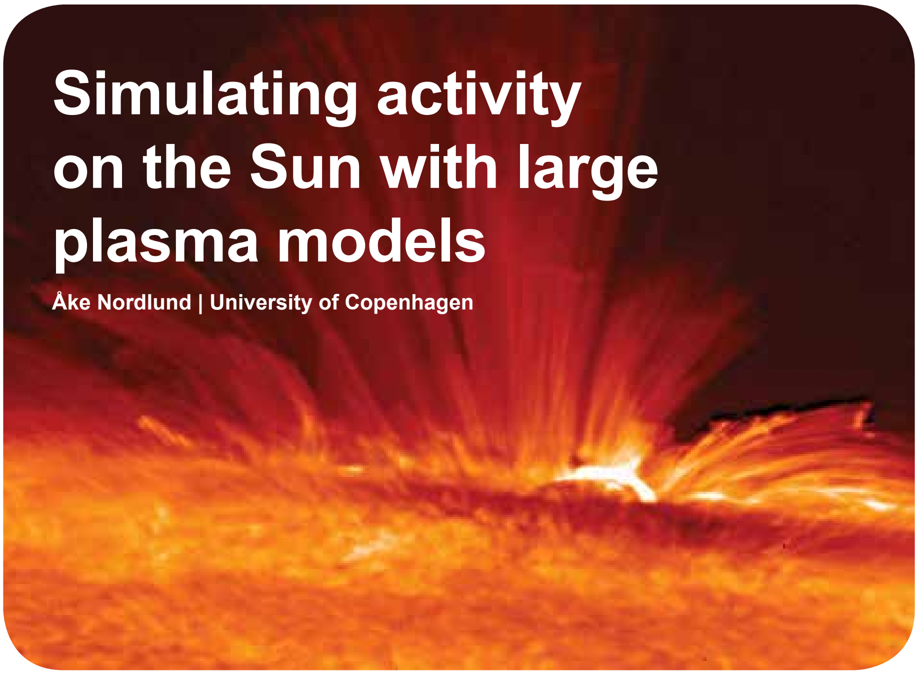
NEWSletter

Volume 10 – December 2012

Simulating activity on the Sun with large plasma models

Åke Nordlund | University of Copenhagen



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The SunFlare project group has studied the relationship between the sub-surface layers and visible layers of the Sun, with a focus on its active regions. The dynamics in the visible layers of the active solar regions is the result of processes that take place in the sub-surface layers. By using the largest plasma simulations ever conducted in solar research, the project team unearthed a basic mechanism responsible for accelerating charged particles on the Sun.

The main objective of the SunFlare project is modelling and understanding the couplings between the sub-surface layers and visible layers of the Sun: the solar photosphere, chromosphere and corona.

– The mass density is much larger in the sub-surface layers than in the visible layers. The kinetic and magnetic energy densities are also correspondingly large. The motions that occur in these layers cover a wide scale range. The motions transport heat to the surface of the Sun, allowing the Sun to maintain its enormous energy output. The motions also generate, stretch, and transport magnetic fields to the surface and, as our simulations have shown for the first time, spontaneously create the structure in so-called Solar Active Regions, professor **Åke Nordlund from the University of Copenhagen** explains. Nordlund heads the team. He is a science co-ordinator as well as a program developer and works closely with the SunFlare project group.

When magnetic fields emerge on the surface of the Sun the energy can be violently released in the form of so-called Solar flares and Coronal Mass Ejections (CMEs).

– Solar flares are extremely powerful explosive events, which ultimately may affect the environment in the Earth's protective magnetosphere. The explosions are often closely accompanied by CMEs, where magnetic energy is converted into intense UV-light emissions, X-rays, gamma rays, as well as highly charged particles. The particles can travel into interplanetary space, resulting in northern lights and magnetic sub-storms in the Earth's magnetosphere, Nordlund explains.

Coupling traditional MHD models with kinetic particle models

The team primarily made use of two kinds of supercomputer programs in the study.

– One program type solves equations that describe the dynamics of magnetized plasma as a fluid. The other treats the same situation in a particle representation, where the gas is represented by up to more than 100 billion pseudo-particles, which are characterized by their mass, electrical charge, and velocity, Nordlund says.

– There are many groups studying the solar atmosphere with supercomputer models, but our group is unique in that it studies all aspects, and does so by coupling traditional MHD models with kinetic particle models. Our models are very detailed and realistic and are readily compared to observations. Sometimes observations are even used as a starting point for data-driven simulations. Furthermore, our MHD models are some of the most extensive and compute-demanding ever conducted and, certainly, our plasma models are the largest ever created in a solar context, Nordlund explains.

Revealing the charged particle acceleration mechanism

The SunFlare team has been able to reveal a basic mechanism responsible for accelerating charged particles on the Sun.

– The dominant physical process was only clearly discovered while running the largest particle-in-cell simulation on JUGENE-supercomputer, with over 3 billion mesh points and more than 135 billion pseudo-particles, Nordlund says.

