

# *Cluster and Cloud Computing – Lecture 1 & 2*

Professor Richard O. Sinnott  
Director, Melbourne eResearch Group  
University of Melbourne  
[rsinnott@unimelb.edu.au](mailto:rsinnott@unimelb.edu.au)

MY DAD SAYS  
THE CLOUD IS  
THE ANSWER TO  
EVERYTHING,  
MISS.



TEST  
1 CLOUD  
2 CLOUD  
3 CLOUD  
4 CLOUD



*Director,  
eResearch  
University of  
Melbourne*

*CEO Own  
Company (real  
time  
systems/telecoms)*

*PhD Distributed  
Systems*

**Multiple PhD/MSc**  
*supervised in this  
area*

*MSc Software  
Engineering*

# Richard



*Technical Director,  
Bioinformatics  
Research Centre  
University of Glasgow*

*Post-doc  
GMD Fokus  
Berlin*

*Distributed  
Systems  
Standards  
creator*

*Chair in Applied  
Computing Systems,  
University of  
Melbourne*

*BSc Theoretical  
Physics*

*Lecturer*

*Technical Director  
National e-  
Science Centre,  
University of  
Glasgow*

*MSc Statistics*

# Luca



*IT Consultant for the  
World Bank, United  
Nations, European  
Union, Asian  
Development Bank*

*Committer at the  
Apache Software  
Foundation*

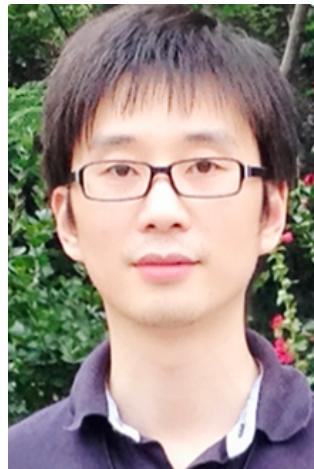
*GIS Software  
Engineer, ESRI*

*Data Architect,  
AURIN Project*

# Yao Pan

University of  
Melbourne  
Doctor of  
Philosophy (PhD)

*Cloud Computing  
Container and  
Orchestration tool  
benchmarking*



devOps  
(SWARM,  
replicATS,  
HATS)

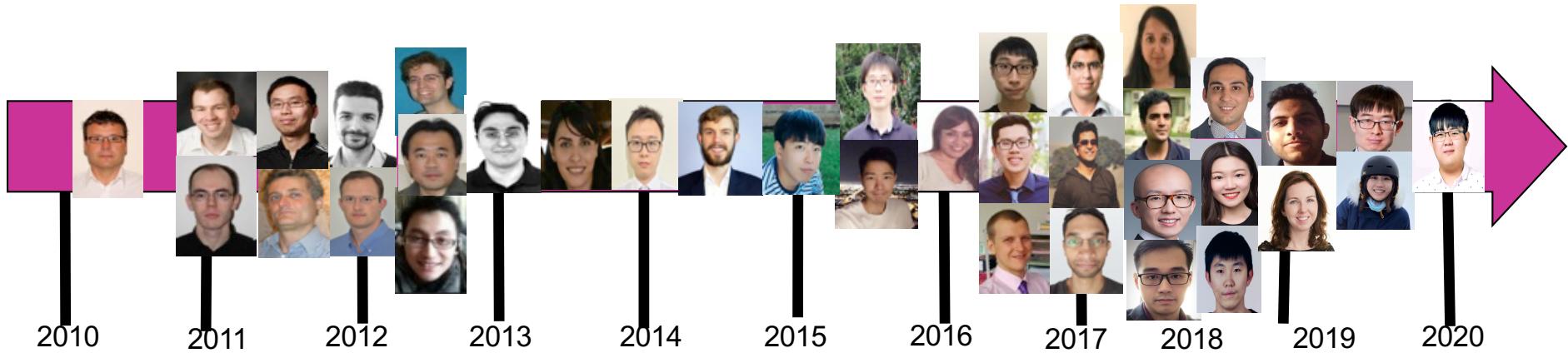
Master of Science IT  
UniMelb

COMP90024 graduate



# Melbourne eResearch Group (2020)

(<http://eresearch.unimelb.edu.au>)



Funding (>\$230m) from many funding sources (DARPA, IARPA, DSTG, EU, JDRF, HCT, NHMRC, ARC, Dept Innovation, Dept Environment, DELWP, VicHealth, Commercial, ...)

**700+ Masters dissertations**

**ALL ABOUT APPLIED COMPUTING**

# Course Contents

- Lectures 1 & 2 – 3<sup>rd</sup> March
  - Information Session & How we got here (Distributed Systems, Grid...)
    - Richard Sinnott
    - NO workshops
- Lectures 3 & 4 - 10<sup>th</sup> March
  - Domain Drivers – tour of some big data projects
    - Richard Sinnott
    - Workshop/demo on driving AURIN (needed for assignment 2)
- Lectures 5 & 6 – 17<sup>th</sup> March
  - Parallel Systems, Distributed Computing and HPC/HTC
    - Richard Sinnott
    - Workshop on Git (Yao Pan)
- First assignment handed out 18<sup>th</sup> March

(Warning SPARTAN & volume students!!! Team of two for assignment!!!)
- Lectures 7 & 8 – 24<sup>th</sup> March
  - HPC @ UniMelb and Practicalities of HPC/HTC
    - Lev Lafayette
    - Linux / HPC practicalities and welcome to Spartan!!!
    - Workshop on using SPARTAN & using mpi4py on SPARTAN

# Course Contents...ctd

- Lectures 9 & 10 – 31<sup>st</sup> March
  - Cloud Computing – Programming Clouds: Getting to grips with the UniMelb Research Cloud!
    - Richard Sinnott & Yao Pan
    - Introduction to Cloud Computing
    - Getting to grips with OpenStack/UniMelb Research Cloud
    - Workshop on Scripting the Cloud (Introduction to Ansible demonstration) (Yao Pan)
- Lectures 11 & 12 – 7<sup>th</sup> April
  - ReST, Twitter (Needed for Assignment II) & Docker
    - Richard Sinnott & Yao Pan & Jinyoung Kim
    - Web services and Representational State Transfer (ReST)
    - Examples of coding/demonstrating ReST and Twitter (Jinyoung)
    - Introduction to Containers (Yao Pan)
    - Workshop on Demonstration of Docker/Docker SWARM/Kubernetes (Yao Pan)

First assignment due in on 7<sup>th</sup> April

Second Programming Assignment handed out 7<sup>th</sup> April

Easter Break

# Course Contents... ctd

- Lectures 13 & 14 – 21<sup>st</sup> April
  - Big Data and Related Technologies
    - Luca Morandini (Data Architect, AURIN)
    - Big Data V-challenges, CAP Theorem and noSQL technologies
    - Workshop on CouchDB via Docker (Luca)
- Lectures 15 & 16 – 28<sup>th</sup> April
  - Cloud Underpinnings and Other Things
    - Richard Sinnott & Yao Pan & Luca Morandini
    - Virtualisation background (Rich)
    - Compare and Contrast AWS with NeCTAR (Yao Pan)
    - Workshop on serverless architectures and demonstration of openFaaS (Luca)
- Lectures 17 & 18 – 5<sup>th</sup> May
  - Big Data Analytics
    - Luca Morandini
    - Big Data Technologies – Hadoop, HDFS, Spark, ...
    - Workshop on Hadoop cluster on Cloud (Luca)

# Course Contents... ctd

## Second Programming Assignment due in 12<sup>th</sup> May

- Lecture 19 & 20 – 12<sup>th</sup> May
  - You (+ pizzas!?! If allowed back on campus...)
    - 12 teams randomly chosen to present their assignment II
    - 15minutes each
- Lecture 21 & 22 – 19<sup>th</sup> May
  - Security and Clouds & demonstration of assignments
    - Richard Sinnott & You
    - 8 more teams randomly chosen to present their assignment II
    - 15minutes each
- Lecture 23 & 24 – 26<sup>th</sup> May
  - Subject Review and Working Through Past Papers
  - Feedback and SES
    - Richard Sinnott

# At the end of the course....

- You will...

- Understand more about the history of cluster and Cloud computing and the current state of the art
- Know more of the domain drivers that are shaping this area – especially the current flavour of the month “big data”
- Understand more on parallel systems, multi-core software development
- Be able to use HPC/HTC systems
- Be able to use Cloud resources
- Be able to develop applications running on the Cloud
- Learning about next generation data management systems
- Be savvy with web based systems development
- Work on a non-trivial software system development as part of a team (=how it nearly always works in the real world!)
- Learn more about the pulse of cities!
- Have software experiences that are in great demand  
Many of my ex-students have jobs in this space (reference machine!!!)
- Have visited a data centre

(if allowed with CV-19!!!)

# Lecture Slides

- On the web before lecture
- They may be updated slightly before the lecture to reflect recent developments
  - Or cover materials that folk want more details on from previous lectures
- Other sources of materials
  - Key papers
  - Interesting articles
  - Snippets from the web
  - Crib sheets for Cloud Computing
  - Crib sheets for HPC

# Course Assessment

- Assignments
  - During semester worth 50%
  - Expected to take about 40+ hours
- Written examination
  - A written examination (two hours) at the end of the semester worth 50%
- All components must be completed satisfactorily to pass the subject
  - At least 50% in all assignments + exam

# Assessments

- (Mini Team) Assignment 1 – 10 marks
  - HPC exercise (big(gish) data processing)
- (Bigger Team) Assignment (40 marks)
  - Social media analytics on the Cloud
  - Team-based approach
  - Self organise vs be organised
    - Importance of being a team player!
    - Peer review...
- Online Exam – 50 marks
- Note
  - Importance of original work
    - Collusion “seriously frowned” upon
    - Note several students last year got 0 for 1<sup>st</sup> assignment for not listening to this!!!

# Computational Resources

- HPC systems
  - SPARTAN cluster – general purpose cluster for UniMelb
    - Provisioned last year
    - Reasonable grunt, but... UniMelb!
    - **Warning!!!**
- Cloud resources
  - UniMelb Research Cloud
    - (<https://dashboard.cloud.unimelb.edu.au/>)
  - (alas NeCTAR – [www.nectar.org.au](http://www.nectar.org.au) no longer possible)
    - **UniMelb resources specifically set aside for course!**

# Workshops / Lab Sessions...?

- In this course workshops are really demonstrations
  - Materials made available before the workshop for you to follow during workshop (or at your own time at a later date)
  - We will teach the theory and then do live demonstrations of solutions
  - There are no hands-on/guided lab sessions
  - Any/all questions/discussions via the LMS
  - I live on Canvas for the next 3 months

# Final Comments

- This is not an easy course!
- I assume that you are already reasonably savvy software engineers, but...
- You'll be exposed to things that are in the sys-admin space
  - Learning how to write scripts
  - Configure network settings
  - Mount volumes
  - Deploy systems
  - ...
- You should be able to work things out yourselves
- MANY students get jobs in this space
  - it is in the sweet spot of what industry wants/needs
  - Ex-students now working for Google, AWS, ...

