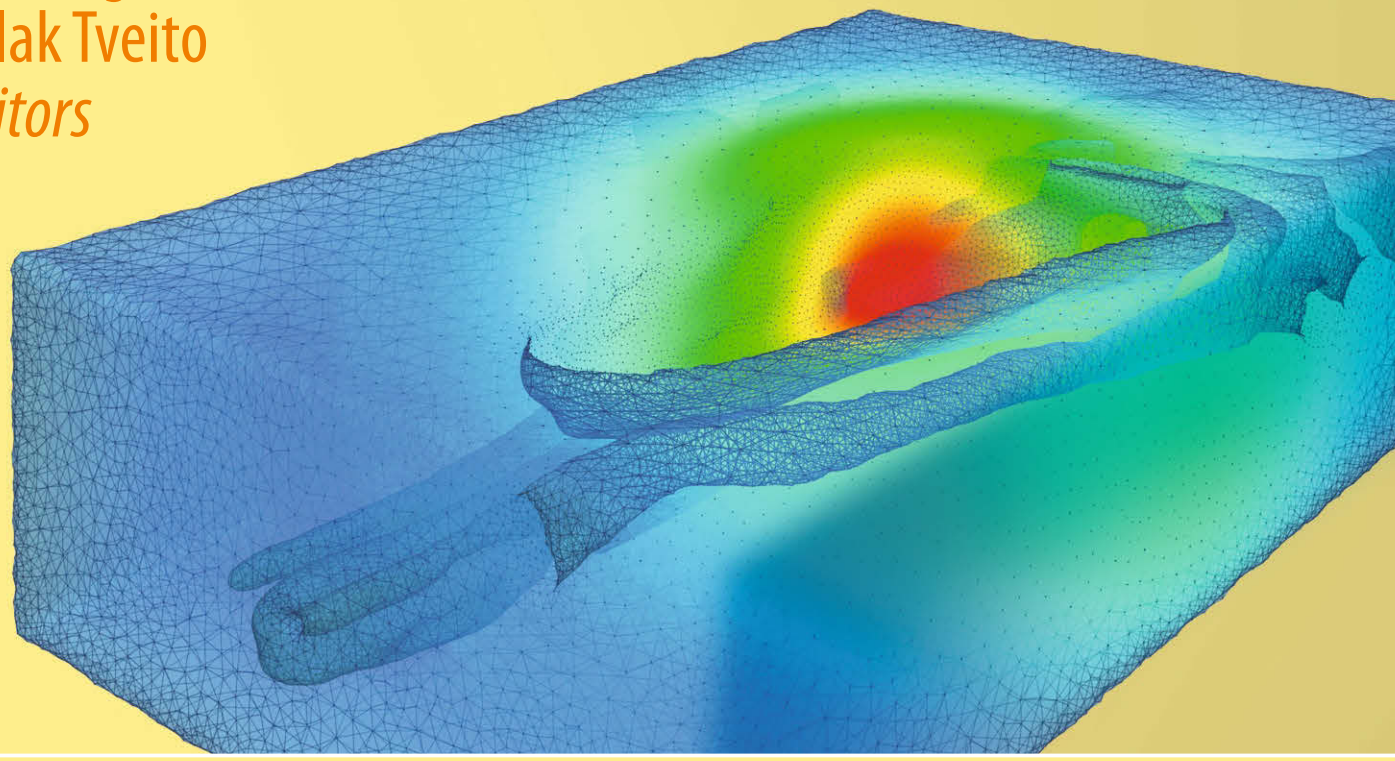
Are Magnus Bruaset
Aslak Tveito
Editors



Conversations About Challenges in Computing

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- by thinking constantly about it

Springer

Are Magnus Bruaset · Aslak Tveito
(Editors)

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Editors
Are Magnus Bruaset
Aslak Tveito
Simula Research Laboratory
Fornebu, Norway

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Preface

We go to work every day, picking up our projects where we left them the day before. It's a mess, of course: complex models, software densely populated with bugs, dubious input data, and so forth.

Most of our attempts to understand matters fail, but every once in while we see the light and are able to add a small contribution to our common collection of scientific knowledge. Enormous amounts of time, money and energy are invested in these attempts to comprehend the world around us. In this light, we should pause now and then to consider which problems most deserve our attention.