Smaller simulations had shown indications of the process, but only the largest simulation was able to conclusively show what occurs.

– A strong electric field develops along the solar magnetic field. As a result, charged particles are accelerated. Protons are accelerated in the direction of the electric field and electrons in the opposite direction. The spatial distribution of the simulated particles agrees well with what we infer from observations of active regions on the Sun, Nordlund says.

The Sun is presently entering its next solar maximum of magnetic activity, Solar Cycle #24, which culminates in 2013. It is believed that solar magnetic activity is directly responsible for launching CMEs into the solar system.

– Our results provide a strong foundation for continued research on the launching of solar storms, propagation of CME-driven plasmas through the solar system, and resulting space weather events that are driven by the interaction between accelerated solar wind (a solar storm) and the Earth's magnetosphere. Some unresolved questions remain. The modelled events are active regions, but the particle acceleration events modelled so far, so-called "pre-flares", are not the most energetic. We are still unable to model the most powerful energetic explosions in the solar corona, Nordlund says.

This research has provided detailed insights into processes that are fundamentally responsible for the onset of solar storms.

– We can only quantify the mechanisms behind solar storms more precisely by synthesizing explosive CME-like conditions in supercomputer models. It will be vital for precise modelling and perhaps even for forecasting space weather events here on Earth.

Charged particle acceleration is known to take place in many different astrophysical contexts, but most occur so far away in the Universe that their details cannot be studied.

– The Sun presents an accessible laboratory for studying a very basic physical process. The methods used are indeed shared with the plasma fusion community: either using magnetic confinement (tokamak fusion reactors) or inertial confinement (laser induced fusion), Nordlund concludes.

The largest continuous run ever done on JUGENE

The SunFlare project was a DECI project from 2009 to 2011 and continued in PRACE from 2011 to 2012. Both phases of the work involved collaborators from the Universities of Copenhagen, Oslo, Stockholm, La Laguna (Tenerife), Michigan State, and the Max Planck Institute for Astrophysics (Garching near Munich). The team has received a new PRACE grant for 2012 and 2013.

Dr **Troels Haugbølle** from the University of Copenhagen was the main programmer of the Photon-Plasma kinetic particle code used for the simulations. He carried out the largest plasma simulations on JUGENE. What makes the supercomputer special is the fact that it has an enormous amount of CPUs, even if the individual CPUs are not very powerful.

– The codes used to run our simulations are very scalable and can run on many CPUs in parallel without slowing down. JUGENE was indeed a perfect match for our research. Furthermore, the machine was set up to do full machine runs. At convenient times the machine is cleaned for other uses, and it can be used exclusively for one application. This was exactly what we needed when we did our largest simulation. We ran it on 262.144 CPU cores for 36 consecutive hours, Haugbølle says.

This was the largest continuous run ever done on JUGENE.

– This enabled us to practice unique science. JUGENE was at that time the only computer in Europe that could enable us to accomplish that, Haugbølle says.'