Questions?

# The Buzz

## Top 10 Strategic Technology Trends for 2013

1. Mobile Devices Battles
2. Mobile Applications & HTML5
3. Personal Cloud
4. Internet of Things
5. Hybrid IT & Cloud Computing
6. Strategic Big Data
7. Actionable Analytics
8. Mainstream In-Memory Computing
9. Integrated Ecosystems
10. Enterprise App Stores



Gartner

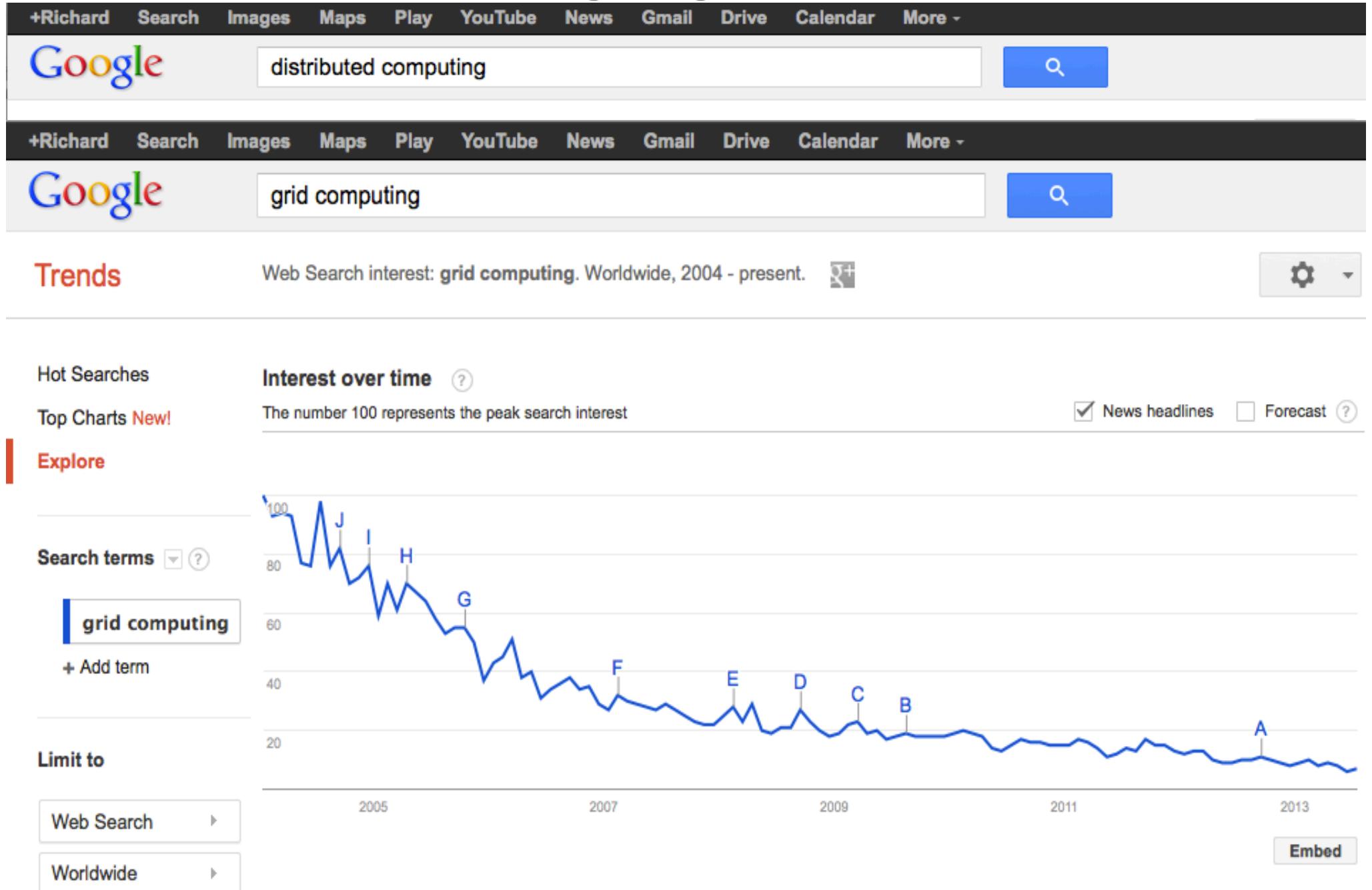
Big Data Drives Rapid Changes in Infrastructure and  
\$232 Billion in IT Spending Through 2016

12 October 2012

Mark A. Beyer John-David Lovelock Dan Sommer Merv Adrian

Big data has become a major driver of IT spending. The benefits to organizations for adding big data to their information management and analytics infrastructure will force a more rapid cycle of replacing existing solutions.

# The not so long ago buzz...



# The latest buzz...

+Richard Search Images Maps Play YouTube News Gmail Drive Calendar More

Google cloud computing

+Richard Search Images Maps Play YouTube News Gmail Drive Calendar More

Google big data

+Richard Search Images Maps Play YouTube News Gmail Drive Calendar More

Google data analytics

## Trends

Web Search interest: data analytics. Worldwide, 2004 - present.



Hot Searches

Top Charts New!

Explore

Search terms ?

**data analytics**

+ Add term

Limit to

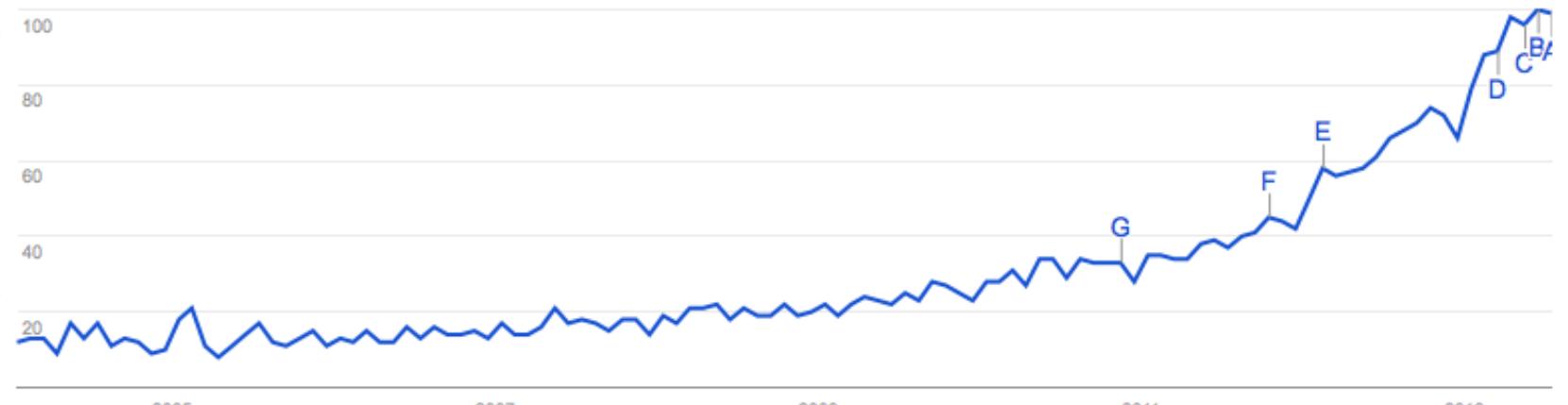
Web Search ▶

Worldwide ▶

### Interest over time ?

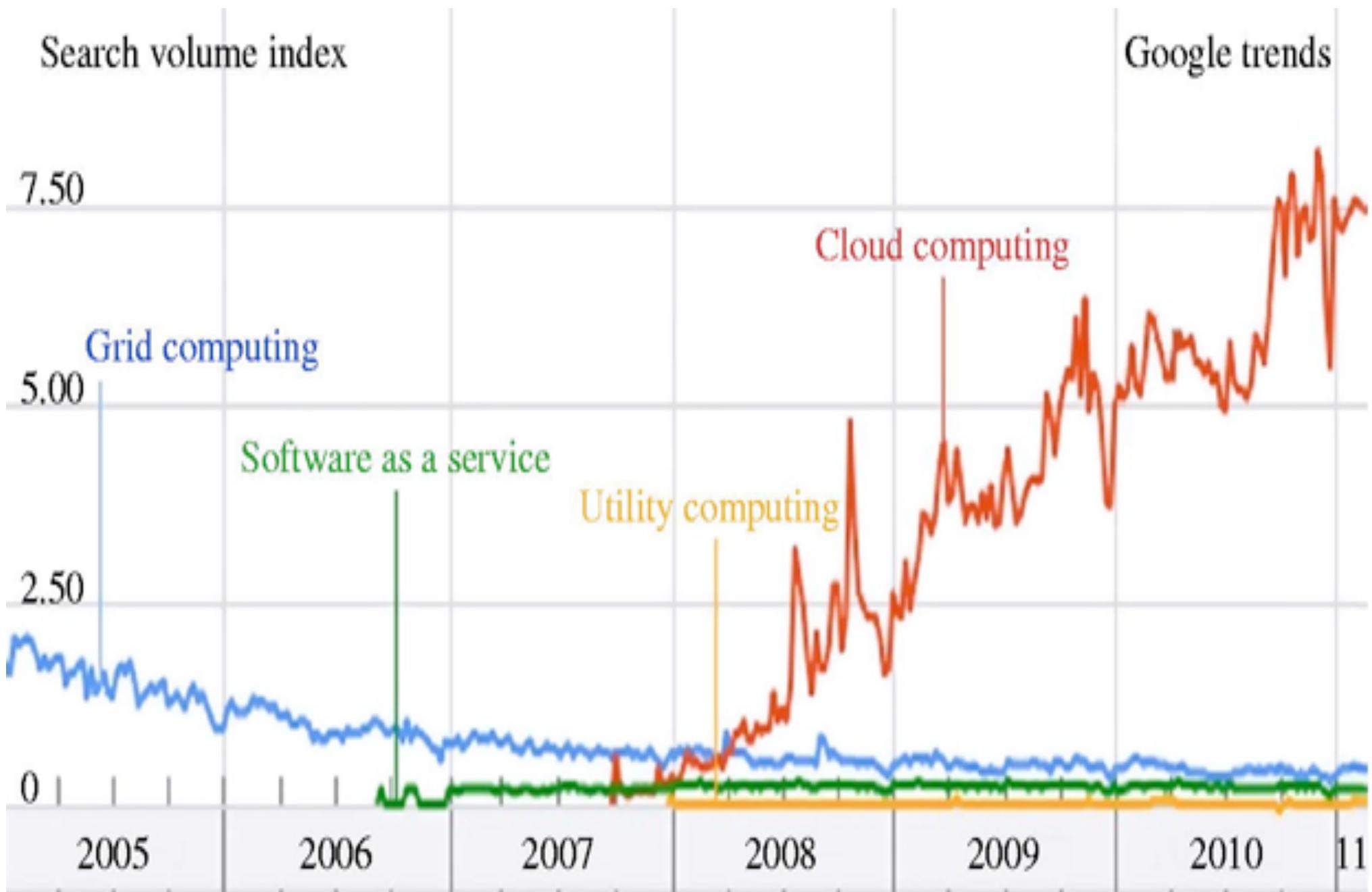
The number 100 represents the peak search interest

News headlines  Forecast ?

