European Network for co-ordination of policies and programmes on e-Infrastructures

D1.2.3 – Proceedings of the eInfraNet Cloud Computing Workshop Leuven, Belgium 29th and 30th of March 2011

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The consortium of the project is presented in the table below:

Participant organisation name	**Short Name**	**Country**
Higher Education Authority	HEA	IE
Higher Education Funding Council for England	HEFCE	UK
SURFfoundation	SURF	NL
Foundation for Science and Technology	FCT	PT
Latvian Academy of Sciences	LAS	LV
Ministry of Science and Innovation	MICINN	ES
CSC - IT Center for Science	CSC	FI
National Information Infrastructure Development Institute	NIIFI	HU
The Scientific and Technological Research Council of Turkey	TUBITAK	TR

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Executive Summary

Fifty seven participants from eighteen countries attended the e-InfraNet Cloud Computing workshop on the 29th and 30th of March 2011, in Leuven, Belgium. The workshop was organised by the Joint Information Systems Committee in the UK (JISC) under the auspices of the e-InfraNet project.

This workshop was the second in a series of workshops focussing on each of the topic areas identified in the e-InfraNet description of work – Green ICT, Cloud Computing and Openness. The objectives of the e-InfraNet workshops are to gather further inputs from partners and external participants on these three areas around which e-InfraNet will build joint activities and, ultimately, propose policy advice and recommendations to the European Commission.

This first workshop on Cloud Computing offered the eInfraNet partners a thorough overview of some of the key themes, questions, issues and challenges relating to the role and impact of cloud computing on e-Infrastructures for science and research. The workshop was organized around a series of presentations from experts in the field of cloud computing, discussion sessions in four breakout groups and round table plenary discussion. Presentations were delivered by experts on the following topics:

- Cloud computing market solutions
- Why invest in Cloud Computing?
- Is Cloud Computing beneficial to research?
- Using Cloud for research
- The SARA HPC Cloud
- What is the impact of Cloud Computing on existing research infrastructures?
- Will grids evolve into cloud computing provision?

This proceedings report captures the content of presentations made at the workshop as well as the debate and discussion that took place around the topics presented. As such it provides an input for the deliverable D1.1.3 – 'Overview of the National Programmes in Europe' and for the action plan on cloud computing to be developed in Work Package 2 of the e-InfraNet project.

The workshop highlighted a wide range of key topics and issues for researchers, funders and policy makers including, relating to:

- cloud economics and full costs;
- the environmental implications of cloud computing;
- implications for funders;
- the role of cloud as part of a rich ecosystem of provision;
- the likely longevity and maturity of cloud technology
- possibilities for transnational collaboration;
- the legal framework;
- the emerging EU strategy on cloud;

Priorities for further consideration and action ('directions of travel') under the auspices of the eInfraNet project may include:

- cloud brokerage – the need for skills, support and brokerage to bridge the gap between cloud users and cloud providers;

- cloud economics - the need for a comprehensive, clear and convincing picture of the full economic and enivornmental costs, benefits and risks of cloud computing;
- horizon scanning - the need for continued international horizon scanning of the cloud field and intelligence briefings for funders and researchers;

The proceedings of the workshop will be discussed and taken into consideration during the preparation of the forthcoming e-InfraNet action plan on Cloud due in February 2012.

1. Introduction

Over the past few years, Cloud Computing has become a significant theme in the strategic planning and delivery of e-Infrastructure for research and along with openness, environmental issues and green computing, 'Cloud' has been adopted as one of three strategic programme themes by the eInfraNet project

The aims of the Cloud Computing Workshop held at the Leuven Institute for Ireland in Europe, Leuven, Belgium on 29-30 March 2011 were:

- to identify key policy, technical and cultural issues associated with using the Cloud at the European, Governmental and Researcher levels
- to discuss the key national and EU collaboration issues that will promote more effective use of the cloud across the ERA
- to identify the priority areas for work to achieve this, including whether the EU should engage on a pan-European level, as a series of individual national initiatives or through collaboration between member and other states.

Four questions were used to guide the design of the workshop programme:

- Why invest in cloud computing?
- Is the Cloud beneficial to Research?
- What is the impact of cloud computing on Existing Research Infrastructures?
- Will Grids evolve into Cloud Computing Provision?

The workshop investigated the tensions between the different understanding of clouds between government/policy bodies, commercial providers/vendors, funding agencies and research communities. The workshop also considered user perspectives on how the cloud can help in the research arena - the real uses that researchers are looking for from the cloud, the barriers: - technical and non-technical such as IPR, cost, data protection, licensing, site/national/pan-national licensing agreements. How to expose the user requirements better; how to get access to cloud resources; policy advice, further workshops/debate on cloud useability and applicability.

The audience for the workshop was drawn from funders, government and policy bodies, cloud providers, vendors and researchers – a total of 57 participants from 18 countries attended

2. Organisation of the workshop

Following the e-InfraNet WP leaders videoconference of 10th June 2010, it was decided that a series of three workshops (one per focus area) would be planned during the project lifetime. The first was organized by CSC in Finland on the theme of Green ICT and Environmental Computing.

The agenda of the second workshop was organized around a series of presentations from experts in the field of cloud computing, discussion sessions in four breakout groups, and round table plenary discussion. Presentations were delivered by experts on the following topics:

- Cloud computing market solutions
- Why invest in cloud computing?
- Is cloud computing beneficial to research?
- Using cloud for research
- The SARA HPC Cloud
- What is the impact of Cloud Computing on existing research infrastructures?
- Will grids evolve into cloud computing provision?

The selection of speakers was done using the contacts of the e-InfraNet partners among the leading specialists of the field in Europe. All partners were asked to invite the best speakers from their networks on the specific topics, and the setup of the agenda greatly benefited from the invited experts.

Four discussion sessions were held focusing on the following questions:

- Session 1: Why invest in Cloud Computing?
- Session 2: Is cloud computing beneficial to research?
- Session 3: What is the impact of cloud computing on existing research infrastructures?
- Session 4: Will grids evolve into cloud computing provision?

Before the workshop, participants were invited to submit pre-workshop position papers with reference to the four questions framed for the workshop discussion sessions. Fifteen responses were received from ten countries. The full text of these responses may be seen in Annex 4 of this document.

The programme for the workshop is presented below:

e-InfraNet Cloud Computing Workshop 29th & 30th of March 2011
Agenda

Tuesday March 29th

12:00-13:00 *Lunch*

13:00-13:15 Welcome

- Mr. Konstantinos Glinos (Unit GEANT and e-Infrastructures, European Commission)

13:15-14:35 Cloud Computing Market Solutions

- Dr. Matt Wood (Amazon Web Services)
- Mr. Russell Clark (Cloud Evangelist, Rackspace Hosting)
- Mr. Luc Gallet (VMware)
- Mr. Ed Zedlewski (Eduserv)

14:35-15:05 Why Invest in Cloud Computing?

- Dr. Malcolm Read (JISC, UK)

15:05-15:35 Discussion Session 1

15:35-16:05 *Coffee*

16:05-16:35 Is Cloud Computing Beneficial to research

- Dr. Ismail Ari (Ozyegin University, Turkey)

16:35-17:05 Using Cloud for Research

- Dr. Max Hammond (Curtis & Cartwright Consulting, UK)

17:05-17:35 Discussion Session 2

17:35 Wrap Up

Wednesday March 30th

09:00-09:30 Presentation- SARA HPC Cloud

- Mr. Floris Sluiter (SARA, Computing and Networking Services, the Netherlands)

09:30-10:00 What is the impact of Cloud Computing on Existing Research Infrastructures?

- Prof. Dr. - Ing. Uwe Schwiegelshohn (Technical University of Dortmund, Germany)

10:00-10:45 Discussion Session 3

10:45-11:15 *Coffee*

11:15-11:45 Will Grids evolve into Cloud Computing Provision?

- Dr. Per Öster (CSC,Finland)

11:45-12:30	**Discussion Session 4**
12:30-13:30	**Summary and Close**
13:30	*Lunch*

The workshop was attended by 57 participants from 18 countries. The list of participants is included in Annex 1 of this document.

Photos from the workshop[1]:

[1] Photos by Torsten Reimer

3. Proceedings

Welcome

Mr. Glinos is the Head of Unit and GEANT and e-Infrastructures at the European Commission.

Mr. Glinos welcomed the organisation of the workshop and spoke about how the Commission has commenced work on a European Cloud Computing Strategy as foreseen in the Digital Agenda for Europe. The main aim here is that Europe is not just 'cloud friendly' but 'cloud active'.

This strategy will deal in the main with the legal, technical and commercial or market issues that need to be resolved to allow the full scale of benefits that cloud offers to be taken advantage of.

The **legal framework** differs from country to country. The issues here revolve around concerns for data protection and privacy, clear rules for the allocation of jurisdiction, responsibility and liability and consumer protection.

The **technical pillar** concerns trust and security issues. Security and availability of cloud services are key issues here. Europe wants to strengthen its role in the standardisation of Application Programming Interfaces (APIs) to ensure interoperability between cloud providers.

The **commercial/market pillar** will involve scaling up pilot projects and working with member states to really harness the power of cloud computing. Stimulating innovation on the supply side will also be crucial here.

The strategy should reconcile the need for cloud management between the public requirements and the commercial offerings and is just one piece of work that the Commission is undertaking in this area. The **Sienna** (Standards and Interoperability for e-Infrastructure Implementation) Initiative was established in 2010 and is contributing towards a future e-Infrastructures roadmap focusing on interoperability and standards. The Commission also launched two infrastructure projects in 2010; The **Stratus Lab** project aims to enhance grid infrastructures with virtualisation and cloud technologies while the **Venus-C** project aims to develop and deploy a Cloud computing service for research and industry communities in Europe by offering an industrial-quality, service-oriented platform based on virtualisation technologies.

Cloud Computing Market Solutions

Dr. Matt Wood represented Amazon Web Services (AWS). He spoke of the value in terms of elastic capacity that their infrastructure services provide.

Amazon is a services oriented company. AWS have adopted this service oriented approach to data storage and offer compute services that can be set up and deployed internationally as required. Dr. Wood spoke of the advantages of these services including elastic capacity that mirrors actual demand and the cost savings leveraged through the Pay as you go model (PAYG). He noted in particular the advantages in terms of agility which allows people to devote more time to their core business or competencies.

With regard to the Open Agenda AWS hosts public data sets at no charge for the community.

Dr. Wood spoke about some examples of how cloud applications are being used in Research i.e. the star cluster project in MIT. When it comes to security Amazon has shared responsibility along with the client and its infrastructure adheres to security certification standards.

Mr. Russell Clark represented Rackspace Hosting and spoke of how his company aims to build the ubiquitous Open Source cloud computing platform that will meet the needs of public and private cloud providers.

Mr. Clark explained that organisations are choosing to work with OpenStack because it is an Open Platform where users can contribute what they need, it facilitates collaboration and it offers freedom to federate or move between clouds. He acknowledged that building and operating a cloud is not easy and Rackspace in response to this do offer a number of support services and solutions to help clients with their deployment issues.

Mr. Luc Gallet represented VMWare and spoke about the virtualized platform services that it offers to its clients.

VM ware provides virtualization software to a wide variety of cloud service providers. It aims to assist businesses in moving into the cloud space through transforming existing data centres into cost effective, flexible private clouds covering all aspects of infrastructure including security and management. The new IT landscape will see expansion in the emergence of applications both new and existing especially SaaS applications. Mr. Gallet commented that weaving all this together into a cohesive secure and compliant whole presents challenges for IT.

He introduced the concept of Enterprise Hybrid Cloud Computing, something that would enable cross cloud federation and coordination giving customers improved choice and flexibility when it comes to costs and agility. He informed those present that VMWare is actively exploring this with a number of other service providers.

Mr. Ed Zedlewski represented Eduserv and spoke about the compelling business case that exists for the wide scale adoption of cloud services across the Higher Education sector (HE) in the UK.

He spoke of how IT consumption across the HEA sector is expanding and the pressure that this is putting on existing ICT facilities.