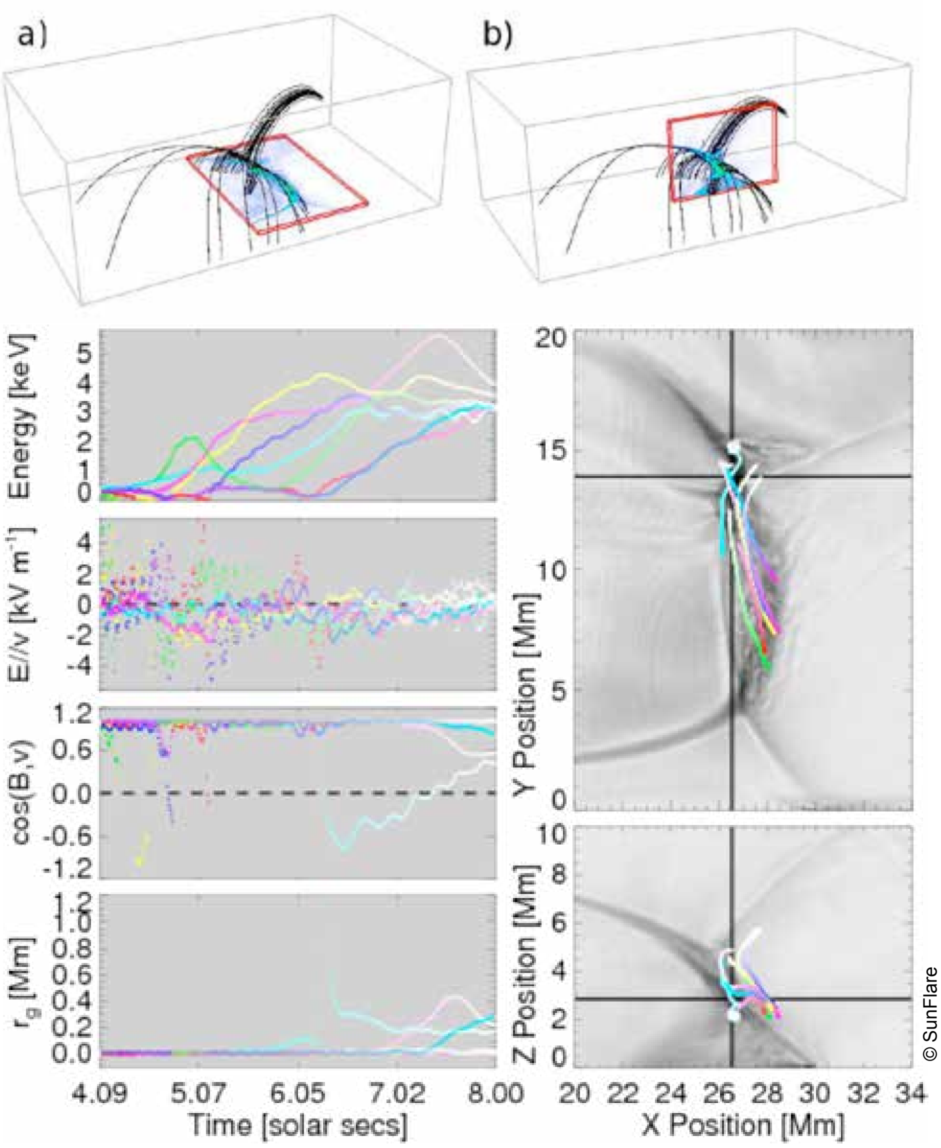
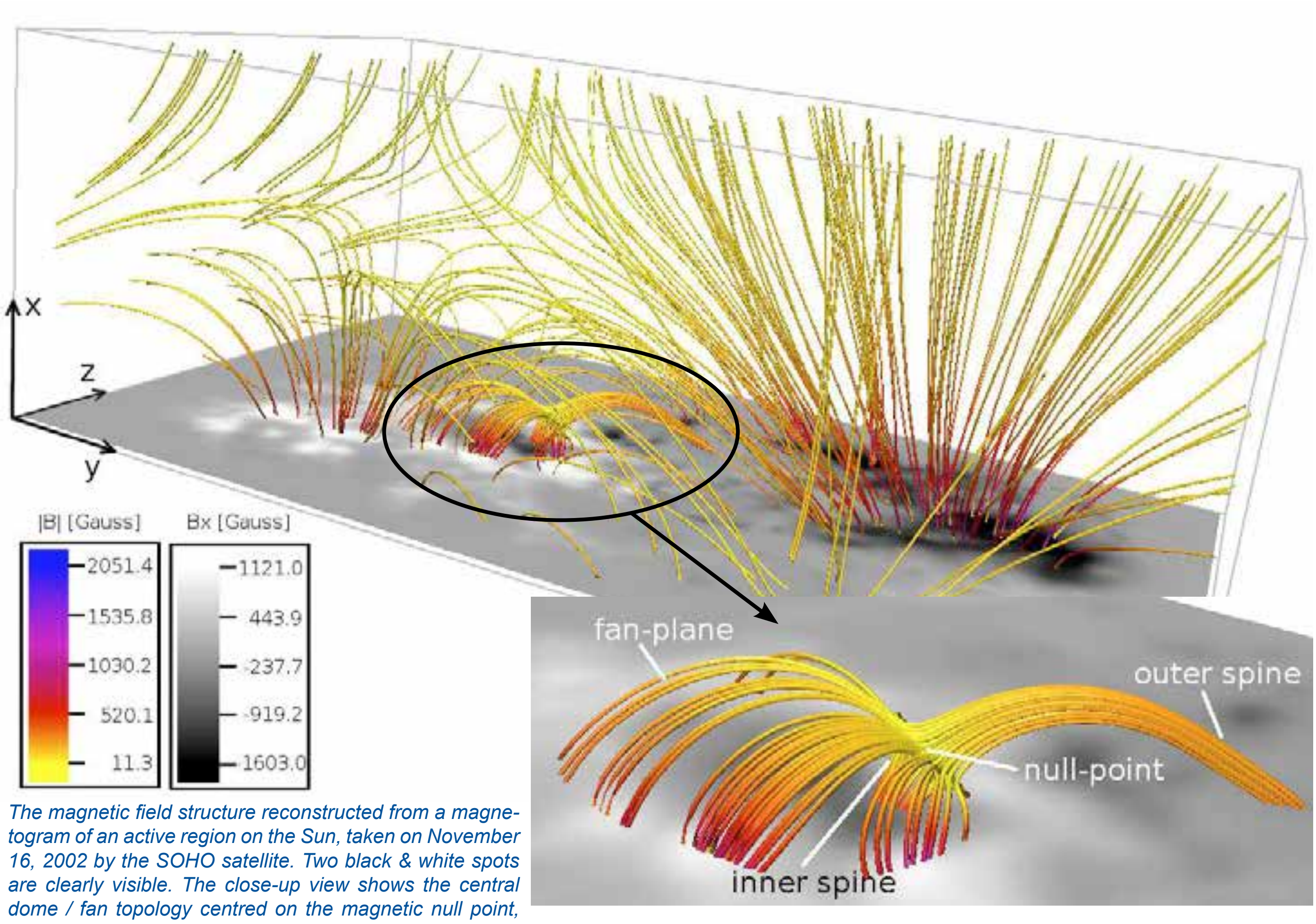
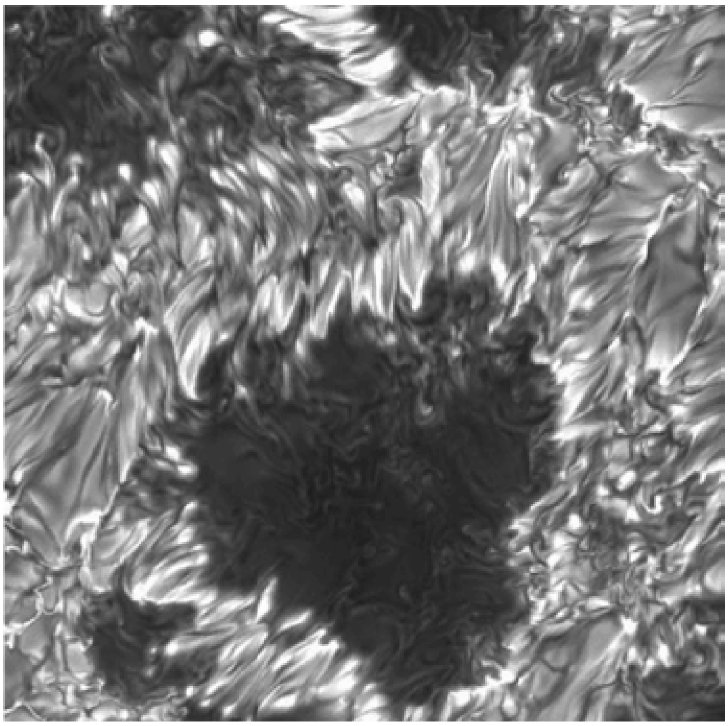