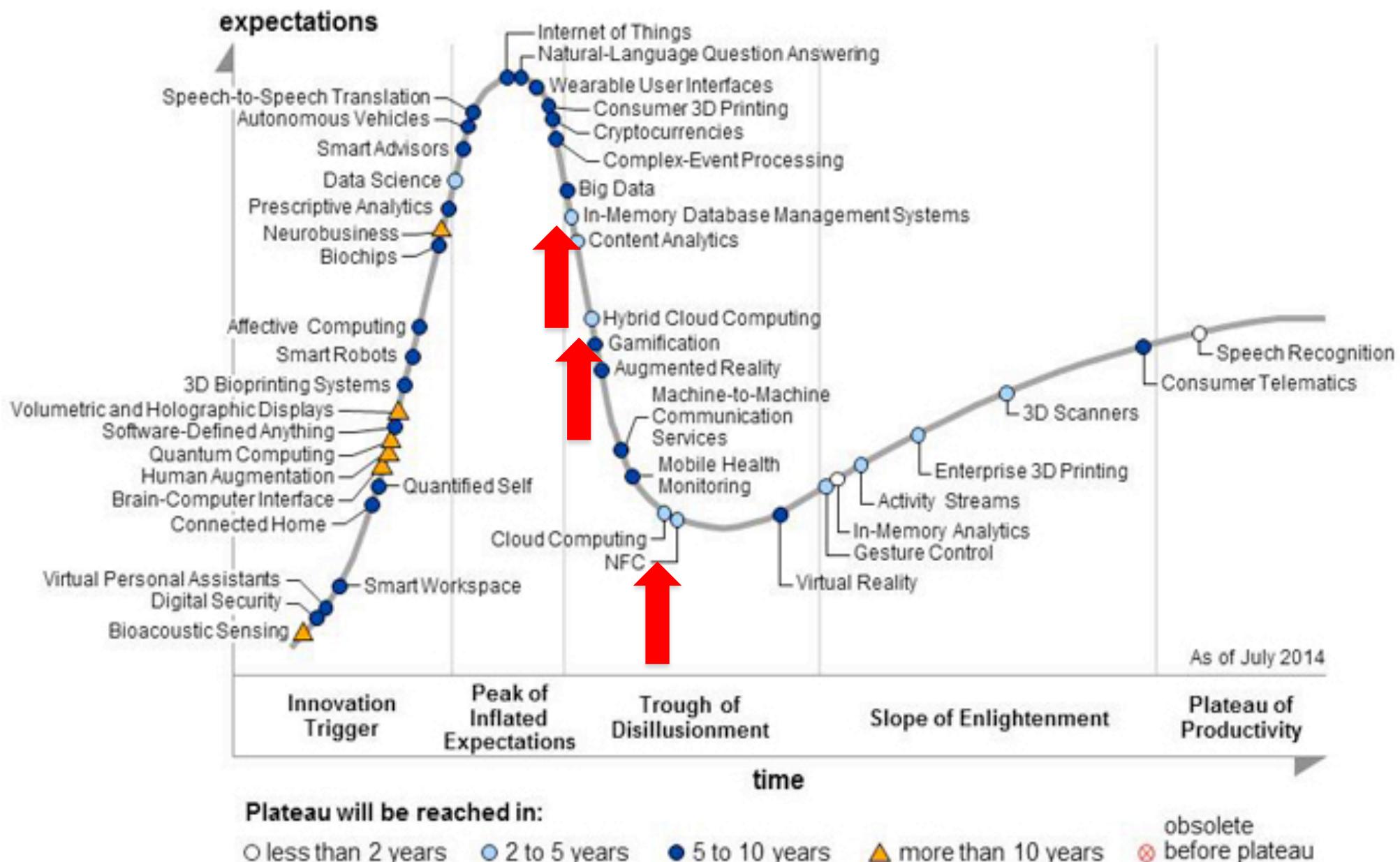


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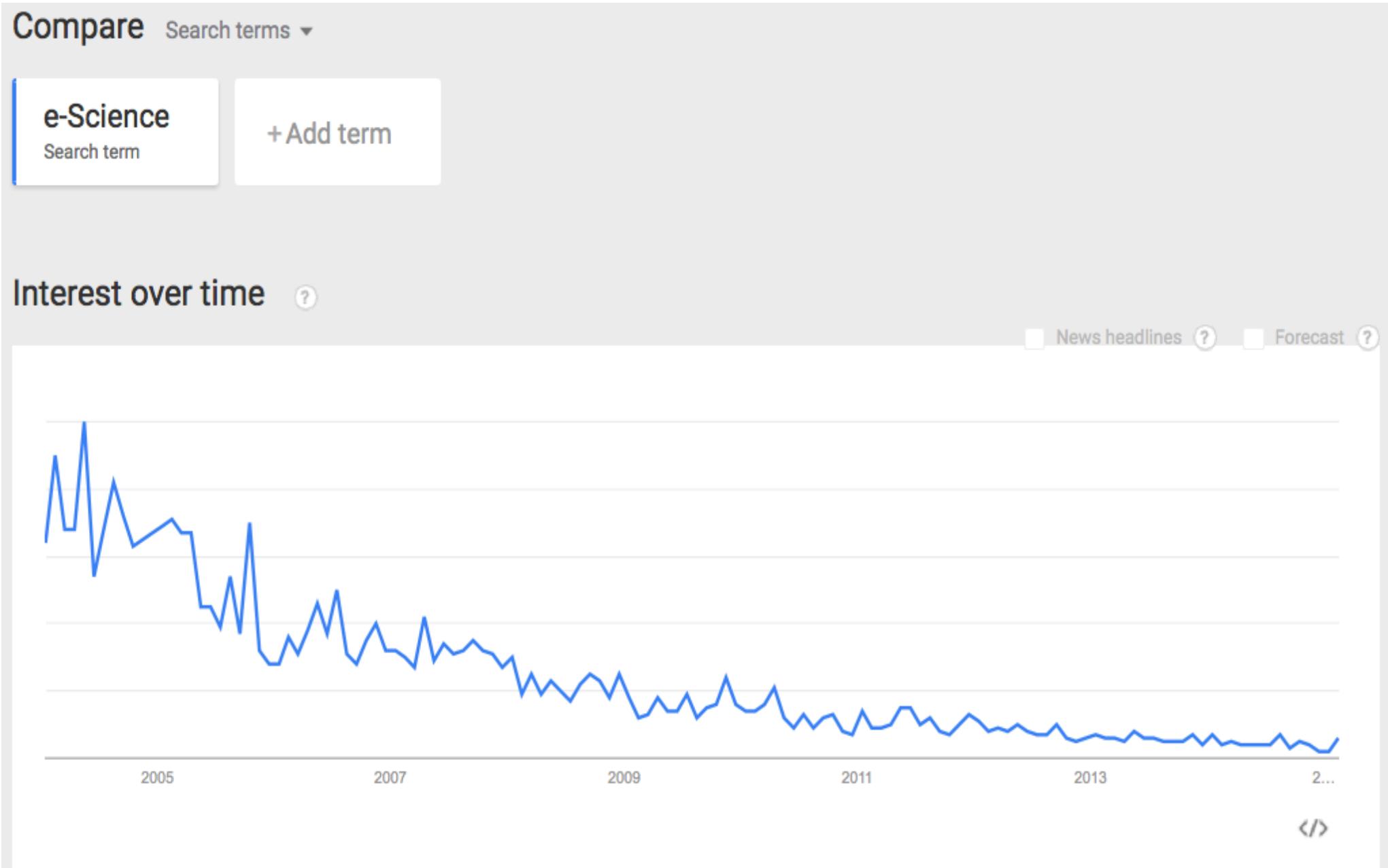
# The cycles we go through...



# The Hype Cycle... (Gartner 2015)



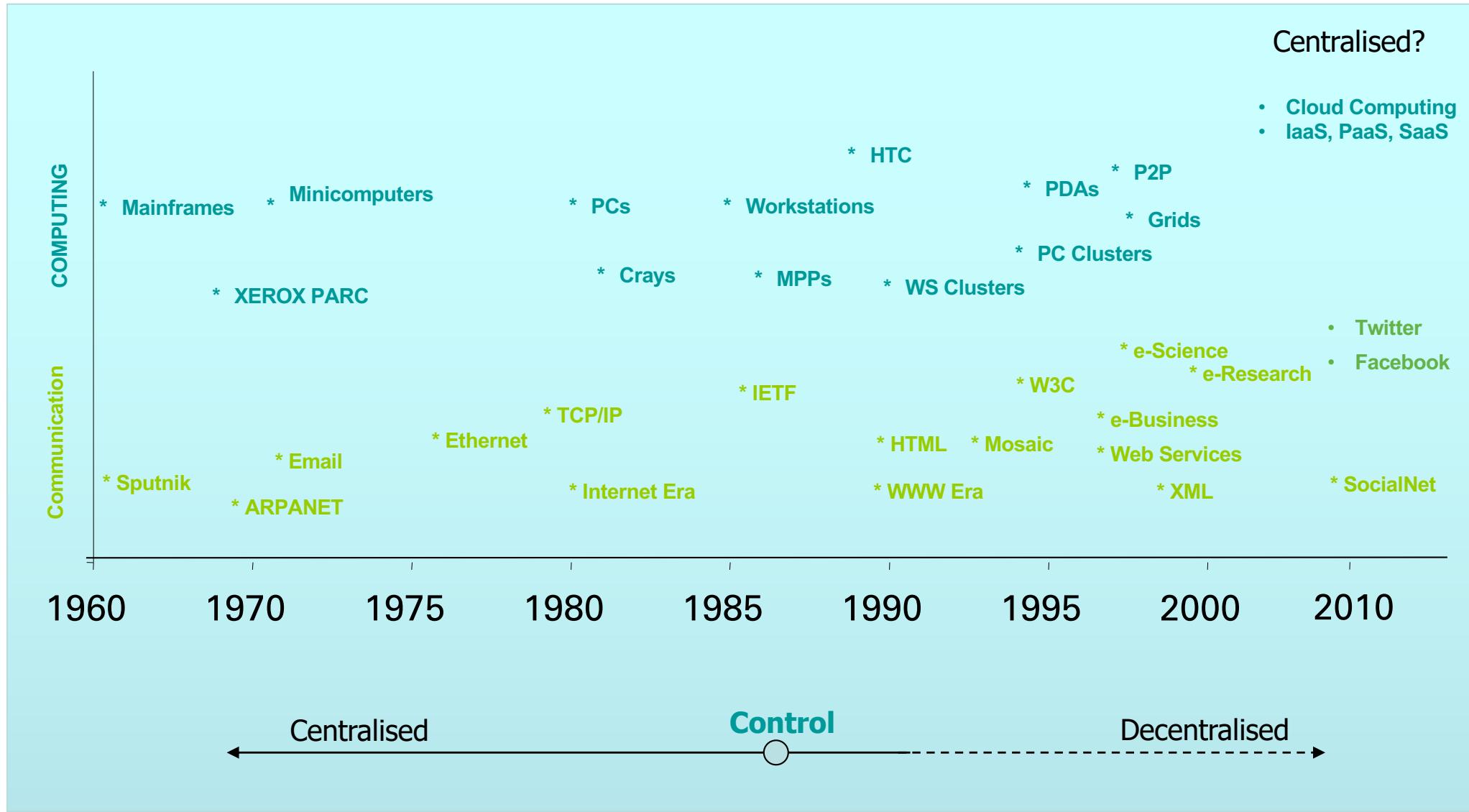
# Not just IT trends...



