Grid Computing Now! Knowledge Transfer Network

The Next Information Infrastructure: Towards 2012!

Roadmap Version 1.0

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Ian Osborne

Project Director

Intellect

"We stand at an important point in the emerging digital age. Increasingly your business services and administration rely on the effective adoption of advanced computing technologies. The opportunities that these technologies present are to encourage innovation and achieve new levels of business efficiency. It is critical that business leaders in the Information Age are able to harness and leverage these capabilities for competitive advantage. Whether it be for improved service delivery and/or increased profit."

Executive Summary

This document is the first published roadmap produced by the Grid Computing Now! Knowledge Transfer Network. It seeks to highlight important trends and developments in the Information Technology (IT) field over the next 5 years and to identify opportunities for innovation to accelerate their added value to the economy. Value may be added to the economy through the introduction of new products and services delivered to the citizen and customers; improvements in the development and delivery of existing products and services; and in the extension of capabilities in the field of knowledge, where an increasing proportion of our workforce is now gainfully employed.

The report comprises two pieces, the first being a summary of technology developments in plan for the next 5 years, derived from information made available publicly by the leading suppliers in the IT sector. Added to this are snapshots of likely developments in the field of communications, relevant for the purposes of projecting forwards the connectivity potential for IT solutions. This section of the report was developed from a presentation created by the author in preparation for the Roadmapping Workshop activity run by the Grid Computing Now! Knowledge Transfer Network in May 2007. The presentation is available from the Grid Computing Now! KTN web site, www.gridcomputingnow.org.

The second part of the report is a summary of the Grid Computing Now! KTN's recent Roadmapping Workshop, facilitated by New Game Plan www.new-game-plan.co.uk, and attended by a good cross section of technologists, academics and users from public and private sector. This workshop sought to identify a set of drivers which would operate on the technology space to encourage and require innovation. The workshop delegates then identified a set of potential innovations, they ranked them for feasibility; novelty and impact; and the prioritised ideas are presented here with a minimum of reformatting from the original expressions.

There are 10 innovations presented, each of which may embody several ideas. They are expressed as loosely framed descriptions of opportunity and may be considered to represent qualified examples of future interest for innovation in public and private sector. The workshop went on to consider the challenges to implementing such ideas and turned this to good effect by identifying promoters to encourage innovation and adoption. Finally, the workshop identified a set of recommendations, or next steps, for each of the major stakeholders represented, to encourage progress in the field.

This document is intended to be of value in the short to medium term for informing plans of the Technology Strategy Board[i] and its Knowledge Transfer Network programme. It should also prove informative for IT and Business leaders everywhere in the UK. The Grid Computing Now! KTN is at the forefront of the movement to champion the adoption of modern computing technologies in the UK, and plans to update this work on an annual basis.

We intend complementing this analysis through links to longer term Roadmapping work underway in the UK e-Science community. This will inform and potentially be informed by the Grid Computing Now! KTN Roadmap as it evolves over time. Please see http://www.rcuk.ac.uk/escience/default.htm .

Further information may be obtained from the author at info@gridcomputingnow.org .

1 Contents

2 Technology Overview

2.1 INTRODUCTION

This section provides an overview of the plans of the industry for the next 5 years along several technology vectors. The information used to develop this overview is typically available in leading vendor technology roadmaps. The intent is to develop a short summary of technology trends and likely impacts on ICT usage. We have not limited our overview to those technologies solely related to Grid Computing, believing that these capabilities are increasingly being incorporated in good systems design and components. Therefore this technology overview provides a broader picture looking forwards to the next information infrastructure. However, we felt it important to start with Grid Computing and the state of the market in 2007.

2.1.1 Grid Deployment: the state of the market in 2007.

Our colleagues in the 451 Group have developed a maturity model and mapped to this the relative levels of adoption and maturity in the leading grid using industries. At level 5, running multiple applications on linked grids with more extensive resource sharing, are the Investment Banks. Between level 3 (Multiple applications on silo'd grids, operated for the line of business) and level 4 (Multiple applications on basic linked grids with very limited resource sharing, centralised control) they place the Financial Services industry; at Level 3 they place the Media industry and between level 2 (single application run for a single line of business) and level 3 they place the Pharmaceutical, Energy and Manufacturing companies that they are tracking in their 250 strong industrial Grid Adoption Research Service (GARS[ii]).

In their research work conducted for Oracle during 2006[iii], Quocirca, asserted that the adoption of grids at the enterprise level had grown to more than 1 in 20 organisations and that large scale cluster Grids was now in use at nearly 30% of organisations. More modest adoption of grid in selected areas had grown to 40%. They asserted that the adoption of grid computing had slowed, inhibited by lack of technology maturity and practical challenges in the management of IT, e.g. ownership of resources; security and funding.

However, the trends towards adoption of service oriented architectures and web services will continue to drive the development of grid enabled infrastructures forward and, skill gaps aside, there seems to be early indicators of the rich potential for a major change in the development and provisioning of applications leveraging these technologies. *See the Cattles Case Study and related Webinar in Grid Computing Now! website.*

2.1.2 Looking forwards

The 451 Group see the adoption of grid leveraging the experience at the leading edge in the creation of different models for computing, dependent upon the user's needs for computing intensity. In the Financial Services world, particularly the trading, risk and pricing modelling applications, there is the possibility to create a **Grid Economy** model for pricing the availability of compute power dependent upon supply and demand principles. At least two investment banks are investing in this idea, the critical elements being the ability to specify the resource requirements in a service level agreement. Pricing of the service would depend upon competing demands and resources utilised. They also see the development of an **High Performance Grid** for use in heavy simulation and modelling tasks for engineering; design and related activities. This

would be purchased on demand and would leverage the experience of the academic National Grid Service. The move towards **Enterprise Utility** is also foreseen as a logical consequence of the high performance clusters currently used in silos, being linked together under a single management regime. Finally, the extension of Enterprise Utility is towards a **Public Utility** where capacity is extended on demand for performance and resilience purposes. There are some early examples of this approach being seen in the marketplace, but currently there appears to be substantial, unused capacity available within the enterprise regime.

2.2 WHAT ABOUT THE UNDERLYING TECHNOLOGIES?

We see the following Technologies to be key drivers in the development of distributed computing infrastructures, they are not an exhaustive set, but we believe them influential:-

Processors: The recent introduction of multi-core processors has sidestepped the issues related to the rapid increase of power consumption and heat generation on the processor die. Multi-core provides for *n* (where *n* will range from 2 to 64, and beyond, in the next 5 years) processors available in each package with similar power curves to the current generation. This will add parallel processing capacity, highly suitable for virtualised applications, and eventual specialisation for handling network and other tailor made protocols, e.g. XML. This strategic shift does however presume the ability of the application developers to take advantage of parallel execution. While performance does not directly scale as *n* increases, Input-Output demands can become the bottleneck. And while there are modest increases in overheads on the use of Hardware Virtualisation, native performance increases and virtualisation support features in modern processor designs can mitigate against these issues to provide improvements in throughput anyway.

