Nordic eScience Action Plan 2.0

eScience and eInfrastructure in an international context

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10 concrete actions for implementation

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Foreword

In 2006, the Nordic Council of Ministers formed an ad hoc eScience Group assigned to propose a joint Nordic eScience strategy, also including eInfrastructures. The Group delivered its report in summer 2007, emphasising the need for long-term, sustainable collaborations within Nordic eInfrastructure and proposing new Nordic programmes within eScience research and education. The initiative was taken further by the Nordic research councils under NordForsk's NORIA-net instrument, forming the Nordic eScience Initiative (eNORIA) group. This eNoria group was asked by the Nordic Council of Ministers for Education and Research (MR-U) to propose an action plan to realise the Nordic eScience Strategy. The first version of the Nordic eScience Action Plan was presented in November 2008, comprising ten concrete actions along three different action lines for implementing an integrated Nordic strategy covering higher education in eScience, eScience research and eInfrastructure.

Following the successful implementation of many actions in the first version of the Action Plan, MR-U under the Swedish presidency of the Nordic Council of Ministers, at the end of 2012, appointed a project leader and an ad hoc expert group to produce an updated version of the Nordic eScience Action Plan, **the Nordic eScience Action Plan 2.0.**

A major reason for initiating the update was the publishing of the report "Vilja till forskning?", produced by a High Level Group appointed by MR-U to perform a study of Nordic research collaboration with a focus on future ambitions, efficiency and direction. In this report, the impact of the implementation of the first version of the eScience Action Plan is pointed to as a success story. The status for the ten actions presented in the first version of the Action Plan is presented in Appendix 1.

Sincere thanks to the ad hoc expert group for its hard work in drawing up the Nordic eScience Action Plan 2.0, which marks a new phase for Nordic eScience and e-infrastructure cooperation. The implementation of the ten Actions listed in this document will be of significant benefit to Nordic research and education.

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– January 2015

Introduction

eScience

eScience is about developing and applying advanced methods and tools within information and communication technology (ICT) in order to exploit an alternate mode of advancing research, complementing traditional theory and experiments. eScience is also about global collaboration and enabling distributed and potentially open access to digital resources and services such as networks, computing, data and instruments within all areas of research.

eInfrastructure

eInfrastructures for research are ICT-based infrastructures enabling modern collaborative science and innovation. Such eInfrastructures include high-performance and distributed computing, high-end storage, advanced networking, middleware services such as authentication and authorisation, and services to support research workflows, handle data and provide application software for e.g. simulations and analysis of large data sets. eInfrastructures also include the support staff and organisational structures needed to operate them.

A changed research landscape

eScience methods and tools, using eInfrastructure services, enable collaboration among distributed research projects and organisations and provide access to distributed resources. Major scientific breakthroughs are increasingly achieved by international, cross-disciplinary teams handling and analysing vast data collections and performing advanced simulations using large-scale computing facilities. The virtual mode of research has revolutionised the way research and innovation are undertaken. The landscape is changing in a fundamental way with new ICT-based tools emerging, and new resources are being made available at an ever increasing pace, providing new opportunities for advancing knowledge for the benefit of society.

Nordic researchers are forerunners

Nordic researchers have been recognised as forerunners in eScience, both in fields which were early adopters of eScience techniques, such as e.g. physics and climate research, and in development of new eScience tools for areas where the use of such techniques has not been widespread so far, e.g. in medicine and social sciences. Also, in recent years the production of both scientific and other forms of digital data has exploded, and as a result of the availability of a multitude of data sets, a vast set of ICT-based research methods and tools is currently being developed to turn data into knowledge.

Today, eScience methods and tools are regularly used and developed by Nordic researchers in a wide range of scientific disciplines and are rapidly emerging in others.

eScience is developing rapidly

The implementation of actions in the first version of the Nordic eScience Action Plan is pushing the development of eScience in a few areas of Nordic strategic interest. However, the international eScience development is extremely rapid. In many countries and regions globally, progress in science is often leap-frogged by focussed eScience efforts (even though the term eScience might not always be used to describe the activities). The opportunities for progress in science and innovation opened up by eScience tools and techniques and open access to data are recognised globally. It is now urgent for the Nordic countries to take action to maintain and further strengthen the competitiveness and visibility of Nordic eScience research and education. This will enable Nordic researchers to lead the way in strategic areas of research and in implementing new modes of science also in the new ages of digital science.

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Joining Nordic forces

In an international perspective, the quality and availability of modern eInfrastructure in the Nordic countries is in general impressive. At the Nordic level, important steps have already been taken to take advantage of the value added from joining forces between the countries, early on by collaborating on e.g. computer communication networks for research and lately also through extended collaboration on implementing actions in the first version of the Nordic eScience Action Plan. However, to underpin leading Nordic research and innovation there is a need to further promote and develop innovative eInfrastructure services and collaborative models. Nordic eInfrastructure has the potential to lead the way in implementing the European eInfrastructure commons as suggested by the European e-Infrastructure Reflection Group (e-IRG). By meeting the needs of Nordic communities, the Nordic eScience and eInfrastructure landscape could serve as a model for other initiatives, e.g. at the European level.