Illustration of the particle tracing used to understand acceleration mechanisms in the solar corona: the upper panels present two planes, cut out from a larger simulation. They are both centred on the reconnection point, marked with a cross, where the magnetic field topology changes. The gray scale pictures show the projected electrical currents, with darker shades representing stronger currents. The trajectories of high energy particles are plotted on top. a) is a horizontal cut in the solar corona, and b) is a vertical cut. The small graphs present the time evolution for individual particles. From top to bottom are the energy evolution, the local accelerating electric field, the angle particles make with the local magnetic fields, and the size of their gyro radius. It can be seen how all the high energy particles move along the strongest currents, almost perfectly aligned with the magnetic field lines, and accelerated by the local electric field.



The magnetic field structure reconstructed from a magnetogram of an active region on the Sun, taken on November 16, 2002 by the SOHO satellite. Two black & white spots are clearly visible. The close-up view shows the central dome / fan topology centred on the magnetic null point, where particle acceleration takes place. This was the starting point for our endeavour: We used observations as a basis for our fluid dynamics simulations to study the large scale dynamics, and to advance the simulation (several solar hours) to a state just prior to the violent reconnection event. We then used the close-up view to trace the reconnection event with a particle code, in order to study the particle acceleration in detail. The results are based on real satellite data, in contrast to the idealized setups normally used in such studies.



The groundbreaking simulations of the solar atmosphere have for the first time shown the formation of sunspots in ab initio simulations purely driven by the convective flows of the Sun.

Further reading:

Gisela Baumann, Klaus Galsgaard, Åke Nordlund, arXiv:1203.1018, accepted by Solar Physics

Gisela Baumann, Troels Haugbølle, Åke Nordlund, arXiv:1204.4947, submitted to Astrophysical Journal

Gisela Baumann, Åke Nordlund, arXiv:1205.3486, accepted by Astrophysical Journal Letters