# Lessons...

- Don't be fooled by the hype
  - Marketing and business drivers
- The basic principles of software engineering persist
  - NeSC -> MeG experiences
    - Data processing,
    - Distributed systems,
    - Security ...
- Learning from experiences is key
  - But obviously working on/with the bleeding edge can do no harm (for grants or on CVs)

# Computing and Communication Technologies (r)evolution: 1960-...!



# Cloud Computing....

- ...is a colloquial expression used to describe a variety of different types of computing concepts that involve a large number of computers that are connected through a real-time communication network (typically the Internet). *Cloud computing is a jargon term without a commonly accepted non-ambiguous scientific or technical definition.* In science, cloud computing is a synonym for distributed computing over a network and means the ability to run a program on many connected computers at the same time. The popularity of the term can be attributed to its use in marketing to sell hosted services in the sense of application service provisioning that run client server software on a remote location.

# Cloud Computing....

- ...Proponents claim that cloud computing allows companies to avoid upfront infrastructure costs, and focus on projects that differentiate their businesses instead of on infrastructure. Proponents also claim that cloud computing allows enterprises to get their applications up and running faster, with improved manageability and less maintenance, and enables IT to more rapidly adjust resources to meet fluctuating and unpredictable business demand. Cloud providers typically use a "pay as you go" model. This can lead to unexpectedly high charges if administrators do not adapt to the cloud pricing model.

[Wikipedia 2016](#)

# Cloud Characteristics

- Five essential characteristics:
  - *On-demand self-service*. A consumer can provision computing capabilities as needed without requiring human interaction with each service provider.
  - *Networked access*. Capabilities are available over the network and accessed through standard mechanisms that promote use by heterogeneous client platforms.
  - *Resource pooling*. The provider's computing resources are pooled to serve multiple consumers using a multi-tenant model potentially with different physical and virtual resources that can be dynamically assigned and reassigned according to consumer demand.
  - *Rapid elasticity*. Capabilities can be elastically provisioned and released, in some cases automatically, to scale rapidly upon demand.
  - *Measured service*. Cloud systems automatically control and optimize resource use by leveraging a metering capability at some level of abstraction appropriate to the type of service.
    - National Institute of Standards and Technology

# Cloud Computing....

- Flavours

- Compute clouds

- Amazon Elastic Compute Cloud
  - Azure
  - ...

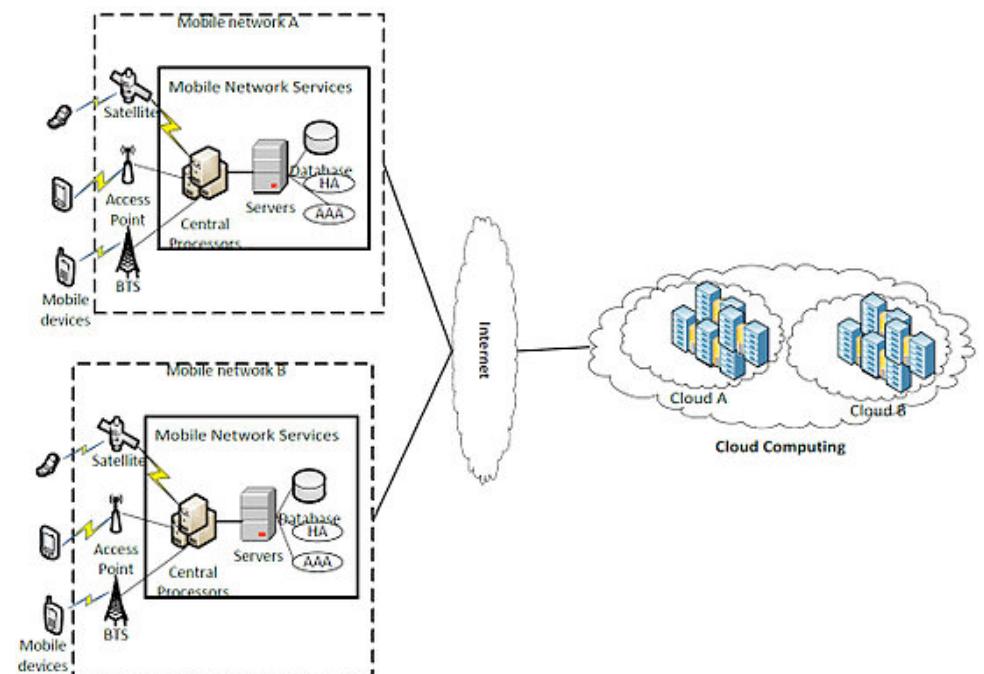
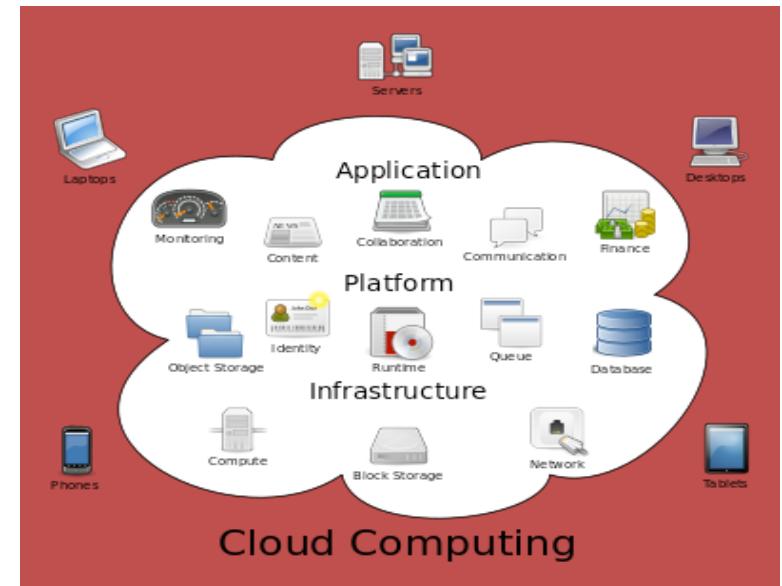
- Data clouds

- Amazon Simple Storage Service
  - Google docs
  - iCloud
  - Dropbox
  - ...

- Application clouds

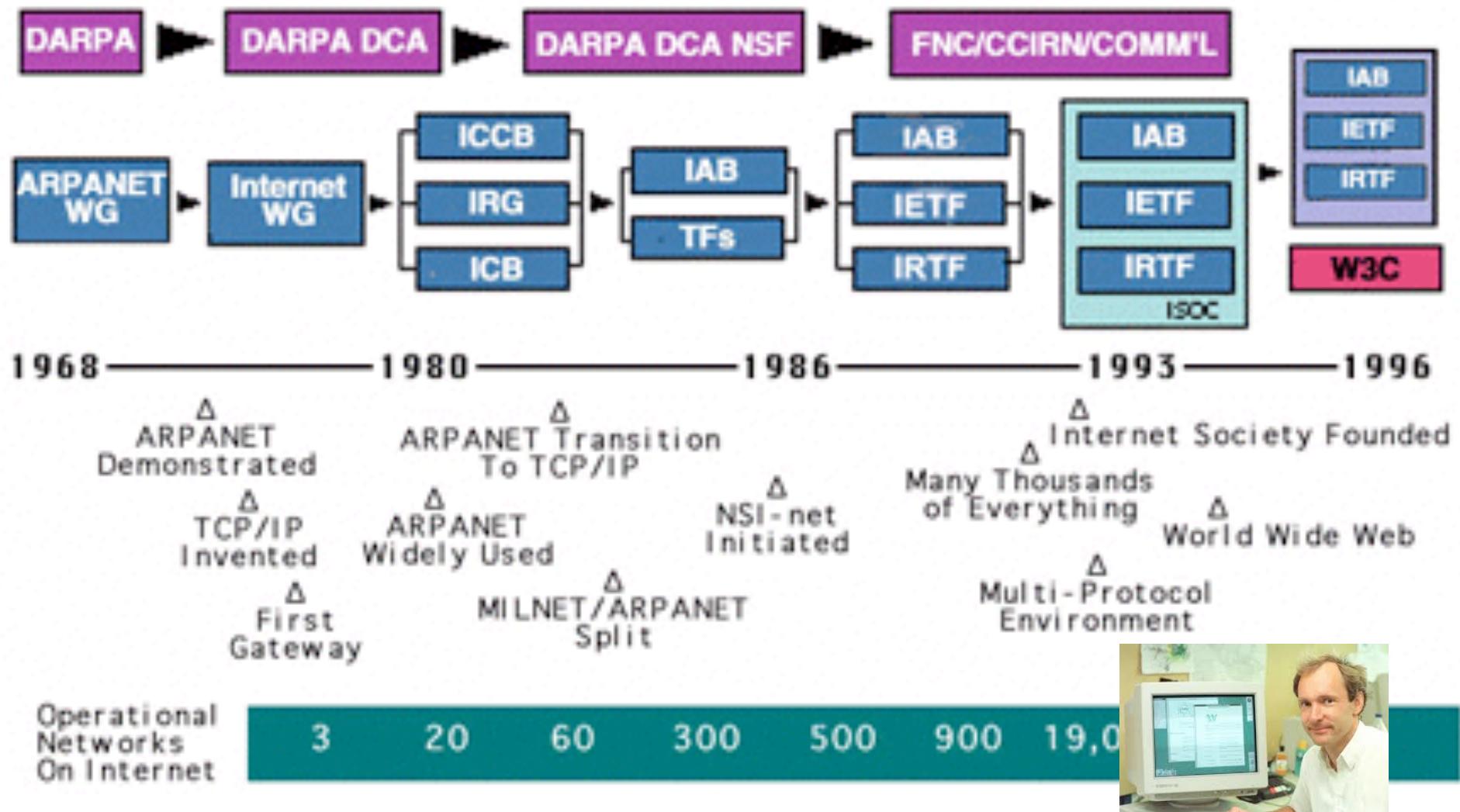
- App store
  - Virtual image factories
  - Community-specific

- Private, public, hybrid, mobile, health, ... clouds
  - Edge, Fog, IoT, ...



