≪UML≫'99 Preface

"While in geometry attempts to square the circle never succeeded, the UML has achieved it: states can be implemented as classes." – "We have made much progress from the time clouds were used."

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

[FR99] R. France, B. Rumpe.
<<UML>>'99 -- The Unified Modeling Language.
Beyond the Standard (2nd International Conference
in Fort Collins, Colorado, USA, Proceedings),
Springer Verlag, 1999.
www.se-rwth.de/publications

supports commonly held views of how the UML is to be applied and that is consistent with widely-perceived successful industrial applications of the language. Furthermore, the semantics should give tool-developers sufficient insights that supports 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 of the paper printing process, Adrian Bunk for setting up and handling the electronic submission process, and Matthias Rahlf 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 organization of ≪UML≫'99 and, in particular the organizers of the last-year 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 organization 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
≪UML≫'99 Conference and Programme Chairs

Organisation

≪UML≫'99 was organized 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)

Organizing Team

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

Adrian Bunk, Ljiljana Döhring, Emanuel Grant, Matthias Rahlf, and all our on-site student volunteers.

Programme Comittee

Colin Atkinson (University of Kaiserslautern, Germany)
Jean Bézivin (Universite de Nantes, France)
Jim Bieman (University of Colorado, USA)
Gregor v. Bochmann (University of Ottawa, Canada)
Ruth Breu (Technische Universität München, Germany)
Jean-Michel Bruel (Universite 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 (University of 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 (University of 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 (Dresden University of Technology, Germany)
Ivar Jacobson (Rational Software Corporation, USA)
Gerti Kappel (University of 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 (ObjeXion, 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 (Munich Univ. of the German Federal Armed Forces, Germany)

Programme Comittee (continued)

Ed Seidewitz (DHR Technologies, USA)
Bran Selic (ObjecTime Limited, Canada)
Richard Mark Soley (OMG, USA)
Jos Warmer (Klasse 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
João Araujo
Jean-Michel Bruel
Luis Caires
John Cheesman
Birgit Demuth
Jawad Drissi
Falk Fünfstück
Reiko Heckel
James Ivers
Elisabeth Kapsammer
Thomas Khüne
Annig Lacayrelle
Katharina Mehner
John O'Hara
Aziz Salah
Stephane Some
Annika Wagner
Joaquim Aparicio
Michael Breu
Christian Bunse
S. Jeromy Carriere
Robert G Clark
Ralph Depke
Mike Fischer
Emanuel Grant
Martin Hitz
Erik Kamsties
Ismail Khriss
Frank-Ulrich Kumichel
Oliver Laitenberger
Paul Mukherjee
Gianna Reggio
Stefan Sauer
Jean Vaucher
Jörg Zettel

Sponsoring Association

IEEE Computer Society Technical Committee on Complexity in Computing, http://www.computer.org/

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

Rational Software Corporation, http://www.rational.com/

Table of Contents

Invited Talk 1 (Abstract)

Architecting Web-based Systems with the Unified Modeling Language 1
Grady Booch

Software Architecture

Extending Architectural Representation in UML with View Integration ... 2
Alexander Egyed, Nenad Medvidovic

Enabling the Refinement of a Software Architecture into a Design 17
Marwan Abi-Antoun, Nenad Medvidovic

Using the UML for Architectural Description 32
Rich Hilliard

UML and Other Notations

Viewing the OML as a Variant of the UML 49
Brian Henderson-Sellers, Colin Atkinson, Don Firesmith

A Comparison of the Business Object Notation and the Unified Modeling Language 67
Richard F. Paige, Johnathan S. Ostroff

Formalizing the UML class diagram using Object-Z 83
Soon-Kyeong Kim, David Carrington

Formalizing Interactions

A Formal Approach to Collaborations in the Unified Modeling Language .. 99
Gunnar Övergaard

A Formal Semantics for UML Interactions 116
Alexander Knapp

Panel 1

UML 2.0 Architectural Crossroads: Sculpting or Mudpacking? 131
Moderator: Chris Kobryn
Michael Jesse Chonoles, Steve Cook, Desmond D'Souza, Sridhar Iyengar, Guus 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 Rácz, 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 Boger

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 279
Shane Sendall, Alfred Strohmeier

Using UML for Modelling the Static Part of a Software Process 293
Xavier Franch, Josep M. Ribó

Framework for Describing UML Compatible Development Processes 309
Pavel Hruby

Invited Talk 2

On the Behavior of Complex Object-Oriented Systems 325
David Harel

Real-Time Systems

UML-RT as a Candidate for Modeling Embedded Real-Time Systems in the Telecommunication Domain 331
Dominikus Herzberg

Modeling Hard Real Time Systems with UML – The OOHARTS Approach 340
Laila Kabous, Wolfgang Nebel

UML Based Performance Modeling Framework for Object-Oriented Distributed Systems 357
Pekka Kähkipuro

Constraint Languages

Defining the Context of OCL Expressions 373
Steve Cook, Anneke Kleppe, Richard Mitchell, Jos Warmer, Alan Wills

Mixing Visual and Textual Constraint Languages 385
Stuart Kent, John Howse

Correct Realizations of Interface Constraints with OCL 400
Michel Bidoit, Rolf Hennicker, Françoise Tort, Martin Wirsing

Analyzing UML Models 1

Generating Tests from UML Specifications 417
Jeff Offutt, Aynur Abdurazik

Formalising UML State Machines for Model Checking 431
Johan Lilius, Iván Porres Paltor

Panel 2

SDL as UML: Why and What 447
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 458
Jean Louis Sourrouille

UML Collaboration Diagrams and their Transformation to Java 474
Gregor Engels, Roland Hücking, Stefan Sauer, Annika Wagner