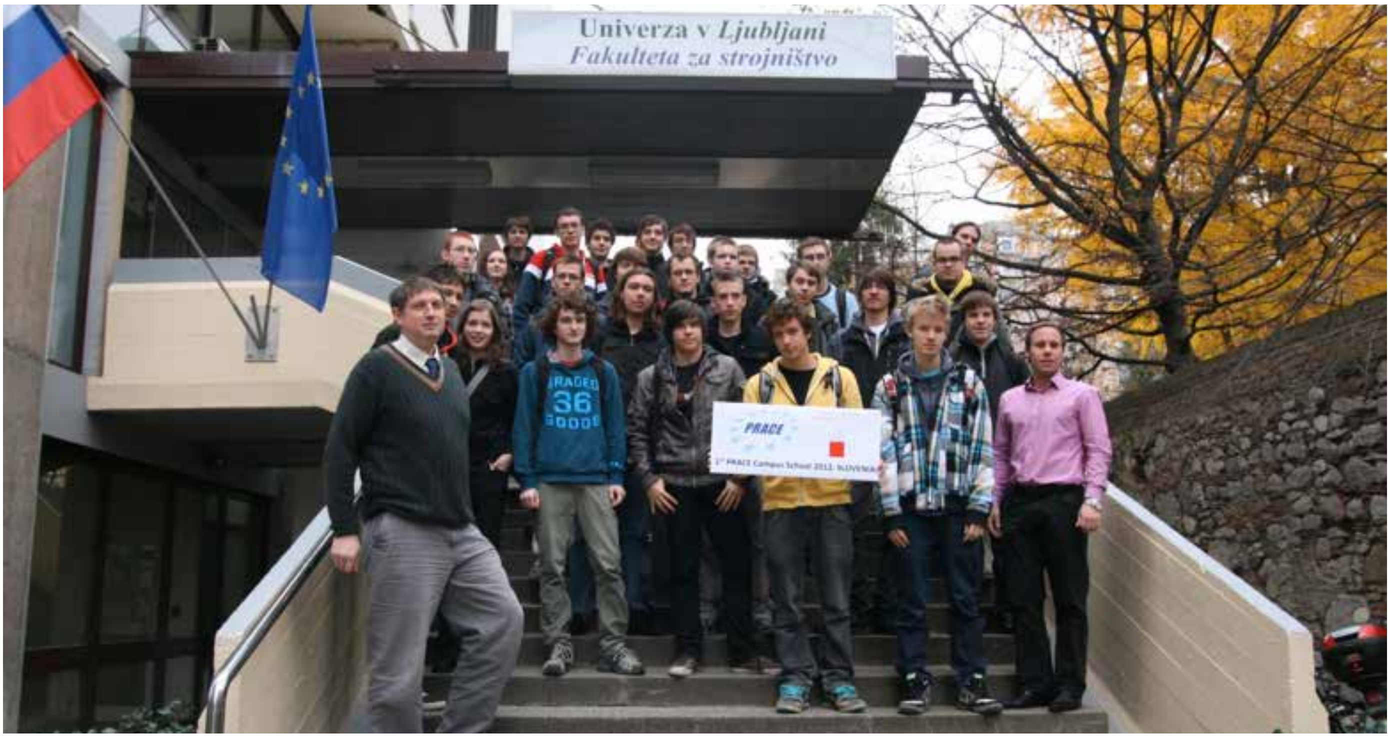
Robert Stein, Åke Nordlund, Astrophysical Journal Letters, 753, L13 (2012)

Damian Fabbian, Elena Khomenko, Fernando Moreno-Insertis, Åke Nordlund, Astrophysical Journal, 724, pp. 1536-1541 (2010)

The Project was awarded under PRACE Project Call 3 and DECI call 6: http://www.prace-ri.eu/DECI-6th-Call
Project title: SunFlare
The project was awarded access to 1,920,000 core-hours of the DECI resource based in Germany, at FZJ(JuRoPA) and 480,000 core-hours at HLRS(NEC SX-9).

http://www.prace-ri.eu/PRACE-2nd-Regular-Call
Project title: Ab Initio Modeling of Solar Active Regions
The project was awarded access to 60 million core-hours of the PRACE Research Infrastructure resource JUGENE based in Germany at GCS@FZJ.

Text: Päivi Brink, Otavamedia Communication (Finland)



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Campus School 2012 in Lubljana, Slovenia

Leon Kos, University of Lubljana

The Faculty of Mechanical Engineering of the University of Ljubljana organized a PRACE Campus School from November 15–17, 2012.

Forty talented high school students were selected from ten of Slovenian's top high schools, based on their excellent academic and extracurricular record. During the 3-day course they learned the principles of HPC programming and gained insight into multi-physics simulations, as well as practical training in programming within a HPC software environment.

Many of these high school students will soon be enrolling in university, where they will use HPC on a regular basis. This event prepared them for the numerous possibilities supercomputing offers in new ideas and innovative solution.

The campus school also raises awareness of HPC among high school students. This is important in promoting supercomputing in general. The students were introduced to PRACE and its objectives, highlighting the important role HPC plays in enhancing the future of research and development in Slovenia and throughout Europe.

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PRACE-2IP: Study of data transfer improvements

Frank Scheiner (HLRS), Petri Nikunen (CSC), Jarno Laitinen (CSC), Jules Wolfrat (SARA)

After having finished your work on a PRACE Tier-0 or Tier-1 system you may ask yourself how to get your terabytes of data out. Or the question is how to import data before you can start your calculations. So, what data transfer tools are available? The following article will highlight the work done in PRACE-2IP to improve the performance and ease of use of data transfer tools.

In most cases secure copy (scp) can be used from/to other, non PRACE, systems for small data transfers, but for large data sets, in the order of terabytes and more, performance can become a problem. The data transfer facilities in PRACE, based on GridFTP and a 10 Gb dedicated network infrastructure, can deliver impressive performance, but only if used in the right way. Also if GridFTP to external sites can be used, performance tuning of the transfers can be a challenge.