Storage: The demand for storage is growing exponentially as digital media takes hold. Hospitals can produce Petabytes (10^{15}) of data, once digital x-rays; ultrasound and MRI scans are included in the patient medical record. We now see the introduction of Terabyte (10^{12}) drives in laptop size disc packaging and explosive growth in storage, network and power requirements for the data centre. The use of grid computing technologies for distributing tasks, presumes the ability to either locate near the data or transport the data to the task executor. The ability to effectively manage the distribution of data sets to match the task distribution is becoming a major challenge at the leading edge today. This will become a key area of concern for the IT user looking forwards. There may well be questions about the viability of Storage Area Networks versus distributed storage; there will also be significant advantages in federating data (i.e. assembling views of data from their own situation into consolidated views) versus the standard assumptions regarding consolidating data into larger databases. *See IBHIS case study in Grid Computing Now! and the related Webinar.*

Networks: The internet is becoming ubiquitous on all platforms and we see an inexorable rise in bandwidth being made available using fibre and copper and new technologies for utilising optical bandwidth. All technologies are IP based and in the next 5 years, 10Gb Ethernet will become more common, this gives the property of global communications reach with minimal observable latency. However, there are some areas where latency is critical, such as sub 8 millisecond round trip for on-line trading, and these applications will exploit purpose built technologies such as InfiniBand, see http://en.wikipedia.org/wiki/InfiniBand for the time being. We see 100MB to the door step becoming more common as cable technologies take hold and also

see early experiments in the deployment of Lambda optically switched networks, each channel providing 10Gb Ethernet, for large scale media applications, such as a campus network for the BBC in the White City.

Mobility: While the network is becoming ubiquitous, wireless access is also becoming ubiquitous within the metropolitan area, on transport modes and with the introduction of new types of Wi-Fi, e.g. WI-MAX, in the wide area away from urban centres. This enables the possibility of Voice over IP and other browsing services available for all handheld and portable equipment. There will be an increase in roaming agreements, probably coordinated by the mobile phone operators – they have the billing systems – which will allow ease of access in different geographies. The technologies underpinning the use of mobile access are ripe for exploitation in surveillance and security applications. There will also be a trend for increased bandwidth to the device through technologies such as Ultra-Wide Band in the local area.

Services/Applications: Perhaps the area of most likely turmoil will be the application area. IT Directors have struggled to maintain their independent silos, encompassing hardware, software, line of business users and budget, in the face of budget squeezes and the need to migrate with hardware and software operating environment changes. Looking forwards, the attraction of a single, unified infrastructure providing a virtual platform for applications is very persuasive. The benefits being scalability, flexibility, resilience and lower cost components. The challenges are significant though. The opportunity to update major software application bundles (e.g. Oracle, SAP) to take advantage of their service enabled designs may be outweighed by the need to architect and deliver new solutions, within a budget which is constrained by operational costs (keeping the lights on) and the need for new business applications. However, we believe that the “services” wave of change will reach the application developer in the next 5 years. Some applications will simply be replaced by Software as a Service (SAAS), the legacy application being retired in favour of an internet based application service provider. The major issue here is the security of company data. However Salesforce.Com, an early example of the genre, is making inroads and becoming influential both as an application provider and supplier of an enabling infrastructure. We expect to see the major internet service providers, Google, Amazon, e-Bay, Microsoft and Yahoo, and application vendors to make further plays in this space, utilising their huge scale of infrastructure for e-commerce. Within the enterprise there will be an increasing amount of service deployment rather than monolithic application development. Software asset reuse will climb significantly. Early examples of this approach show major advantages to IT in the ownership of the application design at the business level increasing IT responsiveness and agility to unprecedented levels, *see Cattles Case Study and Webinar in Grid Computing Now!*. The biggest challenge to the IT Director will be the availability of the process design skills and capabilities to support the business. There will not be much choice though as the businesses turn to more and more ad-hoc collaboration and incorporation of diverse data sources in service enabled applications (mash-ups, etc.). However, on the bonus side s/he may finally escape the application licensing issues which are not keeping up with the development of distributed, virtualised infrastructures.

Complexity: But its not all rosy, the incorporation of large scale data sources and increasing real-time operations, have added to an order of magnitude – or more – increase in complexity. We now have more data than we are able to usefully process and the architecture of monitoring systems is becoming increasingly critical. We need to design data sources in such a way that data is described; its provenance is defined and there is a way of accumulating and analysing the results. An analogy lies in the early days of digital phone systems. The operators put in place digital signalling systems which enable the phone systems

to operate but had little visibility to the traffic. Systems were developed which captured this data and allowed data mining, after the fact. We are now developing auto trading systems for the stock exchange which operate without human intervention and to a set of rules which are designed in the abstract. The consequence is a market trading system which is increasingly automatic in its operation. How can we track these systems and maintain the right data? How can we correct the systems behaviour when the intervals in which it is operating are at the millisecond level? These challenges are replicated in Transport; Healthcare; Bio-technology; Pharmaceuticals and many other applications of computing. Intel talks about Tera-Scale where teraflops of performance are operating on terabytes of data. http://www.intel.com/research/platform/

Identity/Security: Underlying all of this are concerns about validating Identity, a societal challenge, and the inherent security of large scale networks of computing resources transferring tasks and data around the world. The industry has some tools in place which assist in the fundamental assertion of identity, see Shibboleth http://en.wikipedia.org/wiki/Shibboleth_(Internet2) , for an example gaining ground in the grid world; and the traditional approaches to security build on this platform satisfactorily. However, the very nature of computing means that at some point information must be decrypted and operated upon in its natural state. It is at this point that there is a fundamental frailty in any security scheme. Thus we tend to provide physical security around our equipment to avoid risks. Even outsourcers offer their services at varying levels of security against this risk. The truth is that the biggest risks still come from within and there is a burgeoning market for systematic attacks on infrastructures connected to the internet through botnets and a range of strategies for disruption!

Energy: The final challenge to be faced by the ICT industry is its performance in the growing sustainability debate. With an average utilisation of 10-15%, a server in the data centre may be guilty of consuming 6 or 7 times its own power requirements in cooling and distribution, let alone the storage and communications equipment it depends upon. There are current studies underway in the industry aimed at characterising the carbon footprint of data centres and the total consumption of electricity produced. These initiatives will lead to an increasing recognition of the inefficiency of the traditional data centre, all the way from building, layout, energy conversion and cooling costs, and they will highlight the poor utilisation we achieve as an industry. Grid computing and Hardware Virtualisation provide an attractive remedy for some of these problems, at least raising average utilisation to optimum levels (80%) while system management capabilities and modern processors can allow switch off and very low consumption idle states. This may well provide an impetus to the change towards utility service provider in due course. After all, why own your own computers and the challenges they face, if you could be using a carbon neutral service provider? There are several operating in the marketplace already!

2.3 BOTTOM LINE

The pace and trajectory of change in the industry will not significantly alter in the next 5 years. There are some new challenges to be faced; such as adding more ICT capabilities while reducing space and power consumption – particularly in major conurbations; or the development of service enabled business systems to replace monolithic applications; and the increasing complexity in very large scale systems. We are building the tools and capabilities to move forwards and we believe that there are substantial opportunities to capitalise on these to improve IT's contribution and responsibilities to the economy and society as a whole.

3 Roadmapping Workshop

3.1 THE PURPOSE OF THE WORKSHOP

The Grid Computing Now! Knowledge Transfer Network (GCN!) held a 'Brain-Pool' 'Roadmapping Workshop' on 'Next Information Infrastructure' on 30 May 2007 with 25 invited participants from diverse companies and organisations. The overall aim was to '**Develop a shared understanding of the benefits achievable through next-generation computing and how to realise them, and thereby stimulate and guide innovation and economic growth for the UK**'. The Workshop was deliberately designed to look beyond the technological issues surrounding what is generally understood as 'Grid Computing' to the much wider opportunities for real-world applications.

The Workshop was designed to provide the substance for a 'Roadmap' which would be:

- The product of true collaborative working
- Valuable for Grid Computing Now!
- Valuable for the Technology Strategy Board
- Valuable for every participant to use in their own organisations

The Roadmap model shown in Figure 1 builds on that presented in the Workshop and should be used in further developing the Roadmap.

