MiNEMA Winter School 2007 – Scientific Report

Middleware for Mobile Computing

February 12-16, 2007 – Anzère, Switzerland

Summary

In February 2007, the MiNEMA Winter School was organized by the University of Lausanne on the theme *Middleware for Mobile computing*. It gathered around 80 researchers from various european research institutions working on middleware for mobile and ad hoc computing environments, and provided them with a set of high standard tutorials. The winter school also hosted the 8th steering committee meeting of the MiNEMA programme.

The set of proposed tutorials encompassed the domain of mobile computing and its supporting technologies in very broad manner. Indeed, the talks ranged from low-level technical concerns, such as packet radio protocols (Darek Kowalski), to business-level concerns, such as business models for mobile computing (Yves Pigneur). Of course, the core of the winter school was focused on middleware issues, such as gossip-based networking (Anne-Marie Kermarrec), malicious interference in wireless networks (Seth Gilbert), populations protocols (Eric Ruppert), computation in large-scale wireless networks (Idid Keidar), embedded operating systems (David Gay) and peer-to-peer data management (Karl Aberer). The winter school also proposed an industry session, with Apple Computer presenting its mobility strategy and Sun Microsystems presenting the future of the Java Micro Edition, which is targeted at mobile wireless devices.

The format of the winter school was also different from other seasonal schools in that it tried to follow the famous latin quotation *mens sana in corpore sano*. Each day was indeed a mix of mental and physical activities: the morning was dedicated to tutorial sessions, the early afternoon was left free for the participants to exercise some outdoor activities, in the cold and the snow, while the late afternoon was again dedicated to tutorial sessions.

Overall, the vast majority of participants expressed their satisfaction with both the content and the organization of the winter school, via the survey carried out at the end of the event. For the organizing team, in spite of the significant work overhead, it was also a great experience to gather so many young and enthusiastic researchers from the MiNEMA programme.

Scientific content

The complete programme of the winter school is presented in Figure 1 and discussed hereafter. The set of tutorials covered the domain of mobile computing and dedicated middleware in very broad way. The speakers' biographies are given in Appendix A (page 9).

SUNDAY 11	
19:00 – 22:00	Welcome reception

MONDAY 12	
07:30 – 08:30	*Breakfast*
08:30 – 10:00	Gossip-based networking (part I) by Anne-Marie Kermarrec
10:00 – 10:30	*Coffee break*
10:30 – 12:00	Gossip-based networking (part II) by Anne-Marie Kermarrec
12:00 – 17:00	*Optional activity*: Ski (12:30)
17:00 – 18:00	Peer-to-peer data management (part I) by Karl Aberer
18:00 – 18:30	*Coffee Break*
18:30 – 19:30	Peer-to-peer data management (part II) by Karl Aberer
20:00 – 22:00	*Dinner*

TUESDAY 13	
07:30 – 08:30	*Breakfast*
08:30 – 10:00	Communication protocols for packet radio networks: algorithmic approach (part I) by Darek Kowalski
10:00 – 10:30	*Coffee break*
10:30 – 12:00	Communication protocols for packet radio networks: algorithmic approach (part II) by Darek Kowalski
12:00 – 17:00	*Optional activities*: Snow Walk (13:00), Ski (12:30)
17:00 – 18:00	Malicious Interference in Wireless Networks (part I) by Seth Gilbert
18:00 – 18:30	*Coffee Break*
18:30 – 19:30	Malicious Interference in Wireless Networks (part II) by Seth Gilbert
20:00 – 22:00	*Dinner*
21:30 – 23:00	*Optional activity*: Spot a Star (max. 15 people)

WEDNESDAY 14	
07:30 – 08:30	*Breakfast*
08:30 – 10:00	TinyOS2: a tutorial (part I) by David Gay
10:00 – 10:30	*Coffee break*
10:30 – 12:00	TinyOS2: a tutorial (part II) by David Gay
12:00 – 17:00	*Optional activities*: Hot Springs (12:30), Ski (12:30)
17:00 – 18:00	Business models for mobile ad hoc networks (part I) by Yves Pigneur
18:00 – 18:30	*Coffee Break*
18:30 – 19:30	Business models for mobile ad hoc networks (part II) by Yves Pigneur
20:00 – 22:00	*Dinner*
21:30 – 23:00	*Optional activity*: Spot a Star (max. 15 people)

