REAL-TIME PROGRAMMING 2004
(WRTP 2004)

A Proceedings volume from the 28th IFAC/IFIP Workshop on Real-Time Programming, WRTP 2004 and the International Workshop on Software Engineering, IWSS 2004
Istanbul, Turkey, 8 - 10 September 2004

Edited by

M. COLNARIČ
Faculty of Electrical Engineering and Computer Science,
University of Maribor, Slovenia

W.A. HALANG
Faculty of Electrical Engineering,
FernUniversität Hagen, Germany

and

M. WĘGRZYN
Institute of Computer Engineering and Electronics,
University of Zielona Góra, Poland

Published for the

INTERNATIONAL FEDERATION OF AUTOMATIC CONTROL

by

ELSEVIER LTD

ELSEVIER Ltd
The Boulevard, Langford Lane
Kidlington, Oxford OX5 1GB, UK

Elsevier Internet Homepage
http://www.elsevier.com

Consult the Elsevier Homepage for full catalogue information on all books, journals and electronic products and services.

IFAC Publications Internet Homepage
http://www.elsevier.com/locate/ifac

Consult the IFAC Publications Homepage for full details on the preparation of IFAC meeting papers, published/forthcoming IFAC books, and information about the IFAC Journals and affiliated journals.

First edition 2005

Library of Congress Cataloging in Publication Data

A catalogue record for this book is available from the Library of Congress

British Library Cataloguing in Publication Data

A catalogue record for this book is available from the British Library

ISBN 0-08-044582-9
ISSN 1474-6670

These proceedings were reproduced from manuscripts supplied by the authors, therefore the reproduction is not completely uniform but neither the format nor the language have been changed in the interests of rapid publication. Whilst every effort is made by the publishers to see that no inaccurate or misleading data, opinion or statement appears in this publication, they wish to make it clear that the data and opinions appearing in the articles herein are the sole responsibility of the contributor concerned. Accordingly, the publisher, editors and their respective employers, officers and agents accept no responsibility or liability whatsoever for the onsequences of any such inaccurate or misleading data, opinion or statement.

Printed in Great Britain

To Contact the Publisher

Elsevier welcomes enquiries concerning publishing proposals: books, journal special issues, conference proceedings, etc. All formats and media can be considered. Should you have a publishing proposal you wish to discuss, please contact, without obligation, the publisher responsible for Elsevier's industrial and control engineering publishing programme:

Christopher Greenwell
Senior Publishing Editor
Elsevier Ltd
The Boulevard, Langford Lane
Kidlington, Oxford
OX5 1GB, UK

Phone:	+44 1865 843230
Fax:	+44 1865 843920
E.mail:	c.greenwell@elsevier.com

General enquiries, including placing orders, should be directed to Elsevier's Regional Sales Offices – please access the Elsevier homepage for full contact details (homepage details at the top of this page).

28th IFAC/IFIP WORKSHOP ON REAL-TIME PROGRAMMING, WRTP 2004 and INTERNATIONAL WORKSHOP ON SOFTWARE ENGINEERING, IWSS 2004

Sponsored by
International Federation of Automatic Control (IFAC)
Technical Committee on Real-Time Software Engineering

Co-sponsored by
IFIP Working Group on Industrial Software Quality and Certification
U.S. Nuclear Regulatory Commission (NRC), USA
OECD Nuclear Energy Agency NEA/CSNI, France
National Aeronautics and Space Administration (NASA), USA
American Nuclear Society, USA
École de Technologie Supérieure (ETS), Montréal, Canada
University of Maryland, Center for Technology Risk Studies, Maryland, USA
University of Maribor, Faculty of Electrical Engineering and Computer Science, Maribor, Slovenia
Humboldt State University (HSU), California State University (CSU), USA
Turkish National Science Foundation, Turkey
The Turkish National Organization Committee of Automatic Control, Turkey
University of Zielona Góra, Institute of Computer Engineering and Electronics, Poland

Organized by
University of Maryland,
Center for Technology Risk Studies, Department of Mechanical Engineering

Workshop Chairpersons

SYSTEM ENGINEERING Group
Mohammad Modarres *(General Chair)*
Ali Mosleh *(Co-Chair)*

REAL-TIME PROGRAMMING Group
Wolfgang A. Halang *(Chair)*
Matjaž Colnarič *(Co-Chair)*
Marek Węgrzyn *(Co-Chair)*

SOFTWARE ENGINEERING Group
Alain Abran *(Chair)*
Luigi Buglione *(Co-Chair)*

Nihal Kececi *(International Coordinator)*
Steven Arndt *(Technical Program Committee Chair)*

International Program Committee

Alain Abran	Canada
Marian Adamski	Poland
Alejandro Alonso	Spain
Sten F.Andler	Sweden
Sven-Arne Andréasson	Sweden
Steven Arndt	USA
Karl-Erik Årzén	Sweden
Pierre Bourque	Canada
Luigi Buglione	Canada
Alan Burns	UK
Mehmet Ufuk Caglayan	Turkey
António Casimiro	Portugal
Matthew Chiramal	USA
Matjaž Colnarič	Slovenia
Alfons Crespo	Spain
Juan A.de la Puente	Spain
Pavel Ettler	Czech Republic
Christopher Fuhrman	Canada
Wolfgang A. Halang	Germany
Jörgen Hansson	Sweden
Jörg Kaiser	Germany
Nihal Kececi	USA
Swamy Kutti	Oman
Tiberiu Letia	Romania
Jacek Malec	Sweden
Kim-F.Man	Hong Kong
Mathieu Maranzana	France
Mohammed Modarres	USA

