NORDUnet
Nordic Infrastructure for Research & Education

Inspiration Paper:

The Role of NREN's in 2020

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Dokument Publikation Date: April 4th 2011.

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Presented, amended and approved by the NORDUnet Board.

1 Preface

The position paper is intended as inspiration for the GEANT Expert Group work towards a vision for European Research Networking in 2020.

This document is not meant as a technology roadmap - predicting which technological developments will be dominant in 10 years time is at best difficult and irrelevant for the purpose of this document.

Instead this document will analyse the challenges – as seen from NORDUnet - over the next 10 years for the European NRENs and identify a number of key action points that will enable them to become an agile and user centric asset that will provide the right networking infrastructure to the R&E community, and establish a framework infrastructure that enables and facilitates innovation and development.

The paper is structured so that:

- Section 2 proves the background for what NRENs are today,
- Section 3 lists a number of challenges relevant to NRENs but not considering if they are to be solved by NRENs at all, alone or in partnerships with other organizations.
- Section 4 proposes the activities that NRENs should focus on towards 2020, based on the challenges listed in Section 3.
- Section 5 contains the conclusion.

2 Background

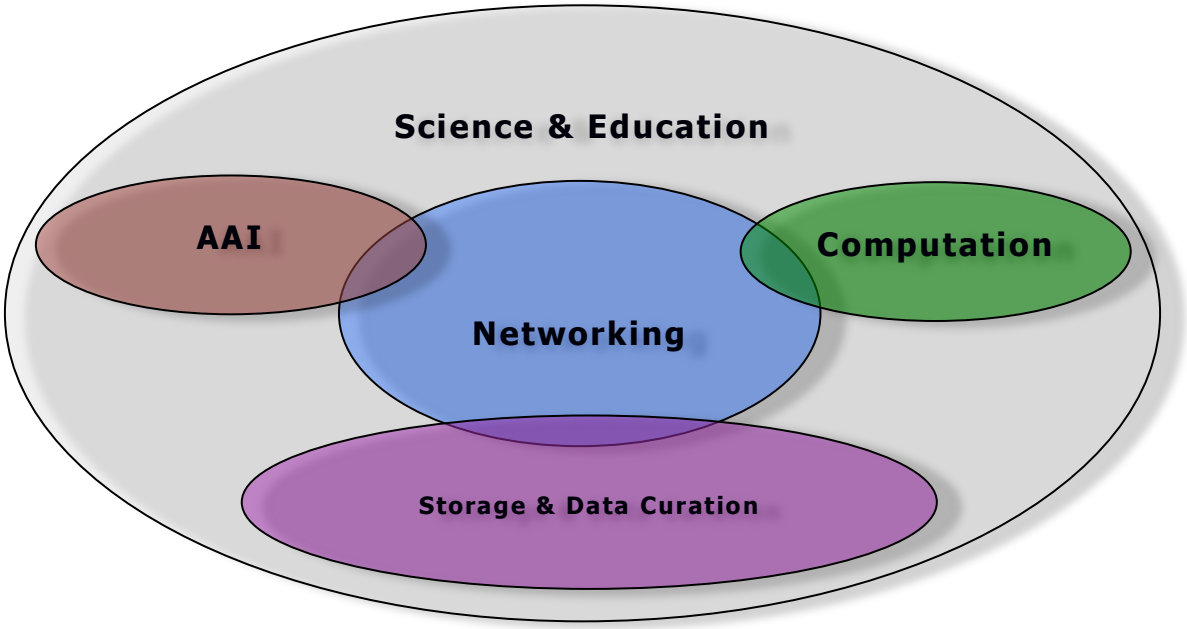
The National Research and Education Network (NREN) organizations arose over the last 25 years from a need for the R&E community to address technical, financial, and administrative issues arising from a rapidly evolving networking environment.

The formation of the NRENs was a recognition that the Internet and communications technologies would play a much different role in the future and would require a consummately broader, more innovative, and collaborative approach. These factors forged the structure of the European NRENs and their peer regional networks in other parts of the world.

The European NRENs have successfully delivered a state of the art network in support of research activities within the European research arena.