THURSDAY 15	
07:30 – 08:30	*Breakfast*
08:30 – 10:00	Population Protocols (part I) by Eric Ruppert
10:00 – 10:30	*Coffee break*
10:30 – 12:00	Population Protocols (part II) by Eric Ruppert
13:30 – 15:00	Industry session
15:00 – 16:00	Steering comity meeting
16:30 – 17:30	*Social Event:* Telecabine & walk to restaurant (20min)
17:30 – 20:00	*Social Event:* Apéro & Cheese Fondue
20:00 – 21:00	*Social Event:* Walk back to Anzère (1h)

FRIDAY 16	
07:30 – 08:30	*Breakfast*
08:30 – 10:00	Local computations in large-scale sensor and wireless mesh networks (part I) by Idit Keidar
10:00 – 10:30	*Coffee break*
10:30 – 12:00	Local computations in large-scale sensor and wireless mesh networks (part II) by Idit Keidar
12:00	*The End!*

Figure 1: Programme of the MiNEMA Winter School

Gossip-based networking

Dr. Anne-Marie Kermarrec, senior researcher at INRIA (France) and leader of the ASAP (As Scalable As Possible) research group, presented a talk on *gossip-based networking*.

Summary. There has been a major scale shift in distributed systems in the past ten years that traditional distributed computing algorithms can no longer accommodate. The key to scalability lies into fully decentralized and self-organizing solutions. The peer to peer communication paradigm fills this gap and has been clearly identified as a relevant means to build large-scale distributed systems. While structured peer to peer networks have dominated at first, unstructured networks are now recognized as efficient infrastructures for many distributed applications. In this context, gossip-based communication has emerged as a powerful tool to build and maintain distributed peer to peer overlay networks whether they are structured or unstructured, IP or wireless-based, and may be used to support many distributed applications. The principle underlying this technique, in analogy with the spread of a rumour among people, is that participating entities continuously exchange information in order to spread it gradually in the system. They are mainly characterized by a periodic exchange of information between peers, usually rely on

some degree of randomness to cope with dynamics and are proven extremely robust. In this tutorial, we will present gossip-based networking and explore the range of distributed settings to which gossip-based algorithms have been applied, from maintaining unstructured IP-based overlays networks to fully structured networks, wireless and ad-hoc networks, in the context of various applicative contexts such as data dissemination, event notification, data aggregation, resource allocation, search, etc.

Peer-to-peer data management

Dr. Karl Aberer, professor at EPFL (Switzerland) and head of the Distributed Information Systems Laboratory, presented a talk on *peer-to-peer data management*.

Summary. In a handful of years only, Peer-to-Peer (P2P) systems have become an integral part of the Internet. After a few key successes related to music-sharing (e.g., Napster or Gnutella), they rapidly developed and are nowadays firmly established in various contexts, ranging from large-scale content distribution (BitTorrent) to Internet telephony(Skype) or networking platforms (JXTA). The main idea behind P2P is to leverage on the power of end-computers: Instead of relying on central components (e.g., servers), services are powered by decentralized overlay architectures where endcomputers connect to each other dynamically. So far, much effort has been devoted to the development of distributed hashtables (DHTs) to index data in a totally decentralized way. Though extremely robust and scalable, these systems suffer from simplistic data models, which mainly consist of unstructured collections of key-value pairs. More recently however, a significant number of uncorrelated research efforts focused on enriching P2P systems with more expressive data models and query languages. As a result, various Semantic Overlay Networks (SON) supporting relational, semi-structured or triple-based collections of data over decentralized P2P networks started to appear. SON systems can be considered as truly unique as they aim at managing structured data in very large-scale, decentralized, heterogeneous and highly dynamic environments. We start with a brief review of current P2P architectures. We then focus on data integration and query resolution in various SON. We conclude the tutorial with an overview of current research trends in the area of Semantic Overlay Networks as well as a description of potential future applications. We illustrate each approach with a high-level description of a particular system.

Communication protocols for packet radio networks: algorithmic approach

Dr. Dariusz Kowalski, senior lecturer in the Department of Computer Science at the University of Liverpool (UK), presented a talk on *communication protocols for packet radio networks*.

