Knowledge Transfer Network

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Technology Strategy Board
Driving Innovation

UK Future Internet Strategy Group

FUTURE INTERNET REPORT
May 2011

Researched and authored by Eddie Townsend on behalf of the ICT KTN

Contact:

Eddie Townsend
Information Communications Technology KTN
Russell Square House
10-12 Russell Square
London WC1B 5EE

www.ictktn.org.uk

Mobile: +44 (0)7766 688752

About the ICT KTN Co. Ltd

The ICT KTN Co. Ltd was established in 2007 as a not-for-profit company with the specific aim of delivering knowledge transfer activity on behalf of the Technology Strategy Board. It was previously known as the Digital Communications KTN Co. Ltd, and has hitherto been promoting knowledge transfer in this important element of the wider ICT sector for which it now has responsibility.

EXECUTIVE SUMMARY

The UK Future Internet Strategy Group (UK FISG) was established under the sponsorship of the Technology Strategy Board, chaired by Nick Wainwright of HP Labs, Bristol, and is coordinated by the ICT Knowledge Transfer Network (ICT KTN). The group comprises senior representatives from industry and academia who are closely involved in the sector. The Business Information and Skills Department and the Technology Strategy Board are also represented and provide guidance to the group on Future Internet definition.

As part of its core activity to provide direction for future work, inform industry and academia about the opportunities offered by the Future Internet and advise the UK Government, UK FISG commissioned this strategic document. In the process of building a wide base of authoritative evidence on which the report has been constructed, over 20 leading figures from industry and academia agreed to participate in a comprehensive interview process. This resulted in over 750 individual items of opinion that have been represented and consolidated to form this report.

So what do we mean by the term Future Internet? The Future Internet is about 'Internet-style' services that will be transformational for UK business and society, not only in the types and span of services, but in the efficient way they are delivered, placing the end user in control of aspects of quality and cost. It is a unique opportunity to bring citizens together and increase business and profitability, creating a new socio–economic fabric. It is a mistake to think of the Future Internet as simply more capable infrastructure in the ground. It is not a replacement of what we have today but is part of the continuum of development. The Internet lets us make connections across previously unconnected services and businesses, breaking down 'silos' and letting businesses put the right combination of services together for customers.

So the first part of our definition of the Future Internet is that it is an evolution rather than replacement. The Internet was initially about communications and then a means of delivering services. The next stage in this progression is a convergence of services, together with massively shared data. Converged services and shared data open up the opportunity for highly efficient, value-added, contextually aware decision support to both business and citizens. But this will not be possible without an advanced wireless and fixed infrastructure to allow access anywhere, anytime, creating an omnipresent fabric linking people and machine-to-machine communications. In fact, one of the main features of the Future Internet will be a massive growth in machine-to-machine communications; no longer will all data be generated only by people. Decision support will largely depend on billions of multipurpose sensors that are able to constantly update a three-dimensional 'picture' of our environment.

The big step change will stem from the ability to interact with 'things' in our environment: so not just to have a web page about a company or building, but to be able to interact with them directly.

The Future Internet:

An evolving convergent Internet of things and services that is available anywhere, anytime as part of an all-pervasive omnipresent socio–economic fabric, made up of ***converged services****,* ***shared data*** *and an advanced* ***wireless and fixed infrastructure*** *linking people and machines to provide advanced services to business and citizens.*

This environment enables the opportunity to deliver services to citizens in a new and much more cost-effective way, driving down costs and greatly improving the end-user experience at the point of delivery, for example:

- integrated transport systems enabled by a mobile Internet infrastructure, where data is shared across organisations to enable people to travel efficiently with the lowest impact to the environment – an 'Internet on Wheels'
- health services designed around the individual, specified by the patient and clinical practitioner and delivered as part of a brokered set of services
- remote monitoring of the elderly combined with energy management packages to enable people to live a longer and more comfortable life in their homes for longer.

Business will also benefit by being able to contract out many of its functions, getting the lowest cost from a worldwide supply chain. Cost-effective high-definition videoconferencing and communications, combined with appropriate management policies, will free employees from daily travel to and from the workplace. They will reduce business costs, protect the environment and improve profitability, whilst reaching customers on a global scale.

The report identifies between £50 billion and £100 billion annual benefit to the UK.

Many of these opportunities are embodied in the 'smart city', with its infrastructure of sensors and smart buildings that offer 24/7 access to services supported by shared data clouds, interacting with citizens and businesses in a concentrated environment. Barcelona, New Songdo City, Incheon and San Francisco lead the way in demonstrating how the Future Internet can be implemented today, providing the **value case** has been made and there is **executive leadership** to drive the new thinking and implementation.