An example of a project that needs to transfer large amounts of data between a Tier-1 site and an external site is Planck. This project is a mission of the European Space Agency (ESA) to map the anisotropies of the cosmic microwave background in unprecedented detail.

Planck was launched into space in 2009 and the observation phase will last until 2013. Gathered data is processed and analysed by the Planck Collaboration until 2014, and will be made available to the public in two data releases, in 2013 and 2014.

Planck is supported by several computing centres, including CSC (Finland, a Tier-1 site) and NERSC (USA). Large amounts of simulations and other computational tasks are done at these centres to support the analysis chain of Planck data. The work is done in collaboration with European and American groups, which requires data transfers on a regular basis between CSC and NERSC.

PRACE-2IP staff assisted here to improve the performance and facilities to transfer the data in an acceptable time period. The gtransfer tool was developed to make this possible.

Gtransfer [1], [2] can ease the tasks of users in several ways. Most important, the users no longer need to remember what was the optimized configuration for their data transfer between site A and site B. Gtransfer automatically will use the optimum settings for a specific data transfer, based on information that must have been provided by PRACE-2IP staff in advance.

Users just have to provide the source and the destination of a transfer and gtransfer will take care of the rest, provided that the user has the authorisation to access both sites. Gtransfer can even help the user by specifying their source/destination files and directories by completing remote paths directly on the command line. This way users can traverse remote directory structures from where they are working; there is no need to first check this with another tool (e.g. ssh).

Fig.1. Instead of using a direct but slow connection (dashed red line) between CSC and NERSC, gtransfer (gt) reroutes the data transfer over SARA (yellow lines) and even so achieves a higher performance.

Gtransfer also will help to overcome two possible obstacles: 1) copying data from the dedicated PRACE network infrastructure to external hosts connected via the internet, because not all PRACE sites allow direct GridFTP traffic to the public internet and 2) slow Internet connectivity of partner sites.

1) Having a dedicated network infrastructure and only a few defined gateways to external networks makes sense for both security and performance reasons. However, it also hinders projects that work in close collaboration with other infrastructures, like for the Planck example.
2) In the past, to copy data to an external infrastructure, a user could either use the internet connection of the site he's working on to copy his data directly to the destination, with the chance of a low performance, or he had to go via the official gateways (PRACE door nodes) manually. In the latter case the user first had to copy his data to one of these gateways and in another step from there to the destination. This included waiting for the first transfer to finish before starting the second one and not to forget to remember all options that improve performance, which is especially important on public shared networks.

With gtransfer there is no difference for this case and a transfer within the PRACE network, because gtransfer will use intermediate hops transparently for the user: The user only has to specify the source and destination of a transfer. Internally gtransfer uses a predefined path and copies data to the destination by using the intermediate hosts (door node sites) as stopover for the data. This same functionality can also improve data transfer speeds for PRACE sites with performance limited Internet connectivity. By rerouting data via the official gateways using the high-performance PRACE network infrastructure and copy data from there to external infrastructures, it is possible to improve the data transfer performance substantially if the door nodes have a better performance to the public Internet than the origin site.

The gtransfer tool is work in progress with additional features added in the future. You can contact PRACE-2IP staff to assist you in using the tool, either by asking your local contacts or using the PRACE helpdesk following the guide on [3].

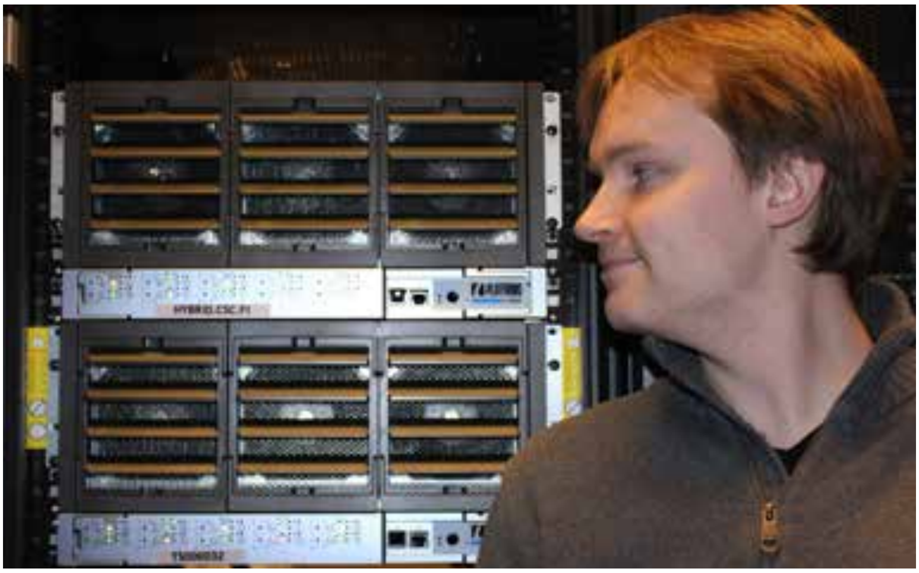
Gtransfer was created at HLRS (Germany) and is licensed under the GPLv3.