Analyzing UML Models 2

Towards Three-Dimensional Representation and Animation of UML Diagrams 490
Martin Gogolla, Oliver Radfelder, Mark Richters

Typechecking UML Static Models 504
Tony Clark

Precise Behavioral Modeling

Analysing UML Use Cases as Contracts 519
Ralph-Johan Back, Luigia Petre, Iván Porres Paltor

Closing the Gap Between Object-Oriented Modeling of Structure and Behavior 535
Holger Giese, Jörg Graf, Guido Wirtz

Static Modeling

Black and White Diamonds 551
Brian Henderson-Sellers, Franck Barbier

Interconnecting Objects via Contracts 567
Luís Filipe Andrade, José Luiz Fiadeiro

How can a subsystem be both a package and a classifier? 585
Joaquin Miller, Rebecca Wirfs-Brock

Applying the UML

Using UML/OCL Constraints for Relational Database Design 599
Birgit Demuth, Heinrich Hussmann

Towards a UML Extension for Hypermedia Design 615
Hubert Baumeister, Nora Koch, Luis Mandel

Why Unified is not Universal? – UML Shortcomings for Coping with Round-trip Engineering 631
Serge Demeyer, Stéphane Ducasse, Sander Tichelaar

Sequence Diagrams

Timed Sequence Diagrams and Tool-Based Analysis – A Case Study 646
Thomas Firley, Michaela Huhn, Karsten Diethers, Thomas Gehrke, Ursula Goltz

Timing Analysis of UML Sequence Diagrams 662
Xuandong Li, Johan Lilius

Coding 2

The Normal Object Form: Bridging the Gap from Models to Code 676
Christian Bunse, Colin Atkinson

Modeling Exceptional Behavior 692
Neelam Soundarajan, Stephen Fridella

Panel 3

Advanced Methods and Tools for a Precise UML 707
Moderator: Andy Evans
Steve Cook, Steve Mellor, Jos Warmer, Alan Wills

Author Index

Abdurazik, Aynur, 417
Abi-Antoun, Marwan, 17
Andrade, Luís Filipe, 567
Atkinson, Colin, 49, 676

Back, Ralph-Johan, 519
Barbier, Franck, 551
Baumeister, Hubert, 615
Belaunde, Mariano, 188
Berner, Stefan, 249
Bidiot, Michel, 400
Birchenough, Alan, 265
Boger, Marko, 204
Booch, Grady, 1
Boulestin, Michel, 447
Bunse, Christian, 676

Carrington, David, 83
Champeau, Joel, 447
Chonoles, Michael Jesse, 131
Clark, Tony, 504
Cook, Steve, 131, 373, 707

D'Souza, Desmond, 131, 265
Demeyer, Serge, 631
Demuth, Birgit, 599
Dhaussy, Philippe, 447
Diethers, Karsten, 646
Ducasse, Stéphane, 631
Dykman, Nathan, 236

Egyed, Alexander, 2
Ek, Anders, 447
Engels, Gregor, 474
Evans, Andy, 140, 707

Fiadeiro, José Luiz, 567
Firesmith, Don, 49
Firley, Thomas, 646
Franch, Xavier, 293
Fridella, Stephen, 692

Gehrke, Thomas, 646
Giese, Holger, 535
Glinz, Martin, 249
Gogolla, Martin, 156, 490
Goltz, Ursula, 646
Graf, Jörg, 535
Griss, Martin, 236

Harel, David, 325
Haugen, Øystein, 447
Henderson-Sellers, Brian, 49, 551
Hennicker, Rolf, 400
Herzberg, Dominikus, 331
Hilliard, Rich, 32
Howse, John, 385
Hruby, Pavel, 309
Huhn, Michaela, 646
Hussmann, Heinrich, 599
Hücking, Roland, 474

Iyengar, Sridhar, 131

Joos, Stefan, 249

Kabous, Laila, 340
Kent, Stuart, 140, 385
Kessler, Robert, 236
Kim, Soon-Kyeong, 83
Kleppe, Anneke, 373
Knapp, Alexander, 116
Kobryn, Chris, 131
Koch, Nora, 615
Koskimies, Kai, 172
Kähkipuro, Pekka, 357

Leblanc, Philippe, 447
Li, Xuandong, 662
Lilius, Johan, 431, 662

Mandel, Luis, 615
Matthes, Florian, 204
Medvidovic, Nenad, 2, 17
Mellor, Steve, 707
Miller, Joaquin, 585
Mitchell, Richard, 373
Møller-Pedersen, Birger, 447

Nebel, Wolfgang, 340

Offutt, Jeff, 417

Ostroff, Johnathan S., 67
Övergaard, Gunnar, 99

Paige, Richard F., 67
Petre, Luigia, 519
Porres Paltor, Iván, 431, 519

Radfelder, Oliver, 490
Ramackers, Guus, 131
Ribó, Josep M., 293
Richters, Mark, 156, 490
Rácz, Ferenc Dósa, 172

Sane, Aamod, 265
Sauer, Stefan, 474
Selic, Bran, 447
Sendall, Shane, 279
Soundarajan, Neelam, 692
Sourrouille, Jean Louis, 458
Strohmeier, Alfred, 279
Suzuki, Junichi, 220

Tichelaar, Sander, 631
Tort, Françoise, 400

Wagner, Annika, 474
Warmer, Jos, 373, 707
Weigert, Thomas, 447
Wienberg, Axel, 204
Wills, Alan, 373, 707
Wirfs-Brock, Rebecca, 585
Wirsing, Martin, 400
Wirtz, Guido, 535

Yamamoto, Yoshikazu, 220