Summary. Packet radio networks model several popular networking environments: Ethernet, wireless networks, sensor networks. The communication protocols used and designed for these networks are different than ones for the other types of networks, because the main communication paradigm is different. More precisely, a station in a packet radio network cannot receive messages when at least two messages are sent to the station in the same time. This situation is called a

collision. The considered communication tasks are: broadcast, gossip, many-to-many and wake-up. We also show that many other tasks can be solved efficiently using the solutions for the considered problems. Among practically used protocols one can list three main groups: random access protocols, channel partitioning protocols and taking-turns protocols. During this lecture we describe the algorithmic backgrounds of these protocols, as well as some other designed algorithms. The complexity of the considered algorithms is analyzed in the specific models. We start with the model of a single-hop radio network, also known as a multiple access channel. Two cases are considered, depending on if a collision detection mechanism is available or not. In the second part of the lecture we extend the algorithms designed for a multiple access channel to multi-hop networks.

Malicious interference in wireless networks

Dr. Seth Gilbert, currently postdoc at the EPFL (Switzerland), presented a talk on *Malicious Interference in Wireless Networks*.

Summary. Ad hoc networks of wireless devices hold significant promise for the future of ubiquitous computing. Unfortunately, such networks are particularly vulnerable to adversarial interference due to their use of a shared, public communication medium and their deployment in unprotected environments. For example, a committed adversary can disrupt an ad hoc network by jamming the communication channel with noise. Continuous jamming, however, might be unwise for the adversary: it depletes the adversary's energy, allows the honest devices to detect its presence, and simplifies its localization—and subsequent destruction. The adversary, therefore, would rather be more efficient, disrupting the protocol using a minimal number of transmissions. The efficiency of the adversary can be quantified, roughly speaking, by comparing the duration of the disruption to the adversary's cost for causing the disruption. In the systems literature, this metric has been informally referred to as jamming gain. For example, if the adversary must broadcast in every round, the jamming gain is 1. By contrast, if the adversary need never broadcast to prevent termination, then the jamming gain is infinite. A jamming gain of 100 implies that the adversary need only broadcast in one percent of the rounds to disrupt the protocol. A second metric, disruption-free complexity, measures how long the adversary can disrupt a protocol without performing even one broadcast. The uncertainty introduced by the possibility of adversarial broadcasts is sufficient to slow down many protocols. If a protocol has large disruption-free complexity, then the adversary can significantly reduce the throughput of multiple consecutive executions, while avoiding the disadvantages of actually jamming.

TinyOS2: a tutorial

Dr. David Gay, designers and principal implementer of the nesC language at Intel Research Berkeley (USA), presented a tutorial on *TinyOS version 2*.

Summary. TinyOS is an operating system for sensor networks that targets small, wireless, battery-driven nodes with very limited resources (e.g., kBs of RAM). TinyOS 1.1, released in

2003, has been very popular but has a number of significant problems: it is not well documented, not very portable or robust and lacks support for many important services (e.g., reliable data dissemination). To address these problems, the TinyOS 2 team drew its members from a variety of institutions representing several hardware platforms, and engaged in a design process resulting in a number of "TinyOS Enhancement Proposals", public documents that describe the design of TinyOS 2. TinyOS 2.0, released in November 2006, is the current result of this ongoing process. TinyOS 2.0 has major improvements in resource and power management, networking and storage. These improvements will increase the reliability and lifetime of sensor networks built using TinyOS, and make it simpler to design and build sensor network applications.

Business models for mobile ad hoc networks

Dr. Yves Pigneur, professor at the HEC School of business of the University of Lausanne (Switzerland), presented a talk on *business models for mobile ad hoc networks.*