[1] http://bit.ly/gtransfer-demo
[2] http://bit.ly/gtransfer
[3] http://bit.ly/prace-helpdesk-guide

PRACE continues evaluating new technologies

Renata Gimenez, Barcelona Supercomputing Center

PRACE is exploring a set of prototypes to test and evaluate promising new technologies for future multi-PFLOPS systems. A common goal of all prototypes is to evaluate energy efficiency to estimate the suitability of those components for future high-end systems. These prototypes accelerate software development, and help computer architects investigate different hardware possibilities and programming paradigms towards the future design of energy efficient supercomputers.



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Olli-Pekka Lehto, (CSC) with the first phase of Scalable Hybrid Prototype.

In this context some pre-production prototypes have already been installed at HPC centres of PRACE partners such as Finland (CSC), Spain (BSC), France (GENCI), Sweden (SNIC) and Ireland (ICHEC), among others funded by the PRACE-1IP (RI-261557) and PRACE-2IP (RI 283493) projects.

Scalable Hybrid Prototype (CSC, SARA, CSCS, T-Platforms)

The official contract between CSC and T-Platforms for the delivery of the prototype has been signed. The first phase of the prototype comprises of ten T-Platforms V-Class blades each with an NVidia Fermi GPGPU and dual Intel Xeon processors. This system will be upgraded in the upcoming weeks with both NVidia Kepler and Intel Xeon Phi cards. It will be located at CSC premises in Espoo, Finland. The second phase will be installed in phases during 2013 into CSC's Kajaani datacenter. The final configuration will feature 256 nodes each with a Xeon CPU and an accelerator (128 Xeon Phi, 128 NVidia Kepler) delivering a total computational power of approximately 400 TFlop/s in single cabinet.

Spanish ARM-based prototype (BSC)

With energy efficiency as an objective, the Barcelona Supercomputing Center (BSC) has deployed a new prototype cluster to explore alternate architectures. The prototype combines energy-efficient ARM cores with a mobile GPU accelerator, and currently achieves 5 GFLOPS per Watt in Single Precision computation (0.8 GFLOPS/Watt in Double Precision), improving on current accelerator-based systems for GPU-centric applications.

The cluster, built of 16 nodes of Quad-core Tegra3 SoC plus a Quadro 1000M mobile GPU connected through a Gigabit Ethernet network, is based on the previous experience of the 256-node Tegra2 cluster deployed in 2011 [www.bsc.es/marenostrum-support-services/tibidabo-prototype]. The new Spanish prototype is located on the BSC premises. It will be used to develop the system software stack on this new kind of architecture, perform scalability tests on a moderate number of computer nodes, and evaluate how BSC's OmpSs programming model mitigates the impact of limited memory and bandwidth from using low-end components.

Results of prototype evaluation in the project were presented at a special Birds-of-Feather session "PRACE Future Technologies Evaluation Results" during the SC12 conference in Salt Lake City (USA).

PRACE BoF Team at SC12
Back: (from left) Sean Delaney, Torsten Wilde, Gilbert Netzer, Front:Alex Ramirez (left)and Radek Januszewski after a successful BoF session at SC12, Salt Lake City.

More information:
http://www.prace-ri.eu/PRACE-prototypes

CRESTA: The concepts, facts and figures

Mark Parsons (Project Coordinator) and Lorna Smith (Project Manager), EPCC at The University of Edinburgh.

The main goal of CRESTA (The Collaborative Research into Exascale Systemware, Tools and Applications) is to develop techniques and solutions which address the most difficult challenges that computing at the exascale can present. It brings together four of Europe's leading HPC centres (project lead EPCC, HLRS, CSC and PDC), a world-leading supplier of HPC systems (Cray), seven application and problem owners from science and industry (DLR, KTH, ABO, JYU, UCL, ECMWF and CRSA), Europe's leading HPC tool company (Allinea) and Europe's leading performance analysis organisation (TUD).

The project has recently reached the end of its first year and during this time we have been working closely on research topics across the exascale domain. In this article I hope to give you an overview of some of these topics and give you a feel for the overall concepts of the project.

CRESTA has two integrated strands: one focused on enabling a key set of applications for exascale (the co-design applications), the other focused on building and exploring appropriate 'systemware for exascale platforms.' Associated with this is one of our key project concepts: the co-design process, with the co-design applications providing guidance and feedback to the exascale software development process, and integrating and benefiting from this development in a cyclical process.

The second important concept within CRESTA is the use of dual pathways to exascale solutions. Many problems in HPC hardware and software have been solved over the years using an incremental approach. Most of todays systems have been developed incrementally, growing larger and more powerful with each product release. However, we know that some issues at the exascale, particularly on the software side, will require a completely new, disruptive approach. CRESTA is employing both incremental and disruptive approaches to achieve technical innovation.