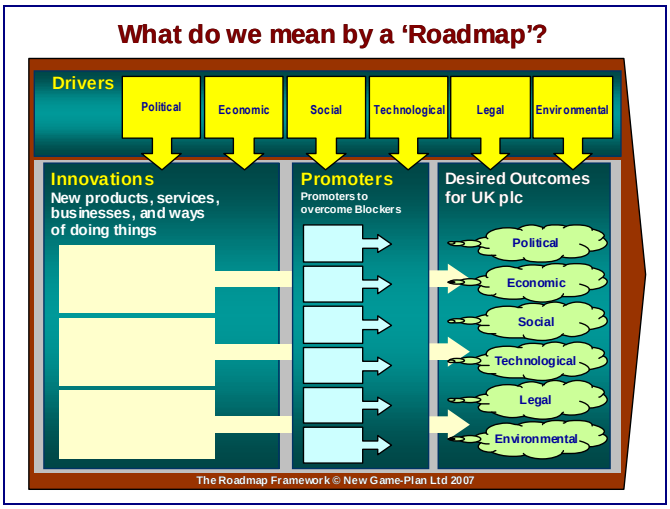


Figure 1. The Roadmap model

The Workshop was focused in particular on developing 'innovations in applications for the next information infrastructure' (with 'innovation' defined as 'useful exploitation of an idea'). The scope for innovations, summarised in **Figure 2**, was deliberately broad. A concise presentation was given by Ian Osborne on likely trends in technology, see section 3 above. These were not in themselves the primary focus for the Workshop, but were presented to support thinking on wider innovations. The period up to 2012 was set as a focus for thinking, but not as a definitive cut-off point.

There were three main achievements from the Workshop:

- A powerful and influential group of stakeholders was brought together to contribute to the work of GCN! in developing a Roadmap for 'Next Information Infrastructure'
- Workshop participants worked together collaboratively to review, share and develop the building-blocks of the Roadmap
- Possible 'Next steps' were defined in a wide range of areas, for further consideration by GCN!, the Technology Strategy Board

We are particularly grateful to our sponsors, the Technology Strategy Board; the Grid Computing Now! KTN Advisory Council; colleagues from the UK e-Science community; members of the Knowledge Transfer Network communities and our partners in New Game Plan for the results obtained.

3.2 THE WORKSHOP PROCESS

The Workshop followed a structured process. There was a mix of presentations, discussions (at table level or with the whole workshop), and individual working. Special technology was used to support the 'Brain-Pool' approach[iv]. This enabled participants to make their own inputs, and to read and comment, or build, on the contributions of others. This collaborative review and development of ideas went far beyond a typical 'brainstorm'.

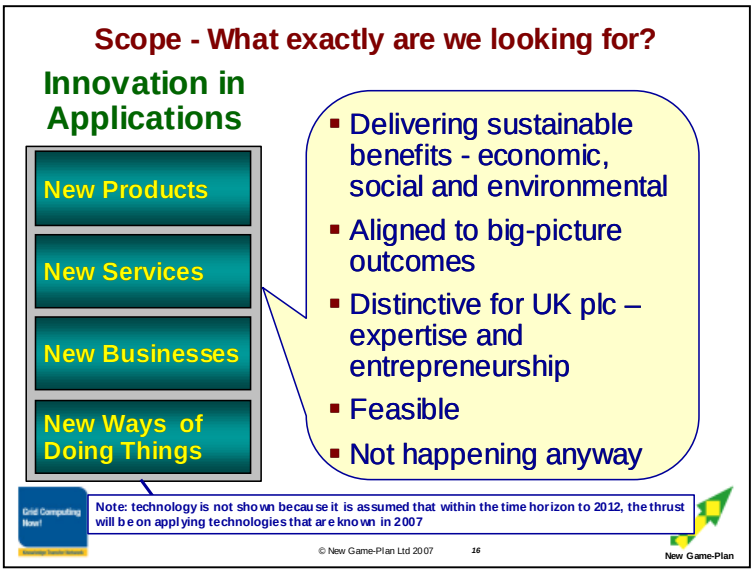


Figure 2. The scope of the Workshop

The Workshop opened with presentations on the scope, purpose and key concepts, and the 'Technology Overview'. The focus then moved on, in a staged process, to: 'Destinations' ('Outcomes', and 'Visions' for the future); developing the main Roadmap building blocks ('Innovations' and 'Promoters'); and, finally, 'Next Steps'.

3.3 OUTCOMES AND DRIVERS

Prior to the Workshop, attendees were invited to review 'starter lists' of 'desirable outcomes' developed from authoritative sources. The lists covered political, economic, social, technological, legal and environmental drivers (the 'PESTLE' model).

Drivers were described as: '*Big-picture trends that are important for the area being analysed but mainly external to it. These are forces that may be positive or negative. They may create new opportunities for innovation or disrupt the status quo.*' Outcomes (deliberately framed as desirable outcomes) were described as: '*The desired results of a course of events and deliberate interventions. They are expressed to focus on end results and their benefits rather than just outputs.*' Drivers and Outcomes are both key Roadmap building-blocks.

In the Workshop, participants provided comments on 'the set of outcomes as a whole', and suggestions for any 'significant omissions'. There was also a plenary discussion. The revised list of 60 outcomes and drivers distilled from these inputs, following the Workshop, and set out in the Appendix, provides a strong basis for these sections of the Roadmap.

The political, economic, social, legal and environmental outcomes and drivers are deliberately pitched at a 'high' level so as to encourage the widest possible creative thinking about the 'big picture' challenges facing the UK. The technological outcomes and drivers, in contrast, are pitched at a more detailed level, reflecting the strong understanding of these areas among participants.

3.4 INNOVATIONS

3.4.1 Workshop development of Innovations

A staged process was used to brainstorm, select, shape, distil and assess 'innovations'. Following consideration of the outcomes, four 'visions' of 'Next-Generation Computing' applied in specific fields were presented. These highlighted improvements to people's lives and business. Participants then developed and shared ideas for innovations in products, services, businesses, and ways of doing things. They focused especially on novel ideas which would: deliver sustainable benefits; be aligned with big-picture outcomes; be distinctive for 'UK plc'; and be feasible.

Some 49 'innovations' were developed through a process of discussion, sharing and commenting. Over the lunch interval, the analysts reviewed print-outs of the innovations and regrouped them. The aim was to identify discrete themes where there appears to be substantial scope for innovation. The analysts also took into account the scope of the Workshop and the desire to focus on innovations which are not substantially already happening.

The process identified 10 'innovation themes'. 30 of the original 49 Innovations were then grouped under these. Hereon, these are described as 'Key Innovations'. They are set out in the next section. Each Innovation element is described in terms of *What* the innovation is; *How* it might be achieved and the *Benefits* that would accrue. In most cases these descriptions are the verbatim summaries generated in the Roadmapping workshop. They are not prioritised.

3.4.2 Key Innovations

3.4.2.1 SECURITY THREATS

WHAT: An application which identifies threats and dynamically reconfigures to counter the effects of the attacker. HOW: Used by Government for defence purposes, operators of transport, energy, telecommunications and computing networks to keep ahead of attackers/terrorists. The technology would always need to be 'one step ahead' of those who would gain from attacking it. BENEFITS: Secure systems impervious to attack.

3.4.2.2 NEW INFRASTRUCTURE

3.4.2.2.1 'GRID-WRAPPER'

WHAT: 'Would you like that wrapped?' A new phase in commercial application production, after development and testing. This 'wraps' the software in a 'Grid Wrapper'. Defines resources; instrumentation (for billing); virtualisation parameters; data requirements; etc. HOW: To prepare software for a Grid Utility. Could be accompanied by a central 'Yellow Pages' of services for those that adhere to the wrapping for others to pick up and use commercially, cutting down on replicated deployments. BENEFITS: Enables a market for buying/selling Grid resources.