Summary. Identifying how insurgents disrupt established markets is a major challenge. In this tutorial, we study techniques for evaluating the disruptive potential of innovative business models. We illustrate these techniques with the case study of Shockfish. Our analysis is composed of three parts. First, we present a scenario-based forecasting approach, which could be helpful before defining a strategy of adoption, deployment, and management of business solutions; this forecasting method seems particularly appropriate since the future in a technology landscape, such as mobile computing and ambient intelligence, is so uncertain and the pace of development so fast. Second, we define a business model ontology, which provides the analyst with a framework for describing the main components of a business model, covering the product innovation, the customer relationship, the infrastructure management, and the financial aspects. Thirdly, we describe an analytical instrument for detecting disruptive innovations. We apply this instrument to a case study in order to discover the disruptive potential of its business model. Todays business environment is characterized by rapid technological change that makes disruptive innovations and new business models possible. However, little analytical tools help in identifying disruptive business models. Therefore we believe there are four reasons why practitioners and academics attending MINEMA could be interested in this tutorial: (1) it presents a rigorous conceptual framework for defining and describing a business model; (2) it shows how this framework can be applied to describe and understand a concrete case study, and, in addition, how it can be used for comparing two business models; (3) it describes an analytical instrument, similar to a multi-criterion decision model, for detecting the potential disruptiveness of a business model; (4) the analytical tools presented in the tutorial are applied to an attractive case study that is a likely potential to disrupt the mobile computing market.

Population protocols

Dr. Eric Ruppert, professor in the Department of Computer Science and Engineering at York University (Canada), presented a talk on *population Protocols.*

Summary. A large number of different theoretical models for mobile wireless networks have been defined in the literature, each making a variety of assumptions about the power of the agents, their connectivity and movement. The population protocol model is an attempt to make minimal assumptions about the agents, and then see what types of simple problems can still be solved. The population protocol model assumes the agents in the system are finite state machines that are identically programmed and move about unpredictably. (The movement is not under the control of the algorithm.) When two agents are close together, they can have an interaction and exchange some of the information stored in their states. A fairness guarantee ensures that agents eventually come into contact with others. A number of variants of the basic population protocol model have been defined. For example, failures might occur, an interaction might be unidirectional instead of a two-way exchange of information, or a probability distribution may be put on the interactions. We examine the class of problems that can be solved in the basic model and a few variants of it.

Local computation in large-scale sensor and wireless mesh networks

Dr. Idit Keidar, Professor at the Technion (Israel) presented a talk on *local computations in large-scale sensor and wireless mesh networks*.

Summary. Distributed computing is currently undergoing a paradigm shift, towards large-scale dynamic systems, where thousands of nodes collaboratively solve computational tasks. Examples of such emerging systems include autonomous sensor networks, wireless mesh network (WMN) infrastructures, and more. Speculative computations will be instrumental to successfully performing meaningful computations in such systems. Moreover, solutions deployed in such platforms will need to be as local as possible. The talk will present two detailed examples of such large-scale local computations: aggregation in large-scale sensor networks, and gateway assignment in wireless mesh networks.

Event assessment

In order to assess the impact of the winter school on its participants, we conducted a short written survey at the end of the event. The results of this survey are summarized in Figures 2 and 3, while the questionnaire used for the survey is given in Appendix B (page 12).

Outcome & lectures. As shown in Figure 2, the outcome of the winter school was positive for the vast majority of the participants and help them better understand the concepts and principles underlying mobile computing. The participants also considered that the speakers explained their material well and incorporated recent developments in the field. Overall, they felt their intellectual curiosity was stimulated.

Interestingly however, half of the participants thought that the school did not really improve their ability to carry out original research. This can be explained by the fact that the subject of mobile computing was covered in a broad manner. As a consequence, it was not always possible