Nordic eInfrastructure has the potential to lead the way in implementing the European eInfrastructure commons as suggested by the European e-Infrastructure Reflection Group (e-IRG).

Objective

Implementation

The objective of the Nordic eScience Action Plan 2.0 is to motivate and describe concrete lines of actions that are necessary to continue and further develop the implementation of an integrated Nordic eScience Strategy covering higher education, research and ICT infrastructure.

The work on the Action Plan 2.0 picks up on the progress made following the first version of the Action Plan presented in 2008, described in Appendix 1, and further underpins the mission of developing eScience and eInfrastructure into Nordic flagship cooperation areas in the context of other international initiatives, e.g. at the European level.

As in the first version, the Action Plan 2.0 suggests that concrete actions are taken along three lines:

A) **Facilitating the Creation of a Higher Education Arena for eScience**

B) **Enabling eScience as an Omnipresent Tool in Research**

C) **Creating Knowledge through Cross-Border Sharing of eInfrastructure**

Ten concrete actions

The Action Plan 2.0 sets out perspectives and objectives for ten specific actions within these areas. Some of these actions build on progress made in the implementation of corresponding actions listed in the first version of the Action Plan while others emerge from new opportunities for Nordic collaboration. Also, some of the actions in the first version of the Action Plan have attracted less interest or have for other reasons become obsolete and are not included in the Action Plan 2.0.

Nordic added value

For all actions in the Action Plan 2.0, collaborative aspects and Nordic added value are perceived to be significant and the organisational framework is understood to be well in place and mature enough to facilitate rapid implementation. Also, the proposed actions are all described in an international context ranging outside the Nordic countries and should be integrated into international efforts for the benefit of Nordic researchers and international research collaboration. Joining forces at the Nordic level will pool complementary expertise and provide the momentum and visibility needed to have substantial impact in international arenas. Nordic efforts can also complement and strengthen other international initiatives, e.g. within Europe.

Action Plan Mission

The mission of the updated Action Plan is to optimise the conditions for scientific excellence in an international setting by exploiting Nordic added value,

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thereby taking a lead in areas of highest strategic value for future research and the development of society. By joining forces and implementing the actions described in the eScience Action Plan 2.0, the Nordic countries will take heed of already established collaboration and support digital research communities and environments with unprecedented research capabilities. The conditions for eScience research and education in the Nordic region are the best, with a unique collection of top-class scientists. Also, the Nordic countries host well-established national eInfrastructure providers, delivering first-class services and support for research.

The Nordic eScience Strategy Revisited

The first Nordic eScience strategy

In 2006, the Nordic Council of Ministers formed an ad hoc eScience Group assigned to propose a joint Nordic eScience strategy. The Group delivered its first report in July 2007, emphasising the need for long-term, sustainable collaboration within Nordic eScience infrastructures and proposing new Nordic eScience programmes within research, infrastructure and education. The strategy discusses how Nordic eScience collaboration can be strengthened to provide sustainability, more efficient resource sharing, joint infrastructures and joint education programmes as well as a clearer organisation for strategic planning and funding and for sharing of responsibilities. One important projection made is that, as a result of the implementation of the strategy, the Nordic region will within ten years be viewed as an eScience and eInfrastructure role model internationally. Today, essential parts of the strategy have indeed been implemented in the form of actions listed in the first version of the Nordic eScience Action Plan. Also, the development of Nordic eScience and eInfrastructure can be seen to have attracted significant international interest and appreciation. The Action Plan 2.0 aims at completing this process, taking the rapid development of the fields of eScience and eInfrastructure also after 2007 into account.

Programmes to promote research and education

The Nordic eScience Strategy proposed three programmes to promote Nordic eScience research and two related education programmes:

- Resourcing computational "Grand Challenge" research

- Establishing a Nordic infrastructure for databases and data repositories

- Reinforcing Nordic eScience collaboration with the Baltics, Europe and beyond

- Establishing a Nordic Master's programme in eScience technologies

- Establishing a Nordic PhD education programme in eScience technologies

The Nordic eScience Globalisation Initiative

As a result of the strategy and the first version of the Action Plan, the Nordic eScience Globalisation Initiative (NeGI) was established at NordForsk. Today, NeGI supports Nordic Centres of Excellence in two selected Grand Challenge areas. However, as a result of the fast development of eScience tools and techniques during the last decade, eScience is now entering as a standard mode of research in all forms of leading research, often driven by the rapidly growing availability of different types of digital data. This suggests that it is important to point to the importance of further development of eScience, alongside theory and classical experiments, as an omnipresent research method for enabling ground-breaking progress in research. The development of data science has led to recognition of eScience as a means of extracting information and knowledge on a larger scale, starting from large amounts of data with little or no prior knowledge of the underlying patterns. This has led to a stronger need for research, development and maintenance of methods, tools and software for integration, management and analysis of data for research and innovation. This complements the need for development of methods and tools for computer simulations identified in the Nordic eScience Strategy from 2007 and points to a general need for further development of data science. This is enhanced even more by a rapid adoption of the Open Science paradigm, which stresses the importance of research on methods, tools and software to make data and research results available and useful and to enable new and reproducible science.