WHAT: A holistic, integrated UK-wide Compute & Storage platform providing access to 'Proxies' that are built into the Platform and are capable of delivering a wide, incremental set of services to users, tailored to their own skill levels and needs. HOW: Users access the Platform and choose the Proxy that provides them with capabilities that match their own skill levels. They then choose from the skill level/set of capabilities that the proxy offers to them that matches the task they wish to carry out. BENEFITS: The tasks that the user needs completed are much more likely to succeed by using the 'right' level of access and the 'right' level of the proxy.

WHAT: Your Business IT provides a comprehensive set of web based software services to the business which requires no special equipment or capability to be maintained on your own premises. HOW: From the range of services available you can select office tools; business resource planning; accounting and information storage and retrieval. The service is provided as a subscribed utility.

3.4.2.2.2 ENERGY-EFFICIENT UTILITY COMPUTING

WHAT: Widespread delivery of Utility Computing and its adoption by industry and commerce. Novelty elements are (1) co-ordinated delivery of IT orchestration, provisioning, virtualization, grid and metering & billing, and (2) industry must embrace process change, particularly give up server hugging. HOW: Most computers would be bought and managed by central IT or outsourcers. Users (people & departments) buy the delivery of computing capability. The use of heat generated by large facilities can be harnessed. BENEFITS: Much better Total Cost of Ownership (TCO) & Return on Investment (ROI) of compute facilities. Much lower carbon footprint. More flexible IT infrastructure - more agile. The emergence and future directions of multi-core processors mean that we can no longer ignore the need for consolidation and the development and exploitation of Utility Computing.

WHAT: 'The Public Grid' as shared processing power. HOW: A publish and subscribe model for processing utility to promote smaller organisations to share and take advantage of free space.

BENEFITS: To open up the grid model beyond large enterprises to make it the normal to source processing power externally but also to leverage existing processing capacity.

WHAT: Data centres/server farms that recover heat to generate power. HOW: 'Bare' servers employ virtualisation to minimise direct interaction with hardware. Reduces cost of data centres through reducing energy bill. Use of virtualisation improves scalability if IT infrastructure for businesses. BENEFITS: Helps resolve issue of power consumption and heat generation of next generation of processors.

3.4.2.3 SMART TRAVEL

WHAT: 'Dial a ride' universal public transport. HOW: Mobile devices used to enter destination, system works out where you are, optimal route and assigns next 'bus' (interconnecting with other vehicles as necessary) and routes it to pick you up - telling user ETA to them and their destination, optionally paying fare. The focus here is on dynamic service provision. BENEFITS: Door to door public transport for all, reduction in traffic congestion, easy to use public transport in locations not personally known, improves public transport provision for some areas not adequately served currently.

WHAT: Dynamic journey planning. HOW: Give in real-time your required arrival time at a place. It dynamically factors in 'now' and true predicted transport times, to tell you when to leave to start your journey. The focus here is on dynamic decision making based on available services. BENEFITS: Hours of time saving, less stress, Environmental benefits.

WHAT: Traffic modelling in real time to provide dynamic routing information for road users. HOW: Live road network data used to predict congestion and provide information to on-board units. BENEFITS: Helps drivers to avoid congestion and improves journey times.

WHAT: The e-Hitchhiker. Personal journey planner integrating both private third-party and public transport. HOW: Enter your location and destination, time constraints and number of passengers, and the system will connect you to whoever can give you a lift and integrate this when appropriate with trains or buses for longer journeys. BENEFITS: Saves energy

3.4.2.4 PROACTIVE HEALTH CARE

WHAT: 'Health Assurance Network' offers a 24/7 monitoring and advice service covering matters connected with personal health. HOW: It would operate rather like a remote monitored burglar alarm system. The system would depend upon a variety of reliable home sampling technologies and mash-ups of known information about individuals; locales and current situations, e.g. transport problems; disturbances; criticality of personal situation. The concept could be viewed as a 'Web 3.0' - focused on advisory services. BENEFITS: With federated access to medical information this system is capable of broader guidance on individual reported symptoms and able to flag up specific risks associated with chronic diseases, and personal safety.

WHAT: A device (possibly service) to provide personal feedback on how changes in diet, food or habits are affecting one's overall health and fitness level. HOW: Would combine information about person with multi sensor data and interpretative rules. More rapid feedback on trends allow tailoring of change and

provide more rounded view than the single parameters often used currently e.g. weight, cholesterol. BENEFITS: Instilling more encouragement, self responsibility and effectiveness into everyday general health and may be trend spotter for long term changes. Valuable if it influences personal diet and lifestyle today to deliver adverse health effects some years into the future.

WHAT: Personal yearly (or more frequent) 'MOT', improves year-on-year as DNA/blood information improves and historic data on you improves. HOW: Enter personal profile (dynamically) blood sample. Your personal dataset is updated and recalculated based on two key factors. 1. New general trends/information. 2. More historic information on you. Could also include a predictive capability. BENEFITS: Running your own life plan!

WHAT: A service (or products) for support of ageing population. HOW: Use wireless technology and objects to provide monitoring of health, safety, enable interaction with outside world, provide companionship and personalised entertainment and advice. The interface would need to be readily usable by people who are likely to be a generation behind in their familiarity with technology, and with impaired motor skills. BENEFITS: Enabling independent, happier lives for elderly - economic and social benefits.

WHAT: Personal health diagnostics system that continuously monitors people unobtrusively and detects any problems early - notifying the individual and medical practitioners as necessary. HOW: Wearable and environmental sensors monitor key health indicators. Linked to automated system customised to individual history and risk factors. Models state of health, identifies impending problems and alerts individual (e.g. prompt insulin injection for diabetes). Serious problems notified to medical people (e.g. early stages of heart attack). BENEFITS: Early identification of serious health allowing timely treatment. Reduction in death/ disability from heart failure/ stroke etc. Give emergency services/ hospitals more time to plan and react. Reduced cost of acute/ emergency treatment.

3.4.2.5 'MYGOV2.0'

WHAT: 'Online ID Cards with Certificates' as a secured shared data hub. HOW: Sharing data within public sector but importantly sourced and owned by individuals, contributing as much or as little data as prepared to give, based on the individual's perception of benefit. Grid applications (e.g. tested under IBHIS) would enable data to be distributed between several local databases, including that holding data provided by the individual, rather than a single overarching database. Software agents could then draw data from the distributed sources according to need (e.g. health care professionals) and permissions given by the individual. Administrative hurdles with issuing/managing certificates would need to be overcome. The InfoCard initiative is relevant here. BENEFITS: Reducing the onus on individuals to reactively respond for public services, such as house moves, employment records, name changes and also promoting proactive checking, health etc.

WHAT: 'MySelf' A new, downloadable directory/application that holds all your public data. HOW: Collects all your NHS,HMRC,Rates, Credit etc. information in a single copy, which can be synchronised regularly. BENEFITS: You see everything about you, can validate it, add to it, and control it.

WHAT: A way of enabling individual Freedom of Information where anyone can see what information is retained by government or business against their name. HOW: A web-enabled access tool where each transaction by government officer or business employee is recorded as a 'tracked change' for the citizen/consumer to see as an audit trail. This will be policed by an independently appointed body to ensure compliance and to avoid a secondary or 'secret' set of records being retained outside of those required by national security services. Individual control of personal data could be built in so that one could decide who sees what information. Anonymised summaries could still be made more widely available. BENEFITS: builds trust between communities, and an open healthier society, this will act as a clear deterrent if the citizen can see their 'error' or failure to comply (e.g. with tax laws) is noted and therefore likely to be followed up.