The Future Internet environment is brought about by technologies that allow the capture of a vastly increased amount of data, ranging from high-definition video to a massive increase in low-cost multi-purpose sensors. The number of connected devices is set to increase worldwide from the current level of 4.5 billion to 50 billion by 2020. This, together with other data sources, has driven the amount of data in the world up to a staggering 988 exabytes in 2010, roughly equivalent to a stack of books stretching from the Sun to Pluto and back.

1,000 bytes	= 1 kilobyte
1,000 kilobytes	= 1 megabyte
1,000 megabytes	= 1 gigabyte
1,000 gigabytes	= 1 terabyte
1,000 terabytes	= 1 petabyte
1,000 petabytes	= 1 exabyte

A key focus of this report has been to identify the main enabling components that will allow a 'market' based on the concept of the Future Internet of converged services and advanced infrastructure and the advanced connectivity and mobility features it provides. Many of these enabling components can be implemented today: for example, the technology to share data or to provide wireless connectivity is available; novel payment models are implemented in businesses such as Apple and Amazon. Fundamentally, the main issue is how to bring multiple elements together around a value case that will justify the required investment and result in a market being created.

The recommendations address areas of strategy, setting the national and local agenda, and the creation of value cases and putting innovation and skills at the centre of the Future Internet initiative. Recommendations on infrastructure cover solving issues of wireless connectivity, global Internet addressing and the creation of massively shared data clouds. Finally, research needs to be undertaken to resolve issues of trust and security for data and access to the infrastructure.

In conclusion, other economies are currently implementing elements of the Future Internet from infrastructure through to the delivery of services and demonstrating the cost savings and societal improvements. The underlying technologies largely exist and can be integrated to deliver the vision described in this report with huge savings to government, local authorities and individual citizens, whilst at the same time creating a new Internet-style economy generating new business and profitability. The UK possesses a strong foundation in technology and innovation to take a leadership position, given the correct level of investment and policies at a national and local level.

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PART I
SUMMARY REPORT

The UK Future Internet Strategy Group (UK FISG) was established under the sponsorship of the Technology Strategy Board, chaired by Nick Wainwright of HP Labs, Bristol, and is coordinated by the ICT Knowledge Transfer Network (ICT KTN). The group comprises senior representatives from industry and academia who are closely involved in the sector. The Business Information and Skills Department and the Technology Strategy Board are also represented and provide guidance to the group on Future Internet definition.

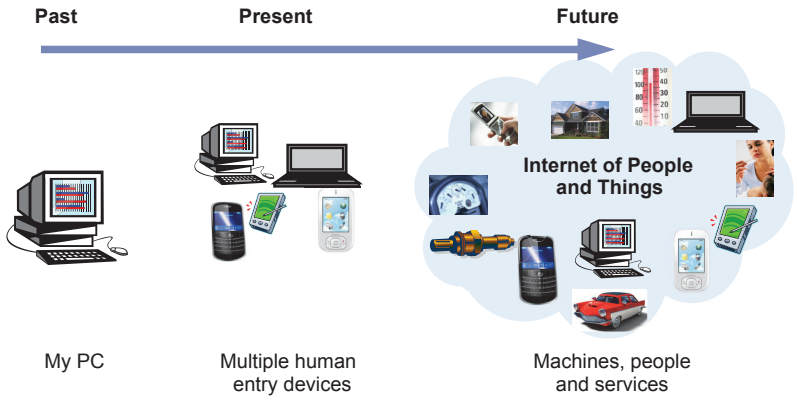
As part of its core activity to provide direction for future work, inform industry and academia about the opportunities offered by the Future Internet and advise the UK Government, UK FISG commissioned this strategic document. In the process of building a wide base of authoritative evidence on which the report has been constructed, 20 leading figures from industry and academia agreed to participate in a comprehensive interview process. This report produced by Eddie Townsend (DC KTN) resulted in over 750 individual items of opinion that have been represented and consolidated.

1 The Future Internet opportunity

The technologies and business models offered by the Future Internet will result in massive opportunity right across business, society and government. If the UK makes the right choices about how we invest in and apply the Internet, then the UK will benefit not only through reduced costs in business and service delivery and new Internet services for business and consumers, but will also, due to the infrastructure and methodologies established as a result, make the UK a very attractive place to invest.

The Future Internet is not a single entity to be released like a new piece of software at a fixed point in time; it is an evolution rather than invention. It is on a continuum of development that is not just about faster broadband, but more about growing 'intelligence' based on an 'Internet of People and Things' (discussed below) and services (see Figure 1). Indeed, to think about the Future Internet simply as faster broadband is to completely miss the point of what this new environment can deliver, both to each citizen in terms of better, more accessible and more efficient services, designed for each individual, and to 'UK plc' in terms of improved competiveness and profitability.