Break

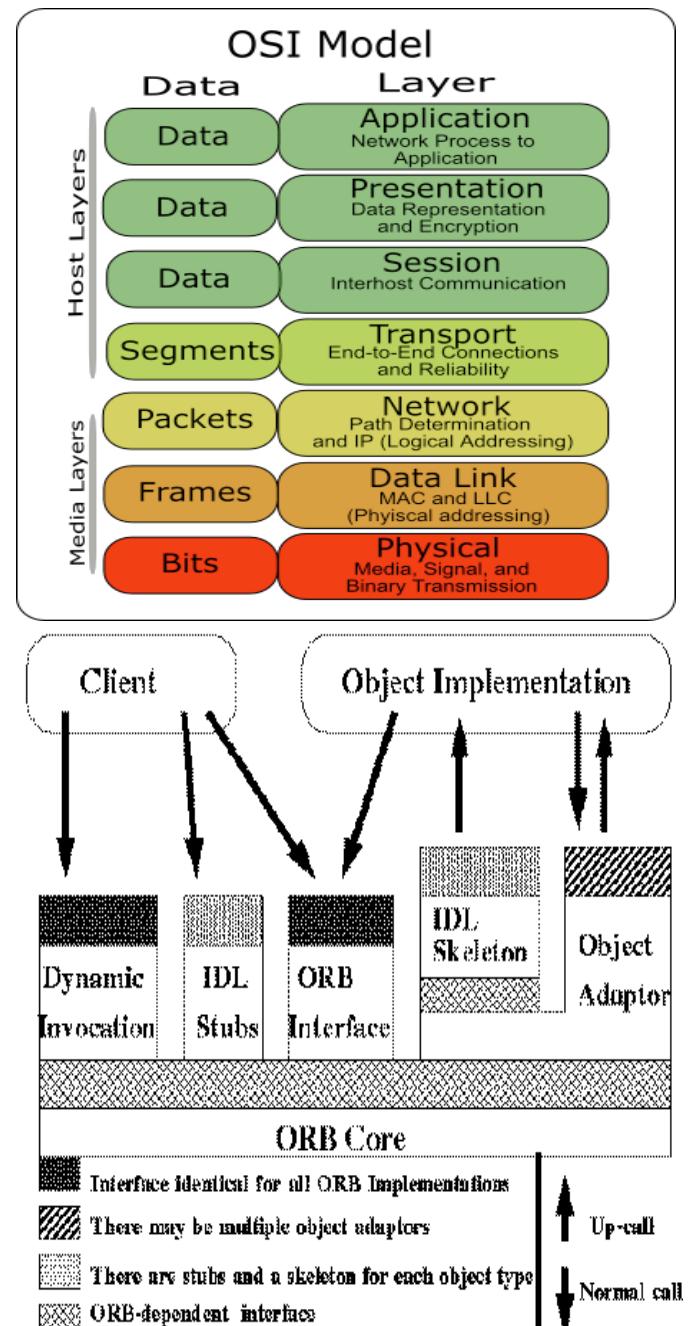
# In the beginning....



- <http://www.internetsociety.org/internet/what-internet/history-internet/brief-history-internet>

# Distributed Systems - A Very Brief History

- Once upon a time we had standards
  - With very detailed conformance, consistency and compliance demands
    - Services, protocols, inter-operability, ...
- Then we had more standards
  - Open distributed processing
  - With slightly less rigorous compliance demands
    - OMG Common Object Request Broker Architecture (CORBA)
    - Distributed Computing Environment
    - Multiple technologies
      - Client server, remote procedure call, ...



# Key distributed systems focus mid-90s

- Transparency and heterogeneity of computer-computer interactions
  - finding/discovering resources (trader!),
  - binding to resources in real time,
  - run time type checking,
  - invoking resources
  - dealing with heterogeneity of systems
    - applications and operating systems
  - focused on computer-computer interaction

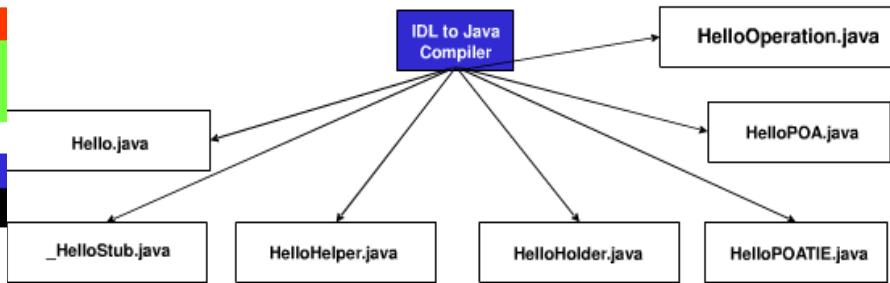
Client.java (Simplified)

```
public class Client {  
    public static void main(String[] args) {  
        String iorFile = "week1.ior";  
        try {  
            File file = new File(iorFile);  
  
            if (!file.exists()) {  
                System.err.println("Error: File " + iorFile + " does not exist!!");  
                System.exit(1);  
            }  
  
            ORB orb = ORB.init(args, null);  
  
            BufferedReader reader = new BufferedReader(new FileReader(file));  
            String string_ref = reader.readLine();  
            reader.close();  
            org.omg.CORBA.Object obj = orb.string_to_object(string_ref);  
  
            Hello server = HelloHelper.narrow(obj);  
            String response = server.getTime();  
            System.out.println(response);  
            ...  
        }  
    }  
}
```

Step of Defining IDL

1. Write the IDL as an interface to the object
2. Compiling Hello IDL

```
$ idl -ir -d generated hello.idl
```



Server.java (Simplified)

```
public class Server {  
    public static void main(String[] args) {  
        String iorFile = "week1.ior";  
        org.omg.CORBA.ORB orb = org.omg.CORBA.ORB.init(args, null);  
  
        // Get reference to the root POA  
        POA rootPoa =  
            POAManager.narrow(orb.resolve_initial_references("RootPOA"));  
        // Activate the POA Manager - else no requests will be processed!!  
        rootPoa.the_POAManager().activate();  
  
        HelloImpl servant = new HelloImpl();  
  
        // Create a CORBA reference for the servant  
        org.omg.CORBA.Object obj = rootPoa.servant_to_reference(servant);  
  
        PrintWriter writer = new PrintWriter(new FileWriter(iorFile));  
        writer.println(orb.object_to_string(obj));  
        writer.flush();  
        writer.close();  
  
        // OK, now just sit back and wait for the action...  
        orb.run();  
        ...  
    }  
}
```

# Challenges of earlier distributed (networked) system implementations

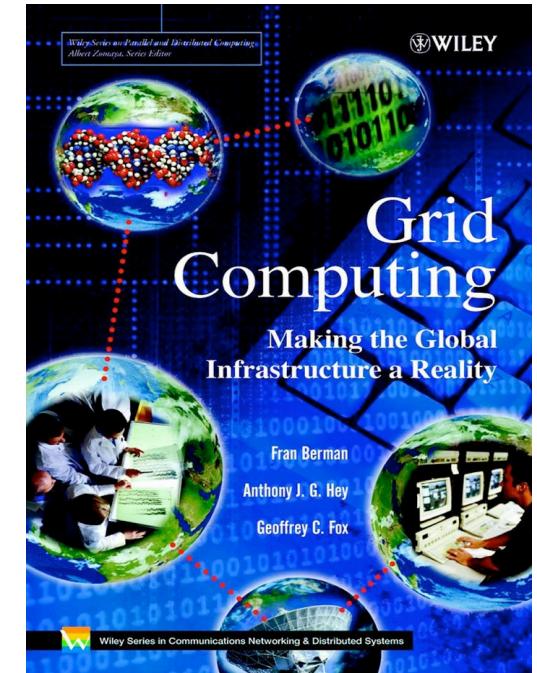
- Complexity of implementations
  - Middleware bloat and lock-in
  - Vision and challenges of reality
- Vendor specific solutions
  - AnsaWare
  - IBM Distributed SOM / Component Broker
  - Microsoft Network OLE
  - IONA Orbix
  - Visigenic Visibroker
  - BEA ObjectBroker
  - HP ORBPlus and Distributed SmallTalk
  - Expersoft PowerBroker
  - Other ORB's
    - Less mature standards
- Scale of the problem area
  - Telecoms, banking, ...
  - The growth (boom!) of the web

CORBA Evolution		
CORBA 1.0 Services	CORBA 2.0 Services	CORBA 3.0 Services
Basic ORB Persistence	IIOP Licensing	Messaging (MOM) <b>Mobile Agents</b>
IR, BOA	Federated IR Compound Documents	Portability (POA) CORBA/ DCOM
C Bindings	C++ Trader Bindings	Multiple Automatic Interfaces Persistence
Naming	Transactions Security	Business Objects IOP Firewall Sup.
Events	Concurrency Collections	Java Binds (Caffeine) <b>Workflow Facility</b>
Life-Cycle	Externalization Time	Object-by-Value Domain-level Frameworks



# Distributed Systems History...ctd

- Enter the web era
  - My first ftp 1993 put/get files to/from Australia
  - Then the web pretty much exploded
- Peer-peer processing
  - File sharing ...
- Scaling of...
  - machines,
  - people,
  - domains of application
- Grid computing
  - From computer-computer focus
  - To organisation-organisation focus



# e-Research and the Grid

'e Research is about global collaboration in key areas of science, and the next generation of infrastructure that will enable it.'

Research will change the dynamic of the way science is undertaken.'

John Taylor

Director General of Research Councils  
Office of Science and Technology



## Grid is infrastructure used for e-Science

- Power Grid Metaphor: compute and data resources on demand  
Major investment by UK Govt (£250m+) to realise this vision
  - Across ALL Research Councils (+ EU + industry + ...)
  - Cyber-infrastructure, European Grid Initiative, Superscience,

# The Grid Metaphor



# Overcoming heterogeneity...

## Guide to International Plugs & Sockets



[WWW.interpower.com](http://WWW.interpower.com)  
formerly Panel Components Corporation

P.O. Box 115, Oskaloosa, IA 52577 (USA)  
Call: (641) 673-5000 Fax: (641) 673-5100  
E-mail: info@interpower.com

Toll-free (U.S./Can./P.R./V.I.)  
Call toll-free: (800) 662-2290  
Fax toll-free: (800) 645-5360

Rev. 8-05

### Continental European

For use in Germany, Austria, Finland, the Netherlands, Norway, Sweden, France/Belgium, and other countries utilizing the CEE 7 standard. (Note: Sweden requires use of socket with separate mounting bracket. France/Belgium require use of different socket types.) The CEE 7/7 is non-polarized.