In addition there is an important environmental impact when the massive carbon footprint across all UK universities is considered. Cloud Computing offers HE institutions a better way to source commodity computing and to share resources (compute, storage and data). It also reduces energy consumption and can optimise resource utilisation (IT, data and people). However there are impediments to its adoption:

- A culture in institutions which favours the adoption of bespoke or DIY solutions in favour of shared services.
- Technical Demands of implementation

He stated that better management information (showing the true costs of the private cloud) and organisational leadership is needed to examine where requirements for

services can be fulfilled by commodity computing and where there is a special purpose requirement.

Why invest in Cloud Computing?

Dr. Malcolm Read is Executive Secretary of the Joint Information System's Committee. Dr. Read spoke of JISC's commitment to investment in Cloud Computing Infrastructure as a way to deliver efficiencies in the UK Higher Education Sector. He spoke about the benefits the cloud gives rise to as well as the need to overcome barriers to its uptake.

The benefits of the cloud include provision of a better service, a reduction in costs, the facilitation of better collaboration and a reduction of hardware overheads as part of a green IT strategy, however in order for real efficiency benefits to be realised at an institutional level a centrally managed approach to contracting and cloud computing is required.

The situation, as it currently stands in many Higher Education and Research Institutions, where there is a proliferation of relatively small computers, lightly loaded and looked after by non professional operators is not sustainable either from a cost or environmental perspective. The benefits, of moving from this scenario to cloud based solutions, when multiplied across every researcher and institution are enormous.

Dr. Read spoke about the need to overcome the barriers to cloud in the research community. Security issues, often a criticism of commercial clouds could be overcome by the construction of a research and higher education cloud built from commercial components. Another way to lever support for the uptake of cloud services would be to restrict the purchase of computer hardware with research grant money. Education of the benefits of Cloud at the management level in Institutions is also needed as the perception that bigger and more sophisticated computing resources are a selling point still persists.

Dr. Read reinforced the importance of getting clarity from commercial providers in terms of what their prices will look like over time. Researchers do not want to be locked into one platform if the price of migration is too high.

Is Cloud Computing Beneficial to Research?

Dr. Ismail Ari represented the Cloud Computing Research Group (CCRG) at Özyegin University in Turkey. He spoke unequivocally of the benefits of Cloud Computing for the Research Community and presented some of the projects that the CCRG is currently working on.

He spoke of how the Cloud paradigm is challenging an established elite who previously controlled Super and other computing resources through enabling and motivating sharing (an example of how CERN, through making resources available to all researchers, is adapting for the cloud was cited). He spoke of the work being carried out by the Cloud Computing Research Group at Ozyegin University. Their philosophy is XaaS or 'everything as a service' with a focus on Platform as a Service (PaaS) projects. These include Data Mining as a Service, HPC as a Service, Infrastructure as a Service and Testing as a Service. Dr. Ari told the group that Cloud Computing enables progress through allowing researchers focus on research and teaching as opposed to dealing with IT issues. It also facilitates a collaborative

approach to resolving research problems. Dr. Ari spoke about the need for academics to be less concerned about owning and managing their own infrastructure (servers, data centres etc.) and advocated a push as opposed to pull method in motivating uptake.

In terms of outlook Dr. Ari foresees huge opportunities for Cloud technologies in the development of SaaS and PaaS services, the emergence of the Mobile Cloud and Support for Smart Systems (Smart Cities and Energy).

Using Cloud for Research?

Dr. Max Hammond is a consultant at Curtis and Cartwright Consultants and was project manager for the JISC commissioned *Using Cloud Computing for Research Project* (published in 2010*).*Dr. Hammond outlined the drivers and barriers to the uptake of Cloud Computing for Research under a number of different headings.

From the **Political** standpoint the degree to which uptake is prioritised will depend on the development of national and institutional strategies in this area. The lack of clear strong policy at a national level (for example at the Research council level) vis a vis the approach taken to provide computational resources for the projects they fund works against adoption

With regard to the **Economic** debate, cloud services, which expose the total cost of provision, often seem more expensive to users in comparison to local provision. The cost benefits tend to accrue at an Institutional or national level and not at the level of the individual researcher.

There is however a concern that funding councils may end up double funding i.e. paying for both the compute infrastructure in addition to paying for usage of cloud services and that a move from capital expenditure to operational expenditure (as a result of a move to the cloud) could expose institutions to higher risk and uncertainty about how much compute and storage will be required. The current economic situation demands efficiencies in the way that research is conducted. Cloud Computing could well be identified a solution here.

Regarding the **social** dimensions Dr. Hammond spoke of the concern among the research community that a Pay as you go model where all compute and storage usage is charged will stifle innovation and deter experimentation.

On the **technical** side the barrier that cloud poses for researchers who are new to research computing is often criticised as prohibitive. On the other hand Commercial Cloud Offerings such as the Microsoft Azure service confers enhanced compatibility for some users (i.e. Non Linux based users).

From the **legal** side questions have been raised about information assurance aspects of cloud computing provision. There is often a perception that local services are more trust worthy then external ones. As regards contract management HEIs need to be aware of the implications of service level agreements (SLAs) before signing them.

As institutions come under pressure to reduce their **environmental** impact, cost structures that charge users directly are likely to be considered. It is difficult to tell conclusively if cloud provision is actually ‘greener’ then local provision however a move to the cloud could have the effect of freeing up valuable space previously used for computer machine rooms.

In his conclusion Dr. Hammond outlined some of the use cases for cloud. It is suitable for short timescale requirements or for applications that are used infrequently for which there is no desire to maintain infrastructure. It also has the potential to cope with sudden peak demands for increased storage and compute requirements (where local resources are insufficient) and provides efficient solutions for data hosting and back up.).

SARA HPC Cloud

Mr. Floris Sluiter represented SARA Supercomputing and Networking Services, the Dutch national High Performance Computing and e-Science Support Centre. He spoke about the advantages of the High Performance Compute Cloud that SARA has developed for the scientific community in association with BiG Grid project

This HPC cloud environment provides researchers with access to their own virtual private HPC cluster that can be configured to match their needs without interfering with the needs of other users. It is flexible, offers self service and on-demand scalability

Users can start from existing templates or build their own cluster. They can even make a copy from current software (on their PC or laptop) and turn that into a HPC cluster in the Cloud without any expensive rewriting or dramatic changes between their development and production environments.

In 2010 SARA invited members of the Dutch Scientific Community to apply for evaluation use of the HPC cloud.Conclusions from the testing phase indicated positive user feedback. Observations included the fact that it operated like a real cluster and that there were virtually no waiting times.

Mr. Sluiter commented that the advantage of SARA delivering this kind of service as opposed to a private provider like Amazon is the support (forensics or analytics) provided by a trusted HPC centre. It also offers virtualisation at a low to moderate cost and is suitable for modest parallelism. He concluded by reinforcing the value add of the HPC cloud to the HPC ecosystem.

What is the impact of Cloud Computing on Existing Research Infrastructures

Mr. Alexander Fölling represented Dortmund Technical University. He spoke about how Cloud is likely to be beneficial to many research infrastructures but that the transfer may pose technical challenges for some applications.

He commented that the Cloud Paradigm is applicable for Research applications based on web services and highly parallel scientific applications but that problems may occur when implementing for strongly coupled applications which are not usually scalable without application adaption.

The steps involved in the transfer of a conventional research infrastructure into the cloud were outlined. The transfer effort is dependent on the level at which the infrastructure is to be established i.e. IaaS, PaaS or SaaS. Mr. Fölling posed the question of whether the research community (including the hardware provider) is willing to accept this additional work and who will pay for the transfer costs involved?

When establishing SaaS infrastructure Mr. Fölling highlighted the need for resources for the new middle layer i.e. the need for algorithm experts who closely cooperate with both the infrastructure providers and the researchers in the target community.

Will Grids evolve into Cloud Computing Provision ?

Dr. Per Öster represented the Finnish IT Center for Science (CSC) and spoke of the impact that a vistualised future will have on Grid Services.

Dr. Oster spoke of how as originally defined Grids had different objectives to Cloud Computing. Grid computing emerged as a way of connecting distributed resources and does not have a distinctive business model per se. Over the years standardisation work has evolved and developments at the European level have seen the emergence of the European Grid Initiative (EGI). Cloud on the other hand is a more service oriented architecture that involves a more direct provider-customer relationship.

Dr. Öster explained to the group how the European Grid Infrastructure Ecosystem works. He commented that cloud will work as another resource on the grid and that it will have an impact along the chain up to the user and how they can view their resources. Virtualisation has changed the nature of ICT provision and users now expect to access services directly. He spoke of the need to move beyond the e-Science community i.e. to support e-government. In terms of a move towards virtualisation within the EGI Dr. Öster informed the group that the EGI would:

- keep the model of federated resources that they have built on to date
- move some control back to the users or people working on their behalf
- work with commercial providers (for some workloads)

To conclude Dr. Öster commented that yes the concept of Grids and Clouds can be married and that work is ongoing in the EGI to progress this with real results to emerge soon.

Workshop discussion groups

The notes from each of the discussion groups held during the workshop are presented in Annex 3 of this document.

4. Workshop Summary, Matthew Dovey, JISC

Matthew Dovey is the Programme Director for Digital Infrastructure at the Joint Information Systems Committee (JISC). He spoke of the wide range of themes that had arisen during the Cloud Computing Workshop.

He commented that two distinct perspectives had emerged from the discussions as to the benefit of clouds: firstly, clouds as a model for buying and selling resources on a usage basis rather than a capital outlay; secondly a more user focused model for accessing and using resources, for example by providing simple application programming interfaces (APIs) for deploying, accessing and using resources.

Various themes had emerged during the workshop:

Clearly, national initiatives where they exist need to be **co-ordinated**. Some of the discussions had focused on the need for both national and European co-ordination in the areas of: interoperability and standardisation, in particular what we need to standardise and when in the innovation life-cycle does standardisation make sense; policies around the use of cloud, in particular legal and management policies and advice; national and European co-ordination in negotiating license agreements with cloud providers and commercial solutions, as well as negotiating software licenses which permit the use of existing software solutions (for example MatLab) on the cloud; and on identifying the impact of cloud on institutional policies, provision and services. Mr Dovey identified the question of where was it appropriate for national and European initiatives to provide provision as opposed to co-ordinate access to existing provision – this was another area for co-ordination. The impact of clouds on national and international network infrastructures, including the potential need for "burst" provision of bandwidth was also raised, and would be an area for co-ordination of the relevant NRENs.

The balance between **costs and benefits** had exercised many of the discussions. It had been identified that this was asymmetric and the balance depended on whether discussions were focused on cloud as a purchasing model or a requisition model.

In terms of purchasing, all the benefits tended to fall on the budget holder rather than the end user. Whilst the budget holder could ensure that costs where directly related to need, it was at the expense of the user having to change practice, adapt to new funding models, port software codes etc. Moving to cloud services would mean that the researchers would become more aware of the real costs involved in undertaking their research, and this might make them more conservative in their innovation and research aspirations. However, increasing pressures on the financial and ecological costs of research may have this result independently of cloud. In some cases the flexibility of cloud payments may itself be a barrier – the pay as you go model not fitting institutional accounting practices.

In terms of requisitioning resources, all the benefits tended to accrue on the user side. It opened up flexible ways of working such as cloud-bursting to provide additional resources to existing solutions and systems; the possibility of scaling up an application running on a laptop to supercomputing power merely by taking a virtual image of the laptop and deploying on cloud systems rather than re-coding the

application; providing self-service systems to those users requiring these and infrastructure which is easier to use and focused on the end user; offering new services, applications and support roles; and the rapid provision of virtualised HPC, grid and other specialised compute infrastructure.

A third theme was the **cultural change** generated by clouds. Clouds forced new models for uniqueness between research groups, who could no longer be defined by what resources (compute, HPC, grid) that group possessed, but there were new opportunities driven more by research innovation than hardware capacity. It forced new models on the research support and the need for collaborative teams across many different support roles (tool development, algorithm development, system administration, etc.) as well as researchers. Researchers would need to be much more aware of the financial, ecological and societal impacts of their researcher but cloud was only one driver for this cultural change. Cloud also forced new models of trust in third party providers (as well as the legal and policy frameworks underpinning this trust).