Figure 1 Internet development



The Internet lets us make connections across previously unconnected services and businesses, breaking down 'silos' and letting businesses put the right combination of services together for

customers. It enables services to be customised and personalised to an incredible degree. An 'Internet style' economy based on characteristics of shared data and converged services, supported by an always-available infrastructure, will enable wide-scale collaboration, scalable innovation and create global opportunity for 'UK plc'. This new economy will create new wealth both through the new services and through suppliers of the underlying technologies.

The Future Internet will be a transformational influence on the service sectors. Energy, transport, healthcare etc. will be able to deliver targeted services to business and citizens at a lower cost than is possible today with a siloed structure. Internet-style services will break down 'walled gardens' to create new services, for example enabling healthcare professionals to devise highly customised solutions to patient needs and putting the patient in charge of quality of delivery. Similarly, transport systems will be responsive to consumer requirements at a local level.

Citizens will for the first time be involved in the quality of service delivery as a direct result of the way citizens and businesses are able to interact with services. This will, in turn, have benefits for social inclusion as individuals and businesses feel a sense of ownership.

2 What is new?

There is a massive increase in the amount of data being generated globally. Data has increased by a factor of 6 in the last four years to an estimated 988 exabytes in 2010, roughly equivalent to a stack of novels from the Sun to Pluto and back. This burgeoning increase is to be sustained by a similar, massive 11-fold increase in the number of connected devices installed, increasing from 4.5 billion in 2010 to 50 billion globally in 2020. Sensors are essential data-gathering elements within machines that will then be able to intelligently communicate without human intervention. These remote assets – which can include all manner of devices from vending machines that can report to a central control when they require refilling, to cars, truck fleets and smart energy meters – are all connected by a capable fixed and wireless access mechanism. These sensors or machines will form a vitally important component of the data, driving contextually aware services, and is referred to as an 'Internet of People and Things'. However, converged services are only possible with massively shared data utilising cloud technology and systems, connected by a pervasive wireless infrastructure.

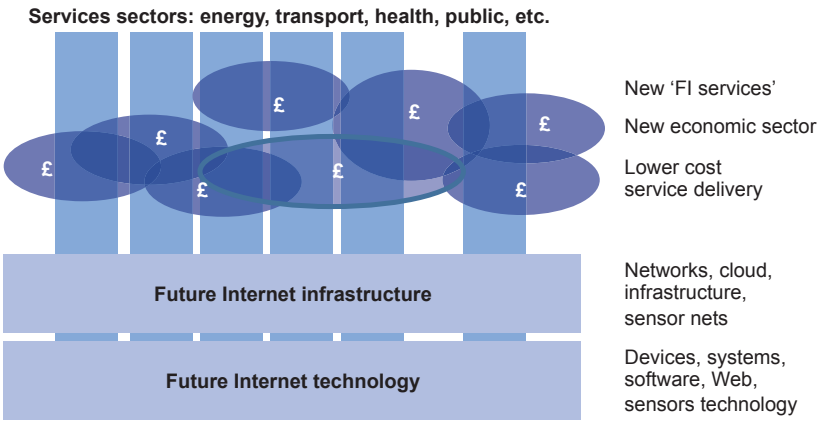
As shown in Figure 2, Internet-style services cut across existing silos, involving citizens and businesses in the provision of services designed for individuals. They are able to do this by sensing the environment and modelling the context in which the service is provided.

This innovative approach is scalable from a city level to a national level, developing new ways of delivering services that engage with each citizen and do things for people and business.

Take, for example, a person reviewing their total health requirements with their GP. They may require real-time heart monitoring, and they may also have longer-term mobility issues. The GP will be able to access brokered services from multiple providers to put a package together that precisely meets the patient needs. This will be achieved efficiently and at the lowest cost to a quality of service controlled by the GP and patient. Another implementation could be similar to eBay, where service and data providers can meet in a virtual environment.