To celebrate the tenth anniversary of Simula Research Laboratory, we invited outstanding scientists from around the world to present their recent achievements and their view on future challenges. The talks were intended to fuel vivid discussion at Simula concerning where our scientific efforts are called for. Given this unique assemblage of scientific leaders in communication technology, software engineering, scientific computing, and computational science, we also invited two celebrated writers to interview them. The results of these conversations are presented in this text, which we hope you will enjoy. In addition you will video clips of all talks from the anniversary conference on the special web site http://challenges.simula.no.

If you are curious to learn more about Simula, we encourage you to browse our web site, www.simula.no, and have a look at the factsheet "This Is Simula" on page 101.

Fornebu, February 2013

Professor Are Magnus Bruaset
Director of Research at Simula Research Laboratory

Professor Aslak Tveito
Managing Director of Simula Research Laboratory

Challenges in Computing December 14–15, 2011

All talks were filmed and are available at challenges.simula.no

Conference program, day 1

Welcome and introduction
Professor Aslak Tveito, Managing Director of Simula Research Laboratory

Opening and announcement of the winner of the Computational Science and Engineering Prize 2011*
Tora Aasland, Norwegian Minister of Research and Education

High-resolution simulation of mantle flow and plate tectonics
Professor Carsten Burstedde, University of Bonn

US Ignite
Professor Keith Marzullo, University of California San Diego & Division Director at the National Science Foundation

Engineering Software in the Future Era: The Role of Uncertainty
Professor Paola Inverardi, University of L'Aquila

Grand Challenges in Computational Inverse Problems with Illustrations from Geophysics
Professor Omar Ghattas, University of Texas at Austin

Conference program, day 2

The Challenges of Computer-based Prediction
Professor Martin Shepperd, Brunel University

Simulating Cardiac Function and Dysfunction
Professor Natalia Trayanova, Johns Hopkins University

Requirements for Pervasive Privacy
Professor Bashar Nuseibeh, The Open University & Lero – the Irish Software Engineering Centre

Model Reduction, Complexity Reduction
Professor Alfio Quarteroni, École Polytechnique Fédérale de Lausanne, and Politecnico di Milano

Challenges in the Evolution of the Internet of Things – Processing Real-World Information in the Cloud
Dr. Heinrich Stüttgen, Vice President of NEC Laboratories Europe

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* The CSE Prize is awarded by Springer-Verlag. The 2011 prize was awarded to Laura Alisic, Carsten Burstedde, and Georg Stadler for their outstanding work on simulating global mantle convection at tectonic plate boundary-resolving scales.

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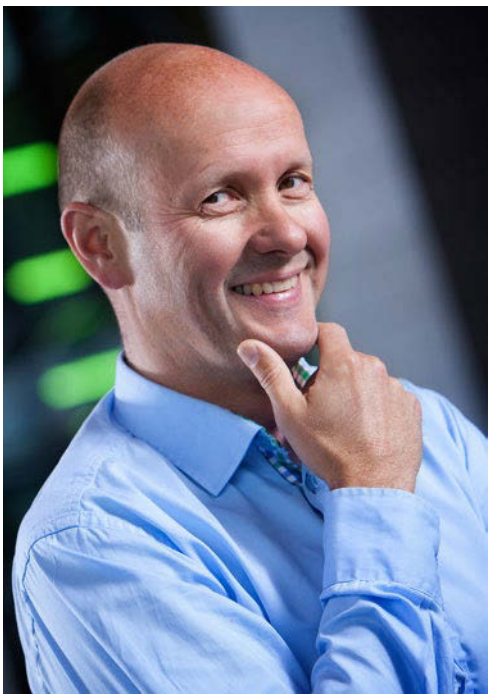
Part I
Communication Systems

The Nature of the Beast

An Interview with Olav Lysne by Kathrine Aspaas



Professor Olav Lysne is on vacation – which means living without a computer network connection at his holiday cottage outside Fredrikstad in south-east Norway. Because a computer network is work. Not only in the shape of emails, online news sites and other digital temptations – we are talking about the *network* itself – the myriad of mainframes, masts, copper wires and routers. That is the area of expertise to which the professor is devoted. For what do we really know about the network's architecture? A lot less than we think. We have created a beast, whose full extent we cannot see and which we have made ourselves dependent on. And this is precisely where Professor Lysne's research project begins. How does this beast behave? And – not least – how can we make network access more robust, given the beast's many unpredictable quirks and caprices? It is certainly no easy matter to obtain a complete overview of the beast's internal organs, for they are governed in large measure by politics and trade secrets.