Finally the idea of cloud as merely a part of a **rich ecosystem of provision** rather than an alternative to existing provision, was reflected in many discussions. Cloud worked well for the long tale of science or for one off experimentation, whilst grids and HPC addressed more specialised requirements: grids being more suitable for highly distributed interconnected applications and HPC for strongly coupled parallel applications. Interoperability, i.e. the ability to move smoothing from HPC to Grid to Cloud was a key issue.

5. Workshop conclusion

This first workshop on Cloud Computing offered the eInfraNet partners a thorough overview of some of the key themes, questions, issues and challenges questions relating to role and impact of cloud computing on e-Infrastructures for science and research. The workshop was attended by 57 participants from 18 countries.

Key topics and issues for researchers, funders and policy makers raised during the workshop included

- **Skills and support needs.** The need to develop the skills and capacity in the ERA to exploit the potential of Cloud. The need for a 'broker' role between the researcher and the cloud provider ('all except computer scientists will need support'). How do we encourage and reward the different roles including both research and research support, which successful research teams must include;
- **Cloud economics.** For an informed debate about the costs, benefits and risks of cloud computing, there needs to be a clear and convincing picture of the financial implications, cost-performance and environmental economics of cloud;
- **How green is the cloud?** From a system lifecycle perspective (design, build, use, dispose), what are the real carbon economics of the cloud? Is it real carbon reductions or merely transplantation?
- **Funding.** From the funding perspective, in the new age of cloud and everything as a service, what is the optimum balance to strike between funding of the research team, national and international facilities?
- **Cloud as part of a rich ecosystem of provision:** how can the complementary roles and positioning of Cloud, HPC and grid be more clearly established? How can each inform and accelerate the development of the other? How should cloud, grid and HPC interoperate?
- **Longevity and maturity.** How long will it last? The age of mainframes lasted 40 years, the PC 20 years, the Grid – ten. How long for the cloud – five years or fifty? There is a continuing need for international horizon scanning in the field;
- **Transnational collaboration.** As the European Cloud Computing Strategy goes 'cloud active', what are the best prospects for pan-European collaboration and co-ordination to this end? A pan-European cloud? Inter-operability standards? An international legal framework? A code of conduct and framework for IT security and ethics? Development support for EU cloud providers? Mechanisms for collaborative license negotiation with service and software providers?

The planning process for the eInfraNet cloud strand will also take into account and influence the emerging EU Strategy on Cloud as described by the European Commissioner for the Digital Agenda and the three key aspects identified:

- First, the legal framework. This clearly has an international dimension and it concerns for example data protection and privacy, clear rules for the allocation of jurisdiction, responsibility and liability, and consumer protection.
- Second, the technical and commercial fundamentals. More research and the

EU playing a stronger role in the technical standardisation of Application Programming Interfaces (APIs) and data formats to enhance interoperability and competition between cloud providers and so on. International standardisation efforts will also have a huge impact on cloud computing; The EU can play a big role here – building on, for example, the SIENA initiative.

- Third, the market. Scaling up pilot projects and pushing the public sector to really make use of the potential of cloud computing as is happening in the US.

In conclusion, three topics are recommended for further consideration and action under the auspices of the eInfraNet project:

- cloud brokerage – the need for skills, support and brokerage to bridge the gap between cloud users and cloud providers;
- cloud economics - the need for a comprehensive, clear and convincing picture of the full economic and enivornmental costs, benefits and risks of cloud computing;
- horizon scanning - the need for continued international horizon scanning of the cloud field and intelligence briefings for funders and researchers.

All these issues will be discussed and taken into consideration during the preparation of the forthcoming e-InfraNet action plan on Cloud due in February 2012.

Annex 1-List of Participants

The workshop was attended by 57 people from 18 countries:

Attendance List			
Name	**Surname**	**Organisation**	**Country**
Ismail	Ari	Özyegin University	Turkey
Lajos	Balint	NIIFI	Hungary
Janis	Blumbergs	Riga Technical University	Latvia
Rob	Bristow	JISC	UK
Maureen	Burgess	HEA	Ireland
Victor	Castelo	MICINN	Spain
Richard	Chapman	University of Bristol	UK
Lauris	Cikovskis	Riga Technical University	Latvia
Felix	Cincarevsky	ISERD (ICT&RI Department)	Israel
Russell	Clark	Rackspace Hosting	UK
Brian	Clayton	University College Cork	Ireland
Ebonita	Curkovic	Croatian Institute of Technology	Croatia
Matthew	Davis	EPSRC	UK
Laurent	Desbat	MESR, DGRI, SSRI	France
Lydia Mutiara	Dewi	Universiteit van Tilburg	Netherlands
Matthew	Dovey	JISC	UK
Marc	Dupuis	SURFfoundation	Netherlands
Inmaculada	Figueroa	Ministry of Science and Innovation.	Spain
Evangelos	Floros	GRNET	Greece
Alexander	Fölling	Technical University Dortmund	Germany
Dirk	Franke	German Aerospace Centre	Germany
Luc	Gallet	VMware	Belgium
Konstantinos	Glinos	European Commission	Belgium
Erwin	Goor	VITO - Earth Observation unit	Belgium
Max	Hammond	Curtis & Cartright Consulting Ltd.	UK
Wim	Jansen	European Commission	Belgium
Dimitris	Kalogeras	National Technical University of Athens	Greece
Peter	Konings	VITO	Belgium
Yakup	Korkmaz	TUBITAK BILGEM	Turkey
Ioanis	Korovesis	NCSR Demokritos	Greece
Damien	Lecarpentier	CSC	Finland
José Ignacio	López	CESGA	Spain
Ludek	Matyska	Institute of Computer Science, Masaryk University	Czech Republic
Pat	O'Connor	HEA	Ireland

Name	Surname	Organisation	Country
Oladunni	Ogunsanya	Higher Education Authority	Ireland
Per	Öster	CSC	Finland
Marco	Paganoni	University of Milano-Bicocca and INFN	Italy
Colin	Pattinson	Leeds Metropolitan	UK
Malcolm	Read	JISC	UK
Torsten	Reimer	JISC	UK
Keith	Rochford	The Irish National e-Infrastructure	Ireland
Miroslav	Ruda	CESNET	Czech Republic
Raül	Sirvent	Barcelona Supercomputing Center	Spain
Ilmars	Slaidins	Riga Technical University	Latvia
Floris	Sluiter	SARA computing & networking services	Netherlands
Arne	Sørensen	State and University Library	Denmark
Eleni	Stavrianoudaki	General Secretariat for Research & Technology	Greece
Peter	Stefan	NIIF	Hungary
Szabolcs	Székelyi	NIIF	Hungary
Lilian	van der Vaart	SURFFoundation	Netherlands
Geert	Van Grootel	Flemish governement, Departement of Economy, Science & Innovation	Belgium
Rosette	Vandenbroucke	Vrije Universiteit Brussel	Belgium
Zeev	Vaxman Fisher	IsraGrid	Israel
Norman	Wiseman	JISC	UK
Matt	Wood	Amazon Web Services	UK
Marek	Zawadzki	Poznan Supercomputing and Networking Center	Poland
Edward	Zedlewski	Eduserv	UK

Annex 2-Break out Group Composition

Session 1 Why invest in Cloud Computing ? Tuesday (15:05-15:35)								
Group	**A (Conference Room)**		**B (Conference Room)**		**C (Breakout Room)**		**D (Breakout Room)**	
Session Chair	**T Reimer**		**D Lecarpentier**		**R Bristow**		**L van der Vaart**	
Session Note Taker	**M Burgess**		**M Hammond**		**N Wiseman**		**E Basak**	
1	VISHO	AJAZI LIKA	Tofig	Babayev	Ismail	Ari	Lauris	Cikovskis
2	Lajos	Balint	Russell	Clark	Janis	Blumbergs	Ebonita	Curkovic
3	Felix	Cincarevsky	Laurent	Desbat	Victor	Castelo	Lydia Mutiara	Dewi
4	Brian	Clayton	Inmaculada	Figueroa	Marc	Dupuis	Evangelos	Floros
5	Matthew	Davis	Dirk	Franke	Alexander	Fölling	Erwin	Goor
6	Ludek	Matyska	Konstantinos	Glinos	Luc	Gallet	Wim	Jansen
7	Malcolm	Read	José Ignacio	López	Dimitris	Kalogeras	Peter	Konings
8	Keith	Rochford	Koraichi	Moussa	Yakup	Korkmaz	Pat	O'Connor
9	Ing. Uwe	Schwiegelshohn	Per	Öster	Ioanis	Korovesis	Raül	Sirvent
10	Zeev	Vaxman Fisher	Karolj	Skala	Colin	Pattinson	Ilmars	Slaidins
11	Matt	Wood	Arne	Sørensen	Miroslav	Ruda	Floris	Sluiter
12	Marek	Zawadzki	Rosette	Vandenbroucke	Geert	Van Grootel	Tengku Mohd	Tengku Sembok
13	Edward	Zedlewski						

Session 2 Is Cloud Computing beneficial to Research ? Tuesday (17:05-17:35)								
Group	**A (Conference Room)**		**B (Conference Room)**		**C (Breakout Room)**		**D (Breakout Room)**	
Session Chair	**M Hammond**		**N Wiseman**		**P O'Connor**		**E Basak**	
Session Note Taker	**R Bristow**		**T Reimer**		**L van der Vaart**		**M Burgess**	
1	VISHO	AJAZI LIKA	Ismail	Ari	Janis	Blumbergs	Brian	Clayton
2	Lajos	Balint	Tofig	Babayev	Lauris	Cikovskis	Matthew	Davis
3	Victor	Castelo	Felix	Cincarevsky	Ebonita	Curkovic	Inmaculada	Figueroa
4	Alexander	Fölling	Russell	Clark	Laurent	Desbat	Peter	Konings
5	Konstantinos	Glinos	Evangelos	Floros	Lydia Mutiara	Dewi	Per	Öster
6	Yakup	Korkmaz	Luc	Gallet	Marc	Dupuis	Raül	Sirvent
7	Ioanis	Korovesis	Damien	Lecarpentier	Dirk	Franke	Ilmars	Slaidins
8	José Ignacio	López	Ludek	Matyska	Erwin	Goor	Geert	Van Grootel
9	Malcolm	Read	Ing. Uwe	Schwiegelshohn	Wim	Jansen	Rosette	Vandenbroucke
10	Miroslav	Ruda	Karolj	Skala	Dimitris	Kalogeras	Zeev	Vaxman Fisher
11	Floris	Sluiter	Arne	Sørensen	Koraichi	Moussa	Matt	Wood
12	Tengku Mohd	Tengku Sembok	Marek	Zawadzki	Colin	Pattinson	Edward	Zedlewski
13					Keith	Rochford		

Session 3 What is the impact of Cloud Computing on Existing Research Infrastructures ? Wednesday (10:00-10:45)								
Group	**A (Conference Room)**		**B (Conference Room)**		**C (Breakout Room)**		**D (Breakout Room)**	
Session Chair	**R Chapman**		**M Dovey**		**M Dupuis**		**E Basak**	
Session Note Taker	**P O'Connor**		**M Burgess**		**T Reimer**		**R Bristow**	
1	VISHO	AJAZI LIKA	Ismail	Ari	Tofig	Babayev	Janis	Blumbergs
2	Ebonita	Curkovic	Victor	Castelo	Lajos	Balint	Laurent	Desbat
3	Lydia Mutiara	Dewi	Lauris	Cikovskis	Brian	Clayton	Dirk	Franke
4	Inmaculada	Figueroa	Felix	Cincarevsky	Matthew	Davis	Luc	Gallet
5	Alexander	Fölling	Russell	Clark	Evangelos	Floros	Konstantinos	Glinos
6	Peter	Konings	Matthew	Dovey	Erwin	Goor	Damien	Lecarpentier
7	Per	Öster	Max	Hammond	Ioanis	Korovesis	José Ignacio	López
8	Colin	Pattinson	Wim	Jansen	Koraichi	Moussa	Malcolm	Read
9	Keith	Rochford	Dimitris	Kalogeras	Marco	Paganoni	Miroslav	Ruda
10	Ing. Uwe	Schwiegelshohn	Yakup	Korkmaz	Karolj	Skala	Raül	Sirvent
11	Geert	Van Grootel	Ludek	Matyska	Ilmars	Slaidins	Floris	Sluiter
12	Zeev	Vaxman Fisher	Lilian	van der Vaart	Tengku Mohd	Tengku Sembok	Arne	Sørensen
13	Marek	Zawadzki	Rosette	Vandenbroucke	Edward	Zedlewski	Norman	Wiseman
			Matt	Wood	Eleni	Stavrianoudaki		