Ali Mosleh	USA
Sias Mostert	South Africa
Leo Motus	Estonia
Marga Marcos Munoz	Spain
Joseph Ng	Hong Kong
Carlos E.Pereira	Brasil
Franz Rammig	Germany
Sylvie Ratté	Canada
Krzysztof Sacha	Poland
Francesca Saglietti	Germany
Abd-El-Kader Sahraoui	France
Ricardo Sanz	Spain
Ulrich Schmid	Austria
Jean-Jacques Schwarz	France
Bran Selic	Canada
Terje Sivetsen	Norway
Jacques Skubich	France
Carol Smidts	USA
Tomasz Szmuc	Poland
Theodor Tempelmeier	Germany
Atoosa P.-J. Thunem	Norway
Grace Tsai	USA
Juri Vain	Estonia
Horst Wedde	Germany
Marek Węgrzyn	Poland
Janusz Zalewski	USA
Dieter Zöbel	Germany

Organizing Committee

Yorgo Istefanopulos *(Chair)*
Nihal Kececi
Jose Hurtado *(Secretary)*

PREFACE

Software-intensive control systems are becoming progressively more complex. Numerous industrial sectors such as telecommunication, automotive, aerospace, or nuclear power generation are examples of areas where software-intensive systems are becoming prevalent, extremely complex, and decisive for human safety and for reliability. As there is an accelerated growth of demands for functionality and dependability of such systems, our intellectual and engineering abilities are being challenged to come up with practical solutions to the problems faced in the design and development of complex real-time and safety-related control systems.

Even though software testing is an essential part of manufacturing embedded systems, and significant research efforts have been devoted to it, the current state of the practice in system and software verification and validation (V&V) leaves much to be desired. In many industries, V&V is not receiving the attention deserved, and other important activities such as testing functional and non-functional requirements, modeling large software systems, conformance, acceptance and qualification testing, or measuring the effectiveness of different V&V approaches have not yet been incorporated into the V&V processes employed. Therefore, it was decided to address these issues in a joint event, merging in 2004 the 28th IFAC/IFIP Workshop on Real-Time Programming (WRTP) with the International Workshop on Software Systems (IWSS).

The goal of this workshop was to communicate state-of-the-art methods to assess quality and reliability of software-based systems with the help of validation, verification and test across various domains, and to advance the state-of-practice in validating software and software-based systems. It brought together leading experts on such diverse aspects in the development of complex control systems with safety relevance as systems engineering, software engineering, risk and reliability engineering, real-time computing, control engineering and ergonomics. They addressed key issues, shared experiences, discussed emerging and common technical approaches, and presented their respective methods to construct complex systems composed of hardware, software, and humans. In addition to the presentation of high quality technical papers, the programme also featured four world class keynote addresses, and several intensive panel discussions. Accordingly, these Proceedings comprise the keynote speeches, the 24 papers presented, and three summaries of the discussions. These contributions come from Brazil, Canada, France, Germany, Greece, India, Italy, Latvia, Poland, Slovenia, Spain, Sweden, Turkey, and the U.S.A.

As it holds for all successful events, this joint workshop required the effort of many individuals and organisations. The authors, presenters, and all speakers are to be commended for a truly excellent job. The International Programme Committee and other reviewers selected the best candidates out of many quality submissions. We are indebted to IFAC and its Technical Committee on Computers for Control. Formal co-sponsorship was provided by IFIP, the United States Nuclear Regulatory Commission, the OECD Nuclear Energy Agency with its Committee on Safety of Nuclear Installations, the (U.S.) National Aeronautics and Space Administration, the American Nuclear Society, the University of Maryland Center for Technology Risk Studies, and the Turkish National Science Foundation. The Turkish National Organisation Committee of Automatic Control as National Member Organisation of IFAC and the Center for Technology Risk Studies of the University of Maryland supported the workshop generously. Members of this Center, of whom Mrs. Nihal Kececi is to be especially mentioned, volunteered significant time to organise and run the workshop. The financial support provided by the United States Nuclear Regulatory Commission is highly appreciated.

All attendees enjoyed the Turkish hospitality. The meeting took place in an Istanbul hotel overlooking the magnificent scenery of the Bosphorus where Europe and Asia meet. This enabled a fruitful technical exchange between the participants in a very friendly and relaxed atmosphere.

Matjaž Colnarič *University of Maribor*	*Wolfgang A. Halang* *FernUniversität Hagen*	*Marek Węgrzyn* *University of Zielona Góra*

CONTENTS

INTRODUCTION

SOFTWARE REQUIREMENT ENGINEERING

REAL-TIME PROGRAMMING TECHNIQUES

DEPENDABILITY AND SAFETY FOR REAL-TIME SYSTEMS

CONTROL SYSTEMS DESIGN

SOFTWARE DESIGN

SOFTWARE ENGINEERING AND COMPLEX ENGINEERING SYSTEMS

AUTHOR INDEX