However, the requirements of research and education continue to evolve. The fundamental mission of engineering and operating advanced networking infrastructure is no longer sufficient to satisfy the current and emerging needs of this dynamic R&E community. Indeed, the user base itself of the NREN is no longer simply research and higher education, but is growing to include a broader social and cultural constituency. To secure the support of the future European NREN, the NREN organizations must recognize these rapidly changing requirements and venture into new services and activities, and engage with other essential related organisations.

In the future, a modern networking infrastructure is one of the important key components of a four-tiered e-Infrastructure supporting the requirements of e-Science and e-Education:



All "e-Projects" will be built on at least one of these pillars, but the use both in relative quantity and technical framework will not be identical from project to project.

3 Changes and Challenges

It is already now evident that continuing the present modus operandi will not adequately enable the NREN user community to leverage the benefit of e-Infrastructure capabilities.

The focus areas below are those envisioned at the time of the creation of this position paper. Lessons learned from the past 10 years have shown us that new requirements can surface in rapid succession. We can be sure that trends, completely unforeseen today, will emerge that require NRENs to act. It is our job to respond in a flexible and diligent fashion to such new challenges, providing the best possible environment for emerging e-Science and e-Education initiatives to flourish.

3.1 Globalization.

Mimicking the larger globalization trend, research is increasingly becoming a global effort. Many research projects, teams, communities, and institutions will be global. Researchers will find global partnerships, and major research programs will exceed the resources and capabilities of any single country – or even a single region.

Global user communities are already required to justify major instruments and programs. To enable and support this trend e-Infrastructures must themselves become truly global. This process must happen without sacrificing the support for more local use, even in the presence of an increasing globalization a large fraction of peoples activities will still be centred around the nation or the local campus area.

3.2 Organization of e-Infrastructure

It is not financially efficient that large e-Science projects (such as those described in the ESFRI roadmap) build and operate their own e-Infrastructure. e-Science projects should build their own middleware structure out of existing e-Infrastructure components only adding project specific middleware where the common e-Infrastructure cannot be adapted efficiently.

Having a single organization or a single line of resource ownership has limited benefits and inherently creates a monolithic organisation with major governance and management challenges. Such large scale centralized approaches exhibit an inherent loss of flexibility and ability to adapt to changing needs.

The European countries have chosen a wide range of models for how to nationally organize the e-Infrastructures described in section 2, some having one centralized organization providing all functionality, other distributing it onto several organizations. Imposing a single, European model on top of this will cause friction and loss of efficiency with organisation focussing more on the politics than on enabling the best possible framework for e-Science and e-Education.

We believe that to be customer centric, a collaborative ecosystem of e-

Infrastructures must be supported.

The different areas of e-Infrastructure must establish efficient and effective ways to work together.

3.3 Short term ad hoc collaborative projects.

Projects will emerge that need high bandwidth for a limited amount of time. Examples are projects using ESS, MAX-IV, XFEL. These expensive data sources are not just unique within Europe, but are unique globally.

These sources are part of the permanent infrastructure for research, but projects using them will have a limited lifetime and changing requirements and usage patterns (unlike, say, the current LHC collaboration).

We will see large-scale, temporary global use of major data sources, leading to a need for a bandwidth-on-demand service that allows European researchers to access instruments and data repositories in other regions of the world, and European instruments to serve a global community of researchers and research programs.

An additional challenge is how to service projects performing network research – like the Future Internet Research & Experimentation projects. These projects have other requirements to the network infrastructure than is provided "off-the-shelf", but NRENs should still be able to service their needs.

3.4 Geographically scattered data sources.

More and more projects will use a wide range of instruments, sensors, and public data repositories, with ever more data. These data sources will not be in a single place, but rather be scattered all over Europe and even globally, where instruments are built, where sensors are connected, or where owners of repositories are collected.

Likewise, teams, institutions, and communities will be geographically scattered. As large scale centralized computational and storage data centres give way to the increasingly distributed grid computing paradigm, we expect to see larger numbers of smaller and geographically distributed facilities acting in unison through virtualization middleware. This will enable much larger computational complexes, but as a result, we will see large data flows from "anywhere to anywhere."