For black (88010920) or brown (88010820) plug



For black (88010611) socket



For black (88010210) socket



For black (88010390) socket



For black (88010350) socket

### Europoplugs

Interpower Europoplugs are wirable. Once shut, they cannot be reopened. For use in Germany, Austria, Finland, the Netherlands, Norway, Sweden, France/Belgium, and other countries utilizing the CEE 7 standard.



<b>Plug with Strain Relief</b>
Part Number <b>88010801</b>
Type CEE 7/7
Color Gray
Rating 16A/250VAC
Approvals

<b>Screw-Mount Socket</b>
Part Number <b>88010610</b>
Type CEE 7
Color Ivory
Rating 16A/250VAC
Approvals

<b>Panel-Mounting Socket</b>
Part Number <b>88010500</b>
Type CEE 7
Color White
Rating 16A/250VAC
Approvals

<b>Duplex Socket</b>
Part Number <b>88010200</b>
Type CEE 7
Color Ivory
Rating 16A/250VAC
Approvals

<b>Socket with Strain Relief</b>
Part Number <b>88010400</b>
Type CEE 7
Color Ivory
Rating 16A/250VAC
Approvals

<b>Panel-Mount Socket</b>
Part Number <b>88010300</b>
Type CEE 7
Color Gray
Rating 16A/250VAC
Approvals

### French/Belgian

France and Belgium use a variation of the CEE 7 socket which contains a male grounding pin and shuttering. The CEE 7/7 plug used throughout Continental Europe has a receptacle for this pin and can be used in France and Belgium. France and Belgium now require safety shuttering on all of their sockets.



For black (88010230) plug



For black (88010220) socket



### Italian

<b>Plug</b>
Part Number <b>88010771</b>
Type CEI 23-16/VII
Color Gray/Charcoal
Rating 10A/250VAC
Approvals

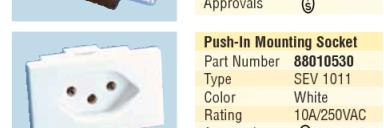


### Japanese Grounding Adapter

When exporting products to Japan or other parts of the world (such as Central America) where 2-wire, non-polarized mains power is typical, include a grounding adapter to ensure that products will be grounded. Shown below is a 3-wire to 2-wire adapter with non-polarized blades.



<b>Grounding Adapter</b>
Part Number <b>88100011</b>
Type JIS 8303
Color Black
Rating 15A/125VAC
Approvals



### United Kingdom/Ireland

Line and neutral contacts of socket are shuttered to minimize accidental entry of an object other than mating plug.



Plug with integral 13A fuse.  
For black (88040021)



Line and neutral contacts are shuttered. For black (88010980)

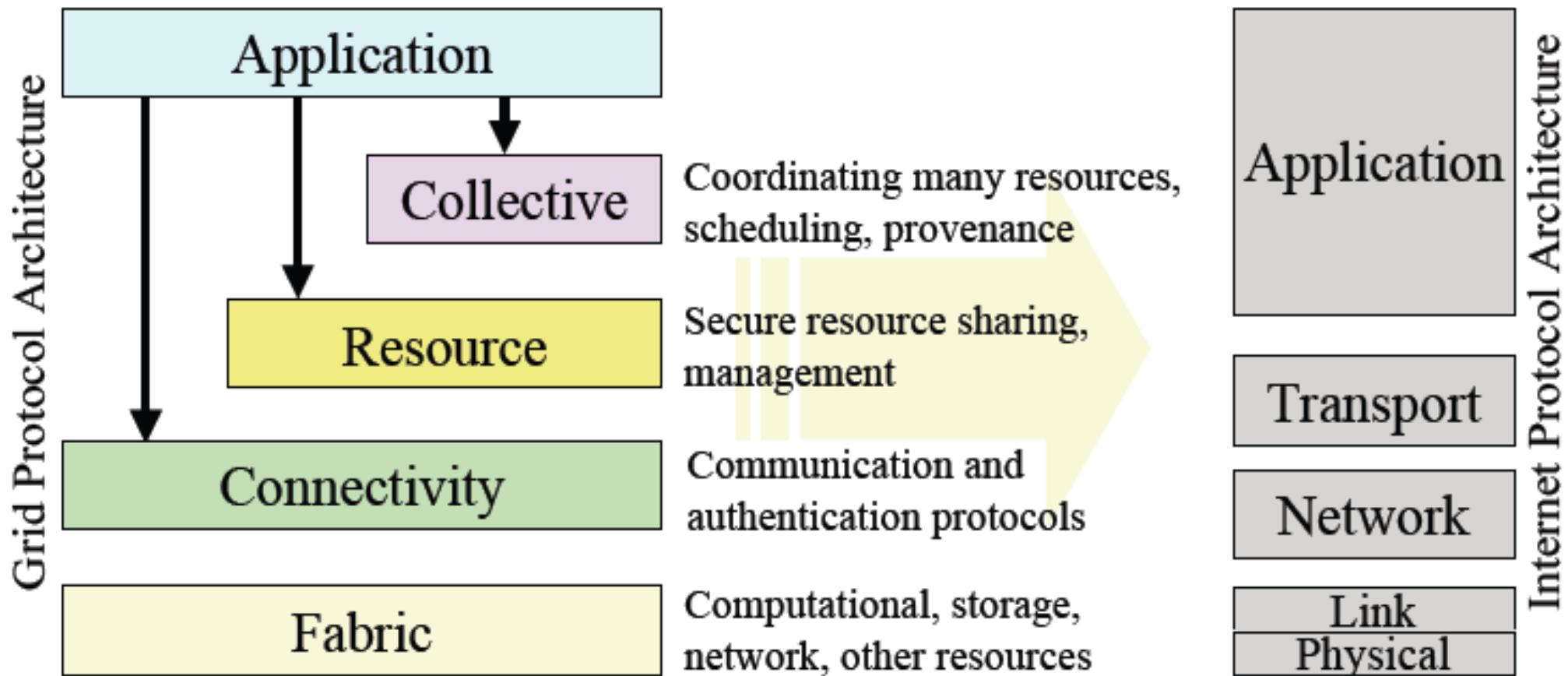
This is only a small sample of Interpower international rewirable plugs and sockets. North American plugs and sockets also available. For specifications of these and additional plugs and sockets, see our web site ([www.interpower.com](http://www.interpower.com)) or catalog. Call for a free copy of Interpower's *Export Designer's Reference & Catalog 10*.



### Order direct from our warehouse in Oskaloosa, IA

- No minimum order requirement
- Same day shipment available for stock item orders received by 6:00 p.m. Central Time
- Most items available from stock
- Free evaluation samples
- Assembly services available
- Technical support available

# Typical (Compute) Grid Architecture



# Grid Standards

- Even increasing numbers and ever decreasing understanding and acceptance/adoption by implementers
  - Global Grid Forum
  - Open Grid Forum
  - OASIS
  - IETF
  - W3C
  - ...



+ many more...

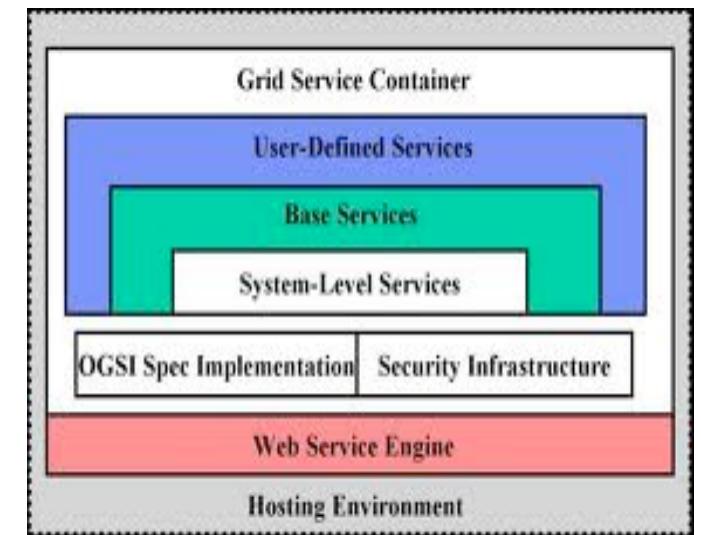
# Grid Technologies... (~2002+)

- Globus Toolkit Project – [www.globus.org](http://www.globus.org)
  - GT2 - Complex software system for large, scale distributed software systems development
    - Physiology of the Grid (Foster et al)  
[www.globus.org/alliance/publications/papers/ogsa.pdf](http://www.globus.org/alliance/publications/papers/ogsa.pdf)
      - *The Open Grid Services Architecture*
    - The Anatomy of the Grid: Enabling Scalable Virtual Organizations (Foster et al)  
<http://dl.acm.org/citation.cfm?id=1080667>
  - MANY MB of source code
    - Many software engineers worked in making this
      - and many more in making it work!!!



# Grid Technologies... (~2004+)

- Move to service-based approach
  - The Open Grid Services Infrastructure (OGSI)
  - [www.globus.org/toolkit/draft-ggf-ogsi-gridservice-33 2003-06-27.pdf](http://www.globus.org/toolkit/draft-ggf-ogsi-gridservice-33_2003-06-27.pdf)
- GT3 – core technologies re-factored as “Grid Services”
  - stateful Web services
  - extension of Web services interfaces
  - asynchronous notification of state change
  - references to instances of services
  - collections of service instances
  - service state data augmenting constraints of XML Schema definition