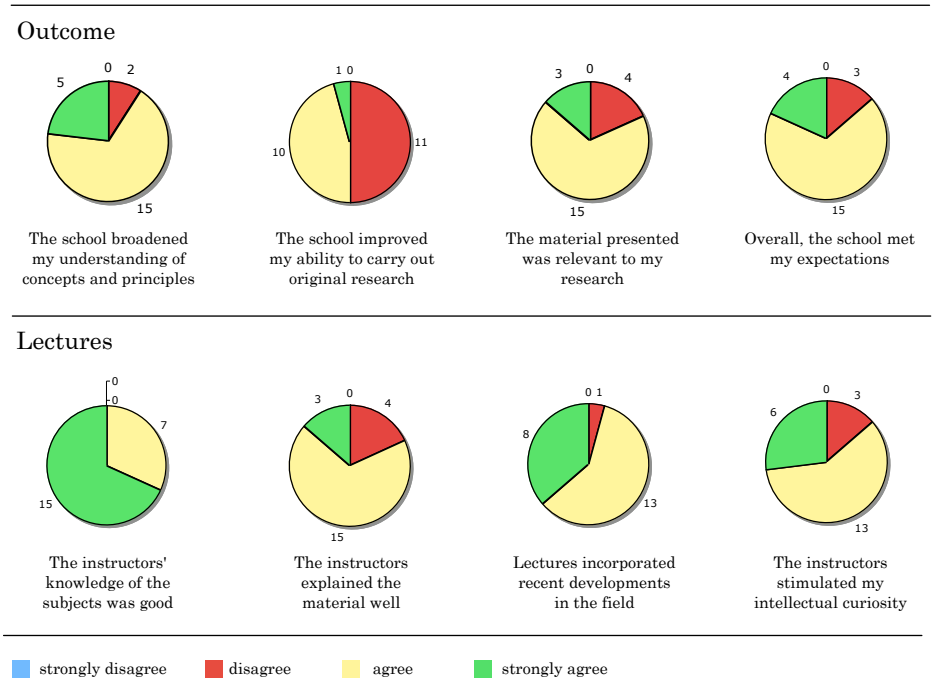

Figure 2: Assessment – Outcome & lectures

to dig into the details of some research topics, to the level that some participants might have wished. It seems that research workshops, where the PhD students are given the opportunity to present their work on specific subjects, are more adequate when it comes to improve their concrete ability to do research.

Communication & organization Regarding the quality of communication and the overall organization, here again the vast majority of the participants considered that the school was well organized and that they were provided with appropriate information. In particular, they thought that the web site was informative before the school started. Also, all participants thought that the various social activities enhanced the winter school experience. Regarding the information provided during the lectures, they considered that the course material was well aligned with the talks and that the lectures captured the overall essentials of the fields, although this last point could be improved.

A clearly negative point was the connection to the Internet, which was shaky near the lobby and clearly unsatisfactory in the lecture room. Note that this might have had an unexpected positive impact on the assiduity of the audience during the talk, as the Internet is known by anyone having given lectures as a very strong competitor when it comes to draw the attention of the audience.

Free comments. The survey questionnaire also provided the participants with the opportunity to freely express what should be kept, respectively changed, in a future similar event. Based