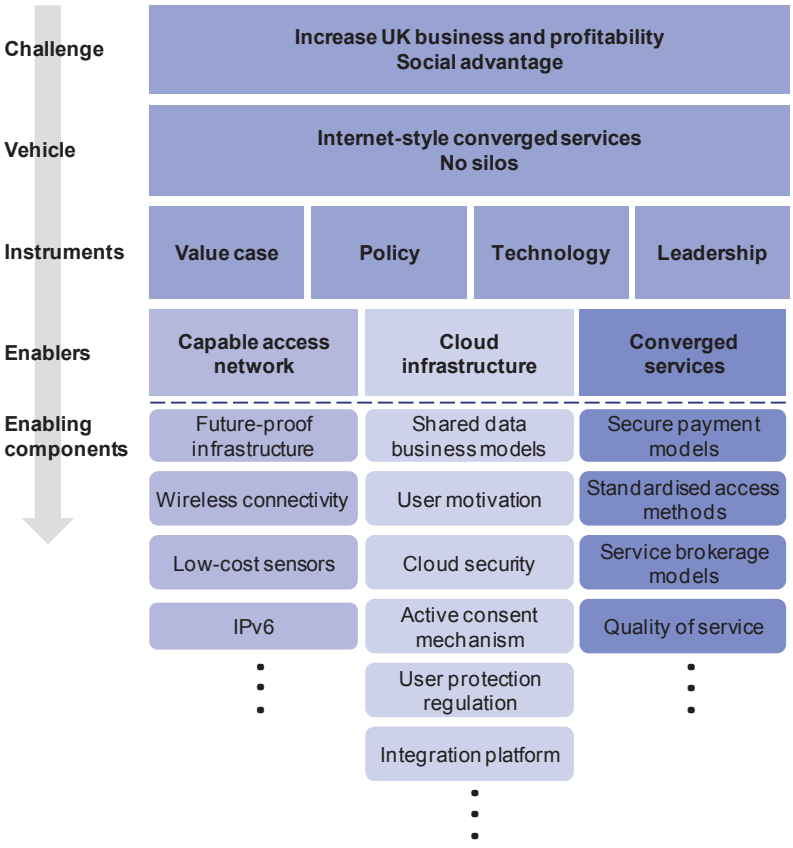
Implementation of a smart environment has a virtuous circle, by first providing a better experience for the citizen, leading to increased use of integrated services, resulting in more data and improved interfaces, giving rise to still better services

Figure 2
Increased revenue from provision of applications



3 Enabling the Future Internet

Figure 3
Meeting the challenge of the Future Internet



The Future Internet already exists in different areas of the world in various forms. Elements of the future environment can be found in San Francisco, Barcelona, Korea and China. Each of these locations can demonstrate live implementations of the sort of joined-up, converged services that are described in this report. The **challenge** for the UK is to utilise the **vehicle** of Future Internet style services to radically change the way businesses are operated and services delivered, to increase

business profitability and provide real social advantage (see **Error! Reference source not found.** above).

The **instruments** or 'levers' that business and government have available to them to influence the direction and pace of take-up of Future Internet style services are the existence of a **value case** for each implementation, a set of **policies** at a governmental level that provides a level playing field, available **technology** to support the implementation and finally a **leadership** structure that pulls the whole implementation together.

A key focus of this report is to identify the main **enabling components** that will allow a 'market' based on the concept of the Future Internet and the advanced connectivity and mobility features it provides. Many of these enabling components can be implemented today: for example, the technology to share data or to provide wireless connectivity is available; novel payment models are implemented in businesses like Apple and Amazon. There are concerns, and the report highlights them, but fundamentally the main issue is how to bring multiple elements together around a value case that will justify the required investment and result in a market being created.

The enabling components fall into three main categories:

- **Capable access mechanism:** A capable access mechanism will encompass a wireless and fixed transport network that is future proof over a 20-year time frame. Advances in video capture and the massive projected increase in data flows will quickly overtake networks that are only designed to achieve 2Mbit/s. For example, super high definition video will require a minimum of 350Mbit/s.

  There are major issues globally with Internet addressing that will not cope with the massive increase in machine-to-machine communications. These include moving from IPv4, with its limited addressing capability, to IPv6, which to all intents and purposes provide infinite address capability. With a programme of awareness and policy, the UK can lead this global shift, benefiting business and enabling the Internet-style economy.

  Fundamental to the infrastructure will be the wide deployment of low-cost wireless senor arrays that can be multipurposed. Sensors exist today, but development of this industry will provide the low-power technology and economies of scale required.
- **Cloud infrastructure:** This is a fundamental aspect of the Future Internet and reliant on the removal of barriers to Internet-style business models, in other words, no 'walled gardens' in the use of data to power services, the development of data security methodologies and trusted access systems that allow a user to access the fabric on the Future Internet anywhere, any time. As people are provided with more customised services, they need to be put in control of that data: not only giving consent to the use of personal data, but also being able to withdraw it. Security of data is also about provenance, especially in the case of decision support services. However, although the main thrust of this report is centred around the role of the 'Cloud', other infrastructures will play a major role and in particular that played by machine-to-machine communications.
- **Converged services:** In the context of this report, the term 'converged services' goes beyond most offerings available today. It represents a transformational change in the way organisations, both private and public, deliver services, requiring them to develop new business models and technology implementations. A new class of service provider will emerge that will create and market service elements that can be applied across multiple sectors. These elements will be aggregated together in any number of ways by a 'broker', to provide the end user with contextually aware applications and decision support services.