Session 4 Will Grids evolve into Cloud Computing Provision ? Wednesday (11:45-12:30)								
Group	**A (Conference Room)**		**B (Conference Room)**		**C (Breakout Room)**		**D (Breakout Room)**	
Session Chair	**P O'Connor**		**M Hammond**		**T Reimer**		**R Bristow**	
Session Note Taker	**R Chapman**		**M Burgess**		**M Dupuis**		**E Basak**	
1	VISHO	AJAZI LIKA	Lajos	Balint	Victor	Castelo	Ismail	Ari
2	Lauris	Cikovskis	Felix	Cincarevsky	Yakup	Korkmaz	Tofig	Babayev
3	Lydia Mutiara	Dewi	Brian	Clayton	Damien	Lecarpentier	Janis	Blumbergs
4	Inmaculada	Figueroa	Ebonita	Curkovic	Per	Öster	Russell	Clark
5	Alexander	Fölling	Matthew	Davis	Colin	Pattinson	Laurent	Desbat
6	Evangelos	Floros	Dirk	Franke	Arne	Sørensen	Wim	Jansen
7	Dimitris	Kalogeras	Luc	Gallet	Tengku Mohd	Tengku Sembok	Peter	Konings
8	Koraichi	Moussa	Konstantinos	Glinos	Lilian	van der Vaart	José Ignacio	López
9	Malcolm	Read	Erwin	Goor	Rosette	Vandenbroucke	Ludek	Matyska
10	Raül	Sirvent	Ioanis	Korovesis	Zeev	Vaxman Fisher	Ing. Uwe	Schwiegelshohn
11	Floris	Sluiter	Marco	Paganoni	Norman	Wiseman	Karolj	Skala
12	Geert	Van Grootel	Keith	Rochford	Edward	Zedlewski	Ilmars	Slaidins
13	Matt	Wood	Miroslav	Ruda	Matthew	Dovey	Eleni	Stavrianoudaki
							Marek	Zawadzki

Annex 3 Discussion Group Notes

Discussion Session 1: Why invest in Cloud Computing?

Group 1.A

- In terms of the key driver to encourage the adoption of cloud solutions those present argued that this is most definitely the cost savings it offers.
- Better Management Information is needed to understand the true cost savings (human resources, energy and long term operating cost) that a move to the cloud can engender
- In order to understand the true nature of the cost savings it is necessary to understand how IT consumption costs are calculated. Insufficient metering of consumption at a level that is meaningful impedes this. It was argued that this type of Information needs to come from the Institutions and researchers. It is no longer acceptable to cite difficulties in estimating usage as an excuse for buying capacity that is surplus to requirements.
- One of the barriers to investment in Cloud technologies is the fear of being locked in to a service. This is all the more relevant at a time when many budgets are being cut.
- Another barrier to uptake is the fact that savings made from a move to the cloud accrue to Institutions as opposed to researchers. New Payment structures need to be developed to redress this imbalance i.e. the possibility of researchers being charged directly for capacity consumed?
- It was argued that limits or restrictions need to be imposed on compute power and storage capacity in order for institutions and individual researchers to optimise usage.
- It was suggested (by a commercial supplier) that one way of doing this would be to allocate a portion of the total research budget to compute in the same way that a portion might be allocated for the recruitment of a Post Doc or PhD student. Efficiencies will be sought out if flexibility in the way that research grants can be spent is restricted.
- Because of security concerns it was suggested that a body/interface that brokers with commercial suppliers on behalf of the research community is needed.
- This type of body could also develop procurement frameworks. It was commented that the argument for or against the use of the cloud is very similar to the debate that took place prior to the establishment of NRENs i.e. should Institutions go to the market themselves or should a body who procures and organises on their behalf be set up.?

Group 1.B

- Data protection, cost efficiencies and long term preservation are all barriers to cloud adoption.

- Cloud can simplify hardware management.
- The focus should be on interfaces. Cloud can make it easy and quick for researchers to start work. This can lower barriers to using scientific applications.
- Need to avoid vendor lock-in.
- Can't define cloud as a single product – it's a whole suite of things.
- The benefits of cloud aren't just cost saving – the flexibility is important too
- Grid is one solution to distributed provision of ideas and services. Does the cloud give more flexibility?
- One of the benefits of the cloud is that computational researchers can run code on many machines, which they might otherwise need to simulate
- Industrial engagement is key. This has to be better than it was with the grid.
- We need to invest in the full set of "services" – technology, skills, and manpower
- Cloud works best at very large scale. This needs investment.
- Key actions:
    - Focus on public cloud to increase efficiency
    - Promote collaboration with industry
    - Work out an approach to co-ordinating interoperability between different clouds (and the data on them)
    - Leverage the size of the e-science community across the EU
- The member states are going to need to define the standards – the EU doesn't have the competencies
- Member states need some guidance on internal investment choices (co-ordination)

Group 1.C

The question is now 'How do we invest in the cloud?' not 'Why'. The cloud can't be stopped and is attractive because it provides 24/7 access – anytime, anywhere. We need to use the cloud efficiently (in terms of programming and data storage) as well as effectively. It's good for providing researchers with opportunities to test a model quickly, with a low budget, thus improving time to market.

1) <u>We need better cost models to evaluate when the cloud should be used.</u>

There are security and privacy issues associated with the cloud – some cloud services do not comply with current local legislation in this area (e.g. Spain). The EU proposals for a common set of requirements for compliance will be welcome. Private clouds can be more helpful as they can more easily comply. For very personal data though, in many countries that data cannot leave the building in which it was created. Therefore management of information flow is a big area for research in the cloud.

There is a need for more good practice examples of how to buy cloud services, though the acquisition of cloud resources should not be different to the acquisition of traditional resources and should be based on a sound analysis of risk, cost and benefit.

2) There is a latent requirement for a brokering service to similar sized organisations within a country or on a transnational basis
3) We need different policies acting across the cloud at different levels for different criteria e.g. its level 4 for security, level 2 for green credentials, etc

Cloud can also balance energy demands across the globe e.g.: process in Japan during their night time for applications running in the daytime in Europe. But also need to consider how that power is created in the different regions – nuclear, wind power or coal, etc.

Group 1.D

- How do researchers manage the rigidity of the financial planning required for Cloud Computing?
- Many researchers have underutilised clusters
- There is a need to overcome the ownership issue?
- There is a need to ensure that virtual machines cannot impact others (security).
- How to provide SLAs for time critical applications such as climate change?
- There is an opportunity for pan-Europe Cloud interoperability.
- There is a need to contribute to Framework 8 consultations.
- Small counties need access to European Cloud facilities to build up their own skills.

Discussion Session 2: Is cloud computing beneficial to research?

Group 2.A

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- It Saves time and money and it offers huge flexibility. However there is a mis match between who gets the benefits and who bears the costs
- Perhaps HEIs should invest their resources in building a cluster for all their computing needs
- What will the researchers who are already in receipt of funds for computing resources use? Research funders need to change the rules of the game.
- How you procure your cloud is a critical success factor
- Recommendations
    - In order to get the right people to use the cloud it might be necessary to make resources available to them to underwrite their risk
    - Not all research is suitable for the cloud
    - Make one 'research cloud' available across Europe (similar to what has been done with Grid)
    - There is a need to standardise approaches across Europe. The EU needs to support what is currently emerging i.e. SIENNA, OGF

Group 2.B

- Participants agreed with statements from the two presentations preceding the group session
- Apart from potential **cost savings**, clouds are useful as they can be very flexible in dealing with fluctuating demands (the point was made that solutions already exist for demands like “1000 cores are needed for task x”, but they are not as flexible); conclusion: **cloud is providing additional flexibility to existing infrastructure**
- The question was raised whether there should be simplified cloud/VM “flavours” for certain disciplines (as there are different Linux distributions with different software). Some doubted this as research may be too diverse to be fitted into “a simple iPhone app style”)
- Can cloud be used to support crowd sourcing projects?
- The question was raised **whether PAYG suited academia**. It was not clear who should pay for it (institution or individual researchers), and it was also argued that PAYG negated the advantage of the cloud being more flexible than existing solutions – if it is to be different from HPC etc. there also should be different models for usage. Other group members countered this by arguing that cloud was cheaper and hence not as scarce as HPC, so charging at the point of use would not necessarily be a problem if researchers had budgets.
- **Cloud bursting to support grid computing** was seen as very promising. It was suggested that universities could even share capacity with others, or that universities with useful services or content (such as research tools or teaching materials) could charge others for access. It was not clear whether this would work well politically.
- It was seen as important to not just think about the bare infrastructure, but to consider useful **services on top** of the infrastructure.
- Policy: Universities need to be aware of licensing issues as cloud computing makes it easy for researchers to share all sorts of software with many students/colleagues.
- Is there a need for a study on a different **licensing model** for software run on the cloud? Do researchers have to buy a “traditional” license for software they only want to run on a VM for a few hours? National or perhaps even EU organisations (brokers) should negotiate with cloud vendors for the HE sector as researchers or HEI don’t have the bargaining power.
- Need to explore i**nternally managed clouds for research** (national, institutional level), for instance to overcome PAYG or privacy/data issues.

Group 2.C

- A number of people in the group agreed that yes Cloud does offer benefits for research but maybe not for each domain. In cases where researchers are working with 100s of terabytes of data, it may turn out not to be so useful. Storing and processing such large datasets in itself is not the problem, but transporting them around may not be efficient. This raises the question whether you bring the data to the processing point, or the processing to the data location.

- Yes, it is stated, it would be beneficial and more interesting if you look at it from the point of view of Open Access, and more specifically the reuse of data. This change in perspective, from 'how do I handle my data' to 'how can this data be reused by others/in other contexts' will provide different answers to the question. This has been seen to happen in the case of climate data e.g. An issue in this context is the IPR stored in data (e.g. in video)– the storage of the data itself is no problem, but access and reuse can be, and it is not a trivial issue.

- Yes, it is stated, it can lower the barrier for researchers technically. But the pay-per-use model may be a financial barrier. Credit card payment, or payment with tokens would be necessary. Do researchers like that model? Many don't, nor do their finance departments. It does raise the issue that spending is difficult to calculate/budget for upfront. From the financial perspective, things are still very uncertain. Will it be cheaper in the end? Will costs only be shifted to the user and become more untraceable or uncontrollable? Will commercial providers lure users in with relatively cheap pricing and raise prices once we are locked in?

- Yet, the fact that it is increasingly easier to monitor and calculate cost in more specific units, and 'meter' further down the line, will make it easier to charge centrally incurred costs of centrally provided infrastructure to departments , and then it becomes easier to compare with decentrally provided and charged services.

- Yes, it is stated, it can be an additional resource for researchers, not necessarily replacing anything, or only partly replacing existing facilities/services. There may be different purposes for Grid, and for Cloud. We need to look more fundamentally at how and to what purpose researchers are accessing infrastructure before assuming anything about Cloud replacing Grid, Grid evolving into Cloud or Cloud offerings on top of Grid. The distinction of user-driven Grid and provider-driven Cloud does seems to become less sharp now that cloud development is starting to become more user-driven. The research world has a lot of infrastructure already that could form a good basis for Cloud offerings. But grids have been expensive and may not necessarily be the best

option. Preferential rates from commercial providers for academia using their fast research network might be a better option. What would definitely be beneficial if there were fewer post-docs spending their time managing clusters instead of spending time on their research and thus working on their academic career

- Concluding remarks: though benefits can be identified for Cloud, it seems hard to identify any fundamental point for or against Cloud. If it is seen as an additional resource that doesn't necessarily replace anything, the question is: what additional research opportunities can it bring? How are researchers going to use it, what are they going to use it for?