3.5 Increasing amount of managed data.

Increasingly all types of public data sources, from all levels of government and international bodies, are being made available to research. Major efforts are being put into data management, storage, security, access control, etc. As more research projects are using this data, network support is required sometimes at sites not traditionally directly connected to research networks. In addition, such data can be made available also by private enterprises, and usage will often be in the form public-private partnership projects (e.g., in medical research). As a result, networking must also support this public-private partnership.

Further, as technology advances, raw scientific sensor data will increase – not just in the current data flow rate, but in the archives as well.

The historical data will be continually reprocessed as newer more accurate models are tested and validated. The output of these simulations and models will become the "results" of tomorrow and this data will then become the basis for further modelling – requiring careful cataloguing and accurate provenance throughout the process. So the data we collect today will be an active component of the distributed virtualized science environment in 2020.

3.6 New groups of users with little technology knowledge.

Traditionally, large-scale users of networking have been technically proficient, as exemplified by the LHC. With pervasive, advanced networking and access to a wider range of data sources, and with collaboration patterns being changed by modern networking, demanding use of networking and e-Infrastructures are spreading. As middleware becomes more sophisticated and insulates the user from the intricacies of the supporting technology, we expect to see a similar increase in advanced technology being applied to endeavours outside of traditional high-end e-Science. Users in the arts and social sciences will be able to tap into large data repositories and collaborate globally often without knowing the underlying technologies that makes it possible. Skype is a simple example, Facebook is a more sophisticated example. Supporting these new user communities requires outreach and new models for understanding and meeting user requirements.

3.7 Mobility.

Users at all levels will expect mobile access. Work is becoming increasingly mobile, and the expectation of users will be a fully mobile environment. Mobile networking will not be restricted to simple web & mail access but will also encompass data collection and sensor distribution.

Researchers and students will be part of comprehensive social and professional net, and will use video and advanced media from portable devices, available anywhere, anytime, changing the way we work and learn on a scale similar to the advent of the Internet. The explosion of smart phones and mobile tablet devices in just the last two to three years provides a bit of insight into the growth trajectory and potential for mobile ubiquitous computing.

One major stumbling block to achieve true mobility is the exorbitantly high roaming prices for mobile data access. The current cost of mobile data access abroad significantly lowers the usability of mobile devices, and makes true cross-border mobility difficult to achieve.

3.8 Social networking

The social networking platforms like Facebook and Twitter changes the communication patterns from unidirectional from producers to consumers, towards a bidirectional pattern and has shown a lot of potential for engaging participants into a really collaborative form of communication.

An additional twist to the challenges provided by social networking platforms is identity management. The users of such platforms are increasingly often being offered to use their social networking identity for other services. Considering how to integrate social networking with AAI frameworks used in R&E will become an important challenge in the future.

Today, social networking platforms are provided by commercial players, and a lot of criticism are raised about the dangers of entrusting so much personal information to the commercial corporation, but these platforms have shown new ways of using network technology that can be very beneficial to society and more especially to e-Education.

Providing a platform that integrates the interaction possibilities provided by social networks with more traditional technologies; especially useful would be the creation of a setup that can combine the functionalities with real-time video- and audio-conferencing while at the same time providing a platform where data can be kept private and only shared with a selected group.

3.9 e-Education

There have been many attempts to bring IT tools into education. Unfortunately the approach has often been highly technical, requiring a level of skills that is often significantly above the capability of the teaching staff.

We need to develop tools for the end users that are as easy and intuitive to use as a turning on the light. This often goes against the technologist's sense of making complex technology available to mere mortals and requires a shift toward simplified and focused user functionality where the "human" is concerned – be it the student or the teacher. With respect to the NRENs, video services provide a good example: In order for video services to become as common in the classroom as a blackboard, NRENs will need to develop tools that integrate media production, media distribution, video- and web based conferencing with social media tools in a way that are intuitive to use for non-technical staff and students. Only by doing this we will be able to make a quantum leap in e-Education

3.10 Cloud Integration

Cloud technology brings not only new possibilities, but new challenges as well. By moving data and computation to external service providers, traditional privacy, security, and reliability mechanisms are challenged by the computational and data storage functions occurring outside the traditional network security perimeter of an organisation. Not only is information security compromised, but proprietary computational processes are compromised. Beyond the security aspects, the business aspects of "vendor lock-in" (technical

or contractual) becomes a risk that must be considered also. While the challenge of keeping data private can be handled using traditional cryptographic techniques, keeping computations private and preventing vendor lock-in is more challenging.

