Grid and Cloud Computing: Opportunities and challenges for e-Science

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Outline

- The experience of the Grid
- Examples beyond e-Science
- Issues and new trends:
  - Green Grid and Cloud Computing
- Cost considerations
- Conclusions

The experience of the Grid 1/3

- Grids for e-Science: a success story so far?
  - Several mature Grid Middleware stacks
  - Many HPC applications using the Grid
    - Some of them (HEP, Bio) in production use
    - Some of them still in testing phase: more effort still required to make the Grid their day-to-day workhorse
  - e-Health applications also part of the Grid
  - Some industrial applications:
    - CGG Earth Sciences

EGEODE VO

The experience of the Grid 2/3

- Grids beyond e-Science?
  - Slower adoption: prefer different environments, tools and have different TCOs
    - Intra grids, internal dedicated clusters , cloud computing
  - e-Business applications
    - Finance, ERP, SMEs
  - Industrial applications
    - Automotive, Aerospace, Pharmaceutical industry, Telecom
  - e-Government applications
    - Earth Observation, Civil protection:
    - e.g. The Cyclops project

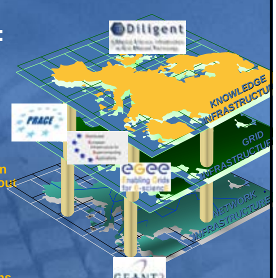
The experience of the Grid 2/3

- Industry also demonstrated interest in becoming an HPC infrastructure provider:
  - On-demand infrastructures:
    - Cloud and Elastic computing, pay as you go…
    - Data centers: Data getting more and more attention
  - Service hosting: outsourced integrated services
- "Pre-commercial procurement"
  - Research-industry collaboration in Europe to achieve new leading-edge products
    - Example: PRACE building a PetaFlop Supercomputing Centre in Europe

e-Science and e-Infrastructures for Research

e-Infrastructures in Europe:

- Research Network infrastructure:
  - GEANT pan-European network interconnecting NRENs
- Computing Grid Infrastructure:
  - Enabling Grids for E-ScienceE (EGEE project)
  - Transition to the sustainable European Grid Initiative (EGI) currently worked out
- Data & Knowledge Infrastructure:
  - Digital Libraries (DILIGENT) and repositories (DRIVER)
- A series of other projects :
  - Middleware interoperation, applications, policy and support actions, etc.



Cyber-Infrastructures around the world:

- Similar in the US:

Examples beyond e-Science

EU BEinGRID: Computational Fluid Dynamics

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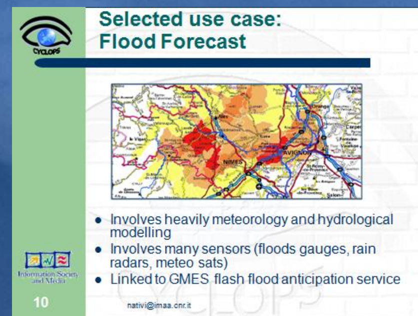
Examples beyond e-Science

CYCLOPS: Flood Forecast



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Examples beyond e-Science

CYCLOPS: Forest Fire propagation

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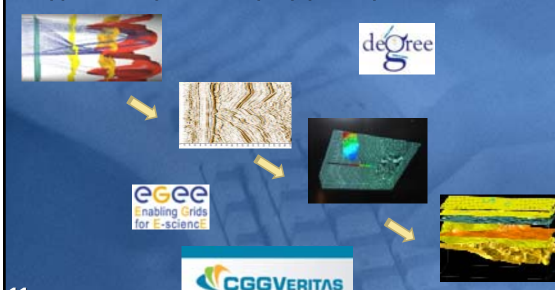
Examples beyond e-Science

EGEODE VO : Seismic processing based on Geocluster application by CGG company (France)



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In summary…

- Grid computing has delivered an affordable and high performance computing infrastructure to scientists all over the world to solve intense computing and storage problems within constrained research budget
- This has also been effectively used by industry to increase the usage of their computing infrastructure and reduce Total Cost of Ownership (TCO)
- Grid is not only aggregating computing resources but also leveraging international research networks to deliver an effective and irreplaceable channel for international collaboration