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Enabling Nordic registry-based research

The Nordic eScience Strategy proposed the establishment of a Nordic infrastructure for databases and data repositories, with a focus on registry research. This issue has been discussed in many constellations during the years since 2007, and it can be seen as a specific aspect of the much wider field of data science discussed above. Nordic cooperation on harmonisation of

*Some of the actions in the **eScience Action Plan 2.0**, e.g. on sharing of digital resources and on establishing an eInfrastructure for sensitive data, are instrumental for bringing Nordic registry-based research forward.*

registries and on setting up policy frameworks that allow cross-talk over research fields and national borders has been pursued by national actors and NordForsk, but further work is needed to accomplish the goal of the strategy. Some of the actions in the eScience Action Plan 2.0, e.g. on sharing of digital resources and on establishing an eInfrastructure for sensitive data, are instrumental for bringing Nordic registry-based research forward. Here, additional actions covering e.g. data standards, security, policies and legislation are also needed. Potentially, a separate action plan with a list of concrete actions is needed to advance this field further.

International collaboration

The Nordic eScience Strategy proposed an intensified collaboration with the Baltics, Europe and beyond, focussed on research and development of new eScience infrastructures, an effort which straddles the border between eScience and eInfrastructure. Here, the Nordic position can be significantly strengthened by Nordic collaboration and common Nordic initiatives within both fields, and since research and research infrastructures are becoming more and more international, this component is even more important today than when the strategy was originally produced. A natural development of the Nordic eScience Strategy is to stress even further that all concrete actions originating from the strategy should include exploring synergies at the international level, and should also encourage sharing of results internationally. For example, information and communications technology (ICT) is present in most of the Horizon 2020 focus areas, and in many cases the activities proposed are directly related to eScience or eInfrastructure. Nordic efforts in eScience and eInfrastructure will normally be of limited value if they do not seek synergies with international initiatives and work towards internationally coherent approaches.

Education in eScience tools and education techniques

The importance of activities interfacing eScience and eInfrastructure is already underlined in the Nordic eScience Strategy. Currently, the use of eScience techniques is spreading into many new areas while at the same time both the power and the complexity of eInfrastructures are increasing. High-quality education in eScience tools and techniques needs to be available for Nordic PhD students to secure the future competitiveness of research and development in academia and industry. PhDs with skills in strategically important disciplines and a broad knowledge of computational and data management techniques are urgently needed, and they must also be skilled in interdisciplinary work and spreading the use of eScience into new areas of research.

Collaboration for sustainable eInfrastructure

Finally, the strategy discusses sustainability of Nordic eInfrastructures. Here, the document proposes a substantial degree of collaboration between the Nordic HPC organisations, including technology and policy development, to set up procedures for cross-national resource allocation and accounting. The strategy has a special focus on the development of grid resources, which during the past years have developed further into more general distributed eInfrastructures for computing and data, including clouds.

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Organisational Framework for Nordic Collaboration on eScience and eInfrastructure

The Nordic Council of Ministers

The Nordic Council of Ministers has the overall role of initiating and supporting Nordic collaboration. Under the auspices of this organisation, the Ministers of Education and Research in the Nordic countries and autonomous areas (MR-U) share overall responsibility for education and research cooperation. Here, the Committee of Senior Officials for Education and Research (ÄK-U) prepares the agenda for the Ministers' meetings and follows up on their decisions.

Organisational framework in place

Within the Nordic countries, there is a long history of collaborative efforts where activities in both research and research infrastructure are coordinated at the Nordic level, including the use of true common pots for funding of joint initiatives. This has led to the necessary Nordic organisational structures for further development of Nordic eScience and eInfrastructure as described in the first version of the Nordic eScience Action Plan being quickly put in place. The organisational frameworks built within and between groups of national actors in the Nordic countries (e.g. funding agencies and eInfrastructure providers) are now well-established. To ensure the best possible coherence, sustainability and efficiency, relevant existing organisational frameworks should whenever possible be used for implementing the actions in the Action Plan 2.0. These frameworks provide an excellent platform to drive further development and implement additional concrete actions providing Nordic leadership in the fields of eScience and eInfrastructure. Strategic actions as outlined in this Action Plan 2.0 are needed to ensure that opportunities for collaboration at the Nordic level are used in an optimal way, leading to more efficient activities and giving Nordic research a competitive edge. The largest Nordic organisation under MR-U is

NordForsk, which is responsible for supporting Nordic collaboration in research and research training. NordForsk has several funding instruments of relevance to this Action Plan 2.0, such as Nordic Centres of Excellence and Nordic Graduate Courses. NordForsk also supports Nordic research infrastructure collaboration and has taken recent initiatives to promote joint Nordic use of such infrastructures and to stimulate interaction and facilitate planning of collaborative efforts.

The Nordic eScience Globalisation Initiative

As a direct result of the first version of the Nordic eScience Action Plan, the Nordic eScience Globalisation Initiative (NeGI) was established in 2011. NeGI has been set up as a programme under NordForsk, and supports a Nordic eScience Grand Challenge programme on research and graduate education in eScience tools and techniques. Here, the main activity is pursued in the form of three Nordic Centres of Excellence within eScience research on climate and environment and on health and social preconditions for health. NeGI is funded by the Nordic Council of Ministers and national funding agencies.

