

## Editor-in-Chief

*Kai Rannenberg, Goethe University Frankfurt, Germany*

## Editorial Board

Foundation of Computer Science

*Jacques Sakarovitch, Télécom ParisTech, France*

Software: Theory and Practice

*Michael Goedicke, University of Duisburg-Essen, Germany*

Education

*Arthur Tatnall, Victoria University, Melbourne, Australia*

Information Technology Applications

*Erich J. Neuhold, University of Vienna, Austria*

Communication Systems

*Aiko Pras, University of Twente, Enschede, The Netherlands*

System Modeling and Optimization

*Fredi Tröltzsch, TU Berlin, Germany*

Information Systems

*Jan Pries-Heje, Roskilde University, Denmark*

ICT and Society

*Diane Whitehouse, The Castlegate Consultancy, Malton, UK*

Computer Systems Technology

*Ricardo Reis, Federal University of Rio Grande do Sul, Porto Alegre, Brazil*

Security and Privacy Protection in Information Processing Systems

*Stephen Furnell, Plymouth University, UK*

Artificial Intelligence

*Ulrich Furbach, University of Koblenz-Landau, Germany*

Human-Computer Interaction

*Jan Gulliksen, KTH Royal Institute of Technology, Stockholm, Sweden*

Entertainment Computing

*Matthias Rauterberg, Eindhoven University of Technology, The Netherlands*

## **IFIP – The International Federation for Information Processing**

IFIP was founded in 1960 under the auspices of UNESCO, following the first World Computer Congress held in Paris the previous year. A federation for societies working in information processing, IFIP's aim is two-fold: to support information processing in the countries of its members and to encourage technology transfer to developing nations. As its mission statement clearly states:

*IFIP is the global non-profit federation of societies of ICT professionals that aims at achieving a worldwide professional and socially responsible development and application of information and communication technologies.*

IFIP is a non-profit-making organization, run almost solely by 2500 volunteers. It operates through a number of technical committees and working groups, which organize events and publications. IFIP's events range from large international open conferences to working conferences and local seminars.

The flagship event is the IFIP World Computer Congress, at which both invited and contributed papers are presented. Contributed papers are rigorously refereed and the rejection rate is high.

As with the Congress, participation in the open conferences is open to all and papers may be invited or submitted. Again, submitted papers are stringently refereed.

The working conferences are structured differently. They are usually run by a working group and attendance is generally smaller and occasionally by invitation only. Their purpose is to create an atmosphere conducive to innovation and development. Refereeing is also rigorous and papers are subjected to extensive group discussion.

Publications arising from IFIP events vary. The papers presented at the IFIP World Computer Congress and at open conferences are published as conference proceedings, while the results of the working conferences are often published as collections of selected and edited papers.

IFIP distinguishes three types of institutional membership: Country Representative Members, Members at Large, and Associate Members. The type of organization that can apply for membership is a wide variety and includes national or international societies of individual computer scientists/ICT professionals, associations or federations of such societies, government institutions/government related organizations, national or international research institutes or consortia, universities, academies of sciences, companies, national or international associations or federations of companies.

More information about this series at <http://www.springer.com/series/6102>

Francisco J. Mata · Ana Pont (Eds.)

# ICT for Promoting Human Development and Protecting the Environment

6th IFIP World Information Technology Forum,  
WITFOR 2016  
San José, Costa Rica, September 12–14, 2016  
Proceedings

*Editors*

Francisco J. Mata  
Universidad Nacional  
Heredia  
Costa Rica

Ana Pont  
Universitat Politècnica de València  
Valencia  
Spain

ISSN 1868-4238 ISSN 1868-422X (electronic)  
IFIP Advances in Information and Communication Technology  
ISBN 978-3-319-44446-8 ISBN 978-3-319-44447-5 (eBook)  
DOI 10.1007/978-3-319-44447-5

Library of Congress Control Number: 2016947782

© IFIP International Federation for Information Processing 2016

This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, express or implied, with respect to the material contained herein or for any errors or omissions that may have been made.

Printed on acid-free paper

This Springer imprint is published by Springer Nature  
The registered company is Springer International Publishing AG Switzerland

# Foreword

The International Federation for Information Processing (IFIP) is the global federation of societies of ICT professionals that aims at achieving a worldwide professional and socially responsible development and use of information and communication technologies. It was established in 1960 under the auspices of UNESCO as an international non-governmental organization (NGO), not-for-profit. Its members are societies, and volunteers come from all over the world to participate in its Technical Committees and Working Groups.

One of its strategic aims, among others, is to advance digital equity worldwide, by promoting accessibility of ICT, good practices, and appropriate access to knowledge and experiences. It also seeks to discover opportunities to use information and communication technologies to promote human development and protect the environment. This is done by organizing and contributing to activities aimed at achieving the UN Sustainable Development Goals (SDGs) and the plan of action of the ITU World Summit on the Information Society (WSIS).

