Jiří Hřebíček
Gerald Schimak Ralf Denzer (Eds.)

Environmental Software Systems

Frameworks of eEnvironment

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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. An umbrella organization for societies working in information processing, IFIP's aim is two-fold: to support information processing within its member countries and to encourage technology transfer to developing nations. As its mission statement clearly states,

> *IFIP's mission is to be the leading, truly international, apolitical organization which encourages and assists in the development, exploitation and application of information technology for the benefit of all people.*

IFIP is a non-profitmaking organization, run almost solely by 2500 volunteers. It operates through a number of technical committees, which organize events and publications. IFIP's events range from an international congress to local seminars, but the most important are:

- The IFIP World Computer Congress, held every second year;
- Open conferences;
- Working conferences.

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 small and by invitation only. Their purpose is to create an atmosphere conducive to innovation and development. Refereeing is less 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.

Any national society whose primary activity is in information may apply to become a full member of IFIP, although full membership is restricted to one society per country. Full members are entitled to vote at the annual General Assembly, National societies preferring a less committed involvement may apply for associate or corresponding membership. Associate members enjoy the same benefits as full members, but without voting rights. Corresponding members are not represented in IFIP bodies. Affiliated membership is open to non-national societies, and individual and honorary membership schemes are also offered.

Volume Editors

Jiří Hřebíček
Masaryk University, Institute of Biostatistics and Analyses
Kamenice 126/3, 625 00 Brno, Czech Republic
E-mail: hrebicek@iba.muni.cz

Gerald Schimak
Austrian Institute of Technology GmbH (AIT)
2444 Seibersdorf, Austria
E-mail: gerald.schimak@ait.ac.at

Ralf Denzer
Environmental Informatics Group (EIG)
Goebenstr. 40, 66117 Saarbrücken, Germany
E-mail: ralf.denzer@enviromatics.org

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Preface

1 ISESS ++ (Ralf Denzer)

1.1 IFIP WG 5.11 and ISESS

The International Symposium on Environmental Software Systems (ISESS) is one of several overlapping forums discussing issues of Environmental Information Systems, Environmental Decision Support Systems, Environmental Software Systems, Environmental Informatics, Eco-Informatics or Enviromatics – whichever of the terms you prefer at a certain time of day.

ISESS was founded by Gerald Schimak and myself in 1995, with great support from the German Informatics Society Working Group 4.6 "Computer Science for Environmental Protection" and the International Federation for Information Processing (IFIP) Working Group 5.11 "Computers and Environment."

Like many things, ISESS started over a couple of drinks (how else, for a German), when a visiting friend, David Russell from Pennsylvania State University, issued an invitation to organize some sort of workshop or conference on his campus. When we prepared for the first ISESS at Penn State, it was at best "a shot in the dark," although I am prepared to swear every oath that neither the Pink Panther nor Inspector Clouseau had any part in the plot.

The symposium has been held in a number of countries since: the United States, Canada, Austria, New Zealand, Switzerland, Portugal, the Czech Republic, Spain, Italy; in some years, joint sessions were held in conjunction with the biannual meeting of IEMSS (International Environmental Modelling and Software Society). ISESS is an official IFIP event which is directly supported by WG 5.11.

The WG itself was led by Giorgio Guariso (1991–1999), myself (1999–2005) and Dave Swayne (2005–2011). Several individuals have served as vice-chairs or as secretaries of the WG and many members of the WG have been active supporters for a long time without holding an official position.

1.2 Jiri's Question

Jiri Hrebicek, the General Chairman of this ISESS 2011 in Brno, has asked me to say a few words in the introduction of these proceedings about where we are now and where we might go in the coming years – our field of work, our WG 5.11 and our conference ISESS. Jiri is particularly interested in opinions regarding what R&D should be fostered, and how the WG and ISESS may support the process to discuss them. I also understand that he is interested in discussing where the contribution of our community can have maximum impact. My dear Jiri: How can any one individual hope to make some sense of such a question? On top of that, have you considered that as a professor I *already* gossip too much?

The first simple answer to your question would point you to other people and be: *go and ask the end users about their needs*. The problem with this simple answer is that it will only deliver a partial answer, for the following reasons:

a) The real end users are often not the deciders of investments, even less deciders of corporate information and communication (ICT) strategies.
b) If at all, they can only indirectly influence priorities of research (for instance through policies which reflect societal needs).
c) If you ask individual users from different domains, you will always get an entirely fragmented picture of individual needs.
d) These needs change all the time with new environmental issues popping up.