The Nordic e-Infrastructure Collaboration

NordForsk has hosted the Nordic e-Infrastructure Collaboration (NeIC) since 2012. NeIC is a distributed organization that facilitates the development of generic data and computing services for a wide range of research applications. Furthermore, NeIC operates dedicated services for high-energy physics; and facilitates development of services for the bio- and medical sciences and the environmental sciences. NeIC has taken responsibility for implementing several of the actions in the first version of the Nordic eScience Action Plan.

Strategic actions as outlined in this Action Plan 2.0 are needed to ensure that opportunities for collaboration at the Nordic level are used in an optimal way, leading to more efficient activities and giving Nordic research a competitive edge.

At the national level, the relevant ministries have the principal responsibility for unified national research and research infrastructure policies and accompanying action, with their respective research councils being instrumental to progress along the eScience research and eInfrastructure action lines in this Action Plan.

NORDUnet

NORDUnet is a long-established research infrastructure collaboration between the Nordic national research and education networks (NRENs). NORDUnet interconnects these computer network providers and connects them to the worldwide network for research and education and to the general-purpose Internet. At the national level, responsibilities for the NRENs are shared between the Ministries for Education and Research, the research councils and the national providers of eScience infrastructure.

Collaboration outside academia

There are also examples of Nordic eInfrastructure and eScience collaboration outside academia. In March 2014, the Swedish Meteorological and Hydrological Institute and the Norwegian Meteorological Institute joined forces in operational weather modelling. The two institutes are now running a common forecasting model and sharing supercomputer facilities. The goal of this collaboration is to improve the quality of weather forecasts through more efficient use of resources. By sharing supercomputer facilities, the two institutes will also get access to more powerful computers than they would through national investments. The collaboration model has drawn international interest, and there are ongoing discussions on expanding the collaboration to include the other Nordic countries.

National organisational frameworks

At the national level, the relevant ministries have the principal responsibility for unified national research and research infrastructure policies and accompanying action, with their respective research councils being instrumental to progress along the eScience research and eInfrastructure action lines in this Action Plan 2.0. However, the policies and structures differ significantly between the Nordic countries. In some of the countries, research policies are determined in a combined top-down and bottom-up setting and focussed eScience

efforts have been established. In other countries, strategies for research are almost fully set by researchers and universities in bottom-up procedures and coherent cross-disciplinary eScience efforts have not yet emerged. The policy for higher education, e.g. in eScience, is typically in the hands of a ministry or a national funding agency and implemented by universities. The provision of eInfrastructure is funded directly by one or several ministries, a national research council, or a combination of the two. All Nordic countries have at least one national eInfrastructure provider responsible for all or parts of the eInfrastructure services for research.

Implementation of the Nordic eScience Action Plan 2.0

Given the structures indicated above, the eScience Action Plan 2.0 directed towards enabling eScience research is a joint effort of NordForsk and the national research councils, while implementation is provided by universities and national eScience initiatives and groups. Also, actions towards establishing and coordinating a collaborative education arena for eScience are chartered to NordForsk, while implementation is again provided by national eScience initiatives and universities. The actions on infrastructure will be dealt with by the established Nordic eInfrastructure organisations NeIC and NORDUnet. Here, coordination and implementation are provided by the national eInfrastructure providers, and involvement of the users of eInfrastructure resources is essential in the process.

A

Action Line A: Creating a Higher Education Arena for eScience

Educational efforts urgently needed

Several examples of successful local and national educational programmes in eScience have appeared in the Nordic countries during the last decade. These efforts are normally focussed on certain educational levels or specific topics. Because of the rapid growth of the eScience field, the number of leading eScience lecturers in each country was found early on to be a limiting factor for developing these initiatives further. During the past years, the development of more and more complex eScience methods, software and computer systems has accelerated even more, and eScience is quickly spreading into new areas, becoming an omnipresent mode of performing research. This has resulted in an even more urgent need than before for extended educational efforts both on using and on developing modern eScience methods, tools and techniques. Education in eScience needs to be part of general curricula, and education on how to develop the eScience tools and techniques of tomorrow needs to be available for interested students in a variety of fields. Also internationally, the need for educating representatives of a new profession, the eScientist or Data Scientist, has been identified as a key issue for future development of both research and society. PhD education for such emerging professions hardly exists today, and, e.g. within the Horizon 2020 framework, initiatives are being taken to improve the professional recognition of these communities and the development of appropriate curricula. In research, eAchievements, e.g. in the form of publishing of valuable data sets and production of reusable software, are slowly becoming recognised as research merits complementing traditional means of publishing research results such as journal papers or conference contributions.

People and competence

Discussions on eScience education are ongoing in many local, national and international forums. The development of eScience is more and more focussed on people and competence rather than hardware resources. Education in eScience methods, tools and techniques needs to move into curricula at all levels to avoid losing an opportunity for future Nordic researchers to have a competitive edge. This also includes education for persons active in working life outside academia, e.g. in R&D-intensive companies.