Group 2.D

- It was argued that yes Cloud does offer solutions to the Research Community but that at present there is still too high a barrier to non technical people to fully leverage these advantages.
- A national support service (similar to that for Grids) acting as a broker between the user and the infrastructure/commercial provider would be really useful in providing professional services throughout the research project life cycle. This support would be of particular relevance when it comes to IP and control, areas where researchers are not always aware of the potential pitfalls.
- The lack of interoperability between standards is problematic and prohibits the application of cloud solutions to problems posed by the research community. People do not want to risk being locked into one technology.
- There are specific types of research that do not lend themselves to commercial cloud applications i.e. research with large data sets, I/O intensive data & research It was argued that there will be a natural work flow to cloud in the areas where its best suited. There will always be domain specific areas where specialised computing provision is still required.
- Another observation was that Cloud provides opportunities to create on demand licensing for software. Licences are now more elastic and are no longer limited to a specific IP.

Discussion Session 3: What is the impact of cloud on existing research infrastructures?

Group 3.A

- Will commercial Cloud Computing suppliers dominate provision to research?
- Will new research applications emerge enabled by Cloud Computing provision?
- While the back-end resources may change there is a need to provide a common user interface.

- Will resources be saved by ease of porting from the PC world to Cloud Computing?
- Technical support will still be required to port applications to parallel processing.
- Centralisation will introduce a funding issue and how it will be managed.
- Currently the funding goes directly to the researcher who is managing a project
- Pushing researchers to Cloud Computing may be counter-productive.
- Opportunity to provide new breed of researchers with ready to use application solutions!
- If national agencies provide Cloud Computing facilities will this achieve efficiencies ?

Group 3.B

- Some argued that yes HPC will most likely endure but probably in some virtualised form. Others maintained that there are sometimes problems with virtualisation. Not all researchers have the technical skills that a move to the cloud requires. Support would be required for researchers at a multi disciplinary level something that is not always available.
- Cloud Computing may attract new users. It was previously difficult to attract users to the grid and HPC as it was based primarily on Linux. With Cloud applications there is scope to use Microsoft which may improve accessibility (i.e. extending to the long tail of researchers). The important thing here is that you no longer need to know how to run a cluster.
- Cloud offers an effective solution to offload middleware effort. Platforms such as Galaxy and Star Cluster were cited as examples. These types of middleware layers are becoming more mature and attracting more users. It was argued by other representatives that Cloud will not get rid of the work required to do large MPI computing.
- Cloud will not impact high spec infrastructures and architectures built to address specific problems. However this subset of users should become smaller and smaller as a higher pace of provisioning comes to be expected.
- Cloud can have a positive impact on the following :
    - The new solutions it offers on top of existing computer power
    - How you can move/transport research results
    - Where you need a real time solution
    - It enables applications that HPC doesn't i.e. SAP

Group 3.C

- **Cost savings** is key factor.

- **Virtualisation** allows decoupling applications from hardware, which was seen as beneficial.

- Cloud is a useful platform for **collaboration** across institutions and with business.

- What will be the impact on the individual researcher? So far it seems that the same resources can be provided via grid, cloud and other technologies, so **the immediate impact on researchers may be limited**.

- Many of the bullet points on the slide with the questions for this session could also have been written down in the early days of grid computing; virtualisation may be key difference.

- The answer to the question of the difference between grid and cloud depends on how you define cloud – cloud not well defined enough for this yet, or rather **different definitions** (focus on PAYG, virtualisation, service etc.).

- How do **Higher Educaiton Institutions have to change** in order to consume cloud services? Set up their own cloud or rent from commercial provider may be first question to answer – cultural issues, privacy, control etc. Even when using an external provider they will need some skill to administer.

- How can you reduce costs when you just add cloud to your existing infrastructure? Are HEI's willing to give up this infrastructure to realise savings?

- Organisations will need to develop **policies on how the services are used**; rules of accountability will have to be established: cloud policy.

- What about in five to ten years, will all researchers use it, will it change their ways of working? **Cloud should become like electricity**, should not force them to change their way of working, it should just work.

- Researchers want to own something (even if it is just their own VM). This will make them feel they have **ownership** and will increase trust.

- The cloud is coming/already here. The impact will be huge, especially with regards to the **long tail** – many of the things that are less prestigious than HPC, but will have more direct impact on researchers (dropbox like services).

- **Disciplines**: IAAS maybe more for science, SAAS across disciplines.

Group 3.D

- Cloud computing will bring the same benefits as Virtualisation
- It was commented that research computing is not limited to HPC. Cloud gives access to the 'long tail' of researchers and is suitable for modest computing requirements.
- There were a lot of questions around data i.e. what is of value and should be kept and how long should it be stored for? How to reconcile making data open and available whilst ensuring protection?

- Should big universities offer “cloud” like facilities to the rest or should this be the remit of private providers who have lower overheads?
- Should the Commission establish small scale experimental clouds, who would run these?
- Regarding Human Resources there is a need for people who can bridge the gap between computing and researchers. New skills are needed for moving up the stack

Discussion Session 4: Will grids evolve into Cloud computing provision?

Group 4.A

- At national level many disparate demands are emerging. There is concern around the degree of duplication going on. Looking to integrate some of these functions / organisations.
- When comparing and contrasting grid and cloud significant differences in the barriers to entry emerge - the degree of knowledge needed. Grid suits compute intensivie research. The cloud is for thousands of researchers with less intensive requirements.
- There are projects focusing on bridging the cloud and grid. Open Nebula is incorporating requirements from the grid model. The cloud is another fabric layer below grid.
- Particular applications have particular needs eg instrumentation grids have specific requirements for performance. There are limits on the cloud - eg service guarantees for performance critical applications. Cloud will need to evolve a lot to meet such a requirement.
- Some jobs wait in job queues for the grid. The Cloud is more immediate and the resources appear to be (effectively) infinite.
- Grid has become a resource for CERN to store vast amounts of data
- Amazon is good for burstable computes - able to spin up resources when needed to handle peak demand. Implications for scale of the grid and use of the cloud to buffer excess demand. Amazon cloud occasionally reaches limits on store - not on disk. Cloud introduces the concept of pricing for features making users more aware of costs.
- The costs of cloud become a point of price comparison for funders / grid planners
- Grids can be thought of as virtual organisations - separable from the hardware platform underneath
- The fact that some researchers are ‘playing’ at being computer operators does come at some opportunity cost to research.
- Cloud-like interfaces may become a feature of grid resources
- Grid is very static in operation and design-once configured it’s hard to change and is not very flexible
- The funding and decision making process is different in each country

- Grid is often highly focused on one specialist application - high end physics however it is also used for bioinformatics and computational chemistry in other countries (e.g. Latvia)
- Grids will face pressure to become more flexible / scalable
- A highly specialised facility is still needed for some communities eg high end physics, environmental computing. The model of special environments for high end research will probably endure for a time yet.
- Researchers are expecting increasingly rapid resourcing and speed of response. There is an expectation with a new generation of users to be able to set systems up quickly (and to change them)
- The researcher of the future will have a different mindset - open science, open innovation, speed of response, daily publication.

Group 4.B

- There was unanimous agreement that grids will be virtualised. If funding is going to be targeted towards cloud then it is natural that grids will move in the same direction. Barriers to accessing grid services are higher than those for cloud.
- It was suggested that Imaging is one area that could be adapted for cloud by the grid community.
- Grid is dealing primarily with IaaS. When conducting scientific research it's hard to repeat an environment for testing if you are using SaaS. Doubt was expressed as to whether SaaS is of interest to grid communities.
- The question of how Grid Providers are going to react was posed querying whether they will be interested in providing more flexible access to their services or whether they will seriously consider the business model that cloud computing provides?
- It was commented that some grids have limits in terms of CPU memory. Cloud could be used to expand possibilities here.
- Many suggested that grid operators are going to have to change their mind set. Cloud simply offers another interface/approach to provide the same resources. NGI's will have to increase their offerings on a support level, move into the application space and make more efforts to understand the user communities. They need to 'start moving up and stop worrying about the infrastructure'
- In terms of their unique selling point it was argued that Grids can be more responsive to the needs of various communities in a very specific way. Commercial providers because of the diversity of the communities they serve cannot be so tailored.

Group 4.C

- Cloud and grid can generally be a "match made in heaven".
- The grid is in some ways more mature and certainly better defined/easier to understand. Culturally, grid is also seen as "less of a business environment".

- There should be a joint support infrastructure for both cloud and grid, not separate.
- Is it worth building large academic clouds to plug into the grid? If this were to be undertaken these clouds should be different from the commercial ones (as they may not have same economies of scale), for instance by adding research specific services.
- Cloud can be useful for the preservation of data.
- Cloud architecture is useful for working with/storing large datasets. Because of this it gives researchers freedom with regards to data.
- Is moving large datasets between clouds an issue?
- Generally, political, financial and cultural issues seem much more problematic than technology.

Group 4.D

We also need to answer the question of *how* Grids will evolve. Poland is looking at how to process personal and medical data in a public resource. Anonymising the data allows the use of the cloud, thus supplementing the resources available to them.

It is likely that there will be a convergence rather than an evolution of one into the other, since the purposes of grids and clouds are different. One is about coordinating resources; the other provides flexibility, probably simpler interfaces, etc. The grid is useful for specific applications whereas the cloud is more generically useful. So there will be a continued need for grids into the future. The cloud could be valuable to grids as their demand profile is very 'bursty'. The challenge will be to conjoin the operating systems of the grid with those of the cloud so that cloud resources can be accessed seamlessly. Need code in the grid environment that understands how the cloud works and which can then identify, acquire and use cloud resources.

National infrastructures are also in the process of virtualising their environments, so they may also be addressing how the grid accesses the cloud. The problem is still to identify the source of funding to use the cloud resources. Grids were set up to enable researchers to find suitable, idle resources elsewhere that could be used to complete the calculations for free. This could be a serious barrier to the take up of the cloud in the grid environment.

There is an analogy with the development of television services: once there was transmission across the internet then the specific barriers to access were withdrawn and the content was widely available to the individual. With the development of the cloud, the case for having these specialised grid resources is diminishing and for the future, individual researchers may appreciate the flexibility and availability of cloud resources without having to go to specialised providers. However some activities, such as high energy physics, have a nature that will always require very specialised and very powerful resources to be available. But even there, it was more a political decision to spread these resources around Europe – it would have been more effective to concentrate them in a single source to support physicists. Different communities also require their own dedicated and customised resources. Current cloud technology is still data-centre centric but may become more distributed in the future, at which point they will need to be addressing the same issues as the grid now.

Cloud providers have improved usability and flexibility of data and computing resources, whereas the grid has solved the issues of dealing with accessing physically distributed resources. Hence the claim is restated that the two systems will converge if each approach can learn from the successes of the other.

1) The grid and the cloud will converge rather than evolve into each other, taking the best features of each and implementing these in the other
2) OpenStack is designed to deal with enormous scale resources – could grid providers start developing this architecture for their own purposes as a start to converge the two approaches

Annex 4 Pre- Workshop Position Papers

4.1 CSC-IT Center for Science, Finland

Dr. Per Öster and Dr. Damien Lecarpentier

Why invest in Cloud Computing?

Cloud computing can provide interesting solutions for a wide range of actors, from businesses interested in reducing the costs of their local infrastructure by outsourcing it to cloud systems, to universities and researchers willing to access specific services at a better cost, or services that are not provided by the grid. For IT providers, cloud computing also represents new opportunities for developing services, which can justify investing in these technologies. This is the motivation behind Finland's new Cloud Software Programme (TiViT), a research cooperation initiative by Finnish ICT leaders and pioneers which aims to build new cloud business models, lean software enterprise models and open cloud software infrastructure. The decision to invest a large amount of money in this initiative (around 65M€ for the period 2010-2013) is based on the idea that in the future, cloud technology will represent a major part of daily life. The software industry is currently experiencing a paradigm shift from traditional installable applications to web-based software, where applications consisting of data, code and other resources live on the web as services and can be located anywhere in the world. The TiViT programme aims to improve the competitive position of the Finnish software intensive industry in global markets.
At European level, one could consider coordinating the national programmes on cloud computing or supporting a few extremely large data centers delivering cloud based services for all of the ERA. Cloud provisioning is currently dominated by the American market. Developing a pan-European cloud strategy would enable to better tailor cloud services to European needs, in particular for research and academic communities. It would also put Europe in a competitive position for important data repositories of world-wide relevance, and allow strategic and/or sensitive data to stay in Europe.