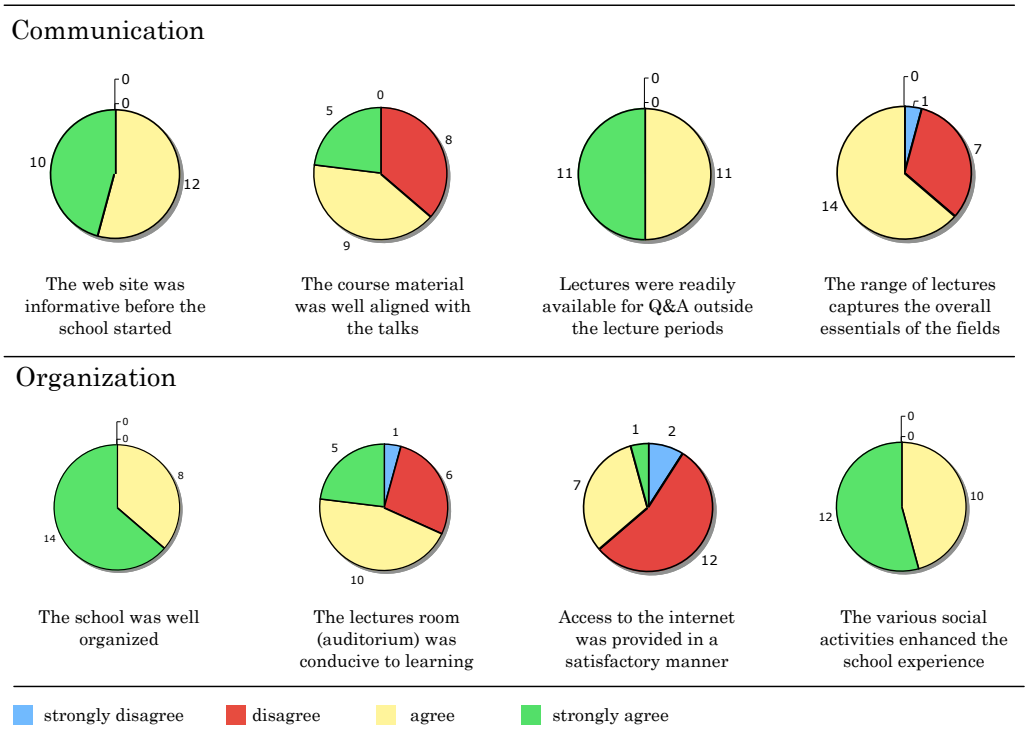

Figure 3: Assessment – Communication & organization

on these free comments, it appears that the lectures and the social activities were among the most appreciated aspects of the winter school. This is good news since the particular format of the winter school precisely aimed at combining intellectual activities with more social and physical activities. Among the aspects that could be improved, the participants felt that real practical examples were missing in some talks. They also would have liked to get their hands much earlier on the slides and papers related to the talks. Unfortunately, this is a recurring issue where organizing such tutorial-based events: one has not real way to put pressure on the speakers to have them send their material well in advance. To conclude, one participant made an interesting suggestion: each PhD students could publish a short abstract of her/his research on the web, so everyone knows who is working on what.

Concluding remarks

To conclude this report, we can say that the MiNEMA Winter School held in Anzère in February 2007 was a success, since the vast majority of participants expressed their satisfaction with both its content and its organization. As for the organizing team, it was a great experience to gather so many young european researchers to listen to high standard tutorials in the domain of mobile computing and to informally discuss their respective researches.

Benoît Garbinato
August 2007
Lausanne

Appendix A – Speakers' biographies

Karl Aberer

Karl Aberer is a full professor at EPFL since September 2000. There he is heading the Distributed Information Systems Laboratory of the School of Computer and Communications Sciences. He is also director of the Swiss National Research Center for Mobile Information and Communication Systems (NCCR-MICS). His main research interests are on distributed information management, P2P computing, semantic web, and self-organization of information systems. He received his PhD in mathematics in 1991 from the ETH Zurich. From 1991 to 1992 he was postdoctoral fellow at the International Computer Science Institute (ICSI) at the University of California, Berkeley. In 1992 he joined the Integrated Publication and Information Systems institute (IPSI) of GMD in Germany, where he became manager of the research division Open Adaptive Information Management Systems in 1996. He has published more than 150 papers on data management on the WWW and in bioinformatics, workflow systems, P2P systems and semantic Web. Recently he has been PC chair of MDM 2006 and ICDE 2005. He has been associate editor of SIGMOD RECORD and is member of the editorial boards of the VLDB Journal, ACM Transactions on Autonomous and Adaptive Systems, Web Intelligence and Agent Systems, and the International Journal of Business Process Integration and Management. He is consulting in research and science policy as a member of the Swiss Research and Technology Council (SWTR).

David Gay

David Gay obtained his diploma in computer science from the EPFL in 1992, and his PhD, on region-based memory management, from UC Berkeley in 2001. Since then he has been working at Intel Research Berkeley on programming languages and operating systems for sensor networks. David was one of the designers and principal implementer of the nesC language, the C dialect used to implement the TinyOS sensor network operating system and its applications. David worked on various parts of the TinyOS 1.x operating systems. Subsequently, David chaired the TinyOS 2 working group from October 2004 to February 2006, and contributed to the design and implementation of many of its subsystems.

Seth Gilbert

Seth Gilbert was born and grew up in Washington D.C. (in Cleveland Park, halfway between the cathedral and the zoo). After high school, he attended Yale University where he majored in Electrical Engineering and Math. After graduating from college, he worked for Microsoft as a software developer and was a member of the Visual Studio.Net team, responsible for developing new team collaboration tools, such as an integrated (and improved) source control system. After two years at Microsoft, he left Seattle for the MIT in Cambridge, where he obtained his PhD.

Idit Keidar

Idit Keidar is a faculty member at the department of Electrical Engineering at the Technion Israel Institute of Technology, and a recipient of the national Alon Fellowship for new faculty members. She holds PhD, M.Sc. (summa cum laude), and B.Sc (summa cum laude) degrees from the Hebrew University of Jerusalem. She was a postdoctoral research associate at MIT's laboratory for Computer Science, where she held post-doctoral fellowships from Rothschild Yad-Hanadiv and NSF CISE. Dr. Keidar has consulted for BBN Technologies (a Verizon Company) in the area of fault-tolerance and intrusion tolerance, and for Microsoft Research in the area of fault-tolerant storage systems. Dr. Keidar's research focuses on reliability in distributed algorithms and system.