Cooperation within education

Within the Nordic countries, competence is still scattered and educational initiatives could often benefit from larger student groups and teacher collaboration. Enabling pooling of competence, course material and students at the Nordic level will lead to substantial added value and opportunities for rapid progress. This will also provide a platform for further activities in the international arena. Cooperation within eScience education will give Nordic research and development, both within academia and other parts of society, a broad competitive advantage. Such cooperation will produce graduates who are empowered to improve the use of eScience techniques in fields where such methods are already used today, and to introduce such techniques in fields where new eScience methods may have immense impact. Also, such a highly competitive educational effort will provide Nordic industry with the technology experts of the 21st century, skilled in the advanced computing technologies that are the foundation for emerging service-oriented business models and knowledge-based industry.

Education in eScience methods, tools and techniques needs to move into curricula at all levels to avoid losing an opportunity for future Nordic researchers to have a competitive edge.

Nordic graduate education

At the Nordic level, NeGI is implementing a programme for Nordic graduate education in eScience tools and techniques. This effort is currently funded at a level of NOK 10 million allocated via a Nordic common pot. At the European level, the Marie Skłodowska-Curie Actions under Horizon 2020 aim at supporting the career development and training of researchers in all scientific disciplines. This is achieved through innovative training networks, individual fellowships, research and innovation staff exchanges, and co-funding of regional, national and international programmes that finance fellowships involving mobility to or from another country.

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Because of the rapid growth of the eScience field, the number of leading eScience lecturers in each country was found early on to be a limiting factor for developing these initiatives further.

Action 1: Training Researchers in eScience Tools and Methods

In parallel with further development of the field, the NeGI effort on graduate education in eScience tools and techniques will be evaluated. A sustainable but dynamic platform for Nordic open graduate education in eScience will be built up, also covering the use and development of eScience in e.g. the humanities and social sciences and providing added value to national and local initiatives pursued by eScience initiatives and universities. The activities will be integrated into relevant European efforts and a special focus will be placed on education in cross-disciplinary data science, preparing Nordic PhDs to take a lead in future data-intensive research and development within and outside academia.

Commencement: 2015
Implementation: 2016 and onwards
Responsible: Coordinated by NeGI/NordForsk and implemented by universities

Action 2: Fostering Nordic eScience Collaboration through Mobility

In order to build a tighter Nordic eScience community and to increase connections to other international eScience and data science initiatives, a concerted mobility platform will be formed to support shorter visits for students and young researchers. The effort will be integrated into relevant European mobility initiatives and will be important to fostering cross-national collaborations. Particular attention will be given to the promotion of networking for young people.

Commencement: 2015
Implementation: 2016 – 2017
Responsible: NeGI/NordForsk

B

Action Line B: Enabling eScience as an Omnipresent Tool in Research

International impact

The Nordic countries have a strong history of eScience research. This is manifested in several ways: by use of advanced eScience methodology in areas like physics, chemistry and earth sciences; by rapid introduction of eScience techniques in new areas; and by strong research on new eScience methods, tools and techniques. By joining forces at the Nordic level the opportunities for providing excellence and scientific solutions at all stages of the eScience process increase even more. Coordinated digital Nordic research communities can create unprecedented international impact by forming collaborative platforms for participation in European and global research initiatives. Also, such communities can and do provide global role models in the movement towards Open Science, making scientific research, data and processes openly accessible to the global research community and creating a global Scientific Commons. Within the Nordic countries, activities leading the way in Open Science have been initiated, and by supporting the culture of Open Science within all research communities, better competitiveness and a higher quality, transparent, collaborative and inspirational research process can be secured for the future.

National eScience programmes

In the Nordic countries, coordinated national eScience programmes exist in Finland (under the name computational science), Norway and Sweden. In these countries, the first phase of the programmes are now coming to an end and discussions on the continued activities are ongoing. By emphasising the topic of Nordic and international collaboration in these discussions, the impact of the national initiatives can be further strengthened. In Denmark and Iceland there are many very strong research groups in eScience, and coordinated efforts are being discussed. Again, a discussion on international and Nordic coordination could result in potential benefits for the eScience researchers in these countries.

NeGI grand challenge efforts

Today, a Nordic eScience research programme focusing on two Grand Challenge areas – eScience in Climate and Environmental Research and eScience Research in Health and Social Preconditions for Health – has been established by NeGI. In total, NOK 82 million in common-pot Nordic funding has been allocated to this five-year effort. In the process of establishing this initiative, it has become clear that other research areas could benefit greatly from coordinated Nordic efforts strengthening eScience aspects and aspects of Open Science, adding significant value to national activities. Within the European Horizon 2020 framework and the Digital Agenda for Europe, as well, Digital Science is referred to as a main driver for Europe's future prosperity and quality of life. The need for a push for using eScience tools and techniques to make all research more open, global and collaborative is stressed. The Nordic ability to perform research leading to new, openly available eScience tools for relevant applications will determine the competitive advantage for the Nordic countries. In this context, eScience can be seen as an omnipresent component of Nordic research efforts, strengthening existing or emerging strategically selected initiatives even further. At the same time, the common Nordic knowledge generated through common research activities will spur industry on to create new products for the global market.

A discussion on international and Nordic coordination could result in potential benefits for the eScience researchers in these countries.