4 Recommendations

The report's main recommendations are as follows.

Structural/ strategic

1 In order to maximise the penetration of Future Internet style services to business and citizens, the UK requires a coordinated strategy that will bring together cross-departmental priorities and initiatives towards this objective. The recommendation of this report is the formation of a high-level cross-governmental Future Internet Advisory Board working in conjunction with the Treasury-led Infrastructure UK initiative that will inform UK Government policy in the areas of interdepartmental priorities to drive innovation and bring together a Future Internet ICT strategy

2 A strategic activity needs to be created around a smart city agenda to drive Future Internet change in the way services are delivered through Future Internet style applications and systems. The activity will lead to creation of a smart city Centre of Excellence that will provide a template for city managers.

Capable access mechanism

3 Future internet services will run on 'cloud infrastructure', a global system of shared communications, computing and storage on a global scale provided by cloud operators from the most appropriate geography taking into account scale, connectivity, costs and jurisdiction. The UK needs security of supply, capacity for services operating under UK jurisdiction, with performance to offer new and interactive services across the whole country. The recommendation of this report is that 'cloud' should be considered as 'critical infrastructure' by the Future Internet Advisory Board with a long-term plan that addresses barriers and accelerators to adequate and appropriate cloud capacity for the UK.

Wireless connectivity

4 Releasing spectrum is a major technology challenge in terms of ensuring the outgoing service is moved into new spectrum and the new service can coexist with the adjacent users of the allocated spectrum. Major technology challenges have to be solved to design radios that can meet these requirements. Compounding the issue is that poor radio frequency (RF) performance increases the demand for spectrum (radio network density). Recent studies have shown a large variation in radio performance for equipment and in recognition of this challenge the ICT KTN Wireless Technology and Spectrum Group voted this as a 2011 priority to address the longer-term R&D challenges to improve radio front-end technology. The working group is working closely with a newly formed Cambridge Wireless Radio Technology special interest group (SIG)[1] to address this challenge. It is strongly recommended that the Technology Strategy Board and the Engineering and Physical Sciences Research Council (EPSRC) have future R&D competitions to address this major technical challenge.

Shared data

5 Shared data is a transformational element of the Future Internet and the foundation on which new and valuable services can be built. However, there are issues around personal data security, data provenance, user

[1] Cambridge Wireless Radio Technology SIG http://cambridgewireless.co.uk/sigs/radiotechnology/

			confidence, motivation, consent and access mechanisms that will require a high level of innovation before we can use these valuable resources to deliver innovative services. The Technology Strategy Board must initiate project work, inviting research to address this whole area. Applications in areas such as smart cities would be an ideal context.
Converged services	🔴	**6**	To enable the delivery of real-time contextually aware services anywhere anytime to a specification, research must be conducted into system architectures access methodologies and payment models that will stimulate an ecosystem of services that have a built-in quality-of-service element. The work should encompass investment already made at a European level.

Key: 🔴 = extensive action required, but issues not yet understood
🟡 = some action required, but issues are known

5 Conclusions

In conclusion, other economies are currently implementing elements of the Future Internet, from infrastructure through to the delivery of Internet-style services and demonstrating the cost savings and societal improvements. The underlying technologies largely exist and can be integrated to deliver the vision described in this report, with huge savings to government, local authorities and individual citizens, whilst at the same time creating a new Internet-style economy, generating new business and profitability. Implementation will occur at national and local levels, supported by UK Government initiatives and targeted investment. There will be an awareness-building phase to convince industry, local government and individuals that there is a clear value case for moving to an Internet-style environment with all the organisational and structural changes required.

The UK possesses a strong foundation in technology and innovation to take a leadership position, given the correct level of investment and policies at a national and local level.

PART II
MAIN REPORT

The Future Internet is a huge and important topic that will be the engine for economic development and social change in the twenty-first century. The UK Future Internet Strategy Group (UK FISG) was established in late 2009, with the aim of providing direction for future work, informing industry and academia about the opportunities offered by the Future Internet and advising the UK Government.

The group was set up under the sponsorship of the Technology Strategy Board, chaired by Nick Wainwright of HP Labs, Bristol, and is coordinated by the ICT Knowledge Transfer Network (ICT KTN). The group comprises senior representatives from industry and academia who are closely involved in the sector. The Business Information and Skills Department and the Technology Strategy Board are also represented and provide guidance to the group on Future Internet definition. (Appendix A gives further information on the UK FISG.)