"Telenor knows its bit of the network. NetCom knows its bit. Ice knows its. They cooperate through agreements which are business critical and therefore confidential. They keep the network's structure secret, partly for commercial reasons, but just as much for reasons of security. Because there are people out there with malicious intent, and there are good reasons to keep the infrastructure undisclosed. So we must accept the unpleasant truth that the network is, and will probably remain, relatively closed and extremely difficult to pin down. We just have to make the best of the situation."

Robust Networks

Let us take a little journey back in time. Around 30 years. To when the internet as we know it today did not exist. Initially, in the early 1990s, it was seen as a bit of fun. Then we got emails and mobile phones on a wide scale, and around 1995 it switched from being fun to being useful. In the years to 2000 it went from being useful to important, and since then that importance has grown and grown. At the same time, a new entertainment perspective has emerged, where games, television and music now rule the roost. And this is where we find the professor's concern.

'There is no reason for any individual to have a computer at home.'
Ken Olsen, Chairman of the US Digital Equipment Corporation (1977).

"Today it is perfectly valid for an operator to say that it doesn't matter if the network is down for a few hours or a couple of days, as happened in Norway during the storm Dagmar. This means more or less that you cannot update your Facebook status for a few hours. It contains a sufficiently large pinch of truth that they get away with saying it now. But in the coming years the network will transition from being important to being indispensable, and this is where we bump up against major social issues. How are we going to tackle the coming sharp rise in the number of elderly people, for example?"

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▶ You do realise that those elderly people are you and me?

"Yes, I'm only too aware of that. Why do you think I'm working on this? Pure self-interest! And how are we going to meet our need for care? That's right, we will be allowed to live at home for as long as possible. But I'm not entirely comfortable with the prospect of the network being down for a few hours or a couple of days if my pacemaker is connected up to it. And if we want to save energy by having smart cars and smart houses, all that will be network based. We are on our way there now, because we have already seen examples where computer networks have halted water supplies. They have prevented doctors from talking to each other and grounded aircraft. They prevent the police from working together. That takes us back to the summer of 2007, when a fire at Oslo's main train station put the capital's anti-terror capability out of action for almost 24 hours. Because of data communication problems. What I'm trying to say with all this is that data communication has now become a *single infrastructure of failure* – in other words, that all other infrastructures will lie on top. Hospitals. Air traffic. Police. Almost all the infrastructures we have to sustain society will have the internet as their cornerstone. Which means we need a more robust network."

At this point we have completely bought into Lysne's message: computer networks are extremely important, and they are merely getting more and more important. We must accept that we are not going to get much insight into the network's architecture, for commercial and political reasons. So now we should be ready for the professor's research agenda.

"Until recently we have been preoccupied with solving technical problems, on the assumption that we have a complete overview of how the system is built up. Now we are being forced to work in a different way – on the assumption that we *don't* know how the system is built up. And there are two things we must do:

1) Study this in the same way we study nature. By observing how the great network beast behaves, and on that basis try and understand as much as possible about how it is constructed.
2) When we have understood how it behaves, we can, hopefully, use this knowledge to create applications that are robust in the face of anything that might happen. How will my pacemaker behave if a power line falls down somewhere? How can we ensure it keeps on working anyway?"

▶ But what about openness – the possibility of making a better map. Won't we someday dare to make it open?

"No, I don't think we would ever dare to do that. We will keep organisations like the Norwegian Post and Telecommunications Authority (NPTA), which is both a watchdog and a collector of information. We may envisage a situation in which they insist on having a complete overview themselves, but keep that information as close to their chest as the network operators do. And with good reason. We may also envisage them sharing information with selected, critical entities that they trust. But we're not there yet."

▶ So we have to keep studying the beast from the outside. How do you do that in practice?

"For example, by measuring the networks' uptime. We carried out a major measuring exercise in the run-up to the electronic voting system trial in the autumn of 2011, which included ten local authorities. The Ministry of Local Government and Regional Affairs wanted to test how certain they could be that the networks would be up during the election trial. Since the NPTA did not provide that information, they commissioned us to measure uptime over an entire year – for all operators – in all polling stations. We discovered, for example, that there must be some kind of undisclosed relation between Telenor and NetCom, because when Telenor has problems in its core network, NetCom's customers can also be hit far harder than Telenor's. This is just one example of the kind of analysis we perform. We are currently in the process of rolling out a new structure in which we will