This approach will not tell you which type of R&D is needed broadly. It leaves you with multiple *micro-level views*.

A second simple answer to your question would also point you to other people and be: *go ask the people who have the big picture*, for instance, those who define large-scale ICT policies or those who prepare mind-boggling visionary large-scale projects. I am not sure if this will give you a lot of *concrete* answers to your question, because naturally such efforts stay at a *macro-level view* for at least some of their time.

What you would like to know, Jiri, may be at a level in between these two views, and I think that our scientific community already has some answers, although you may have to collect them from many sources and make some systematic sense of them. The ISESS forum is hopefully contributing to this process.

1.3 Vision of an IT Infrastructure for Decision Making

If there is a dominant topic recently, then it is the notion of a networked information infrastructure which allows users of different domains, expertise and capabilities to share information and services, and which provides them with the necessary information for their decisions at anytime, anywhere, on-demand and in an ad-hoc fashion if needed. In Europe, the terms "single information space for the environment" (SISE) and "shared environmental information system" (SEIS) have been introduced, and although other parts of the world may use other words, they are often after the same thing. The various efforts, for instance, in Australia to build a continent-wide information resource for the water domain is very similar. Along with this vision, activities to provide fundamental services as a baseline are underway, as pointed out in the paper "eEnvironment: Reality and Challenges for eEnvironment Implementation in Europe" of Hrebicek and Pillmann in these proceedings. One might ask the questions: Why has this notion been so dominant recently? Is it more like a high-level political wish, or a nice-to-have wish, is this vision really reflecting the needs of a majority of end users? In order to discuss this question, we can consider several types of applications.

For those applications that require integration across (geographic, political, organizational, domain) boundaries, it is obvious that they are supported by a SISE. Such applications may be at continental scale or cross-boundary applications.

Then there is a type of application that requires a high degree of flexibility in the combination of existing information and services, maybe because the decisions taken are too complex and cannot be completely predefined, or due to the fact that it is simply too expensive to build a dedicated software system supporting them. Such applications include those that have to react to unforeseen factors. A SISE which supports on-demand information processing of "whatever is available out there" in an efficient way clearly supports these applications.

Finally there are applications that do not necessarily need to rely on the SISE, but which may just become more efficient because end users are relieved of stupid, time-consuming tasks, or which could greatly improve their performance if respective services were available in the infrastructure.

Where we are with the vision of an ICT infrastructure for environmental decision making is anybody's guess, and it is also somewhat subjective. It is essential that more and more applications using the SISE come on-line in real life (and not in R&D projects *alone*). For this, *all* barriers preventing integrated distributed work flows need to be coped with. Only if end users and organizations get value and quality for money from the SISE will there be a growing awareness that it is worth investing in it oneself.

1.4 Some of the Gossip

As part of the preparation of this preface, and after writing chaps. 1.1 to 1.3, I contacted 25 individuals (not including Gerald and Jiri) who have been important contributors in this line of work for quite a while, in academia, government and industry. I received 12 replies and will try to summarize the majority of the opinions in terms of achievements, deficits and opportunities. It is interesting to note that most replies received included not only technological but also many "soft factors."

1.5 Achievements

Environmental data and information management are generally considered very mature and the underlying technology is solid. Sensor networks and earth observation give access to an ever-increasing amount of observation data, and it can be expected that in the future there will be more (cheap, mobile) sensors producing types of data not available today.

The achievements in data and service standards and their practical importance are recognized and have greatly improved inter-operability at least at the syntactical level. There has been considerable progress at the conceptual level of distributed services; for instance, the use of the service-oriented architecture (SOA) paradigm and application of reference models have demonstrated that multiple autonomous organizations can connect via this paradigm.

Spatial data infrastructures are being consolidated at a national level, and coordinated international activities are progressing toward the integration of heterogeneous information sources. There is also some drive toward providing geospatial applications and data over reduced barriers.

The simulation of environmental phenomena has reached an unprecedented level of detail, and it is quite possible to embed complex models in decision support systems, maybe for the first time really "from a local to a global scale." Concepts are underway toward flexible modeling as well as decision support frameworks that make the implementation of concrete systems more affordable.