UK FISG commissioned this report, to describe the opportunities that the Future Internet offers and to identify the challenges that these pose for the aspirations of the UK. In the process of building a wide base of authoritative evidence on which the report has been constructed, 20 leading figures from industry and academia agreed to participate in a comprehensive interview process (see Appendix B for a complete list of contributors, and Appendix C for a sample questionnaire). This resulted in over 750 individual items of opinion that have been represented and consolidated to form the major themes of this report. Data have also been included from industry reports, especially in the areas of worldwide trends for data, machine-to-machine devices and IPv6 adoption. The report covers many facets of the sector, including estimates of the potential benefits to society, services, service costs and business competitiveness.

The report has been peer reviewed at each major stage in its development, starting with a UK FISG review of the themes emerging from the initial interview process. A further review of the initial draft was completed again by the UK FISG and finally at a whole-day workshop attended by a majority of the contributors. The report thus provides a consensus of opinion of those who are intimately involved in the issues and opportunities around the Future Internet.

The report discusses the following aspects of the Future Internet:

- how the Future Internet will evolve into an always-available, omnipresent environment
- the opportunity offered by the Future Internet
- the explosive growth of data and the different types of data that will underpin the Future Internet
- the challenge of implementing the Future Internet
- the components that will enable the vision of the Future Internet to be realised
- case studies illustrating aspects of the Future Internet that have already been implemented
- how to promote the innovation required for the development of the Future Internet in the UK
- recommendations to ensure that the UK benefits fully from the Future Internet.

1 What is the Future Internet?

The Future Internet:

*An evolving convergent Internet of things and services that is available anywhere, anytime as part of an all-pervasive omnipresent socio–economic fabric, made up of **converged services**, **shared data** and an advanced **wireless and fixed infrastructure** linking people and machines to provide advanced services to business and citizens.*

The Future Internet is much more that en extension of the existing Internet

The term 'Future Internet' can mean many things to many different people. It conveys an impression of some new protocol or infrastructure that will replace the existing, familiar one, a global communications transport medium that allows more or less instantaneous communication with billions of other individuals and organisations. The Internet has already opened up opportunities for commercial and public organisations to offer services hitherto unthought-of. It has been a disruptive influence allowing people to access goods and services normally supplied by a third party: the travel industry is a well-known example, allowing the individual to bypass traditional travel agents to find the best deals with hotels and airlines. However, the Future Internet will offer so much more.

The Future Internet: evolution rather than invention

The Future Internet is not a single entity to be released like a new piece of software at a fixed point in time, but an evolution rather than an invention. It is on a continuum of development that is not just about faster broadband, but more about growing 'intelligence'. Indeed, to think about the Future Internet simply as faster broadband is to completely miss the point of what this new environment can deliver, both to each citizen in terms of better, more accessible and more efficient services, designed for each individual and to 'UK plc' in terms of improved competiveness and profitability. Nevertheless, it is certainly true that in order to deliver the full potential of the business models that will emerge, faster broadband and always-available connectivity, particularly from wireless, will be a necessary component. Seeing the Future Internet as an innovative and enabling business and social environment, rather than in terms of the technology, changes the way it is viewed. There start to be interesting and cost-reducing ways of living, as well as further opportunities for increasing competitiveness, rather than the focus being on the cost of putting up more masts or laying more cable.

1.1 The Internet of People and Things

Extensive data from both people and machines will enable more targeted services

Online businesses, such as Apple's iTunes or Amazon, currently 'learn' about user tastes and requirements and offer users goods and services that are tuned to these specific requirements. In the future, however, it is not just from people that this intelligence will be gleaned. There will be an increasing number of machines supplying packets of data, for example washing machines, smart phones with GPS always on, sensors in our homes and on our person. In some cases, these devices will each have their own IP address that will allow them to be interrogated from anywhere. All of this 'Internet of People and Things' (see Figure 1) will contribute to