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The flip side…

- Major issues with wide adoption of Grid computing in eScience, e-Business, industry etc. have to do with:
  - Cost of operations and management complexity
  - Not a solution for all problems (latency, fine grain parallelism are difficult)
  - Difficult to use for the average scientist
  - Security and reliability
- Power consumption and heat dissipation are becoming a limiting factor to consumer based distributed systems
- We are observing the limits of Moore's law

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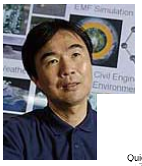
Switching Gears: "To Distribute or Not To Distribute"



- Prof. Satoshi Matsuoka, TITech
- Keynote at Mardi Gras Conference, Baton Rouge, Jan.31, 2008

QuickTime?and a ..ZW) decompressor ..ed to see this picture.

QuickTime?and a TIFF (LZW) decompressor are needed to see this picture.

- **In the late 90s, petaflops were considered very hard and at least 20 years off …**
- **… while grids were supposed to happen right away**
- **After 10 years (around now) petaflops are "real close" but there's still no "global grid"**
- ***What happened?***

What Happened?

- It was easier to put together massive clusters than to get people to agree about how to share their resources
- For tightly coupled HPC applications, tightly coupled machines are still necessary
- Grids are inherently suited for loosely coupled apps (e.g., Monte Carlo, Parameter Sweep), or enabling access to machines and data, and the integration of the

QuickTime?and a TIFF (LZW) decompressor are needed to see this picture.

- **With Gilder's Law, bandwidth to the compute resources will promote thin client approach**
- **Example: *Tsubame* machine in Tokyo**

Virtualization and Cloud Computing

- *"There's Grid in them thar clouds!"*
  - I. Foster's blog, ANL & UC, Jan. 8, 2008
- Clouds have a very simple user API effectively hiding all the complexity of an *ad hoc grid* on the back-end
  - e.g., Amazon's EC2 & S3, IBM's Blue Cloud and others …
- ***If so, will this enable mass-market grids?***
  - **Users don't have to be aware of using "a grid"**
- ***If so, what does "cloud interoperability" require?***
  - **Is *virtualization* a means of achieving this?**
- ***Major opportunity for synergy***

How to Manage Sets of VMs in Distributed Environments?

- Virtual Workspaces?
  - Dynamically provisioned environments
- Implementation using VMs
  - Encapsulated configuration and fine-grained enforcement
- Easy way to build VMs?
  - rPath, OSFarm (CERN), Bcfg2 (ANL)
- Managing Virtual Clusters
  - *Contextualization*

Emerging new trends: Green Grid and Pay per … CPU/GB

- The Green Grid, IBM Big Green and other IT industry initiatives try to address current HPC limits in energy and environmental impact requirements
- Computer and data centers in energy and environmental favorable locations are becoming important
- Elastic computing, Computing on the Cloud, Data Centers and Service Hosting are becoming the new emerging solutions for HPC applications
- Many-multi-core and CPU accelerators are promising potential breakthroughs

New trends: Cloud computing and storage on demand

Cloud Computing: http://en.wikipedia.org/wiki/Cloud_computing

Amazon, IBM, Google, Microsoft, Sun, Yahoo, major 'Cloud Platform' potential providers

Operating compute and storage facilities around the world

Have developed middleware technologies for resource sharing

First services already operational - Examples:
Amazon Elastic Computing Cloud (EC2) -Simple Storage Service (S3)

New trends: Cloud computing and storage on demand

http://www.itjungle.com/bns/bns100807-story02.html
http://www.itjungle.com/tug/tug050307-story05
http://www.computerworld.com/action/article.do?command=viewArticleBasic&taxonomyName=mainframes_and_supercomputers&articleId=9073758&taxonomyId=67&intsrc=kc_top