Is the Cloud Beneficial to Research?

Any IT infrastructure that can improve the researchers' capability and productivity is beneficial to research. Cloud computing is obviously in this category. Scientific computing can benefit from cloud computing in the same way as business: on demand resources, software as a service, platform as a service, infrastructure as service and so on. Clouds can offer some specific services to researchers at a better cost, temporary access to a specific environment, piloting of services, and sharing or publication of services. Cloud-based services can prove particularly useful for small research groups requiring additional IT services.

What is the impact of cloud computing on Existing Research Infrastructures?

Existing Research Infrastructures can find some cloud-based solutions to facilitate the operation of their data, and general services such as back-ups and repositories to store large amount of data. Clouds can therefore give research infrastructures added flexibility for operating their data and developing services.

Will Grids evolve into Cloud Computing Provision?

This question cannot lead to a straightforward answer. Grids and clouds have very different working models and fulfil different goals: grids emphasise the sharing of resources and the collaboration between scientists in an open and distributed way, while clouds are essentially motivated by profit and rely on proprietary interfaces with a pay as you go approach. Saying that grids will evolve into cloud computing would mean changing radically the way science is done today, which is unlikely to occur. Beyond the benefits of the grid collaborative model for scientists, one has to take also into consideration that most scientific communities have unique and complex research requirements which, currently, cannot be fulfilled by the Cloud. These requirements have also been the raison d'être of tailored and publicly funded grid-style infrastructures.

Rather than a shift from one model to the other, what we are likely to see in the near future is a growing integration of cloud services into the grid infrastructure (this is already happening, for example, in EGI which uses some cloud technologies to simplify and optimise the use of its distributed infrastructure). The two technologies offer users different benefits and are likely to complement each other in the future.

4.2 Curtis and Cartwright Consulting Ltd., United Kingdom

Dr. Max Hammond

Why invest in Cloud Computing?

I think it's important to consider what we might mean by "invest". Part of the benefit of cloud computing is that there should be less capital investment and these costs can be transitioned to OPEX. There's no doubt that "cloud" (which, of course, means different things to different people in different contexts) is providing new business models and potentially a new flexibility in provisioning services, but it's not a panacea. Invest based on business cases, as for any other investment of time or finance.

Is the Cloud Beneficial to Research?

This is a bit like asking whether spectrometers are beneficial to research. The answer is a resounding "perhaps"!

I don't think I know what "the cloud" is. I know a set of techniques and technologies and business models, but in the majority of cases what we're talking about is your service or data being hosted in someone else's data centre. If that works for your particular needs, then cloud services will be beneficial. At a very high level, the major benefits of cloud technologies within research are likely to be on 'peaky', compute-intensive tasks, or those that need rapid reconfiguration and flexibility, or those that need a particular technology for a short period which is not already available.

What is the impact of Cloud Computing on Existing Research Infrastructures?

I think it'll fit in with them, rather than replace them. Cloud technologies and business models are at present not particularly suitable for replacing much research computing (which by its very nature usually demands either tightly-coupled parallelism, or high levels of data flow and storage). It's the "medium-performance" tasks, and particularly

new and innovative research tasks where cloud technologies are likely to find traction initially.

Will Grids evolve in Cloud Computing Provision?

At present grids mostly exist to link up HPC resources, so for the reasons discussed above, they're not really in the same game as cloud vendors. That said, the NGIs could create a focus for cloud activity, standards setting, resource brokering etc. I don't see a necessary link between grids and clouds.

4.3 Eduserv

Mr. Ed Zedlewski

Cloud computing and storage services offer massive potential for cost savings and improved service delivery in a decade during which Higher Education and Research will be under intense financial pressures. This is particularly true when IT consumption is measured across the Higher Education sector as a whole in which there is significant commonality in the end user services. To fully realise the potential benefits it is important to seek the highest level common denominators. For some organisations this could result in outsourcing the whole data centre and everything within it and for others it will be more appropriate to rent third party server computing and storage capacity.

In academia, perhaps more so than most other sectors, there is a culture of IT asset ownership and where outsourcing is seen to be insufficiently intellectually demanding. Whilst cloud technologies remain complex to operate and in many aspects still immature, the resulting provision, of compute and storage capacity, is a commodity product. Leaders and decision makers need to be well informed about relative costs and implications of buying cloud services instead of product ownership and operation. In particular, true operating costs should be exposed to allow effective and depersonalised decision making by budget holders.

Investment is needed to understand or develop the appropriate business models and people skills to manage cloud service suppliers and end user consumers. Because of market immaturity there is currently insufficient predictability in the consumer costs or supplier rewards. Success is more likely if we can identify those IT requirements which are core to the business and those which are peripheral and then further subdivide those peripheral requirements which can be delivered on common or shared platforms against those which are unsustainable.

Well managed cloud services can deliver highly available computing resources and protect data from loss or corruption. Cloud computing also provides a richer environment for researchers where raw and derivative data can be more widely shared. In addition there is the potential to provide more resource and greater focus on research outcomes rather than development of short-lived technical and operational IT skills.

4.4 Higher Education Authority, Ireland

Mr. Pat O'Connor

Why invest in Cloud Computing?

Some Irish institutions are already investing in their own Cloud Computing facilities. While recognising the potential benefits that Cloud Computing provision can provide, a decision to invest in National or pan-European facilities would depend on the cost comparisons vis commercial suppliers.

A major consideration for use of shared Cloud Computing facilities will be addressing the privacy and security issues. The Irish government has decided to establish an expert group to address security and privacy issues arising from cloud computing.

Is Cloud Beneficial to Research

Provision of Cloud Computing facilities for Higher Education and Research has the potential to meet the growing capacity needs of the community while providing economies of scale. We would envisage these facilities would be provided in support of existing institutional capacity. The other potential is for specialised Cloud Services.

What is the impact of Cloud Computing on existing research infrastructures

We visualise Cloud Computing providing additional capacity and functionality to existing research infrastructures. HEAnet is establishing a National Data Store facility which will provide short term, backup and archival facilities.

Will grids evolve into Cloud Computing Provision?

From a policy perspective we would wish for the provision of Grid Facilities to evolve into Cloud Computing infrastructures. This has the opportunity to remove duplication of networks and support organisations.

4.5 Isragrid, Israel

Dr. Zeev Vaxman Fisher

Why invest in Cloud Computing?

Total life cycle of a server is very expensive. The real cost of a server (labour, energy etc) is way over its initial cost. However, the real utilization of a server is usually low and in many cases the server is not needed to be up all the time. The inevitable conclusion is that resource sharing and standardization (cloud computing) is mandatory in order to reduce costs. Also, cloud enables 'on demand' billing models.

Another issue is green IT. The amount of energy that is wasted is enormous.

Is the Cloud beneficial to Research?

There's no doubt but that cloud is beneficial since it enables easy access (simplicity, immediate, on demand) to resources and hence enables research tasks to be completed in a more timely manner.

What is the impact of cloud computing on Existing Research Infrastructures?

Cloud is now the back door for researchers in order to get resources fast in parallel to existing research infrastructure. Before the cloud, it was hard to get "private" resources without purchasing flow and sometime explain why it is needed. I call it the back door since it is not controlled and sometimes overall implementation time is much longer since each researcher has to be the system administrator of his own machine. For example, install tools for himself. The control issue can be very dangerous in terms of IP, backups and other. The researcher is usually not exposed to system processes that happen behind the scenes of the infrastructure he uses.

Will Grids evolve into Cloud Computing Provision?

I can't call it evolve. It's not that cloud is up there and grid is somewhere down. Grid should use the cloud computing technologies in order to overcome major deficit it has now (security, sw installations, control). I think that the hybrid approach (grid use cloud technology for the resource layer) is a winner and must be investigated and implemented in large scale

4.6 Joint Information Systems Committee, United Kingdom

Dr. Malcolm Read

Why invest in Clouds?

The answer is efficient, cost effective infrastructure because it opens up access to industrial scale economies in deployment and use of infrastructure and applications. That leads to financial benefits and in turn carbon and other environmental benefits. Cloud can also potentially cope with sudden peak demands for increased storage and compute requirements, and provide a suitable ‘neutral platform’ for HEI / business collaboration.

As far as investment in cloud is concerned, cost is certainly the main driver. It is particularly attractive to smaller institutions without the capital budget for wholesale rip and replace that are able to secure access to upgraded infrastructure which they could not otherwise afford (and, in the case of Software-as-a-Service, the modularisation of large applications into services in the Cloud is anticipated to release institutions from being locked into costly IT contracts with monolithic software vendors). Large data centres can use economies of scale to be significantly cheaper (although this needs to be looked at closely because it does not have to be true for all use cases) and can be flexible in delivering layers of a standardised, modularised service. NB These may both require changes in culture, specifically expectations of ‘fine-tuning’ of services to meet specific requirements, but there are benefits in doing so. For example, "the European Space Agency is utilizing Amazon EC2 for the data-processing needs of its Gaia mission, set to launch in 2012. The 40GB per night that Gaia will generate would have cost $1.5 million using local resources (read “a grid” or “a cluster”), but research suggests it could cost in the $500,000 range using

EC2." (from http://gigaom.com/2010/03/22/to-space-and-beyond-the-rise-of-research-driven-cloud-computing/)

Similarly a well optimised large data centre will use less energy and help battle rising carbon emissions- the inherent inefficiencies of running infrastructure at maximum capacity that the cloud model proposes begs the question as to why institutions need data centres anymore.

Having more storage and compute available on demand is also very useful for dealing with sudden peak usage and projects that on occasion need to crunch larger data. However, Cloud is not necessarily a suitable replacement for HPC (see http://www.hpcinthecloud.com/blogs/Elite-HPC-and-the-Cloud-Culture-Clash-97588689.html; see also http://cloudscaling.com/blog/cloud-computing/grid-cloud-hpc-whats-the-diff for an illustration of the differences between Grid, Cloud and HPC).

Another key factor is that using cloud can make it easier to collaborate with business. If for instance a spin-off company should come out of a project that uses web resources it may be easier to hand over control to something run on a virtual machine. Similarly, for partnerships with industry using an external cloud provider can make it easier to collaborate as both HEIs and industry often restrict external access to their systems.

Cloud also offers opportunities for innovation by putting computing resource in the hands of end-users. Services like e-Science Central (see http://www.esciencecentral.co.uk/), a 'Science-as-a-Service' platform that combines Software-as-a-Service, Social Networking, and Cloud Computing enabling users to upload data, share it in a controlled way with colleagues, and analyse it using either a set of pre-defined services or one's own (which can also be uploaded for sharing) – considerably reducing set-up costs and the need to maintain one's own systems, with complete control over what, when and with whom to share.

Why build a private cloud?

The key word here is Trust. Researchers and HE staff need to be able to trust the reliability and integrity of the cloud they use (Safe Harbour Patriot Act etc, as well as sustainability of data and overall reliability).

There's no reason though why the Research &Higher Education cloud can't be built from commercial components and indeed JISC intends to do just that through the University Modernisation Fund-funded brokerage structure. However the Cloud itself and an institution's connections to it must be as safe and reliable as the physical IT hardware it is replacing otherwise the economic benefits are meaningless.

There are four critical enabling factors of cloud computing:

- virtualisation and automation
- pay per user software
- data centres
- broadband connectivity

As such, cloud computing is only as effective as the data centre it is housed in and so cloud computing growth will only happen if there is continued growth of the data centre sector.

4.7 Leeds Metropolitan University, United Kingdom

Professor Colin Pattinson, Mobile and Converging Technologies,

Why invest in cloud computing?

The commoditisation of IT services which cloud computing provides means that economies can be made in delivering those services, since providing access to a service is potentially lower in cost (first cost and maintenance) than supporting the hardware and software itself, upgrades and changes to match demand (increased or reduced) may also be simplified.

Cloud Computing offers organisations the opportunity to outsource (offshore) IT services, therefore affecting their energy/ carbon reduction targets N.B. this has the effect of moving carbon, it does not stop its production – though it may reduce the overall volumes. (This is itself subject to ongoing debate: the energy cost of the network provision needed to support cloud access is an open question).