Need for major efforts

The need for research on eScience methods and software is becoming an urgent issue. In many cases, the use of eScience is dependent on legacy tools that are difficult to maintain and difficult to use efficiently on current and future computational resources. There is a clear need for a coherent process and major efforts targeted towards enhancing the base of methods and software base for a range of research areas, including research on new algorithms and implementations for computer simulations and data analysis. Here, several successful efforts already exist at the Nordic level, and the combined strength of the field in the Nordic countries provides the foundation needed for taking a lead internationally in this field.

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Action 3: Strengthening eScience Aspects of Nordic Research

eScience aspects of selected Nordic research efforts will be emphasised by applying the experience gained from the Grand Challenge programme initiated by NeGI. Future Nordic research efforts will very often be dependent on large volumes of data, which may be distributed over several locations, and/or involve extreme resources in terms of computing capacity. eScience will be introduced as a mainstream mode of Nordic research, and eScience aspects will be included in calls for proposals and evaluations. Descriptions of how eScience techniques can be used to strengthen the impact of Nordic research efforts will be included in the descriptions of research programmes and projects, and eScience aspects will be stressed in evaluation procedures and grant agreements. Here, the strengthening of eScience aspects is closely connected to both Action Line A (eScience education) and C (eInfrastructure) in the Action Plan.

Commencement: 2015
Implementation: 2016 and onwards
Responsible: NordForsk

Action 4: Nordic Research on eScience Methods and Software

A joint research programme will be established to address research on methods and application software for Nordic research, underpinning the eScience component of research programmes and projects and strengthening areas where added value of joint Nordic efforts can be found. The programme should implement a holistic approach, building on the needs of important research communities and establishing and retaining the necessary competence of future Nordic eScience research. The goal of the programme is not only to advance knowledge on eScience methods and software, but also to provide a pool of expertise for the development of the eScience tools of the future, bridging the gap between research on new eScience tools and techniques, eInfrastructures, and using eScience for solving strategically important problems in science and technology. The programme will be integrated into or complement other international efforts.

Commencement: 2015
Implementation: 2016 – 2017
Responsible: NordForsk, the Nordic Council of Ministers and the national research councils

5

Coordinated digital Nordic research communities can create unprecedented international impact by forming collaborative platforms for participation in European and global research initiatives.

Action 5: Nordic Pilot Projects within Open Science

The Nordic countries have a strong record in driving the development of open science, including open access to research results, data, tools and procedures. eScience is both an enabling factor and a driving force for the evolution of the open science paradigm. Building on recent experience and activities, a few Nordic pilot research projects in a few strategically chosen fields will be initiated, including the full paradigm of open science in all phases of the establishment, implementation and reporting processes. The activity will be consistent with (but elaborate further on) the Horizon 2020 open data pilot and should explore synergies with emerging international efforts.

Commencement: 2015
Implementation: 2016 – 2018
Responsible: NeGI/NordForsk

C

Action Line C: Knowledge Creation through Cross-Border Sharing of eInfrastructure

Modern eInfrastructure

Modern eInfrastructure is essential for progress in any field of research. The provisioning of eInfrastructure for research is implemented in different ways across the Nordic countries. Commonly, national eInfrastructure provider organisations deploy a range of services for the benefit of the national scientific communities. At the Nordic level, the national provider organisations have a long history of collaboration through NeIC (and its predecessor NDGF) and NORDUnet. At the European level, NORDUnet plays a coordinating role on behalf of the national research networks in the Nordic countries. In contrast, the Nordic countries participate individually in European computing and data infrastructures such as the Partnership for Advanced Computing in Europe (PRACE), the European Grid Infrastructure (EGI) and EUDAT. Also, Nordic researchers and initiatives take part in activities focussing on data handling and analysis, such as the Research Data Alliance (RDA).

History creates future platform

For the future, the decades-long history of Nordic eInfrastructure collaboration through NORDUnet and NeIC provides a platform for further alignment of national efforts. Internationally competitive research is dependent on access to high-quality eInfrastructure services. Common multi-national eInfrastructure services are preferable to duplicate national silos that cannot communicate across borders. Through economy of scale, the national eInfrastructure organisations could collaborate to provide a broader range of high-quality standardised services to a larger user community at lower cost. The effect will not only be increased competitiveness but also a lower threshold for new and innovative constellations of Nordic researchers. Frameworks for cross-border sharing of resources and coordinated procurement of resources and services can result in further improved services for national and Nordic user communities and more efficient overall use of funding. In recent years, some new pilot collaborative activities have been established between the Nordic countries, partly as a result of the first version of the Nordic eScience Action Plan. The Nordic HPC pilot project for the joint procurement and operation of an HPC resource is an example of such collaboration.

Integration in international efforts

Nordic collaboration on eInfrastructure is pursued by exploiting and strengthening the links between the partners, thereby enabling stronger collaboration between national research communities in the Nordic countries. The action line on eInfrastructure will be pursued with a view to open access and EU policies, and efforts will be integrated into or complement relevant priorities under the Horizon 2020 programme and on the ESFRI Roadmap.

Common multi-national eInfrastructure services are preferable to duplicate national silos that cannot communicate across borders.