Anne-Marie Kermarrec

Anne-Marie Kermarrec is a senior researcher with INRIA since 2004. She is leading the ASAP (As Scalable As Possible) research group at the IRISA/INRIA lab in Rennes France, focusing on large-scale dynamic distributed systems. Her current main research area is on peer to peer overlay networks, resource management and search in large-scale distributed systems, and gossip-based algorithms. Before joining INRIA in February 2004, she was a researcher with Microsoft Research in Cambridge since March 2000. She obtained a PhD from the University of Rennes (France) in October 1996 in the area of fault-tolerant distributed shared memory systems and an habilitation à diriger les recherches in 2002 on large-scale application-level multicast. She also spent one year (1996-1997) at Vrije Universiteit in Amsterdam (NL) working in the GLOBE project in collaboration with Maarten van Steen and Andrew. S. Tanenbaum.

Dariusz Kowalski

Dariusz Kowalski is a senior lecturer in the Department of Computer Science at the University of Liverpool. He received his MSc in Mathematics in 1996 and PhD in Computer Science in 2001, both from the University of Warsaw, Poland. He was a postdoc at the University of Quebec at Outaouais, Canada (2001-2002), and then he received the NSF-NATO postdoctoral fellowship in the Dependable Distributed Systems Group at the University of Connecticut, USA (2002-2003). In 2003-2004 he was visiting the Max-Planck Institute on Computer Science, Saarbruecken, Germany. Before joining the University of Liverpool in June 2005, he was an assistant professor at the University of Warsaw (2004-2005). His research is on algorithms and data structures, including: distributed fault-tolerant algorithms, robust cooperative computing, communication protocols in networks and algorithms for distributed agents.

Yves Pigneur

Yves Pigneur is professor of the information systems at the HEC School of business of the University of Lausanne. He has a PhD from the University of Namur in Belgium where he used to be research-assistant in the field of computer-aided requirement engineering. In 1994, he was visiting professor in the IS department of Georgia State University (Atlanta) and the Hong Kong

University of Science and Technology. In 2004, he is visiting professor in the IS department of the University of Bristish Columbia in Vancouver. His interests cover information system design, requirement engineering, management of information technology and e-business.

Eric Ruppert

Eric Ruppert was educated at the University of Toronto, Canada where he completed a PhD in Computer Science in 1999. He spent a year as a post-doctoral fellow at Brown University in the United States and has been a faculty member at York University in Canada since 2000. He has also spent time as a visiting professor at the Ecole Polytechnique Federale de Lausanne, Switzerland. His research is on the theory of distributed computing, focussing on fault tolerance, shared-memory algorithms, data structures and the relationships between different models of distributed systems. He is also particularly interested in complexity lower bounds and impossibility results for distributed problems.

Appendix B – Assessment questionnaire

MiNEMA Winter School / 12-16 February 2007 **Feedback Form**

Rate the items using the following scale:

1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree

I. OUTCOME	Scale			
1. The Winter School broadened my understanding of concepts and principles.	1	2	3	4
2. The Winter School improved my ability to carry out original research.	1	2	3	4
3. The material presented in the Winter School was relevant to my research.	1	2	3	4
4. Overall, the Winter School met my expectations.	1	2	3	4

II. LECTURES	Scale			
1. The instructors' knowledge of the subjects was good.	1	2	3	4
2. The instructors explained the material well.	1	2	3	4
3. Lectures incorporated recent developments in the field.	1	2	3	4
4. The instructors stimulated my intellectual curiosity.	1	2	3	4

III. COMMUNICATION	Scale			
1. The Winter School web site was informative before the school started.	1	2	3	4
2. The course material was well aligned with the talks.	1	2	3	4
3. Instructors were readily available for Q&A outside the lecture periods.	1	2	3	4
4. The range of lectures captured the overall essentials of the field.	1	2	3	4

IV. ORGANIZATION	Scale			
1. The Winter School was well organized.	1	2	3	4
2. The lecture room (auditorium) was conducive to learning.	1	2	3	4
3. Access to the Internet was provided in a satisfactory manner.	1	2	3	4
4. The various social activities enhanced the Winter School experience.	1	2	3	4

V. COMMENTS
1. What were the best things about the Winter School?
2. What could be improved for the next Winter School?

Appendix C – List of participants

Name		Affiliation	Email
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