Among the activities organized or promoted by IFIP to attain the above goals, one flagship event is the World Information Technology Forum (WITFOR), initiated by this organization in 2003. WITFOR intends to bring together members of the ICT community from governments, academia, industry, and associations, to discuss recent proposals aimed at reaching the sustainable development goals, promoted by the United Nations, to improve global conditions by: reducing poverty and hunger; achieving universal education; promoting gender equality; ensuring environmental sustainability; combating diseases and reducing mortality.

WITFOR investigates successful ICT strategies in developing countries and examines different initiatives and projects on effective, context-sensitive development and use of ICT applications. It is intended to:

- Help put ICT-enabled development initiatives on the agenda of different organizations, governmental bodies, and groups currently involved in ICT.
- Work with different groups to ensure that senior policy makers and political leaders are aware of the developmental potential of ICT and promote its diffusion and sustainable effective use.
- Assist international organizations and donor agencies to include issues of the spread of ICT and access to information into their loan and funding programs and be more proactive in using new technologies to reduce existing social tensions and conflicts.
- Encourage scholars, analysts, and researchers to put the issue of digital equity higher on their research agendas.
- Encourage industrialized nations, as individuals and groups, to listen to and learn from colleagues around the world about their unique concerns over access to ICT.
- Develop guidelines on these issues and advise governments to formulate and follow the best strategy for the use of ICT in order to achieve global ICT equity.

WITFOR has been organized by IFIP periodically since 2003 in cooperation with several stakeholders in different host countries. So far WITFOR has been held in Vilnius (Lithuania), in 2003; in Gaborone (Botswana), in 2005; in Addis Ababa (Ethiopia) in 2007; in Hanoi (Vietnam) in 2009; and in Delhi (India), in 2012. Among the topics addressed in these editions we find: preparing the ground for ICT (2003), building the infrastructure (2003, 2005, 2007, 2009), economic opportunity (2003, 2005, 2007, 2009), empowerment and participation (2003, 2005, 2007), health (2003, 2005, 2007, 2009, 2012), education (2003, 2005, 2007, 2009, 2012), environment (2003, 2005, 2007, 2009), social, ethical, and legal aspects (2003, 2005, 2007, 2009), agriculture (2005, 2007, 2009, 2012), and e-government (2009, 2012).

WITFOR 2016 was organized by IFIP in cooperation with the Costa Rican Ministry of Science, Technology and Telecommunications (MICITT) and the five Costa Rican public universities members of the National Council of Rectors (CONARE): Universidad de Costa Rica, Instituto Tecnológico de Costa Rica, Universidad Nacional, Universidad Estatal a Distancia, and Universidad Técnica Nacional. This is the first time that WITFOR was held in Latin America and we hope this conference will help to build bridges of understanding between different regions in the world, as well as to produce a fruitful exchange of experiences and opinions between academics, practitioners, and decision-makers, contributing in this way toward the creation of a more sustainable and equitable world.

We thank the financial support of IFIP and CONARE, and the collaboration of MICITT and the Costa Rican public universities. Without their contribution, it would not have been possible to organize WITFOR 2016.

July 2016

Gabriela Marín Raventós  
Ramon Puigjaner  
General Chairs

## Preface

We are very pleased to introduce the proceedings of the World Information Technology Forum 2016 (WITFOR 2016), held in San Jose, Costa Rica, during September 12–14, 2016.

WITFOR 2016 was the sixth edition of the World Information Technology Forum, and the first one organized as an academic conference. Previous editions were structured as discussion forums. Similar to previous events, WITFOR 2016 pursued the presentation and discussion of ICT-related strategies and projects to promote development worldwide. Therefore, this conference was aimed at the interface between development and technology.

A call for papers was issued under the general theme of “ICT for Promoting Human Development and Protecting the Environment.” Within this theme, four major topics were included encompassing the Sustainable Development Goals (SDGs) recently adopted by the United Nations: ICT and cross-cutting development issues, ICT and environmental problems, ICT and human development problems, and ICT and economic development problems.

In all, 45 papers were submitted by authors from 25 countries, representing all continents. After a thorough peer-reviewed process—in which each paper was reviewed by at least three members from a distinguished Technical Program Committee (TPC)—24 papers were accepted; 22 of them are included in these proceedings. We would like to thank the members of the TPC for their valuable effort and contribution during the review process. Their work was of great importance to guarantee the quality of the conference.