The technical issues for mitigating the risk of vendor lock-in could be the creation of a vendor agnostic framework for handling data and computation. Such a framework could also provide the added benefit of allowing easier migration between private and cloud like models. As we will see in many forward-looking aspects of this paper, such abstraction and virtualization continue to show their value to future "e-Activities" and e-Strategies.

Secure cloud-computing remains at this time an open research topic. And there are legal and policy issues associated with cloud networking that are not resolved yet – such as controlling the dissemination of private medical data into clouds that may be internationally distributed. Networking technologies will be an integral component of cloud-based solutions. Therefore the NRENs must monitor these developments closely and engage in the development and deployment of secure service architectures.

But there are whole classes of IT tasks and applications that are not sensitive to such issues and can benefit from emerging cloud technologies. In the near term, the NRENs must address the integration of secure yet open networking in the cloud.

3.11 Security and Data Ownership

With the introduction of cloud storage, cloud computing, and virtualization in general, a whole new set of security challenges arise in addition to the traditional security issues.

The easy access to scalable commercial computing and storage resources enable new scientific capabilities but at the same time poses a number of significant security risks in term of data protection and retention in an environment owned and operated by commercial companies in other countries. Even though data can be protected by encryption this does not solve the issue of computational security, nor does it address the risk associated with releasing confidential research data into an uncontrolled and untrusted environment.

In addition, the there need to be found ways where data can be stored and secured in a coherent manner and backed up to other facilities. Resiliency and disaster recovery in a virtualized services world is a very new and complex challenge. This is an area that will require new development and coordination for cloud based resources to be used by the general NREN community. Such development will require significant human and IT resources that typically will not be available at the campus level. The NRENs, with their high degree of interaction and collaboration, are well positioned to address these distributed services challenges.

Security will continue to pose very complex challenges to the network and broader IT community in 2020.

3.12 Software Development & IPR

The need to innovate the networking and IT technologies will necessarily rely on professionals and aggressive software development efforts. Applied research – taking new concepts and experimenting with them – leads to more refined and effective models for new architectures and services. Realizing these new networking architectures in software and systems has been a weak spot in the NREN model for many years.

Research is funded to develop proofs of concept, and then no further development is undertaken to produce production ready software. Isolated cases of individuals developing important tools, or a group tasked to address certain needs, placing the resultant software in the public domain has been a poor method for developing a cohesive and comprehensive approach to evolving the network technologies. A more intentional strategic approach is needed.

With the research community as a partner, the future NREN will be uniquely positioned to develop production quality software based on the results provided by experimental research. This simple new aspect of NRENs can reduce the uptake of new technologies by ten years or more and will be critical to both maintaining technical leadership and to encourage commercial adoption of the technologies.

At the same time the NREN's will have limited resources and therefore need to create "software development communities" spanning multiple NRENs. By joining efforts and coordinating and collaborating on software development activities, we can avoid duplication of effort and multiple non-interoperable solutions, and will be more effective in developing deployable and supportable technologies to both the European community as well as the broader global network community. With respect to emerging network technologies, the NRENs and the research community form the pocket of expertise to standardize, develop, and deploy these technologies and services.

The end game is to deploy these new technologies and create a new market where commercial partners will then take over or develop their own versions of the technologies – thus completing the lifecycle of innovation.

3.13 Network Media distribution

Bringing media production and distribution services to a level where it can be used easily by teachers require a different approach in shaping such services. The special knowledge needed will often not be present at all campuses.

The development of such services will be a benefit for all campuses and also give a significant boost to more remote areas.

There is no doubt that this is an area where NREN's through collaboration will be able to provide economies of scale and provide services with significant enabling capabilities to the community.