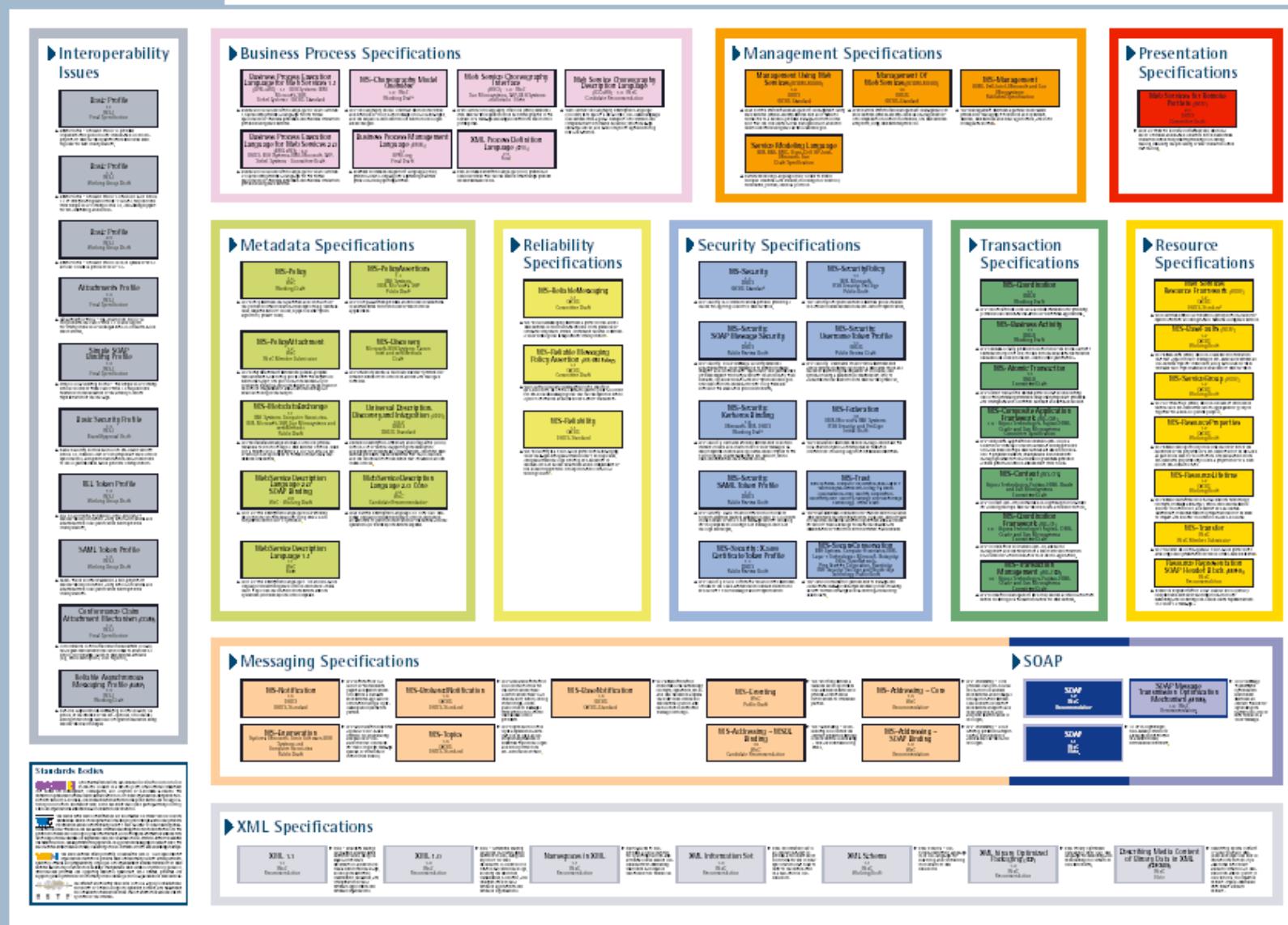
# Grid Technologies... (~2009+)

- Complete reassessment of OGSI approach to be “purer” web services
  - Web service resource framework (WSRF)
  - GT4 implemented this
    - Many software engineers hardened their skill sets using this  
(is one nice way of putting it!!!!)  
*The only way to make software secure, reliable, and fast is to make it small*  
AS Tanenbaum
- Also MANY other standards and efforts ...
  - Business and commercial drivers
    - Vendors shaping standards to their commercial advantage



# Flux of Web Service Standards (simplified!!!)

# Web Services Standards Overview



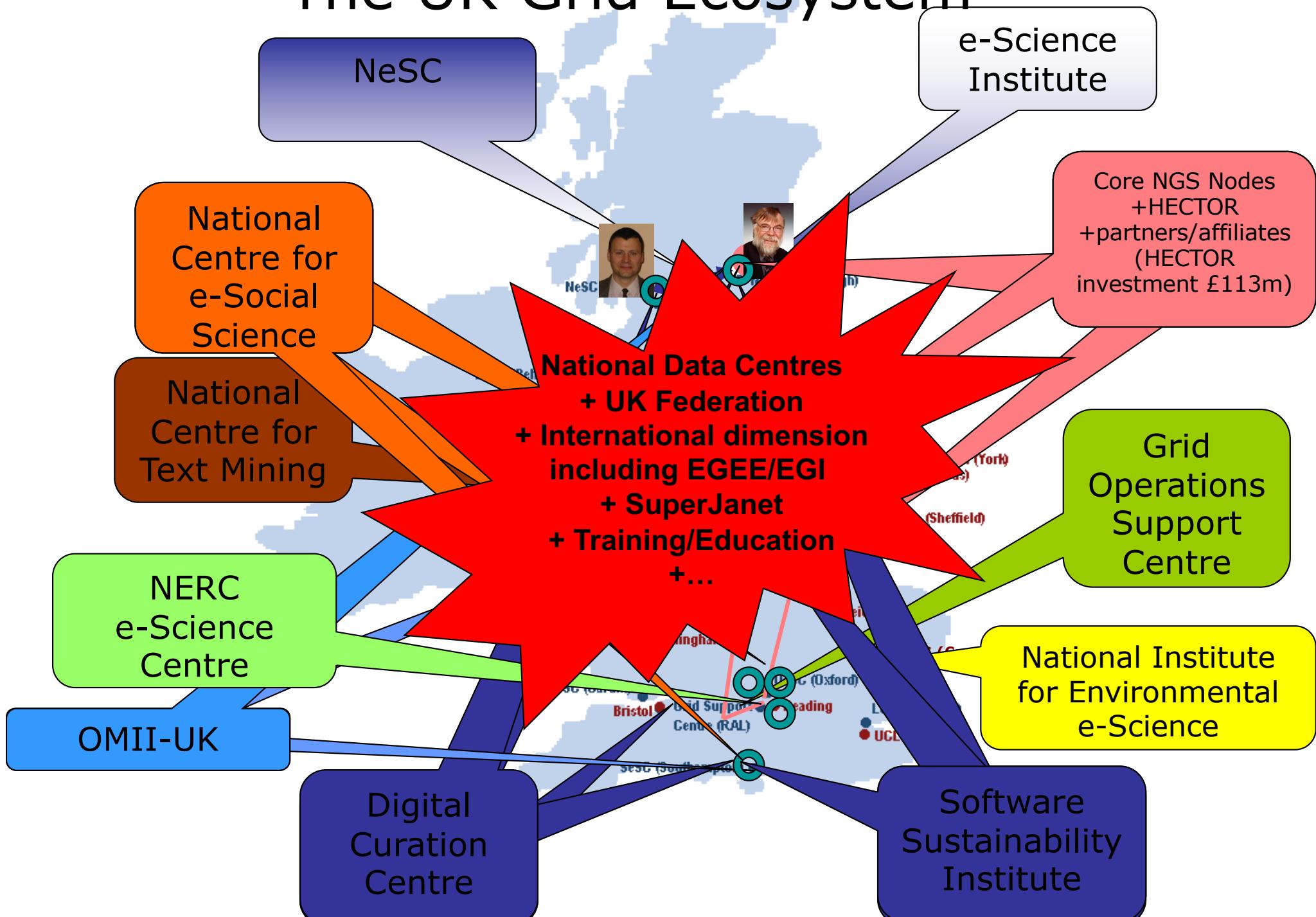
*The nice thing about standards is that you have so many to choose from...*

*The development of robust Grid security infrastructures is very much dependent upon agreements on technologies and practices. Standardisation plays an extremely important role in this regard. With the move of the Grid community towards web services and service-oriented architectures, web service security standards and their associated implementations are crucial. Unfortunately it is the case that a multitude of specifications and proposals for web service standards have been promised and put forward, or merely promised. There are often cases of web service standards covering similar topics resulting in multiple competing specifications such as WS-Notifications and WS-Eventing; WS-ReliableMessaging and WS-Reliability; WS-Orchestration, WS-Co-ordination and WS-Choreography, along with the many varieties of workflow or business process languages that have been put forward to name but a few examples of the issues in the proliferation of web service standards. It is also the case that at the time of writing, many web services standards are only in working draft or draft status, often with no associated implementations or acknowledged conformance or interoperability definitions. Claiming conformance or compliance to a particular web service standard is thus often not possible (or meaningful!).*

*It is also apparent that although many standards use the common prefix “WS-”, this does not mean that there is an agreed WS-Architecture. This stems from a variety of reasons: vendor and commercial issues; political aspects and also the different bodies involved. For example the Internet Engineering Task Force (IETF) ([www.ietf.org](http://www.ietf.org)); the World Wide Web Consortium (W3C) ([www.w3.org](http://www.w3.org)); the Organization for the Advancement of Structured Information Standards (OASIS) ([www.oasis-open.org](http://www.oasis-open.org)); and the Web Services Interoperability Organization (WS-I) ([www.ws-i.org](http://www.ws-i.org)) are some of the most prominent bodies. The consequence of this profusion of standards and standards making bodies, and the lack of consensus on the core web service architecture, impacts directly upon development of Grid standards, architectures and associated implementations and middleware.*

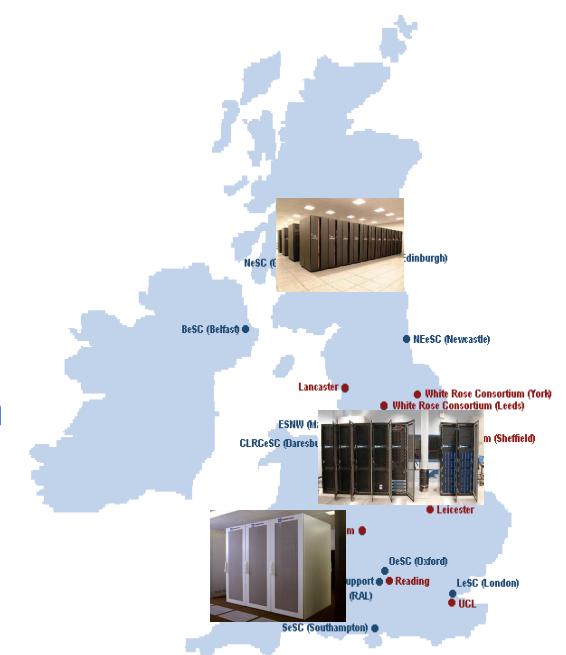
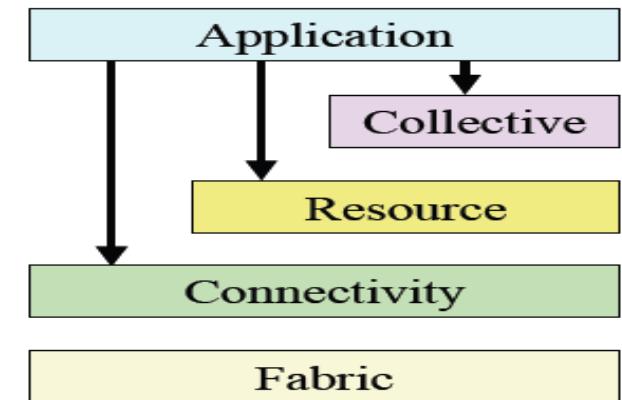
**Me: Grid Security : Practices, Middleware and Outlook**