The six co-design vehicles within CRESTA represent an exceptional group of applications used by European academia and industry to solve critical grand challenge issues. They provide a representative sample from across the supercomputing domain including: biomolecular systems, fusion energy, the virtual physiological human, numerical weather prediction and engineering. CRESTA will enable these applications to prepare for, and exploit, exascale technology, enabling Europe to be at the forefront of solving world-class science challenges.

"Systemware" represents any additional enabling software required for the applications. For CRESTA, this involves five distinct areas with the aim of producing an integrated suite including open source interfaces, standards and new software. this ranges from performance, debugging and pre and post-processing tools, through key numerical libraries, programming languages and models to operating systems.

The University of Edinburgh is a charitable body, registered in Scotland, with registration number SC005336.

CRESTA

NEWS IN BRIEF

The PRACE council welcomes Belgium as the 25th member of the Research Infrastructure.

Belgium will join PRACE as a member and will be represented by DGO6 of the Walloon government. Up to and including the 5th PRACE Call for Proposals, Belgium has participated in 2.3% of PRACE projects as leader or collaborator. Belgium benefitted from 1.10% of the total performance offered by PRACE hosting members. Find out about the PRACE Members here: http://www.prace-ri.eu/Members

PRACE Regular Call 5: Records Galore!

The 5th PRACE Regular Call for Proposals, which opened on 17 April 2012 and closed on 30 May 2012, received 80 applications for resources on the six PRACE Tier-0 systems. A record number of 57 of the applications successfully passed the in-depth evaluation of the peer review process and were awarded the core hours needed to perform their research. Abstracts and additional information on all 57 projects is published on the PRACE website: http://www.prace-ri.eu/PRACE-5thRegular-Call

HPCwire's Readers' and Editors' Choice Awards 2012: PRACE partners receive well-deserved recognition!

Every year since 2003 at SC (http://sc12.supercomputing.org/) HPCwire announces the winners of the HPCwire Reader's Choice Awards. This year, out of the 7 PRACE partners and systems nominated in 6 categories, 3 received the highest recognition from HPCwire's readers for being among the most outstanding organizations in the HPC domain: FZJ / JCS, ICHEC and GENCI. Certain technology used by PRACE members was also awarded. Find out more in the press release: http://www.prace-ri.eu/HPCwire-Award-Winners-2012

PRACE 6th Regular Call for Proposals

The PRACE 6th Regular Call for Proposals opened on 18 September 2012 and closed on 14 November 2012. The peer review process is now in full swing and the allocation decision is anticipated for 21 February 2013.

Call for Proposals for DECI-10 closed (Tier-1)

Tuesday 6 November 2012

PRACE-2IP is responsible for the Tier-1 access through the DECI calls. DECI-10 Call received EC funding under (RI-283493).

Opening date was the 5th November 2012 and closing date 14th December 2012, 12:00 CET. DECI-10 call received 88 project proposals.

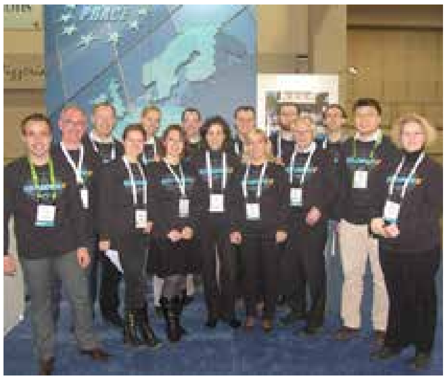
PRACE FEATURED EVENTS

The 5th PRACE Industrial Executive Seminar will take place in Stuttgart, Germany on 15th-16th April 2013

The seminar will showcase results obtained by companies using the PRACE infrastructure, review PRACE's Industrial Offer and introduce PRACE's Industrial Advisory Committee (IAC). Key decision makers in the area of modelling, numerical simulation and technology will attend and keynote speakers from Europe's leading innovative companies will make presentations on exciting HPC applications. Thematic sessions, seminars and workshops will be hosted. The Competition for the Most Innovative HPC Industrial Solution – Second Round will also take place. More information will be available soon at http://www.prace-ri.eu/PRACE-Industrial-Seminar-2013

PRACE Summer of HPC 2013

Summer 2013 will see the launch of the PRACE Summer of HPC. This programme will offer up to twenty undergraduate and postgraduate students summer placements at HPC centres across Europe. Participants will spend two months working on projects related to PRACE technical or industrial work to produce a visualisation or video for use in outreach activities. Flights, accommodation & a stipend will be provided to successful applicants and prizes will be awarded for the best participants. Application will open on January 25th 2013 via www.summerofhpc.prace-ri.eu.



PRACE Booth Team at SC12

PRACE dedicated staff was present to answer all questions about PRACE.

Contact: *info@prace-ri.eu*

Editor-in-chief: *Tiina Leiponen, CSC*

www.prace-ri.eu

e-infrastructure