The papers selected for WITFOR 2016 can be classified into seven broad topics: environment and sustainability; education; health; digital equity; gender; economic development and infrastructure; and e-government and smart cities. The broad range of issues dealt in these papers, and the different points of views reflected in them, make these proceedings valuable for researchers, practitioners, and decision-makers interested in using ICT for promoting human development and protecting the environment. In addition, they demonstrate that WITFOR can evolve into an academic conference to help further the objectives of IFIP to foster international cooperation; to stimulate research, development, and applications; and to encourage education, dissemination, and exchange of information on all aspects of computing and communication.

WITFOR 2016 was complemented by keynote speakers, demonstrations, and panel sessions. In addition, the Second Conference on Science, Innovation, and Information and Communication Technology of the United Nations Economic Commission for Latin America and the Caribbean was co-located with WITFOR 2016. This allowed for an exchange of opinions and discussions among participants in both events.

We would like to acknowledge the general chairs, Gabriela Marín Raventós and Ramon Puigjaner, for their huge effort in organizing this event. The same would not have been possible without their hard and enthusiastic work. We also appreciate the

work of everyone involved in the organization of the conference. Last, but not least, we also thank the authors and participants of WITFOR 2016.

We hope that the collection of papers in these proceedings assist in furthering the understanding of ICT issues and applications related to development, and also facilitate a fruitful exchange of experiences between academics, practitioners, and decision-makers.

Francisco J. Mata  
Ana Pont  
Technical Program Chairs

# Conference Chairs

## General Chairs

Gabriela Marín Raventós      Universidad de Costa Rica, Costa Rica  
Ramon Puigjaner              IFIP, Spain

## Technical Program Chairs

Francisco J. Mata              Universidad Nacional, Costa Rica  
Ana Pont                         Universitat Politècnica de València, Spain

## Program Committee

Julio Abascal                    Euskal Herriko Unibertsitatea, Spain  
Jose Aguilar                    Universidad de los Andes, Venezuela  
Noura Aknin                    Université Abdelmalek Essaïdi, Morocco  
Benjamín Barán                Universidad Nacional de Asunción, Paraguay  
Elena Gabriela Barrantes      Universidad de Costa Rica, Costa Rica  
Pablo Boronat                 Universitat Jaume I, Spain  
Louiza Boualouche-  
Medjkoune                      Université Abderrahmane Mira de Béjaïa, Algeria  
Heilyn Camacho                Aalborg University, Denmark  
Sergio Camorlinga              University of Winnipeg, Canada  
Héctor Cancela                Universidad de la República, Uruguay  
Indira Carr                      University of Surrey, UK  
Ignacio Casas                 Pontificia Universidad Católica de Chile, Chile  
Bernard Cornu                 Centre National d'Education a Distance, France  
Roberto Cortés                Instituto Tecnológico de Costa Rica, Costa Rica  
Cecile Crutzen                Open Universiteit Nederland, The Netherlands  
Paul M. Cunningham            IIMC/IST-Africa, Ireland  
Valentina Dagiene              Vilnius University, Lithuania  
Kevin Daimi                    University of Detroit Mercy, USA  
Penny Duquenoy                Middlesex University, UK  
Amado Espinoza                Medisist, Mexico  
Simone Fischer-Hubner        Karlstad University, Sweden  
Inés Friss de Kereki            Universidad ORT, Uruguay  
José A. Gil Salinas            Universitat Politècnica de València, Spain  
Wayne Goddard                Clemson University, USA  
Víctor M. González            Instituto Tecnológico Autónomo de México, México  
Dorothy Gordon                Advance Information Technology Institute, Ghana  
Helena Grunfeld                Victoria University, Australia

Roger Harris	Roger Harris Associates, Hong Kong, SAR China
Richard Heeks	University of Manchester, UK
Magda Hercheui	University College London, UK
Asha Kanwar	Community of Learning, India
Kai Kimpa	University of Turku, Finland
Anton Knierzinger	Private Pädagogische Hochschule der Diözese Linz, Austria
Winfried Lamersdorf	Universität Hamburg, Germany
Louise Leenen	Council for Scientific and Industrial Research, South Africa
Ernst Leiss	University of Houston, USA
Erick Mata	Instituto Tecnológico de Costa Rica, Costa Rica
Ramiro Montealegre	University of Colorado, USA
Christina Mörtberg	Linnéuniversitetet, Sweden
Yuko Murayama	Iwate Prefectural University, Japan
Edward Mutafungwa	Aalto University, Finland
Vikas Nath	HotPopRobot.com, Canada
Erich Neuhold	Universität Wien, Austria
Paul Nleya	University of Botswana, Botswana
Norberto Patrignani	Politecnico di Torino & Università, Cattolica del Sacro Cuore, Italy
Sebastián Rovira	United Nations Economic Commission for Latin America and the Caribbean, Chile
Sindre Røsvik	Giske Kommune, Norway
Rodrigo Santos	Universidad Nacional del Sur, Argentina
Alain Senteni	Hamdan bin Mohammed Smart Universit, United Arab Emirates
Siraj Shaikh	Coventry University, UK
Leon Strous	Central Bank of the Netherlands, The Netherlands
Hiroshi Takeda	Jikei Institute, Japan
A Min Tjoa	Technische Universität Wien, Austria
Izak van Zyl	Cape Peninsula University of Technology, South Africa
Chris Westrup	University of Manchester, UK
Diane Whitehouse	The Castlegate Consultancy, UK