Because everyone is doing it / expects you to do it: new and developing applications are likely to become cloud-orientated, it may be that maintaining a non-cloud provision and meeting user expectations becomes difficult to do. (This is perhaps the strongest driver of all!)

Is the Cloud Beneficial to Research?

Define “research”: Will the cloud generate new research areas? Apart from those directly related to cloud provision, probably not. Will the cloud assist researchers to work more effectively and efficiently? Possibly, easier access to resources, and the ability to share resources and data could be beneficial, as could the access to enhanced processing capability and data volumes: it is likely that in some areas where complexity of processing and data has been a limiting factor, that cloud resources could extend that limit.

There is the possibility that cloud could affect the way in which research projects are typically resourced: purchasing cloud services instead of the physical server which traditionally forms part of many research bids could affect the overall cost structure of bids (assuming the financial model used by cloud providers is as expected).

What is the impact of cloud computing on Existing Research Infrastructures?

See comment above: except in some special cases, research infrastructure is not materially different from any other IT infrastructure, and thus is likely to be subject to the same drivers. Therefore “research infrastructures” for the cloud can be expected to follow the same pattern as other IT provision, namely that they will provide access (brokerage) to resources which are services (commodities) as opposed to physical components, systems etc.

Will Grids evolve into Cloud Computing Provision?

It is more likely that “grid” will become one of the services accessible over the cloud: e.g. providing an HPC service over the cloud, which will look much the same as it currently does over the net, except that the user’s data will be in the cloud, and they may have a choice of HPC services - Alternatively, they may not know which of many HPC services they are using.

Extrapolation of Moore’s law might suggest that – in time – the resource available via the cloud makes such separate grid provision unnecessary, I am sceptical about this.

4.8 MESR-Ministry for Higher Education and Research, France

Mr. Lauren Desbat

Why invest in cloud computing?

Existing and emerging large data centres, virtualization technology developments, IaaS, PaaS, SaaS concepts and offers are facilitating the construction of a new economic model for information processing and computing. The cloud computing market growth estimation seems to be more than 15% per year. The Cloud computing European market should be €7 Billions in 2012 (based on Gartner estimation). Europe seems to be late on this market. However European software and service offers are strong and European data centre hardware offer is progressing. In the framework of the French Investment Programme « Investissements d'Avenir 1», France will finance industry driven projects to support the construction of a cloud infrastructure and to develop an ecosystem around this cloud infrastructure (support of hundreds of M€). The first call (http://www.industrie.gouv.fr/fsn/cloud-computing) concerns collaborative R&D projects around services and virtual data management on the cloud (support of tens of M€). This is a French contribution and support to cloud development but we think that the European level is crucial for the cloud infrastructure and service industry development.

Is the Cloud Beneficial to Research?

Cloud computing induces Computer Science research around parallel processing, fault tolerant algorithms, information access, information security, virtual data localisation control and security, etc. If cloud computing is a good model for information treatment in industry, it should also be a good model for research information treatment or for research administrative data treatment.

What is the impact of cloud computing on Existing Research Infrastructures?

The development of cloud computing should impact network infrastructures if it is widely used within research communities (however network use will continue to grow, with or without cloud computing). We do not envisage a fast impact of cloud computing on HPC infrastructures such as PRACE or national HPC infrastructures : High Performance Computing activities are based on supercomputer architectures with too high price/performance cost for general cloud market. However, a dedicated HPC cloud computing offer could exist.

Will Grids evolve into Cloud Computing Provision?

It is clear that grids (EGI, NGIs) will benefit from cloud technologies. From my point of view, grid and cloud models are very close: they both offer virtual systems and services to users (cloud provides an economical model). The French NGI France Grilles is collaborating with computer scientists in order to experiment with cloud technologies. France Grilles will contribute to the EGI cloud expertise. France Grilles could evolve to a cloud offer if this is the EGI model.
The main questions around cloud (and particularly for non academic clouds) concern data and information security (crucial for research and innovation), existence of the services required (research has sometimes very specific needs) and the cost for the same service quality.

4.9 National Information Infrastructure Development Institute, Hungary

Dr. Lajos Balint

Why invest in Cloud Computing?

The question is rather: "Should one invest in cloud computing?" and/or "What and how to invest in cloud computing?" .Considerable emergence of cloud principle and practice has impressively happened within the commercial sector by offering access to the wide potential user community easy, well manageable, in most cases affordable solutions to their computing and data storage requirements. The research networking segment of that potential user community has recognised the opportunities stemming from that seemingly new principle and practice. NRENs have responded differently: some are making agreements with commercial cloud providers, some others started building their own cloud infrastructure/services, again others look for a combination of the two options. Grid techniques, earlier developed and applied by the research networking community, are well applicable and exploitable in these efforts - indeed, there are numerous common features of the two approaches. (Moreover, some say that there is nothing new in clouds but rather "cloud" is just a new buzzword to the same thing - introducing service oriented solutions in the e-Infrastructure field by integrating available resources, applying AAA, SLA, etc., and adding necessary middleware.) Investing therefore is nothing else than either paying for commercial services or allocating funds and other (equipment and/or human) resources to the necessary developments and service provision. As a final conclusion: investing is unavoidable in order to cope with the new IaaS directions. The real question is hidden in the details - what and how to invest. The answers to these detailed questions will likely emerge over time.

Is the Cloud Beneficial to Research?

Cloud itself is not very interesting for most disciplines. Exemption is R&D directly devoted to information and communication technologies. On the other hand, the emergence and fast proliferation of the IaaS paradigm has had a considerable impact on how research is done. The complexity of Research Infrastructures in general, and the e-Infrastructure (providing the indispensable means for communicating, co-operating and collaborating among large, disperse research teams, for collecting, storing, processing, exchanging, and utilising enormous amounts of scientific data, for remotely accessing distant, distributed resources like experimental facilities, measuring equipment, HPC machinery, etc., and more recently also for establishing and operating virtual European or global research communities) is impossible without

providing service oriented support to the users. That's why clouds are not only beneficial but essential for doing research these times. Moreover, clouds do help also in building an environment for overarching the entire innovation chain by combining and integrating research, development, and innovative wide exploitation of the new products and services stemming from new scientific results of leading edge research activities.

What is the impact of Cloud Computing on Existing Research Infrastructures?

Cloud computing (or rather, cloud techniques, since clouds are supporting not only computing but practically all research activities dealing with information - which indeed means all disciplines and their multidisciplinary and interdisciplinary combinations) is providing a completely new framework for research in general. Existing research infrastructures are consisting of advanced facilities providing support for any kind of activity elements of research at large. However, clouds themselves aren't able to solve all existing problems of how to best utilise the opportunities provided by the infrastructure. Man-machine (and especially human-computer) interaction is still not friendly enough and easy to use yet for making the utilisation as simple as possible. But most importantly, clouds will not replace the basic feature of scientific research - looking for new ideas, searching for new solutions to the important problems of society and economy, answering crucial questions related to various issues to be duly dealt with, especially in the area of grand challenges human mankind is facing worldwide. Nevertheless, the tool provided by the e-Infrastructure and by the service oriented cloud approach considerably simplifies the big tasks especially by making available the extremely large amount of collected information and helping the management of the information flow. The major impact of applying clouds certainly appears in the emergence of service oriented development and operation of the infrastructure.

Will grids evolve into Cloud Computing Provision?

Using the future tense in this question is not completely correct - the grid approach, the grid technique, and the grid solutions are already there, built in at the cloud architectures and services. Moreover, probably clouds couldn't even emerge without the grid results achieved during the last decade. The answer to the question is definitely yes, grid evolution is a major contributor to cloud development. However, cloud is a bit more, by focusing on the IaaS principle and practice. On top of that, clouds (and especially the presence of commercial services in the cloud area) are providing an important impact on moving towards a well established business model for service provision on IaaS basis and for doing research by exploiting the infrastructure services. Until recently AAAI in the e-Infrastructure area has duly concentrated on the first two components, authentication and authorisation, but neglected the accounting aspect in the Authentication-Authorisation-Accounting Infrastructure. The increasing complexity of research, the strengthening co-operation between public and private actors in the RDI (research-development-innovation) chain, the fast growing costs of the large-scale RI (research infrastructure) facilities, the internationalisation (globalisation) of joint research activities, the geographical distribution of functionally integrated infrastructure facilities-equipment-tools complexes, the combination of different kinds and sources of funding in the RDI activities, etc., do all require such a well established business model, applying also a stable, sustainable, well applicable, inspiring accounting system. Clouds will surely help the evolution also in this sense.

4.10 Ozyegin University, Turkey

Professor Ismail Ari

Why invest in Cloud Computing?

Cloud Computing is about providing “Everything as a Service” (hardware or software) and then doing a “better” job in terms of

- ease of access & use, system availability, data reliability,
- scalability, performance, energy-efficiency,
- time-to-market, utilization,
- testing, security and other metrics

Compared to the traditional –locally installed and managed- systems, this is a good proposition for many users in different disciplines and with different use cases, as they don’t have to deal with the intricacies of IT-related issues. Instead, they can now focus on their own scientific or business problems. Governments and private businesses should invest in Cloud Computing to open up existing hardware and software resources/tools to their private organization or even Internet-scale crowds, so that everyone can solve their research, business or personal data storage & processing problems. Next, we should all invest time and effort in developing new cloud applications to truly enable Collaborative Intelligence (Human-Human, Human-Machine, and Machine-Machine), so that we can make effective progress in all human frontiers. Cloud computing is therefore both an enabler for new opportunities and a time-money-energy saver.

Is Cloud Computing beneficial to research?

Cloud computing is especially beneficial to research. The research problems we are addressing are getting harder and harder; most of the easy problems have already been solved. We need technologies that will help us join forces and Cloud is one of them. The research community is mainly represented by academics, graduate students, and industrial or governmental research laboratories. These people have bursty needs for IT: they investigate a topic for months to years and then need lots of resources (or expensive resources) to implement and test their hypothesis. In between, the resources acquired are not fully utilized. Infrastructure-based focus on IT or Cloud represents just one limited perspective (i.e. IaaS in Cloud or Virtualization). We need to create Cloud-based centres of excellence for all scientific fields where all of the infrastructure, software platforms, and data processing pipelines have been optimized and relevant training is provided.

Today, many research groups find themselves in a position to collect, store and analyze huge amounts of data. In the SuperComputing 2010 conference, CERN officials were talking about managing ExaBytes = 1018 bytes of LHC/Physics data and opening this data up for analysis by thousands of researchers concurrently. CERN’s solution was also based on Cloud Computing and is already in use. Ease of sharing of data (and artefact) as well as requests for platform and tool independence are some of the determining factors.

Cloud computing also relates to the educational pipeline that feeds the research community, which is the Higher-Education system. With fast changing technology

universities have difficulty adopting and maintaining state-of-the-art technologies. Cloud-based solutions (e-science, e-labs, online course management systems, etc.) provide the easiest way for them to stay up-to-date.

What is the impact of cloud computing on Existing Research Infrastructures?
Researchers have already started experiencing the ease of access and use of different kinds of Cloud-based software and hardware services for their scientific or engineering needs. These people will be reluctant to acquire and manage their own research IT infrastructures (unless they want to be Cloud-service providers themselves). First, the utilization of existing resources will increase and then they will physically disappear from many premises. On Amazon Web Services (EC2) approximately 50K new instances (virtual machines) are created each day. This means that by around 2015, the majority of the servers and services (80%) will live in the cloud.

Grids and Clouds will probably co-exist, but Grids will have diminishing importance.

Grids inter-connect Supercomputers and serve mainly to the High-Performance Computing (HPC) community. Grid users have been limited to a few select research fields such as high-energy physics and astronomy. Grids are advertised as being "free", but their openness to generic public use is debatable. It feels more like a club membership. The questions asked by Supercomputer owners about how many CPU-hours or GB you will need up front, deter researchers from attempting to use them.

4.11 Rackspace

Mr. Russell Clark

Why invest in cloud computing?