3.14 Public - Private Partnerships.

Increasingly, partnerships and collaborations between public bodies and research institutions and private enterprises are being emphasized in research projects and research funding. Networks must be able to service the new communities that arise, and must themselves enter into public-partnership to reach the objectives and to advance the state of the art.

3.15 Green IT & the Environment

Climate change will remain a major challenge during the next 10 years. ICT contributes large CO2 emissions, and reduction in CO2 emissions must be an integral component of NREN strategic planning. At the same time, e-Infrastructures provide us the opportunity to further reduce CO2 emission through smart use of optical networks in conjunction with use of zero-carbon energy sources. Major initiatives aiming to dramatically reduce energy use in networking are already under way (cite: Alcatel). Europe must pursue both technological and organizational ways to reduce carbon emission. Likewise, advanced computing resources must be deployed in the quest to find new zero-carbon energy sources. The research and education community, and specifically the research and education e-Infrastructures have an important role to play.

4 NREN 2020

With the changes and challenges described in Chapter 3 it is clear that the NRENs must evolve to meet the constituency requirements.

This section presents some crucial aspects of how networking and infrastructure for research and education is organized nationally and on a European level. The objective must always be to maximize the benefit of the infrastructures to the communities served, and to be able to serve as wide a range of communities as possible.

To support new and diverse user groups and communities, and in order to meet the demands of a growing number of large e-Science projects, a user-centric approach must be used in building and managing e-Infrastructure. As many of the new pan-European users and global communities are not familiar with the capabilities of networking and e-Infrastructures, and may not be actively engaging the providers or asking for services, it is instrumental that e-Infrastructure providers reach out, identify users, educate, and evangelize the benefits of e-Infrastructures.

For a successful European research arena, it is crucial that networks and other e-Infrastructures enable European and global collaboration in all areas of research and education, not only the traditional users of advanced networking. The services provided by the NRENs must be rooted in the needs of the users and tailored towards the users, this in turn implies that new initiatives should be based on a solid understanding of what the actual requirements from the user communities are.

Therefore it is our opinion that NRENs 2020 must provide a user centric approach that integrates the following concepts:

- **The NREN as a Global Network Service Provider**
- **The NREN as a Community Service Provider**
- **The NREN as the e-Science enabler**
- **The NREN as the e-Education enabler**
- **The NREN's as an Innovative Framework Provider**

These 5 concepts will be described in the chapter 4.1 to 4.5.

4.1 The NREN as a Global Network Service Provider

4.1.1 Global Foundation Layer Network Infrastructure

The landscape of networking is changing rapidly. With the requirement for global reach from virtually all scientific and educational areas and the current ad hoc and manpower intensive ways of expanding network reach, the NRENs must institute substantive changes to meet these demands in the future.

There are a number of core building blocks in the process of creating the global network of the future:

- ***Federation*** - Europe must be able to take advantage of the many advanced, national resources for research. Doing so is the only way to reach the objective of world-class networks and services at an affordable cost. Duplication of effort and resources is not financially sustainable. Technologies that allow larger infrastructures to be built from components provided by collaborating but autonomous entities are therefore essential. We call this approach to ICT deployment "federation."
- ***Open Exchanges*** will be critical components of global network infrastructure. Open Exchanges will allow global networks to work together freely and flexibly, enabling a broader range of European and global partnerships not the least of which will include dramatically enhanced public-private partnerships. Open Exchanges will enable cross-border collaboration and sharing, and will connect e-Infrastructures beyond networks.
- **Virtualization** is a key enabling technology for 2020 and will allow individual user communities to construct globally distributed and dedicated networking environments from the quilt of regionally provided e-Infrastructure. Virtualization will allow user communities to align by affinity rather than by national or geographic happenstance. Therefore traditional funding models will need to evolve to support such initiatives, and the NRENs will need to develop mechanisms for accounting and costing the virtualized services they provide. Technologies still remain to be developed to address these virtualized resource management and planning issues, and the NREN organizations will be the focal point of that applied research and software development.

4.1.2 Mobility for Users & Sensor Networks

The user community is rapidly becoming mobile, both in terms of moving between campuses and countries but also increasing demanding to work from virtually anywhere.

In addition, the number of remote sensor networks based on mobile technology is expected to increase substantially as the commoditisation of such devices will drive the price down making them viable for a larger set of applications.