Interactive, graphics-based systems, particularly those which make information on the Internet available for local use, have contributed to the transfer of information to stakeholders and have improved the confidence in applying decision theory as part of finding a solution to a given problem.

In terms of "soft factors" it is noted that – at least for those working regularly in our application area – some common understanding of terminology has been reached between modelers, IT specialists and application specialists. Common problems have been identified and examples of good practices are known.

The scientific communities have become broader rather than narrowed down. Several individuals note that 15 years ago one would have thought of classic environmental media, whereas today fields like industrial ecology, sustainable development and risk management are part of many systems being built.

1.6 Deficits

The majority of individuals have expressed the opinion – in one way or other – that there are several large gaps between what has been made available *at the conceptual level*, and what is done *in practice*, an opinion which I share in most cases.

At the data level, there is a gap between the ever-increasing availability of data and the lack of easy discovery and access – the issue of ownership being part of the problem. There is also a large gap between data and data semantics, including the quantification of uncertainties which would be needed for larger-scale data sharing among specialists of different fields. As data sharing involves individuals from neighboring disciplines (and sometimes remote disciplines), and because decision making today often requires the involvement of experts from many disciplines, the issue of semantics is of on-going importance, and there is hope that mainstream IT will deliver improved concepts and tools.

At the level of supporting end users with decision support systems, several individuals express the opinion that there have been too many prototypes and too few "real-world" decision support systems (DSS) that are used on a daily basis by decision makers. This is probably the case and may be due to the fact that these systems are often quite complex and may need considerable improvement in usability. One colleague thinks that there may have been too much focus on the technological side and that "we may have lost the customers in the process." I share this opinion partially, but I do not know what the alternative would have been; I think that for complex DSS we are still in the phase of experimentation, and more driven by the technology side. In any case it will be necessary to get more DSS on the end user desk.

There is a particularly large gap between sophisticated design concepts and how systems are being built today. For instance, many applications are still completely hard wired and there is a lot of re-inventing of the wheel (why should it be different in our line of work...). Although high-level concepts and software engineering paradigms (like reference models, systematic use of SOAs and so forth) exist, they do not even make it into the requirements of public tenders in many cases. There seems to be a general lack of knowledge, even in some self-announced software companies, that these concepts even exist, and what they mean in the context of an application project or an IT strategy of a customer. Perhaps these concepts have not been sufficiently communicated and practical training is a necessity.

The current level of service standardization is also not considered sufficiently mature, which is particularly important because the availability of more generic services would both promote inter-operability and re-use, i.e., this could have a considerable impact. This is particularly the case for services going beyond the classic "discovery and access" services, supporting higher-level analysis, for instance, for data fusion, simulation or semantic inter-operability. There is also a need of concepts for tailoring generic services to application domains.

The "softer" deficits mentioned belong to several categories. First of all there is the issue of digital rights and making more existing data available for general use. Secondly there is the above-mentioned lack of competence of a considerable number of the players in "the ICT team." There is a lack of training in the application of sophisticated and proven concepts developed since the mid-2000s. It also seems to be the case that there are still project developers out there who have not understood what proper user involvement is, which leads to a poor record of performance for at least some decision support systems. At the same time, customers seem to have a need to better identify how they can avoid hiring a bad software company.

1.7 Opportunities

Several individuals identify opportunities through a more "systematic approach." On one hand this can be a clearer foundation based on a "solid understanding of the nature of data, information and knowledge," but this would also apply to improved use of semantics for annotation, which would in turn improve discovery, access and use of information resources. Proper tools to cope with uncertainty and complex systems with multiple feedback loops are under this category and semantics could also be used to describe models in order to improve their use. A better way to communicate uncertainty and risk could be of great benefit for stakeholders.

In more practical terms, the use of reference models for corporate and multi-organization ICT strategies is considered a key factor in organizing the SISE. Improved use of standards, in particular to foster the creation of thematic profiles of generic services, is considered necessary toward this goal. It is also expected that the increasing number of sensors will support new types of applications not available today. It will also be beneficial to improve high-level frameworks

and reference models toward better support of distributed service orchestration, trust-worthiness and robustness. Improved computational analysis, for instance, in the area of data fusion, should become part of the generic service framework.