# Contents

## Environment and Sustainable Development

The Role of ICT to Achieve the UN Sustainable Development Goals (SDG) . . . .	3
<i>A. Min Tjoa and Simon Tjoa</i>	
Principles for Re-Designing Information Systems for Environmental Sustainability . . . . .	14
<i>Richard Baskerville, Jan Pries-Heje, and Jan Recker</i>	
Automated Plant Species Identification: Challenges and Opportunities . . . . .	26
<i>Erick Mata-Montero and Jose Carranza-Rojas</i>	
Environment Monitoring Using Commercial Off-the-Shelf (COTS) Technologies: A Case Study of the Odd-Even Rule for Pollution Control in Delhi . . . . .	37
<i>Vikas Nath and Artash Nath</i>	

## Education

Challenge to Promote Deep Understanding in ICT . . . . .	47
<i>Valentina Dagiene</i>	
Computer Animation as a Vehicle for Teaching Computational Thinking . . . .	53
<i>Leonel Morales Díaz and Laura S. Gaytán-Lugo</i>	
Transforming Low Socioeconomic Status Schools to Learning for Well-Being Schools . . . . .	60
<i>Heilyn Camacho</i>	
Transformative Applications of ICT in Education: The Case of Botswana Expansive School Transformation (Best) Project . . . . .	68
<i>Paul Thabano Tapela Nleya</i>	

## Health

Identification of Design Patterns for Serious Games in an Educational Videogame Designed to Create Awareness on Dengue and Malaria Fever . . .	85
<i>Eduardo Ramírez Elizondo</i>	
A Community Assets Infrastructure for the Secure Use of Mobile Computing Devices in the Rural Health Landscape . . . . .	96
<i>Kevin Kativu and Dalenca Pottas</i>	

**Digital Equity**

Progressing Toward Digital Equity . . . . . 109  
*Ramon Puigjaner*

Telecenters for the Future in Tea Estates of Sri Lanka . . . . . 121  
*Sirkku Männikkö-Barbutiu, Thomas Westin, Ranil Peiris,  
and Peter Mozelius*

Mobile Internet Tariff Models: Technical or Political Decisions?  
A Costa Rican Case Study . . . . . 132  
*Alexander Castro-Reyes and Gabriela Marín-Raventós*

guifi.net: A Bottom-up Initiative for Building Free  
Telecommunication Infrastructure . . . . . 144  
*Miguel Pérez, Pablo Boronat, José A. Gil, and Ana Pont*

**Gender**

Typifying Mechanisms for Gender Digital Equity in Latin America. . . . . 159  
*Gabriela Marín-Raventós and Marta Calderón-Campos*

Women in ICT: Opportunities for Their Inclusion in an International  
Labor Market . . . . . 171  
*Ana M. González, Beatriz Revelles, Elisabet Almeda,  
Núria Vergés Bosch, and José S. García*

**Economic Development and Infrastructure**

Can E-Commerce Provide a Solution to the Coffee Paradox? The Case  
of Costa Rica . . . . . 181  
*Francisco J. Mata, Ariella Quesada, and Gabriela Mata-Marín*

Innovation and Governance: The Role of Sharing Economy . . . . . 195  
*Elia Brugnoli, Alberto Polzonetti, and Matteo Sagratella*

e-Bridge 3.0: A Strategic Approach to Structural Health Monitoring  
of Bridges in Costa Rica . . . . . 205  
*Cesar Garita and Giannina Ortiz*

**E-Government and Smart Cities**

ICT and Citizen Efficacy: The Role of Civic Technology in Facilitating  
Government Accountability and Citizen Confidence . . . . . 213  
*Rebecca Rumbul*

Promoting Quality e-Government Solutions by Applying a Comprehensive Information Assurance Model: Use Cases for Digital Signature. . . . . 223  
*Ricardo Villalón-Fonseca, Alejandro Mora-Castro, Rodrigo Bartels-González, Miguel Carballo-Chavarría, and Gabriela Marín-Raventós*

Emergence and Ubiquity in the Smart Cities. . . . . 235  
*Jose Aguilar*

**Author Index** . . . . . 245