This will change the scope significantly for the NRENs that will have to provide such connectivity services in collaboration with commercial providers.

4.1.3 *Local Collaboration.*

Europe should consider different models of collaboration and different solutions, based on local needs and local opportunities.

We should take advantage of cultural similarities and established patterns of collaboration, and the increased trust of local human networks. Local collaboration is not an anti-thesis to European collaboration or European solidarity; on the contrary, regions can work for Europe, advancing European initiatives by making the most of all available resources.

There are several good examples of local collaborations in European e-Infrastructure. And local collaboration in networking will make a good fit with local collaboration in other areas of infrastructure.

Regional collaboration is also an important instrument in countering the digital divide in a financially challenged NREN Landscape.

The current flat model stems from a time of only a few European NRENs and does not scale. The existing model does not allow the European R&E community to take advantage of opportunities that arise. Allowing networks to self organize and to peer to create structure that best fits the community needs is the natural way of things. And self-organizing structures are often the most adaptable and resilient and over the long term.

4.1.4 Governance.

We must continue the on-going effort to professionalize the governance of European e-Infrastructure providers, specifically GÉANT and DANTE. Important progress has been made; it is essential to maintain the momentum. For successful European e-Infrastructures, this European governance efforts must be matched by a professionalization at all levels of R&E networking in Europe, as well as in other areas.

4.1.5 Cross-Border Resource Access.

It is essential that European networking provide cross-border access to resources such as computing, sensors, large instruments, and data resources. Such resources will remain scattered throughout Europe, and users communities will access them across national borders. There will always be national resources and national initiatives in Europe, taking advantage of national opportunities. For a successful pan-European research arena, we must leverage these resources where they are and enable all of Europe to benefit. European networking must support this in an effective way both regionally and on a European scale. Often, such cross-border access will go hand-in-hand with regional collaboration.

4.2 The NREN as a Community Service Provider

In addition to providing cost effective networking capabilities for the user community, the NREN's must leverage their position within the R&E environment by expanding the set of services built upon those foundational networking capabilities. These value-added services will be based upon core technical competencies of the NREN, and will provide significant economies of scale. These services would otherwise be technically difficult or prohibitively expensive for the user community to obtain or support on a campus by campus basis.

A number a such services have all ready been identified:

- Global identity management
- e-Campus services
- Video conferencing services
- Web based collaboration tools
- Media distribution services
- Cloud services based on commodity and community offerings
- Social networking service and interoperability

Towards 2020 it is highly likely that the user community will require a number of new services that we today are unaware off and that the NRENs will be in a primary position to develop and deploy.

4.3 The NREN as the e-Science enabler

To support new and diverse users groups and communities, and in order to meet the demands of a growing roster of large e-Science projects, a user-centric approach must be used in building and managing e-Infrastructures.

For a successful European research arena, it is crucial that networks and other e-Infrastructures enable European and global collaboration in all areas of research and education, not only the traditional users of advanced networking.

Therefore the NREN's must:

- Actively participate in activities with other stakeholders that seek to create an "e-Science Plug", seamlessly integrating storage, AAI and computing into an easy to use "e-Laboratory". I.e. the researcher must be able to conceive of their models or processes and then realize them through a set of intuitive, simple, reliable, and powerful tools at their finger tips and through their laptop, their iPad, or even their smart phone, or any other enabling interface. Today's e-Infrastructures require a high technical skill level to install and maintain and wider adoption requires an effort into making the tools easier to use and more pervasive.
- Enable new user communities to take advantage of e-Science Tools. Many of the new users pan-European and global communities are not familiar with the capabilities of e-Infrastructures, and may not be actively engaging the providers or asking for services. Therefore it is instrumental that e-Infrastructure providers reach out, identify users, educate, and evangelize the benefits of e-Science and the usage of e-Infrastructures. Here the NREN's can play a crucial role as e-Science enabler.
- Provide easy to use collaborative tools as mentioned in 4.2 to enable virtual research organisation to work together seamlessly across borders.

4.4 The NREN as the e-Education enabler

Despite several attempts the development of e-Education services has been many but scattered and difficult to implement.