WHAT: My GoSer provides a single point of contact for all government services, ranging from tax authorities to requests for intervention in local road network (e.g. a hole in the road which needs to be fixed). It retains a strong identity and authentication capability and allows the citizen to review and request modification to stored personal information. It provides access to essential services, such as voting; routine services (waste removal/recycling); and access to information about the area in which a citizen resides. It is obviously accessible on many platforms. It is from here that the citizen may elect to allow their personal information to be made available on a wider scale, such as Electoral Roll to marketing organisations on receipt of an appropriate fee, which would be taxable of course!

WHAT: A service that provides a means whereby users can influence or rectify problems they encounter in their day-to-day lives within the community that cannot be resolved through normal channels or where such channels do not exist. HOW: The user accesses a web-based 'Software as a Service' (SaaS) service that analyses, classifies and forwards the problem to the most appropriate organisation that can deal with it across boundaries that would normally prevent resolution. BENEFITS: The general population of the UK will feel and BE empowered to solve the problems that together have a major impact on their lives instead of feeling frustrated and powerless in the face of BIG government.

3.4.2.6 TRUSTWORTHY INFORMATION AND KNOWLEDGE

WHAT: Information sharing framework in which controls on 'who' can use the information and 'what for' are conveyed/stored along with the information itself. HOW: Works by controlling improper use of pieces of information and by introducing accountability of those that have used the information. BENEFITS: Should lead to a reduction in information misuse, either accidental or deliberate; applicable in all walks of life; basis for building trust and engendering confidence in information owners/originators that their information is less likely to be misused.

WHAT: A system for validating information that is shared. HOW: Information is checked and validated before it can be shared. A key requirement is to establish a trusted, properly warranted information provider, as well as maintaining accurate data. BENEFITS: There is less information around but it is all more useful.

WHAT: It is a framework aimed at building trust in the field of information management. HOW: It is used to bring together and to refine the fragmented technologies, and methodologies that already exist along with those that have yet to emerge. Its overall purpose is to get to the point where the next generation

of IT Infrastructure and management methodology is capable of being trusted. BENEFITS: People will have confidence in the management of the information and the information itself, enabling an acceleration of the knowledge economy.

WHAT: True valuable data capture. HOW: currently data capture and 'cataloguing' is structured, the data that is needed needs capturing, including items that you don't know need keeping, i.e. association, time/place of capture. It would be helpful to allow for annotation after capture, potentially by anyone (although it would be important to ensure high quality and reliable systems for annotation). This would build on existing products (e.g. from Verity/Autonomy). BENEFITS: True Knowledge management.

3.4.2.7 LICENSING MODELS

WHAT: IPR licensing models for technology improve and adapt with the same speed as technology advances. HOW: Technology developers use new models to market their products in an affordable manner for their potential customers, potential customers are not inhibited from deployment or adoption of new technologies by the legal and commercial structures of a previous generation of technology. BENEFITS: Faster and deeper adoption of new technologies, improved commercial responsiveness, competitive advantage.

3.4.2.8 EDUCATIONAL OPPORTUNITIES

WHAT: A new curriculum approach which equips students with the knowledge skill and understanding to adopt and adapt emerging technologies and services (to aid their learning, social interactions etc). HOW: Within schools to ensure that students are equipped to access, evaluate and utilise effectively and in novel ways a wide range of data; BENEFITS: will lead to enhanced personalisation of learning, curriculum enrichment, a culture of collaboration and, ultimately, increased productivity & innovation in research and business.

WHAT: Provision and collection of information, education, cultural and science etc through social networking and entertainment media such as second life. HOW: Used by second-lifers etc. BENEFITS: Facilitates access to information, services and products for different part of population. Harness the energy of community to build new data collections on variety of topics - health care issues, security, etc.

3.4.2.9 MASH-UPS

WHAT: Fusing vision and location (and other sensor inputs) to provide context relevant network information. Combining data for example can augment the significance of individual 'points'. Useful in safety, medical and environment but the novelty lies in careful combination of already existing data. Maybe local or access to significant computation resource can enhance data relevance for example in security or fire emergency services where actions are often limited by the partial nature of information to assess and act.

3.4.2.10 INTEGRATIVE BIOLOGY

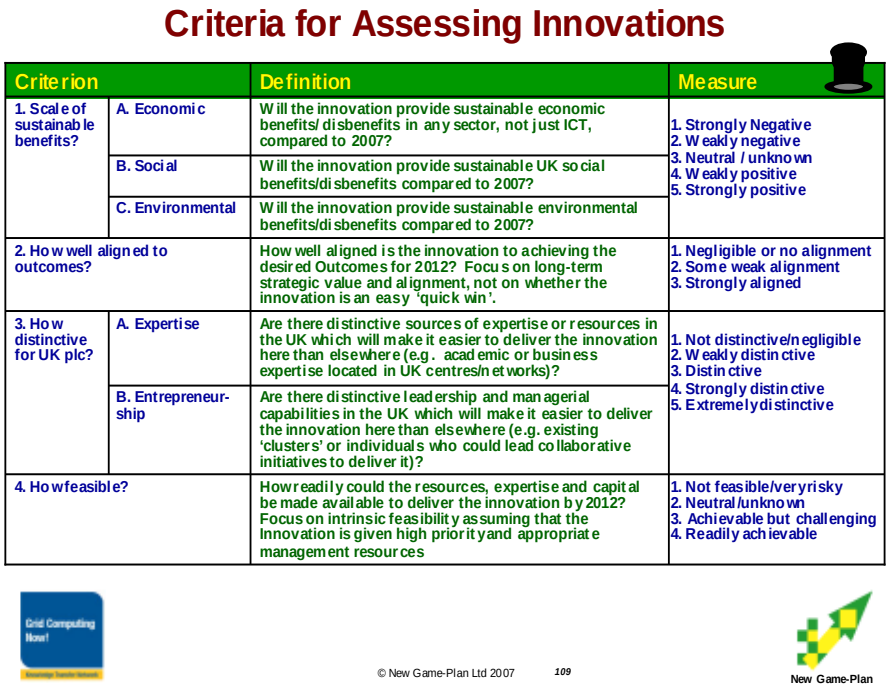
WHAT: Focussing on making biology more quantitative and predictive as a necessary step along the route to personal medicine. HOW: The use of measurements, combining them and providing feedback to enable better steps. BENEFITS: Addresses cultural and skills-based differences in bringing together wider social and scientific skills.

3.4.3 Assessment of the innovations developed in the Workshop

Participants were given lists of the 10 distilled innovations and asked to consider whether these, as a set, 'are adequate to proceed to our next stage of Roadmapping?' The response options were:

- 'Yes'
- 'They are adequate, if account is taken of my concerns'
- 'I'm not comfortable that we continue'.

Any further comments could also be entered. No-one indicated that they were 'uncomfortable' about continuing. Participants were fairly evenly split between the other options.