Enabling data science

The Nordic countries have comprehensive databases and data repositories owned by national authorities for administrative or monitoring purposes. No other part of the world has such comprehensive data, namely within the area of social sciences and the humanities. In addition, new valuable scientific data is collected and generated all the time – at an almost explosive rate. Most of these unique data structures are currently underused for research – more often than not, due to legal, organisational and policy restraints rather than technical restraints. An important opportunity for the infrastructure action line is to enable the combined use of the existing national databases and data repositories within selected research areas, as well as to initiate activities improving the ability to use newly-generated scientific data. In so doing, the many non-technical restraints must be overcome.

The Nordic countries have major roles in several life science infrastructures, such as the ESFRI projects ELIXIR and BBMRI.

Sharing sensitive data

The Nordic countries have major roles in several life science infrastructures, such as the ESFRI projects ELIXIR and BBMRI. The Nordic countries also have high-quality health registries for research, as has been demonstrated by the NordForsk NORIA-net on registry research. International and national legislation sets a challenging framework for data sharing. eInfrastructure enabling responsible sharing of sensitive data will be established to tap the potential of these research opportunities and further stimulate collaboration in these areas. The infrastructure will enable storage, computation and responsible sharing of anonymised research data subject to legal terms of use. Benefits include increased availability and reuse of data and increase of potential cohort size.

Green computing

Green computing is an area of particular interest to the Nordic countries. The ever-growing energy requirements of data centres is a global issue, and the ability of the Nordic countries to encompass both power efficiency and environmental responsibility in data centre design and operations is a potential competitive advantage. The increasing need for computing resources for research may call for new strategies at the Nordic scale, again integrated into or complementing other international efforts.

Software maintenance

The case for eScience research in new methods and software was made in Action Line B as a means of leveraging the opportunities provided by modern hardware and data flows. But such new scientific software, as well as the vast amount of existing legacy code, needs sustained maintenance by in-the-field software experts. Nordic groups have trademarked several scientific software packages and have contributed to many others. Examples can be found within chemistry, life sciences, physics and climate science. The efforts involved in software maintenance cannot be characterised as research, but rather as eInfrastructure. This is also explicitly recognised by the European Commission in the call texts of Horizon 2020. For example, coordinated Nordic efforts could be established for participation in the Horizon 2020 eInfrastructure calls for establishing Centres of Excellence in scientific software.

Nordic groups have trademarked several scientific software packages and have contributed to many others.

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Action 6: Nordic Sharing and Exchange of eInfrastructure Resources

A Nordic framework for sharing and exchanging computing and data storage resources will be implemented. This will build on federating authentication, authorisation and accounting structures and be integrated into international initiatives. Mechanisms for resource exchange, compliant with national rules and regulations, will be implemented. This action provides an essential foundation for the enhanced Nordic research collaboration described in other actions in this Action Plan.

Commencement: 2014
Implementation: 2015 – 2017
Responsible: NeIC/NordForsk, NORDU-net and the national eInfrastructure providers

Action 7: A Nordic Federated Cloud

Cloud computing has become an established paradigm for running services on external infrastructure, where virtually unlimited capacity can be dynamically allocated to suit the current needs of scientific communities and where new instances of a service can be deployed within a short time frame. This is an emerging paradigm also in the research sector and a common Nordic approach could mitigate duplication of efforts and benefit from scale and increased elasticity, thereby offering computing resources to Nordic researchers in a flexible manner. Nordic federated cloud services for research will be developed and integrated into relevant international initiatives.

Commencement: 2014
Implementation: 2015 – 2016
Responsible: NeIC/NordForsk, NORDU-net and the national eInfrastructure providers

Action 8: Nordic High Performance Computing Collaboration

NeIC has coordinated recent evaluations of the Nordic HPC project and the Nordic use of European PRACE resources. These projects have explored different modes of international collaboration on large-scale computing, and the evaluations have revealed a potential for strengthened Nordic collaboration on high-end computing investments and operation. A science case and a business model for Nordic HPC collaboration should be developed, taking national assessments as the starting point. Improved Nordic HPC collaboration could pave the way for synchronised or shared investments, thereby providing more researchers with access to the high-end resources and enabling them to take a lead within the field of environmentally-friendly data centre facilities.

Commencement: 2014
Implementation: 2015 – 2016
Responsible: NeIC/NordForsk and the national eInfrastructure providers

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Action 9: Nordic eInfrastructure for Sensitive Data

The Nordic countries have major roles in several life science infrastructures, such as the ESFRI projects ELIXIR and BBMRI. They also have high-quality health registries for research, as has been demonstrated through the Nord-Forsk NORIA-net on registry data and by several other groups and task forces. eInfrastructure services enabling responsible provisioning of access to sensitive data will be developed to enable exploitation of these research opportunities and further stimulate collaboration in these areas. The infrastructure will enable storage, computation and responsible sharing of anonymised research data subject to legal terms of use and in close collaboration with data owners. This action will build on the framework for authentication and authorisation developed under Action 6.

Commencement: 2014
Implementation: 2015 – 2017
Responsible: NeIC/NordForsk and the national eInfrastructure providers

Action 10: Nordic eInfrastructure for Scientific Software

Nordic groups have trademarked several scientific software packages and made critical contributions to many others. By ensuring a leading role in selected software initiatives, the Nordic countries can influence the relevant maintenance strategies, thereby catering to the interests of Nordic user communities. Nordic efforts will be supported for selected scientific software packages and for providing the basis for coordinated participation in the Horizon 2020 eInfrastructure calls for Centres of Excellence in scientific software.