A number of recent ICT developments are considered good opportunities as well. One can, for instance, imagine synergies between social networks and decision making, including volunteered information and presentation of information in virtual worlds. The area of mobile applications is considered a key opportunity, because mobile location-based Apps for everyday use could reach a much larger number of users more easily. This could also include computer vision for monitoring purposes.

Cloud computing and virtualization are a new type of platform that could help to turn systems into trusted services, and they allow for new types of business models through alternative service delivery.

It was interesting to see that the largest number of comments regarding "soft factors" came under the question regarding opportunities for the coming years. First of all there is a need to show more concrete examples of identifying and adopting good practices, and communication in the scientific community regarding good practices is worth fostering. For decision support systems it would be important to identify "cohorts of environmental decision makers" who exist in significant numbers, which may be just another way of saying that we need to go toward more standardized (although maybe domain-specific) products. It would be valuable if one could quantify the benefits of ICT-supported decision making and if the scientific community could give some better "proof" that systems really help decision makers to make better decisions.

Several individuals see considerable opportunities in reaching out to larger scientific communities, for instance, in the area of sustainability, industrial ecology or the interface between environment and health. Collaboration across societies and scientific communities in particular at the interface to modelers is considered particularly important. Improved funding for real interdisciplinary projects between ICT and application teams would help to bridge gaps as well. A SISE will also need organizational and legal frameworks beyond the ICT.

1.8 Conclusions

Despite the long list of deficits in the previous chapter, which reflect practical deficiencies, we have seen many successful applications of ICTs in different areas of environmental management, sustainability, risk management and so forth. But we have also seen far too many "prototypes-only" and far too many badly designed systems that are quietly buried by their end users after a short period of time. I think that the WG, in collaboration with other scientific communities, can make a contribution by spreading information about good practices and by involving even broader communities, both in terms of discipline and of geography. My personal opinion as a computer scientist is that it is our responsibility to seek the communication with the end user, and not the end user's responsibility to find us.

2 Framework of ISESS 2011 (Jiri Hrebicek)

2.1 Predecessors of ISESS 2011

The first and second proceedings of the International Symposium on Environmental Software Systems (ISESS 1995 and ISESS 1997) were published and printed by official IFIP publisher Chapman&Hall:

- R. Denzer, D. Russell, G. Schimak (eds.), Environmental Software Systems, Chapman & Hall, 1996, ISBN 0 412 73730 2.
- R. Denzer, D. A. Swayne, G. Schimak (eds.), Environmental Software Systems Vol. 2, Chapman & Hall, 1998, ISBN 0 412 81740 3.

Then IFIP changed publisher and the third proceedings of ISESS 1999 were published and printed by official IFIP publisher Kluwer:

- R. Denzer, D. A. Swayne, M. Purvis, G. Schimak (eds.), Environmental Software Systems Vol. 3 - Environmental Information and Environmental Decision Support, Kluwer Academic Publishers, 2000, ISBN 0 7923 7832 6.

The fourth and fifth proceeding of ISESS 2001 and ISESS 2003 were published and printed by the organizers of the symposium themselves under IFIP ISBN:

- D. A. Swayne, R. Denzer, G. Schimak (eds.), Environmental Software Systems Vol. 4 - Environmental Information and Indicators, International Federation for Information Processing, 2001, ISBN 3 901882 14 6.
- G. Schimak, D. A. Swayne, N.T. Quinn, R. Denzer (eds.), Environmental Software Systems Vol. 5 - Environmental Knowledge and Information Systems, International Federation for Information Processing, 2003, ISBN 3 901882 16 2.

In a similar way the sixth and seventh proceedings of ISESS 2005 and ISESS 2007 were published by the organizers but this time on CD and USB under IFIP ISBN:

- D. A. Swayne, T. Jakeman (eds.), Environmental Software Systems, Vol. 6 - Environmental Risk Assessment Systems, International Federation for Information Processing, 2005, IFIP ISBN 3-901882-21-9
- D. A. Swayne, J. Hrebicek (eds.), Environmental Software Systems, Vol. 7 - Dimensions of Environmental Informatics, International Federation for Information Processing, 2007, IFIP ISBN: 978-3-901882-22-7.

The eight proceedings of ISESS 2009 were published again on a USB, but not under IFIP ISBN:

- D. A. Swayne, R. Soncini-Sessa (eds.), Environmental Software Systems, Vol. 8, 2009, C.R.L.E University of Guelph ISBN: 978-3-901882-364.