Criteria for Assessing Innovations

Criterion		Definition	Measure
1. Scale of sustainable benefits?	A. Economic	Will the innovation provide sustainable economic benefits/ disbenefits in any sector, not just ICT, compared to 2007?	1. Strongly Negative 2. Weakly negative 3. Neutral / unknown 4. Weakly positive 5. Strongly positive
	B. Social	Will the innovation provide sustainable UK social benefits/disbenefits compared to 2007?	
	C. Environmental	Will the innovation provide sustainable environmental benefits/disbenefits compared to 2007?	
2. How well aligned to outcomes?		How well aligned is the innovation to achieving the desired Outcomes for 2012? Focus on long-term strategic value and alignment, not on whether the innovation is an easy 'quick win'.	1. Negligible or no alignment 2. Some weak alignment 3. Strongly aligned
3. How distinctive for UK plc?	A. Expertise	Are there distinctive sources of expertise or resources in the UK which will make it easier to deliver the innovation here than elsewhere (e.g. academic or business expertise located in UK centres/networks)?	1. Not distinctive/negligible 2. Weakly distinctive 3. Distinctive 4. Strongly distinctive 5. Extremely distinctive
	B. Entrepreneur-ship	Are there distinctive leadership and managerial capabilities in the UK which will make it easier to deliver the innovation here than elsewhere (e.g. existing 'clusters' or individuals who could lead collaborative initiatives to deliver it)?	
4. How feasible?		How readily could the resources, expertise and capital be made available to deliver the innovation by 2012? Focus on intrinsic feasibility assuming that the Innovation is given high priority and appropriate management resources	1. Not feasible/very risky 2. Neutral/unknown 3. Achievable but challenging 4. Readily achievable

Figure 3. Criteria used in the Workshop to assess innovations

The innovations distilled in the Workshop were assessed against the criteria shown in **Figure 3**. The weightings for each assessment scale are shown. It was stressed that the assessment was intended to be indicative, not definitive, an aid to decision-making rather than a binding judgement on which innovations should be taken into account in developing the Roadmap.

The Table in Figure 4 shows the five Key Innovations which received the highest scores in the Workshop assessment for each of the criteria: 'Alignment to outcomes', 'Total UK Distinctiveness' (the total of scores for 'Expertise' and 'Entrepreneurship'), 'Total Benefits' (the total of scores for 'Economic', 'Social' and 'Environmental' Benefits) and 'Feasibility'. These 'high-scoring' Key Innovations have been identified from a visual inspection, looking across the results for all the individual innovations.

	Innovation	Distinctiveness	Alignment	Benefits	Feasibility
1	Security threats		X		
2	**New infrastructure**	X	X	X	X
3	**Smart Travel**	X	X	X	X
4	**Proactive health care**	X	X	X	X
5	'MyGov2.0'	X			
6	Trustworthy Information and knowledge				
7	Licensing models				
8	**Educational opportunities**		X	X	X
9	Mash-ups				X
10	**Integrative biology**	X		X	

Figure 4. Key Innovations receiving the highest relative scores in the Workshop assessment

3.4.4 Post-Workshop development of innovations

Following the Workshop, the 10 Key Innovations were carefully analysed and developed further taking account of:

- Comments from participants made during the workshop at various stages and captured in the verbatim output.
- The Assessments performed during the Workshop (see the charts for each Innovation above) and further analysis afterwards (see **Figure 4)**
- The 19 ideas for innovations which were excluded from the Workshop distillation because they were initially judged to be out of scope, not strictly 'innovations', or 'to a large extent happening already'
- The core-team's subject-matter knowledge

This review resulted in one Key Innovation being 'split' into two since it was made up of distinct ideas that should not have been merged (number 2, divided into 2a and 2b). Similarly, it was concluded that Innovation 7 should be treated more as a 'promoter' than an innovation.

3.5 PROMOTERS AND BLOCKERS

Participants were given an opportunity to consider 'promoters' (which 'accelerate or enable achievement of innovations and desired outcomes') and their corresponding 'Blockers'. Over 60 contributions were received from the Workshop. These have been distilled into the 17 promoters and blockers shown in Table 5 below.

The distillation also takes account of contributions recorded in the subsequent Workshop session on 'Next steps'. In particular, many of the suggestions for actions by 'business', 'Government', public bodies' and 'activities for small task groups' have been integrated into the distilled list below. The list in Table 5 accordingly provides a firm basis for developing this section of the Roadmap.

Promoter		Blocker
1	Promotion/Pilot 1: Run a programme to promote Next Information Infrastructure specifically to the ICT industry i.e. boost adoption within and between companies in the ICT sector. Should include proving use of shared applications across the firewall. Identify and resolve interoperability issues. Must be designed to achieve 'mindset' change as well as making the 'rational case'. Key individuals are the Chief Information Officers (CIOs).	The relatively low current level of implementation compared with what is possible. Will facilitate extension to other sectors based on this experience.
2	Promotion/Pilot 2: Pioneer use of Next Information Infrastructure by public bodies in a way that accelerates 'Joined-up Government' and resolves the most difficult challenges (technological and legal). Possibly focus on less familiar domains e.g. education. Should include procurement practices that help rather than hinder. Consider running a system like SAP or KM over a Grid.	The current lack of 'critical mass' and remaining technical and regulatory concerns.
3	Promotion/Pilot 3: Government to build business and public confidence by raising awareness of, and the ability to take enforcement action of, of appeal authorities and processes (e.g. the Ombudsman).	Lack of public confidence in the safeguards to protect the security and privacy of personal information.
4	Promotion/Pilot 4: Government to pioneer a 'citizen controlled' model for exchange of personal data in return for tangible benefits.	Citizen resistance to surrendering control of personal information when alarmed by perceived risks but unclear on benefits.
5	Promotion/Pilot 5: Run a pilot for advanced gaming and entertainment. Designed to resolve difficult challenges but different ones to those covered by pilot 1.	Lack of engagement by younger generation.
6	Promotion/Pilot 6: Develop the benefits case tailored to specific user groups/applications for moving to Next Information Infrastructure. Should include hard financial numbers.	Lack of evidence on benefits that is sufficiently compelling to overcome the inertia.
7	Promotion/Pilot 7: Get highly-mobile workers (e.g. sales representatives, care workers, engineers) to run a pilot for a dynamic journey planner and assist service with the Public Carriage Office cab operators (black cabs).	Perceived complexity and the belief that it is uneconomic to add additional vehicles to already overcrowded road networks for marginal benefit.
8	Develop a set of standards, good practices and, as required, supporting legislation to address, shared services, information ownership, security, privacy and other issues. Ensure effective process (avoid getting 'bogged down'). Ensure a strong 'user voice' and a concern for interoperability and open standards.	User resistance to uptake based on security and privacy concerns, and difficulty in building 'critical mass' without assurance of interoperability and openness of standards.
9	Government to provide specific financial incentives to develop and adopt Next Information Infrastructure justified by 'pump priming' innovation for the UK and potential non-market (e.g. environmental) benefits.	Current inertia in certain sectors and current shortcomings in the ability to measure environmental costs and be rewarded for reducing those costs.
10	Develop a new market ecosystem for the provision of software across 'Next Generation Infrastructure' including mechanisms for financial transactions, ownership controls and licensing.	Next generation computing being limited more by practical availability of software than underlying infrastructure (servers and storage).
11	UK businesses to develop new technologies that address personal security and privacy issues associated with ICT. Include fingerprints, personal security tokens.	Citizen concerns over security and privacy creating resistance to uptake of new technology.