# The UK Grid Ecosystem



# How hard can a compute Grid be...?

- Information Systems
  - What resources are available
    - Servers, CPUs, memory, storage, queues, OS, applications, databases, ...
- Monitoring and Discovery Systems
  - What is the status of those resources
    - Queues empty/very full
    - Machines running for a week
    - Hard to tell for some applications...?
- Job scheduling/resource brokering
  - Please run these {jobs}
    - Fastest, most secure/reliable, cheapest ...
      - Jobs need inter-process communication...?
        - » never get resources vs resource starvation
        - » Physics pilot jobs workaround
  - Virtual organisation support
    - I'm a chemist and want to run my simulation



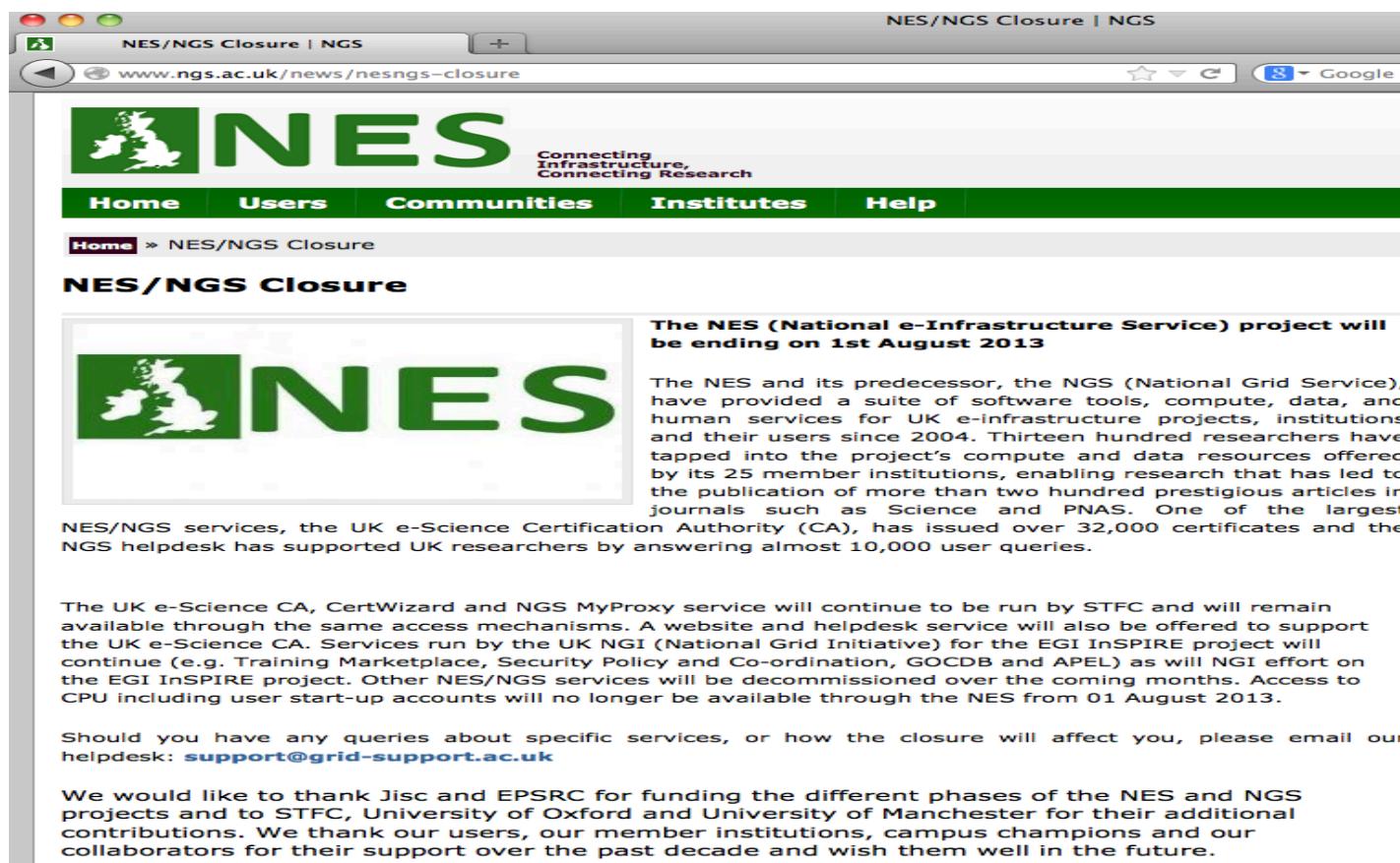
# Fragility of it all...

- How I broke the UK e-Science Grid...



# Other Challenges

- Security
  - Public Key Infrastructures
    - *\$> openssl pkcs12 -in cert.p12 -clcerts -nokeys -out usercert.pem!*
- ???? (more in later lectures)



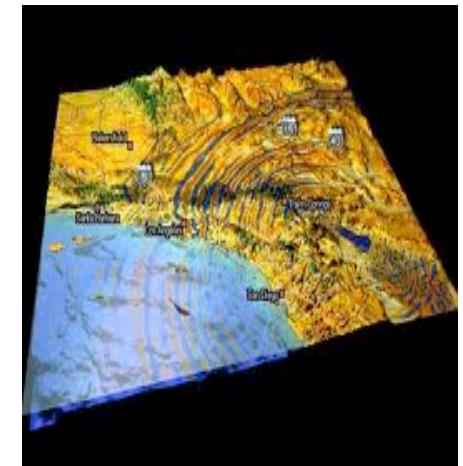
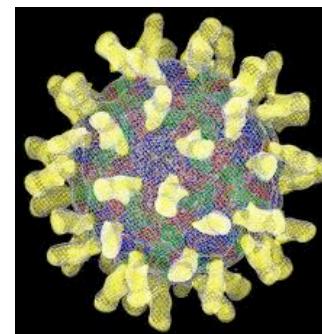
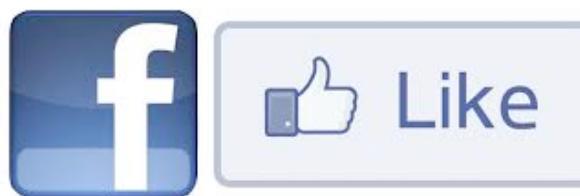
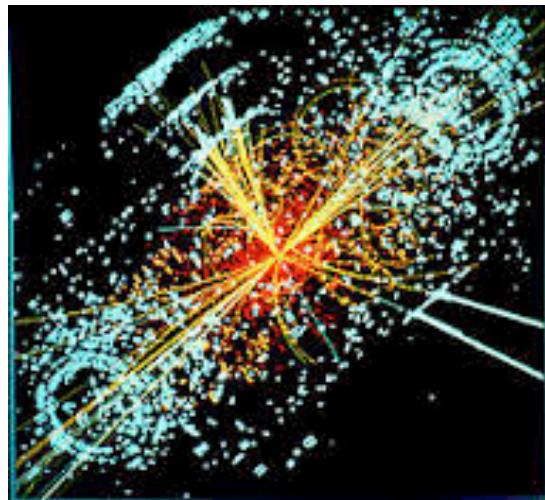
The screenshot shows a web browser window with the title bar "NES/NGS Closure | NGS". The address bar contains "www.ngs.ac.uk/news/nesngs-closure". The main content area displays the NES logo (a green map of the UK with the letters "NES" overlaid) and the text "Connecting Infrastructure, Connecting Research". A navigation menu at the top includes "Home", "Users", "Communities", "Institutes", and "Help". Below the menu, a breadcrumb trail shows "Home > NES/NGS Closure". The main heading is "NES/NGS Closure". A large green banner on the left side of the page features the NES logo. To the right of the banner, a message states: "The NES (National e-Infrastructure Service) project will be ending on 1st August 2013". The text below explains the closure: "The NES and its predecessor, the NGS (National Grid Service), have provided a suite of software tools, compute, data, and human services for UK e-infrastructure projects, institutions and their users since 2004. Thirteen hundred researchers have tapped into the project's compute and data resources offered by its 25 member institutions, enabling research that has led to the publication of more than two hundred prestigious articles in journals such as Science and PNAS. One of the largest NES/NGS services, the UK e-Science Certification Authority (CA), has issued over 32,000 certificates and the NGS helpdesk has supported UK researchers by answering almost 10,000 user queries." At the bottom of the page, there is a note about the continuation of services: "The UK e-Science CA, CertWizard and NGS MyProxy service will continue to be run by STFC and will remain available through the same access mechanisms. A website and helpdesk service will also be offered to support the UK e-Science CA. Services run by the UK NGI (National Grid Initiative) for the EGI InSPIRE project will continue (e.g. Training Marketplace, Security Policy and Co-ordination, GOCDB and APEL) as will NGI effort on the EGI InSPIRE project. Other NES/NGS services will be decommissioned over the coming months. Access to CPU including user start-up accounts will no longer be available through the NES from 01 August 2013." A footer provides contact information: "Should you have any queries about specific services, or how the closure will affect you, please email our helpdesk: [support@grid-support.ac.uk](mailto:support@grid-support.ac.uk)". Finally, a thank you message concludes: "We would like to thank Jisc and EPSRC for funding the different phases of the NES and NGS projects and to STFC, University of Oxford and University of Manchester for their additional contributions. We thank our users, our member institutions, campus champions and our collaborators for their support over the past decade and wish them well in the future."



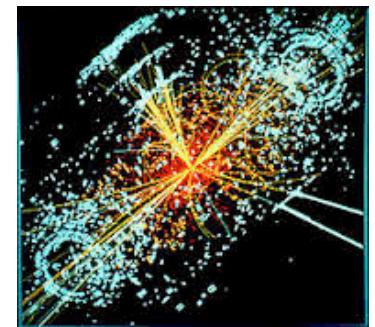
(NOT TO SCALE)

# Doom and gloom...!?!?

- But...



# High Energy Physics?



- Why did/does Grid work for them...?
- Size, scale and resourcing
  - GridPP
  - Enabling Grids for e-Science (EGEE)
  - European Grid Initiative
    - Huge numbers of admins making systems tick over
      - (=not searching for Higgs Boson)
  - Heterogeneity vs homogeneity
    - Specific versions of operating system
      - Scientific Linux v4, v5
    - Specific versions of middleware
      - Unilateral updates/deployments
        - » globus-\*, gLite-wms-\*
        - » edg-job-\*, lcg-job-\*, GANGA
  - Well-defined problem...



# My philosophy since...

- Less focus on complex middleware stacks
  - FAR too much focus on technology issues
    - More on customer needs and making a difference
- And to inspire you (and make you think what you do with social media!!!)
  - A snapshot of what you will be doing with Twitter analytics!



Questions?