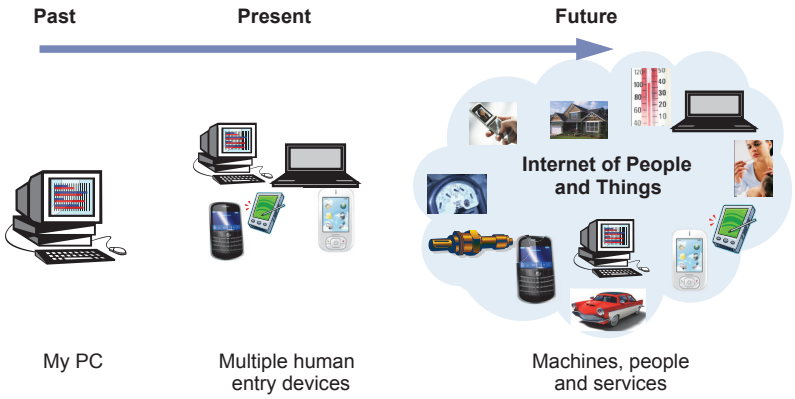
the pool of data from which Web operators will be able to draw information and ultimately knowledge: knowledge that can be used to provide better and more targeted services across all our needs. The 'Internet of People and Things' disrupts today's Internet, with its limitations of human-entered data.

Figure 1
The 'Internet of People and Things'

Improved, tailored services at lower cost that are available anywhere, anytime

This expansion of sources of input to the Web will not depend on some large separate computer or even the PC in the home, but will evolve to form a new dimension to our normal environment, ever present and largely unnoticed, but able to deliver a huge opportunity in terms of improved standards of living and reduction in costs to business, provided through services measured to meet our individual needs, whether in transport, health or energy. With the development of wireless services and improved connectivity, these services will always be available whenever and wherever they are required (see Figure 2).

Figure 2
Internet development



1.2 Machine-to-machine communications

Massive growth in machine-to-machine generated data

Not all devices will necessarily be connected to the Internet, although the resultant services may be. Anytime anywhere access to real-time intelligence from remote machines or devices is changing the way that multinational businesses operate. A massive increase in new applications is projected as organisations realise the potential for M2M communications in increased efficiency and revenue opportunity.

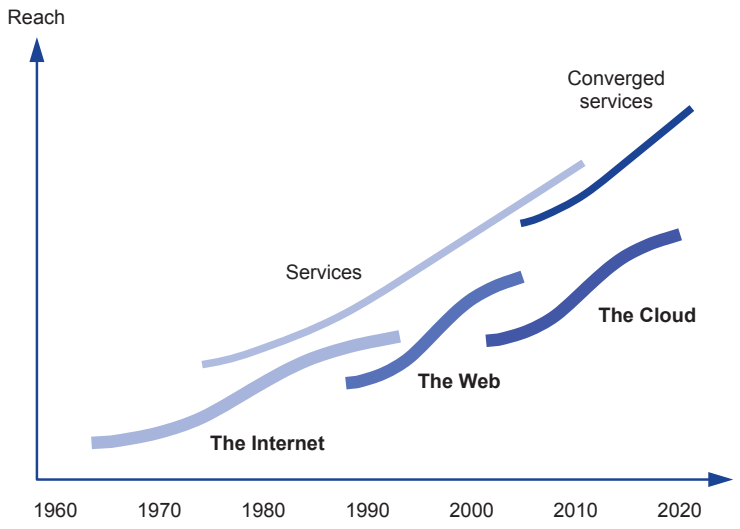
M2M communications is the networking of intelligent communications-enabled devices, managing themselves and exchanging information without the need for human intervention. These devices can be present in practically every application and industry from energy to health and transport. They will provide real-time information about the environment in which they operate and will build a multidimensional picture of the environment or people they are monitoring. The sensors embedded in the machines include a SIM-like card that is able to receive and transmit data wirelessly to a central control where the data can be combined with other sources to provide intelligence that can be acted upon. Different wireless protocols will be employed, depending on the context they are positioned in and the distance over which the communications have to occur.

1.3 The Cloud and converged services

The Cloud is central to the development of converged services

With the increase in machine-to-machine communications, the advent of the 'Internet of People and Things' and a massive growth of data generally, combined with the need to make data available across the Web, has come the introduction of 'the Cloud'. The Cloud allows the effective sharing of data and information across users and services. It is the enabling technology that will complete the convergence of the basic transport of the Internet with the intelligence of the advanced Web and the ability to share and draw value from data to support multiple business models to form the Future Internet (see Figure 3).

Figure 3 Convergence to create the Future Internet



Convergent scalable ecosystem

This idea of convergence at the level of the Future Internet is one of its most important characteristics and is reflected in the way services are delivered. It will mean a breaking down of sector silos. Where, for example, health data can currently only be used by health professionals and energy-related data only by energy companies, in the Future Internet such data will be shared according to user consent for multiple purposes. Data from one

vertical sector can be 'repurposed' for a different use in another sector. In so doing, it will create an ecosystem that will be scalable across all services.

This report will explore these concepts in terms of:

- the opportunity offered by the Future Internet
- the leadership the UK can take in what is a global environment
- what urgently needs to be addressed if the UK is not to lose out in this Future Internet evolution.