12	Develop a consistent vocabulary around technology and products including 'what is Grid?' Promote adoption of this vocabulary by vendors.	Current imprecision in terminology that often causes confusion and acts as an obstacle to even basic communication.
13	Government to invest in research in key areas including: management of highly complex infrastructures and user-friendliness of IT and wide access.	Current shortcomings in capability to manage ever-more complex infrastructures and concern over 'exclusion' of certain citizen groups.
14	Identify opportunities associated with Next Information Infrastructure but from the viewpoint of the benefits sought by users and citizens (market-pull). Be informed by detailed analysis of factors that constrain uptake of technology and use this to design innovations accordingly. Use this to enrich the list of Innovations on the Roadmap.	Current lack of user and citizen perspectives in developing the capabilities, in particular to address newer economic, social and environmental drivers.
15	Develop skills needed in the UK for Next Information Infrastructure. Give due priority to this in the curriculum and encompass skills not just for technology itself but also for entrepreneurship and effective *use* of technology.	Current skills gaps.
16	Analyse the implications of the Roadmap for potentially 'excluded' groups of the population, including the elderly, and identify ways in which technology could be developed/promoted specifically to address the special requirements of these groups and to mitigate potentially negative impacts of these developments.	Social exclusion affecting key groups who could benefit immensely from Next Information Infrastructure but who lack the abilities or resources to do so.
17	Knowledge Transfer. Provide services and support along the lines of the KTN model (within GCN! or by other KTNs). Include: catalysing networks, promoting knowledge transfer, developing and disseminating case-histories, identifying strategic needs and providing a first-stop 'portal' for information and advice.	To satisfy various needs: to share learning between sectors and disciplines, to promote understanding of Next Generation Computing, to promote some commonality of approach as part of a strategic vision for UK, and to promote this specifically with other KTNs outside the ICT sector.

Figure 5. Distilled promoters and blockers

3.6 NEXT STEPS

Workshop Participants were invited to offer thoughts on 'next steps' under nine headings, as follows:

- What is your 'Number 1' priority?
- What should business do?
- What should Government do (e.g. policy)?
- What R&D is needed (especially R&D needing public money)?
- What should public bodies do (e.g. practical support)?
- Which organisations/individuals need to see the Roadmap?
- Do you have any other messages for Grid Computing Now!?
- Are there any specific challenges that could be tackled by small task groups?
- Do you have any final inputs (e.g. any priorities that the Workshop has missed)?

These contributions have been thoroughly reviewed. Many have been fed into the analyses and distillation set out in other sections of this report. Key points are summarised below.

3.6.1 Priority actions

Suggestions for **'priority' actions** focused on a range of issues, including: establishing common standards and legal frameworks; promoting successful models for others to follow; encouraging changes in attitudes; and networking different interests (e.g. users and vendors). These have been taken on board in distilling the list of promoters and blockers (see section 6).

3.6.2 Actions for ICT companies

The following actions specifically for '**ICT companies**' have been distilled from the contributions received on 'actions for business':

- Make internal IT 'sustainable', building on their ability to think laterally, act as pioneers and solve issues that need to be solved for other sectors too:
    - Look carefully at IT arrangements with a view to moving themselves actively to Next Generation Infrastructure, considering IP and legal licensing issues as well as the practicalities of sharing infrastructure and resources.
    - Determine the full end-to-end costs of processes and operations including energy and waste. This new, holistic analysis should be the reference point for management decisions, not earlier more narrow assessments of financial costs alone.
    - Make radical improvements to efficiency (e.g. in energy use) drawing on process changes, new technology and new business models.
- Be prepared to partner in innovation value chains to develop new products and business models.
- Do more to understand and communicate the *benefits* of technology to people and organisations, rather than simply the technical capabilities.

3.6.3 Actions for the public sector

The **public sector** at all levels needs to recognise its special responsibility in pioneering the development of Next Information Infrastructure. This responsibility reflects:

- The huge 'critical mass' constituted by public services
- The criticality of solving issues of security and privacy between the State and the citizen
- The criticality of setting standards that require, at least in part, regulatory underpinning
- The long-standing goal to achieve 'joined-up' government and the clear role of IT infrastructure in achieving this
- The long-standing goal to 'modernise' government at all levels, seeking greater efficiency and effectiveness and minimising its environmental footprint
- How the desired outcomes that are *strategic* for the UK, depend (as evidenced by the Roadmap), on Next Information Infrastructure.

The Government and public bodies accordingly need to play a major role, acting directly on many of the innovations and promoters set out in this report, to advance Next Information Infrastructure. Relevant actions embrace all the policy mechanisms available to Government, including the provision of: information, advice, research, stimulation for networking and collaborative working, appropriate regulation, economic incentives, and voluntary agreements with business sectors. The public sector also has a critical role to play in leading by example, in both words and deeds.

3.6.4 Actions for Grid Computing Now!

Participants strongly supported the continuation of the work of the Grid Computing Now! KTN. Key suggested areas for future activity include:

- Continue to develop the Roadmap, recognising that these take time to develop and to become 'owned', seeking inputs from more diverse groups, and focusing further on the timeline
- Move away from the term 'GRID' by developing new descriptors (e.g. 'Next Information Infrastructure') which can be clearly defined for effective communication
- Actively link to other Knowledge Transfer Networks or industry bodies to support innovation of Grid applications, as highlighted for several of the innovations set out here (section 5)
- Promote Next Information Infrastructure to businesses (e.g. establishing business 'Oscars' for innovation) and the general public, to build a groundswell of political support

Participants stressed that the Roadmap 'only makes sense for the UK if everyone shares it'. Webinars and the GCN! web site have important roles to play here in inviting feedback from diverse groups. Once created, it will be important to maintain the Roadmap as a 'living document'.

Specific **sectors or organisations which need to be informed about the Roadmap** (some directly and specifically, with bespoke briefings, others via more general contact) include:

- All Government Departments
- Regional Government Offices in England
- Devolved administrations (e-Wales, Scotland, and Northern Ireland)
- Regional Development Agencies
- Technology Strategy Board (especially to inform Innovation Platforms, Collaborative Research and Development Competitions and other Knowledge Transfer Networks)
- The Office of Government Commerce
- Knowledge Transfer Partnerships (Universities)
- European Commission

3.7 ROADMAPPING - THE WRAP

The output of the roadmapping workshop has become an input to the planning of the next phase of the Grid Computing Now! Knowledge Transfer Network for which an extension proposal is being prepared for submission in the Autumn of 2007. The combination of the Technology Overview which set some of the context for the Workshop and the Key Innovations developed, jointly provide an insight into the wide range of potential for computing technologies looking forwards, including "grid". As far as the future for Grid Computing Technologies themselves are concerned, the following is a recent quote from Cameron Purdy, an IT innovator, originally with Tangosol, a Data Grid software company recently purchased by Oracle, the leading US based Database System Supplier.

> "Fundamentally, we will have succeeded with "grid" when we no longer have to explicitly think about "grid". For example, the qualities of service that applications can achieve today by being architected on an Oracle Coherence Data Grid will become just another part of standardized infrastructure, just like we take database connectivity and transactions for granted today in application servers. Whatever the next generation of middleware infrastructure ends up looking like, I can say that it should have the ability to support continuous availability and scale-out across hundreds of servers while automating the complexity of managing such an environment." Cameron Purdy, Tangosol, now Oracle, InfoQ August 13 2007.

The Grid Computing Now! KTN finds itself at the epicentre of this strategic shift in the industry as we move from discrete, linked systems towards the large scale computing infrastructures of the future. The Innovations identified in this roadmap present attractive opportunities for developing new capabilities and addressing existing environmental challenges. It's an exciting place to be and an exciting time to be there!

