessler

A Classification of Stereotypes for Object-Oriented Modeling Languages .... 249
Stefan Berner, Martin Glinz, Stefan Joos

First-Class Extensibility for UML - Packaging of Profiles, Stereotypes, Patterns ........................................... 265
Desmond D’Souza, Aamod Sane, Alan Birchenough

Process Modeling

UML-based Fusion Analysis ............................................ 278
Shane Sendall, Alfred Strohmeier

Using UML for Modelling the Static Part of a Software Process ....... 292
Xavier Franch, Josep M. Ribó

Framework for Describing UML Compatible Development Processes .... 308
Pavel Braby
Invited Talk 2
On the Behavior of Complex Object-Oriented Systems .................. 324
   David Harel

Real-Time Systems
UML-RT as a Candidate for Modeling Embedded Real-Time Systems in
the Telecommunication Domain ........................................ 330
   Dominikus Herzberg
Modeling Hard Real Time Systems with UML – The OOHARTS Approach 339
   Laila Kabous, Wolfgang Nebel
UML Based Performance Modeling Framework for Object-Oriented
Distributed Systems ......................................................... 356
   Pekka Khakkulu

Constraint Languages
Defining the Context of OCL Expressions ................................ 372
   Steve Cook, Anneke Kleppe, Richard Mitchell, Jos Warners, Alan Willis
Mixing Visual and Textual Constraint Languages ....................... 384
   Stuart Kent, John Howse
Correct Realizations of Interface Constraints with OCL ............... 399
   Michel Bidoit, Rolf Hennicker, Françoise Tort, Martin Wirsing

Analyzing UML Models 1
Generating Tests from UML Specifications ............................... 416
   Jeff Offutt, Aymur Abdmazik
Formalising UML State Machines for Model Checking .................. 430
   Johan Liljus, Iván Porres Pallor

Panel 2
SDL as UML: Why and What .............................................. 446
   Moderator: Bran Selic
   Philippe Dhaussy, Anders Ek, Øystein Haugen, Philippe Leblanc,
   Birger Møller-Pedersen
Coding 1
UML Behavior: Inheritance and Implementation in Current Object-Oriented Languages .................................................. 457
  Jean Louis Sournia
UML Collaboration Diagrams and Their Transformation to Java .......... 473
  Gregor Engels, Roland Hücking, Stefan Sauer, Annika Wagner

Analyzing UML Models 2
Towards Three-Dimensional Representation and Animation of UML Diagrams ......................................................... 489
  Martin Gogolla, Oliver Radfelder, Mark Richters
Typechecking UML Static Models ............................................. 503
  Tony Clark

Precise Behavioral Modeling
Analyzing UML Use Cases as Contracts ................................. 518
  Ralph-Johan Back, Luigia Petre, Iván Porres Faltor
Closing the Gap Between Object-Oriented Modeling of Structure and Behavior ....................................................... 534
  Holger Giese, Jörg Graf, Guido Wirtz

Static Modeling
Black and White Diamonds .................................................. 550
  Brian Henderson-Sellers, Franck Barbier
Interconnecting Objects via Contracts ................................... 566
  Luis Felipe Andrade, José Luiz Fiadeiro
How Can a Subsystem be Both a Package and a Classifier? ............ 584
  Joaquin Miller, Rebeca Wirfs-Brock

Applying the UML
Using UML/OCL Constraints for Relational Database Design ........ 598
  Birgit Demuth, Heinrich Hussmann
Towards a UML Extension for Hypermedia Design ................... 614
  Hubert Baumeister, Nora Koch, Luis Mandel
Why Unified is Not Universal? – UML Shortcomings for Coping with Round-Trip Engineering ................................. 630
  Serge Demeyer, Stéphane Ducasse, Sander Tichelaar
Sequence Diagrams
Timed Sequence Diagrams and Tool-Based Analysis – A Case Study . . . . 645
   Thomas Firley, Michaela Huhn, Karsten Diethers, Thomas Gehrke,
   Ursula Goltz
Timing Analysis of UML Sequence Diagrams ............................ 661
   Xuandong Li, Johan Lilius
Coding 2
The Normal Object Form: Bridging the Gap from Models to Code . . . . 675
   Christian Bunse, Colin Atkinson
Modeling Exceptional Behavior ............................................. 691
   Neelam Soundarajan, Stephen Fridella
Panel 3
Advanced Methods and Tools for a Precise UML ......................... 706
   Moderator: Andy Evans
   Steve Cook, Steve Mellor, Jos Warmer, Alan Wills