Investment in cloud computing offers a number of key benefits

1. Scaling is rapid and resource appears infinite to the user which means that you can rely less on the variable success of predicting and planning scale and rather scale as the need arises.
2. The utility nature of cloud computing allows you to pay for use and can go up and down eliminating the need to pay for peak loads. Workloads that are temporary in nature specifically benefit from this feature.
3. The need for upfront capital investment in computing resources is largely removed. Investment can start out small and grow with success and increased demand for resource.
4. Cloud computing platforms enable developers to control the resource requirements of the application as it scales improving operational efficiency.

Is the Cloud beneficial to research?
Research undoubtedly faces similar challenges to commercial organisations which is traditionally the core of our business.

- More demand for resource than resource available to the organisation.
- Pressure to use resources ever more efficiently

- Requirement to be more flexible and agile to respond to external demands
- Getting sign-off for capital expenditure is complex, time consuming and accuracy is closely scrutinised.

What is the impact of Cloud Computing on Existing Research Infrastructures?

As Rackspace see's more Institutions experiment with, and adopt, parallel processing (as part of distributed computing) for all kinds of computational models, the impact of Cloud Computing is that it enables these Institutions to rapidly deploy and more easily scale in a way that has rarely been possible with in-house physical infrastructure.

4.12 SARA HPC Cloud, Netherlands

Mr. Floris Sluiter

Why invest in Cloud Computing?

HPC Cloud computing offers researchers more flexibility then existing HPC facilities can offer. With our HPC cloud, users can completely tailor the environment around an application and therefore do not have to port the application to an environment. Also it is possible to divide resources unevenly, for example a machine with a single-core CPU, but a very large amount of RAM memory. Also long running processes are possible, for example for web services. The actual cost of the hardware is higher when compared to dedicated single purpose machines because of the virtualization overhead. Importantly, we see that this is more than compensated in the shorter time one spends in porting applications. The cost to obtain a solution is therefore less.

However, this is less true when the application is used continuously or in parallel for millions of CPU hours. When that is the case, the cost of the overhead can become higher than the cost of porting to a dedicated infrastructure that is optimized for that type of use. So it is not the most cost-effective answer for every application.

Is the Cloud beneficial to Research?

Yes, our HPC Cloud is a very flexible tool. Especially fast and dynamic research fields, for example bioinformatics, benefit from the agility. In these fields, researchers use many different and sometimes in house developed tools that need specific environments and are therefore hard to accommodate on existing HPC facilities. The HPC cloud offers the ability to clone their existing environment onto a virtualized HPC system. We have in our test environment already 30 user groups and together they used 350.000 core hours. Already in the first few weeks researchers were able to use it in their actual research and the HPC cloud was used to store and analyze scientific data. Researchers also particularly like the ability to run any operating system they need. In the same cluster they can combine, for example, virtual machines running Microsoft Windows with virtual machines running Linux, to get the best of both worlds.

What is the impact of Cloud Computing on Existing Research Infrastructures?

We find it to be complementary to our other facilities. We offer GRID (we are a tier 1 site for the LHC), the Dutch National Super Computer Huygens, the Dutch National Compute Cluster LISA, a GPU cluster, and various storage, networking and visualization offerings. Our HPC cloud adds to this a system that can be easily and rapidly adapted to various needs. It is, at a small cost of the virtualization overhead, a system that provides a fast “time to solution” for our researchers.

Will Grids evolve into Cloud Computing Provision?

We see that various grid service providers will also offer virtualization services on that grid, i.e. starting a virtual machine in a grid job. However, Grid facilities are usually built for high throughput computing (HTC) and not so much for High Performance Computing. The difference is that in HTC the results are obtained by starting many jobs on relatively cheap hardware. Because there is a large quantity of this type of hardware, the total number of jobs can still finish within reasonable time. This type of computing works very well when your application can be divided in small independent tasks. In HPC the results are obtained by coupling many high end machines, using high speed connections. Because they are tightly coupled, it is possible to keep tasks synchronized with each other. So tasks can cooperate on the same larger problem. This type of computing works well when your application can not be easily divided into separate tasks. However, the difficulty is that the application still needs to be ported to and mapped on a particular HPC system. HPC Cloud computing provides a flexible way to adapt the system to the applications. It still requires work, but in some cases much less.

Cloud Computing to us means “self service and dynamically scalable”. The self service part we take very serious: Users get full access to their virtual private compute cluster and can configure everything, including network and security settings. Dynamically scalable is that they can expand and shrink according to their needs. This type of service delivery can be applied to any service. In our case we apply it on HPC IAAS (infrastructure as a service). It can indeed also be applied to other types of infrastructure, HTC in the case of Grid, or for example web- and databaseservers that most commercial Cloud vendors offer.

4.13 South East European Research Area for e-Infrastructures (SEERAEI)

Mr. Floros Evangelos (on behalf of the SEERA-EI network)

Why invest in Cloud Computing?

Investing in any kind of computing infrastructure from which the research and education community can benefit, is of key interest to both European governments and the EC itself. If this infrastructure can be further shared by the pan-European community, this would then follow the federated model provided by similar technologies like Grids. The potential benefits of Cloud computing like consolidation

of resources, reduction in operation costs and in the total cost of ownership (TOC) of computing infrastructures in general, are well known and have been already analysed in various contexts. In addition, Clouds promise to reduce the digital divide for countries that cannot invest in large scale computing infrastructures, much like the Grid concept. Depending on the cloud provisioning model (public, private, hybrid) or architecture (IaaS, PaaS, SaaS), clouds can facilitate access to high-end computing capabilities lowering the access barrier enabling more communities to access state-of-the-art computing infrastructures. This is of particular importance form many countries in South-Eastern Europe.

Is the Cloud beneficial to Research?

Clouds promise to bring simplicity, flexibility and access to unprecedented computing capabilities. Combined with user-friendly interfaces, cloud computing would be of great benefit for the research community. As cloud technologies are still in early stages of design and implementation it is important to take into account scientific and research-specific use cases in order to ensure that the technology will be able to satisfy particular requirements imposed from these application areas.

What is the impact of cloud computing on Existing Research Infrastructures?

Consolidation of resources, which is one of the basic merits of Cloud computing, will most probably impact the number of resource providers and the way they operate. Cloud computing brings a centralized model of resource provisioning, thus it's natural to expect that there will be a reduction in the number of providers as the computing resources will be offered by a small number of large computing centers. The impact on the actual infrastructure is that of the need arising to actually work on the access interfaces - since the underlying physical fabric is the same. For example the existing Grid computing infrastructure could be wrapped up within the cloud and efficiently reused. From the end-user point of view the above will facilitate a short migration path since they will not have to radically change the way they interact with the infrastructure.

Will Grids evolve into Cloud Computing Provision?

Clouds are residing in the evolutionary path of Grid computing, at least for what concerns the core enabling technologies (middleware, protocols etc). Grids are still relevant since their fundamental concept promotes collaboration and federation of resources. On the other hand early experiences with Cloud infrastructures suggest that this paradigm can cover a broader range of use cases than Grids. Moreover, it would be inefficient to invest on building parallel infrastructures, and certainly work should be dedicated interfacing and wrapping up existing ones. What is important, is to keep the federating and sharing philosophy of the Grid and evolve existing technologies that enable it. Otherwise, there is a high risk that the investment of Grid computing will be lost and Cloud implementations will diverge from the collaboration principle.

4.14 The State and University Library, Aarhus Denmark

Mr. Arne Sørensen

Why invest in Cloud Computing?

The sharing possibilities of the cloud are the obvious reason: The pooling will provide for both low prices, up-to-date technology and ease of use.

Scaling up and down of storage and computing facilities will be easy.

Obstacles: The drawbacks are the security and control issues mentioned above. Especially long time preservation and data protection for sensitive personal data.

Is the Cloud beneficial to Research?

The answer is yes: Cloud solutions are very agile in providing infrastructure on demand. Cloud providers could specialize on large scale solutions thus providing and applying front line technology for the benefit of the researchers.

Obstacles: “One size fit all” may not allow for sufficient freedom in certain areas of research. This could be the case for research areas in computer science itself.

What is the impact of cloud computing on Existing Research Infrastructures?

Probably some low cost and obsolete computational services could be upgraded to more up-to-date technology solutions with faster, bigger and better facilities.

Ultimately the computational needs for research groups which today are fulfilled by local or regional facilities could be made available through Cloud Computing facilities almost parallel to other basic infrastructures such as power supply.

Obstacles: Again “One size fit all” may not allow for sufficient freedom in certain areas of research.

Will Grids evolve into Cloud Computing Provision?

Although the Grid concept has been around longer than Cloud, it seems more advanced as a concept: In fact it can be considered as a combination of several Clouds into solutions.

The Grid has its roots in Supercomputing and up till now it has mostly been seen as computational power. Data is transferred to a network of computing nodes doing simultaneous calculations of some sort.

The answer to the question is: Both ways – The Grid will evolve into Cloud Computing and Cloud Computing will evolve into the Grid.

4.15 SURF, Netherlands

Mr. Leo Plugge

Is the Cloud beneficial to Research?

Yes. Only a small number of researchers have a need for capability computing, i.e., High Performance Computing systems with large numbers of cores. The majority of researchers are well served with capacity computing, systems that share their computing power with several up to many users. This capacity computing is exactly what cloud computing excels at. Cloud computing helps us to attain economies of scale by sharing resources between researchers who need capacity (not capability) computing for specific time.

The size of the economies of scale is determined by the amount of user needs that can be served.

What is the impact of cloud computing on Existing Research Infrastructures?

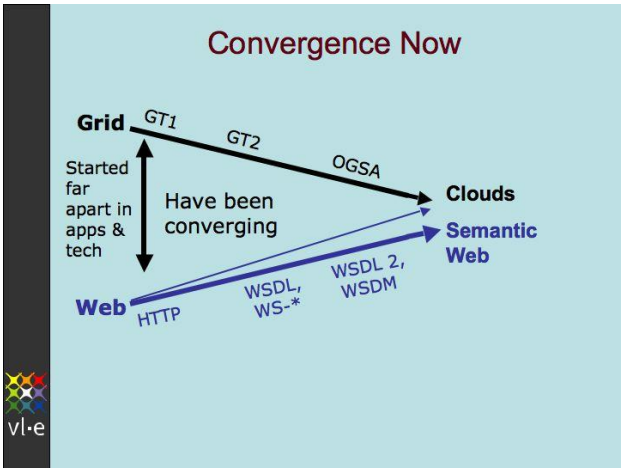
The most important impact would be making the current Grid infrastructure simpler to use and to manage, through:

- Virtual machines to deal with heterogeneity
- High-level programming abstractions
- Handle fault-tolerance, malleability and connectivity problems automatically
- Middleware-independent APIs
- Modularity

In doing so, cloud computing would open up resources for a larger research community, i.e., many more than the relatively small number of researchers in the big sciences.

Will Grids evolve into Cloud Computing Provision?

Below is the vision of Bob Herzberger, where first generation Grid Technology (GT1) led to GT2, then to the Open Grid Services Architecture, where it meets with the developments in Web technology, into Cloud technology. The question is not so much if, but when grids will evolve into cloud computing



Why invest in Cloud Computing?

Currently it is difficult to beat commercial providers like Amazon and Microsoft by building a shared private research cloud. However, there are good reasons to invest in a private European research cloud because:

- It means investing in (the development of) European expertise on cloud computing. Currently, most providers are US based and Europe is lagging far behind.

  Spending on cloud computing
  - 57% in the U.S.
  - 31% in Europe
  - 12% in Asia.

  Adoption of infrastructure as a service (e.g. Amazon's EC2)
  - 93% of that spending is done in the U.S.
  - 6% in Europe
  - 1% in Asia.

  Example: ESA is dependent on Amazon EC2 for the data-processing needs of its Gaia mission (launch in 2012). Do we want such a dependency?
- More control of data. Not all data should be open or out of our controle outside Europe.
- Investing in research clouds means investing in good facilities to attrack (and keep) top researchers, and top research.
- (see Question 1) Only a small number of researchers have a need for capability computing, i.e., High Performance Computing systems with large numbers of cores. The majority of researchers are well served with capacity computing, systems that share their computing power with several up to many users. This capacity computing is exactly what cloud computing excels at. Cloud computing helps us to attain economies of scale by sharing resources between researchers who need capacity (not capability) computing for specific time.