4 Appendix

Distilled outcomes and drivers

Category	Ref	Desired OUTCOMES…	Responding to these DRIVERS…
Political	DP01	National security is assured while protecting personal liberty in a democratic society.	Changing threats to national security
	DP02	Public services are high-quality, efficient, affordable, inclusive, citizen-centred, trusted, and personalised.	Increasing public expectations of public services
	DP03	Citizens are engaged meaningfully in policy development.	Increasing demand for democracy and inclusion
	DP04	Energy supplies are secure (e.g. from political conflict, terrorist attack, and the effects of the depletion of existing resources).	Increased demand for energy
Economic	DE05	UK businesses are still competitive in providing value-for-money in the global marketplace.	Globalisation of markets
	DE06	The UK is the location of choice for global businesses to source some capabilities.	Globalisation of sourcing
	DE07	Businesses are efficient, collaborative, adaptable, and innovative.	The fast-changing global economic environment
	DE08	There is flexible access to goods and services.	Expanding online channel for commerce
	DE09	Knowledge-based businesses and careers are sustainable in the UK.	Shift to the knowledge economy (including creative industries and financial services)
	DE10	Corporations and institutions are trusted.	Compliance with corporate governance
	DE11	Business continuity is assured.	Threats to business continuity
	DE12	Existing businesses and new forms of business are more productive.	Business collaboration efficiency
	DE13	The regulatory climate for business positively encourages creativity, calculated risk-taking, innovation and growth.	Concern over the stifling of entrepreneurial initiative (e.g. potentially through process-driven regulation).
	DE14	People have effective access to authoritative information and services anytime, anywhere, and under their personal control.	Developments in IT infrastructure
Social	DS15	Information is far more readily-available in visual formats to complement word and data formats.	Need for effective communication (including communications across barriers of language and culture within a global marketplace)
	DS16	People are interacting with and through technology more effectively, and more fulfilled as a result.	Networked people
	DS17	People are entertained and more creative in their spare time.	Demand for leisure and cultural services
	DS18	People are better informed and educated, equipped with the skills to use information appropriately, and qualified and motivated for work.	Demand for learning

	DS19	People who do not want to be part of the 'knowledge' economy or lack the skills to be so nevertheless enjoy rewarding and fulfilling lives.	Need to avoid social exclusion
	DS20	People live longer and have more active lives, mentally and physically.	Ageing population
	DS21	Elderly people who can no longer look after themselves receive high standards of care at a cost which is affordable to society as a whole.	Ageing population
	DS22	There is better understanding, development and delivery of health related services.	Public expectations of publicly-funded health care
	DS23	Activities are 'e-enabled' (e.g. citizen engagement with government).	People always connected
	DS24	People live in a safe, secure and essentially crime-free or environment.	Rising anti-social behaviour
Legal	DL25	Services are supplied without undue fear of litigation.	Rise of the litigation culture
	DL26	Human rights are valued and a promoter for trade.	Human rights to be reflected in nation's laws
	DL27	On line commerce expands as fraud, theft and espionage are controlled and consumer confidence in the online security and privacy increases.	Rise of online crime
Environmental	DN28	Energy is conserved and used sustainably through better knowledge.	Responding to climate change risks
	DN29	The energy demands of computing are reduced.	Responding to climate change risks
	DN30	There is effective adaptation to climate change.	Responding to climate change risks
	DN31	Climate change is effectively mitigated.	Responding to climate change risks
	DN32	Natural disasters are anticipated and impacts managed through effective advance protection and post-event response.	Natural disasters
	DN33	Public transport systems are integrated, efficient, managed to reduce congestion, affordable and readily accessible for all.	High costs, congestion, and their impacts, on users of all forms of public transport
Technology - Processors	TP34	It is possible to do more, better, faster, for less.	Processing power and storage increased by successive waves of technology (including multicore and parallel processing)
Technology - Storage	TS35	It is possible to do more, better, faster, for less.	Information storage - accessible and inexpensive
Technology - Networks	TN36	Film & TV are available on demand and through open distribution.	Increasing network bandwidth
	TN37	Resources are optimally used and risks are managed.	Networked 'intelligent' equipment
	TN38	Citizens, including traditionally socially-excluded groups (e.g. the elderly, infirm) are empowered.	Networked information

	TN39	The discovery and presentation of knowledge is improved.	Networked information
Technology - Mobility	TM40	Home entertainment networks are provided and enhanced.	Wireless networking
	TM41	More sensor-based systems are available for e-response, pollution monitoring, etc.	Wireless networking
	TM42	Location-specific services are provided.	Mobile networked devices - cheap and powerful
	TM43	New patterns of working (e.g. working from home), and social and business networking are developed.	Mobile networked devices - cheap and powerful
Technology - Services and Applications	TA44	A market is created for these services that drives efficiency and innovation.	Semantic-based search and retrieval
	TA45	Business start-up and growth is flexible, unconstrained by IT infrastructure.	Virtualisation of computing resources
	TA46	Productivity is improved.	Service-oriented software
	TA47	Increased knowledge & understanding enables smarter and quicker decisions.	Computational & distributed science
	TA48	Innovations are enabled.	Computational & distributed science
	TA49	Resources are optimally used and risks are managed.	Modelling & control systems
	TA50	Commoditised systems are provided.	ICT Open Standards
	TA51	The distribution of goods, services and utilities is more efficient.	Powerful, distributed sensors, combined with Modelling & Control Systems
Technology - Identity and Security	TI52	Products and services are developed and delivered collaboratively.	ICT Open Standards
Technology - Complexity	TC53	Risks to health and environment are averted.	Powerful, distributed sensors
Technology - Energy	TE54	There is effective collaboration without travel.	Cheaper & better videoconferencing
	TE55	IT resources are more highly-utilised with less waste.	Virtualisation of computing resources
	TE56	IT resources are deployed more efficiently.	Energy-efficient systems combined with Modelling and control systems.
Technology - non-ICT	TX57	There is better personal awareness, prevention and treatment of inherited diseases.	Ability to 'design' biological systems
	TX58	Enhanced crops and animals deliver higher performance in agriculture.	Ability to 'design' biological systems
	TX59	High-value products are manufactured from biological systems.	Ability to 'design' biological systems
	TX60	Personalised medicine informs people (e.g. about inherited conditions, their state of health at any one time, their life expectancy), and enables them to make appropriate diet and lifestyle choices to improve their health.	Ability to 'design' biological systems

5 ABOUT GRID COMPUTING NOW!

The Grid Computing Now! Knowledge Transfer Network (KTN) is a UK government intervention to stimulate the market adoption of grid computing to increase the UK competitiveness of UK plc. The role of the KTN is to bring together innovators from Academia; Industry and Government to accelerate the adoption of technologies which can make a positive impact to the nation's economy.

Grid Computing Now! is a collaborative project involving Intellect, the UK Hi-Tech Trade Association, the National e-Science Centre in Edinburgh and a consortium led by CNR Ltd, including the InterForum Foundation (ITFF), British Chambers of Commerce, Oracle and IBM.

The project is aimed specifically at exploiting the benefits of grid computing technologies in UK public and private sector organisations through the establishment of a Knowledge Transfer Network (KTN). Its mission is to secure UK commercial leadership in the provision and exploitation of grid computing. The project has been funded for 3 years starting in February 2005 and is part of the DTI-funded[v] Technology Programme.

At the time of publication the Grid Computing Now! KTN has approximately 900 members from the Public Sector, Industry and Academia.

For more information see

Grid Computing Now! KTN: www.gridcomputingnow.org

Technology Strategy Board: www.technologyprogramme.org.uk

Intellect: www.intellectuk.org

CNR Ltd: www.cnr.co.uk

National e-Science Centre: www.nesc.ac.uk

[i] http://www.berr.gov.uk/innovation/technologystrategyboard/index.html
[ii] GARS: the 451 Group's Grid Adoption Research Service, see http://www.the451group.com/gars/451_gars.php
[iii] Quocirca Insight Report: Grid Computing Update, June 2006 http://www.quocirca.com/pages/analysis/reports/view/store250/item2991/?link_683=2991
[iv] See http://www.new-game-plan.co.uk/Services/Brain-Pool.htm
[v] In July 2007 the Department of Trade and Industry was split in two. The DTI Technology Programme has become the sole responsibility of the Technology Strategy Board, an "arms-length" body, which is supported by Government Departments, DAs, RDAs and Research Councils.