The NRENs have a key role in providing an easy to use toolset based on the services described in 4.2 enabling users without technical skills to take advantage of e-Education services like:

- Easy to use media production services.
- Easy to use media distribution services under AAI control to easy distribution but at the same time retaining control of copyright etc.
- Easy to use virtual meetings and teaching facilities.
- Training and support of e-Education toolsets

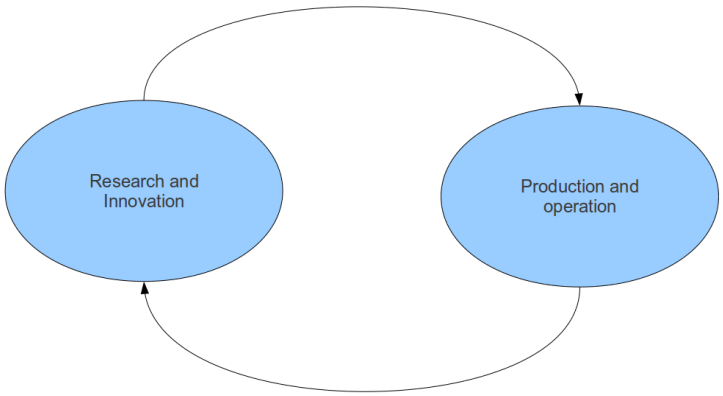
4.5 The NREN's as an Innovative Framework Provider

It is clear from the significant changes we have seen over the past two decades that new "game changing" ideas cannot be planned to the same extent as more focussed product and service development activities.

It is therefore paramount that the NRENs help facilitate an environment where new ideas have the sufficient conditions to flourish. Therefore, the NREN's must:

- Provide state of the art services that allows innovative use of technology and that can act as a platform for the development of the technology,
- Proactively promote the technological possibilities to the user communities, carry out the essential steps needed to bring network related researchers activities to a level where they can be used to build new activities on.
- Provide a common software and services development mechanism based on federated resources to provide new innovative and collaborative services
- Provide a commonly accepted IPR so that legal obstacles do not hinder development projects.

It is our belief that a lot of innovation and new development happens at the forefront of technology and that a competitive parameter is going to access to a state of the art infrastructure as well as knowledge about its potential.



5 Conclusion

From recent discussions within the NREN Community it has become clear that only a few NREN's have a long term vision and/or strategic plan. But strategic plans are essential to meet the challenges of 2020 and support the changing landscape of research and education. NREN's must take an active role and develop strategies to meet the challenges.

The technologies, possibilities, and impact are complex and pervasive, and users cannot be expected to understand what it means to them or to ask for services. NREN's must assume a leadership role, reaching out to user communities, evangelizing the new possibilities, engaging users who have previously not used advanced networking, and anticipating and fielding new technologies and services in advance of user requirements.

NREN's must accept the responsibility to educate users in what is possible. NREN's must engage with eEducation communities and support the future of teaching and changing student needs beyond simple provisioning of Internet access. NREN's must step forward to assume the role of integrator for the diverse e-Infrastructures, for the many projects, and for the communities.

We believe that active leadership is crucial, and that NREN's are well placed and well organized to fill this role, and to provide a comprehensive vision for networking and future infrastructures. NREN's have a strong tradition for collaboration and have assumed leadership before. Some professionalization of NREN organization and collaboration is needed, and it is crucial that we maintain strong, flexible, collaborative organizations and exploit regional opportunities.

To make the NREN an enabler of education and science to the user community the NREN has to focus on ICT architectures. An ICT architecture consists of recommendations and standards for information structures, data formats and system interfaces. It should be emphasized to the user communities that a common ICT architecture is a prerequisite for the sharing of services and resources on a national and international level which again will facilitate effective collaboration nationally and global

Traditionally, different areas of e-Infrastructure tend to have very different cultures and different approaches to community, collaboration, and how to organize on a European level. This is unlikely to change on a 10-year horizon but we must actively put frameworks in place that facilitate cross infrastructure and cross community collaboration.

If we do this, world-class networking and network services provided to an ever-broader community in a user-centric manner will be possible by 2020.