Commencement: 2014
Implementation: 2015 – 2016
Responsible: NeIC/NordForsk and the national eInfrastructure providers

Postscript

This report has been drafted by an ad hoc expert group appointed by the Nordic Council of Ministers for Education and Research. The group consists of representatives of national funding agencies, the Swedish presidency of the NCM, Nordic eInfrastructure providers, large-scale research facilities, public sector IT, industry and innovation, and the Digital Agenda for Europe. The updating project has been performed by NordForsk with the Director of the Nordic eScience Globalisation Initiative (NeGI) as project leader. The members of the ad hoc expert group are: Sverker Holmgren, project leader (picture), Eva Stensköld, Gudmund Høst, René Buch, Roar Skålin, Pentti Pulkinen, Juni Palmgren, Steen Pedersen, Daniel Melin, Pauli Kuosmanen, Anni Hellman, Peter Sloth and Helge Holden. During the work, the expert group has convened for three physical meetings and also exchanged comments over email.

An important basis for the work with the eScience Action Plan 2.0 has been the conclusions on eScience/eInfrastructure agreed on at the conference Joint Nordic Focus on Research Infrastructures - Looking to the Future, organised by the Swedish Ministry of Education and Research, the Swedish Research Council, NCM and NordForsk in November 2013. During the work, the ten actions proposed in the updated action plan have been presented and discussed in many forums, including the Nordic e-Infrastructure Collaboration (NeIC) Board (at that time consisting of representatives of national eInfrastructure providers and funding agencies in the Nordic countries), the NeGI Steering Committee, the NordForsk Board, the Joint Committee of the Nordic Research Councils for Natural Sciences (NOS-N), and the NordForsk High-Level Advisory Group on Research Infrastructures.

Sverker Holmgren. Photo: Terje Heiestad

Appendix

Status for the ten actions listed in the first version of the Nordic eScience Action Plan

Many of the actions in the first version of the Action Plan have been brought forward and at least partly implemented. Both NeGI and NeIC (hosted by NordForsk) can be seen as main results of the eScience Action Plan from 2008, even though NeIC builds on earlier collaborative activities.

Action line 1. Education

Action 1: Training Researchers in eScience Tools and Methods
NeGI has taken the responsibility for this action and has allocated a total of NOK 10 million for 2013-2017 for a Nordic graduate education programme in eScience tools and techniques.

Action 2: A Nordic eScience Master's Education
No actions have been taken.

Action 3: Sharing and Specialising Nordic eScience Educational Modules
No actions have been taken.

Action 4: Fostering Nordic eScience Collaboration through Mobility
Some activities within NeGI support mobility and networking, but no concerted actions as described in the Action Plan have been taken.

Action line 2. Research

Action 5: A Nordic eScience Programme for Research into Grand Challenges
NeGI has taken the responsibility for this action. NOK 40 + 40 million has been allocated to two eScience research programmes on climate/environment and health/social preconditions for health. Furthermore, NeGI is currently preparing a programme for Nordic research projects within eScience tools and techniques. NeGI funding at a level of NOK 12 million has been allocated for this effort.

Action 6: Strengthening National eScience Initiatives
NeGI has taken the responsibility for this action. In Sweden and Finland, major national eScience research efforts were initiated in 2010. In Norway, the eVITA programme was started as early as in 2006. So far, the approach in Denmark and Iceland has been to support strong eScience research groups directly within regular structures, and essentially no special strategic efforts have been made in eScience research.

Action line 3. eInfrastructure

Action 7: Open Access to National Data Repositories
eNORIA organised a task force on this topic which produced a final report in 2009. However, no major action was taken on the grounds of this report. In 2011, the NORIA-net on Registries was established to strengthen Nordic cooperation on registry-based research.

Action 8: Facilitating Sustainable Grid Infrastructure Collaboration
The Nordic eInfrastructure Collaboration (NeIC) was initiated as a direct follow-up of this action. NeIC comprises the existing Nordic eInfrastructure support for high-energy physics (earlier under NDGF) and provides a stable platform for this. Also, the NeIC strategy covers eInfrastructure support to a selected set of Nordic research areas (including the NeGI projects) and support for general eInfrastructure services at the Nordic level, developed and operated in collaboration with the national providers of computing and storage and based on a co-funding model. In 2013, the Nordic research councils agreed on a long-term (10-year) MoU for NeIC.

Action 9: Implementing Cross-Border Sharing of Resources
NeIC forms the platform for extended Nordic collaboration on data storage, handling and analysis as well as for high-performance computing. Also, NeIC is currently planning and building services for facilitating cross-border sharing of national resources. However, no coordinated proposal for which services are to be supported and how these should be funded exists today.

Action 10: Environmentally-Friendly Nordic High Performance Computing
During 2011, the national providers in Denmark, Iceland, Norway and Finland established a Nordic HPC pilot project comprising a medium-size computational cluster hosted by a commercial co-location host in Iceland. The pilot project has been evaluated by an international panel under NeIC. Simultaneously, the Finnish eInfrastructure provider CSC established a remote cost-efficient facility for computing hardware which is similar to the facility used for the Nordic HPC pilot project.

Mid-2014