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Amazon EC2 and S3

- EC2 Beta Service: Web-Services based
  http://www.amazon.com/gp/browse.html?node=201590011
  - $0.10 per hour - Small Instance (Default)
    - 1.7 GB of memory, 1 EC2 Compute Unit (1 virtual core with 1 EC2 Compute Unit), 160 GB of instance storage, 32-bit platform
    - EC2 Compute Unit (ECU) - One EC2 Compute Unit (ECU) provides the equivalent CPU capacity of a 1.0-1.2 GHz 2007 Opteron or 2007 Xeon processor
- S3 storage services: WS-based (REST and SOAP) http://www.amazon.com/S3-AWS-home-page-Money/b/ref=sc_fe_l_2?ie=UTF8&node=16427261&no=3440661&me=A36L942TSJ2AJA
  - *Storage: $0.15 per GB-Month of storage used*
  - *Data Transfer: $0.10 per GB - all data transfer IN*

    $0.18 per GB - first 10 TB / month data transfer OUT
    $0.16 per GB - next 40 TB / month data transfer OUT
    $0.13 per GB - data transfer out / month over 50 TB

Services may be given below actual cost for various reasons

EGEE cost estimation 1/2

Capital Expenditures (CAPEX):

a. Hardware costs: 55.000 CPUs - 25PB storage ~ in the order of 100M Euros (60-140M)
Depreciating the infrastructure in 5 years:25Meuros per year (10-15M to 40-45M)
b. Cooling and power installations (supposing existing housing facilities available)
25% of H/W costs: 25M, depreciated over 5 years: 5M Euros (2-8M)

Total: ~ 30M Euros / year (15M-45M)

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Slide Courtesy of Fotis Karayannis

EGEE cost estimation 2/2

Operational Expenditures (OPEX):

a. 20 MEuros per year for all EGEE costs (including site administration, operations, middleware etc.

b. Electricity ~10% of h/w costs: 10M Euros per year (other calculations lead to similar results)

c. Internet connectivity: Supposing no connectivity costs (existing over-provisioned NREN connectivity)

Total 30M / year

CAPEX+OPEX= 60M per year (45-75M)

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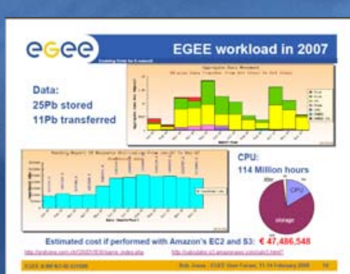
Slide Courtesy of Fotis Karayannis

EGEE if performed with Amazon EC2 and S3

Similar order of magnitude (~47M Euros), probably more cost effective



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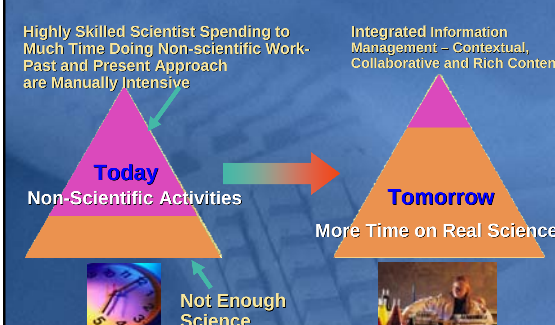
Slide Courtesy of Bob Jones

The Goal… More Time For Science



Conclusion 1/2

- We are at a flex point in the evolution of distributed computing (nothing new under the sun…)
- Grid remains a good solution for a reduced number of communities (and often for social/political reasons)
- Cloud computing and hosted services are emerging as the next incarnation of distributed computing with some obvious additional advantages (think of data centres located in Iceland or Siberia)

Conclusion 2/2

- The emphasis should move in making computing easier for the "normal scientist"
- We should critically re-think and avoid over engineered solutions (learn from the past experience)
- If we will be successful we will be able to enable major new scientific discoveries and industry and commerce will follow as it has always happened…

Thanks

Thanks to the organizers for the kind invitation and to all of you for your attention