2.2 Collaboration with IFIP and Springer

The editors of these proceedings decided to use the new IFIP publishing channel, which is Springer, and to publish the ISESS 2011 proceedings electronically (as a CD) in the IFIP *Advances in Information and Communication Technology* (AICT) series.

The IFIP AICT series publishes state-of-the-art results in the science of information and communication technologies. The scope of the series includes: foundations of computer science; software theory and practice; education; computer applications in technology; communication systems; systems modeling and optimization; information systems; computers and society; computer systems technology; security; artificial intelligence; and human – computer interaction.

The principal aim of the IFIP AICT series is to encourage education and the dissemination and exchange of information about all aspects of computing.

One of the goals of this event is to merge the knowledge and interests of members of WG 5.11 "Computers and Environment" and the ISESS 2011 conference dedicated to information exchange among scientists and businesses involved in the development and use of environmental informatics for the delivery of state-of-the-art eEnvironment services in Europe and worldwide.

Therefore the conference focuses specifically on the following topics:

- eEnvironment and Cross-Border Services in Digital Agenda for Europe
- Environmental Information Systems and Services—Infrastructures and Platforms
- Semantics and Environment
- Information Tools for Global Environmental Assessment
- Services and Environmental Tools for Urban Planning and Climate Change Applications and Services

ISESS 2011 is a meeting place for experts on leading-edge technologies, and it aims to foster the standardization and integration of environmental data and information flows, which are essential pre-requirements for managing our natural resources in a framework of sustainable development.

ISESS has become open to governmental institutions, international and intergovernmental organizations, environmental agencies and networks, scientists, academicians, politicians, businesses, public administration and decision makers in the field of environmental information, experts from ICT industry, specialists of theoretical and applied informatics, consultants, students and the concerned public.

The editors hope that you find new knowledge and ideas in the IFIP AICT proceedings of ISESS 2011 and from its website, where you can read reviewed contributions of authors and experts on leading-edge ICT technologies for environments of the above-mentioned topics.

3 Vision of IFIP WG 5.11 (Gerald Schimak)

Since many years now, IFIP WG 5.11 "Computers and Environment" is running, under the umbrella of IFIP, this ISESS conference series. We hope that this conference will turn out to be as fruitful as all its predecessors and proves once again as the R&D reference event in Enviromatics.

The vision and mission of the WG 5.11 was always to foster the improved application of information technology in environmental research, monitoring, assessment, management and policy. This is still valid but over the last few years the picture has changed slightly and new challenges have popped up.

Challenges, stemming from requirements realizing a SISE and SEIS or when setting up the Strategies for the Digital Agenda for Europe, demand for new services, new collaboration strategies in decision making and cross-border information exchange. This is not only valid for Europe but also applicable worldwide, if we consider the ICT needs in GMES or GEOSS in ICT and eEnvironment.

In order to achieve our mission mentioned above my personal vision and hopefully also the one of IFIP WG 5.11 for the future is:

- To establish a platform / forum among and between ICT and environmental professionals.
- Hold knowledge-centric conferences worldwide to exchange information about state-of-the-art technology and prepare the ground for the future.
- Provide expert advice to government, multinational organisations and industry.
- Provide strategy and policy makers with intuitive ICT concepts and solutions.

One of the first upcoming tasks of WG 5.11 will be the adoption of our WG member list of well-known experts in the fields of ICT and the environment domain as well as from related sectors like energy or mobility.

Acknowledgments

The editors are grateful to all authors for their valuable contributions to the conference and the members of the Programme Committee for reviewing more than 100 submitted abstracts. Special thanks go to the representatives of the International Federation for Information Processing, DG Information Society and Media of the European Commission as well as the Joint Research Centre for their kind support and useful advice with respect to the collaboration and organization of ISESS 2011.

We would like also to thank Masaryk University, its Institute of Biostatistics and Analyses, the Ministry of Environment of the Czech Republic, and the Technology Centre AS CR for the scientific and organizational support of this

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Last but not the least we thank all partners involved in the preparation of this conference as well as all sponsors for their valuable cooperation and patience.

June 2011

Jiří Hřebíček
Gerald Schimak
Ralf Denzer

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