In summary, the Future Internet represents an always-available, omnipresent environment that will enable businesses of all sizes to compete in a global market and for citizens and business to design services that are tailored to their individual needs at the lowest cost of delivery.

2 The Future Internet opportunity

The Future Internet could encourage significant investment

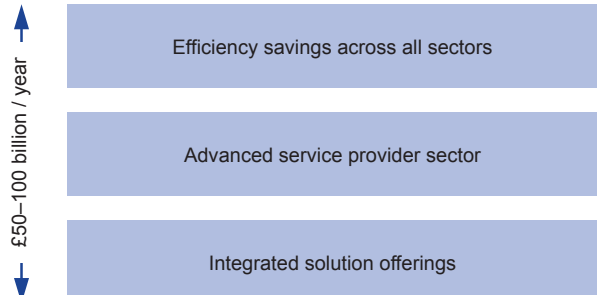
The technologies and business models offered by the Future Internet will offer massive opportunity right across business, society and government. The Future Internet not only offers ways of reducing costs in business and service delivery, but also, due to the infrastructure and methodologies established as a result, makes the UK a very attractive place to invest. An item that repeatedly came up in the interview process was how few major international ICT companies are headquartered in the UK and there was a suggestion that this limited 'UK plc' opportunity – opportunity derived from corporate investment decisions about where to base R&D, manufacturing and services. These investment decisions are made on the basis of proximity to markets, cost, skills and an available infrastructure that will allow efficient operations to take place.

Involving citizens in the quality of services and management of cost

There are three main areas of opportunity, as shown in Figure 4. Firstly, large ICT companies such as IBM and HP have concluded that there is significant business in developing and rolling out solutions that will provide a platform for shared data and converged services. Secondly, once the platform and shared data are in place then, given the resolution of the issues identified in this report, a new economic sector will emerge to provide thousands of innovative applications and services elements. Finally, the new environment of brokered and efficient services will have a massive impact on the way providers address the delivery of services in health, transport and energy etc. This will have the effect of involving citizens in the quality of the delivery of the service and the management of its cost.

Businesses will be free to develop new structures and ways of reducing costs, improving delivery to customers and increasing profits.

Figure 4
Areas of opportunity arising from the Future Internet



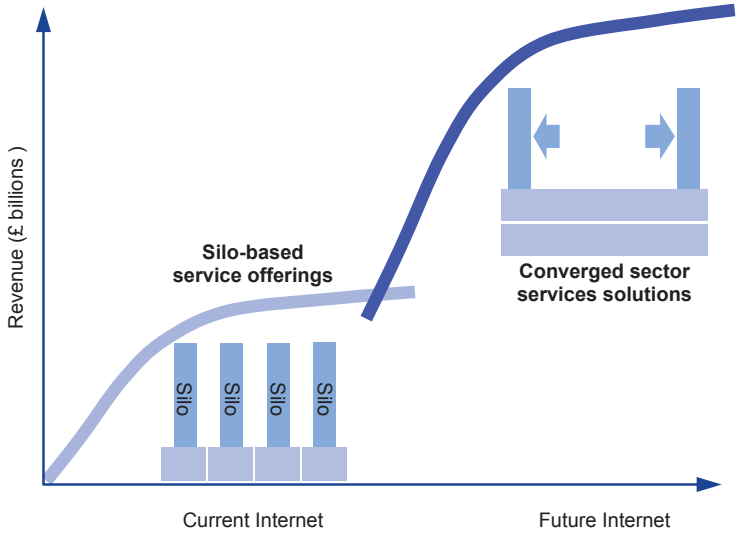
An estimate of the total realisable benefit of the Future Internet exceeds £50 billion per year to the UK as a whole, arising from reduced costs in health care, transport, energy etc., reduced costs for businesses and new business opportunities benefiting firms of all sizes.

2.1 Integrated solution offerings

Greater revenue opportunity from integrated services

Major international companies that currently supply ICT solutions into each sector as independent installations have completed analysis showing that offerings of integrated, multisector solutions, based on a value case to the customer, will greatly extend their revenues over a siloed approach (see Figure 5). An integrated platform also provides the enabling factor for multiple applications to be developed. The UK at a national level, and especially at a city level, has the opportunity to work with industry to define these structures and solutions.

Figure 5
Increased revenue from provision of integrated services



2.2 Advanced service provider sector

Availability of integrated platform offering accessible applications

One of the key factors allowing the implementation of the Future Internet and a whole new applications and services sector, is the availability of an integrated platform that will expose application interfaces (APIs) and allow developers to market services and service elements. Of course, the

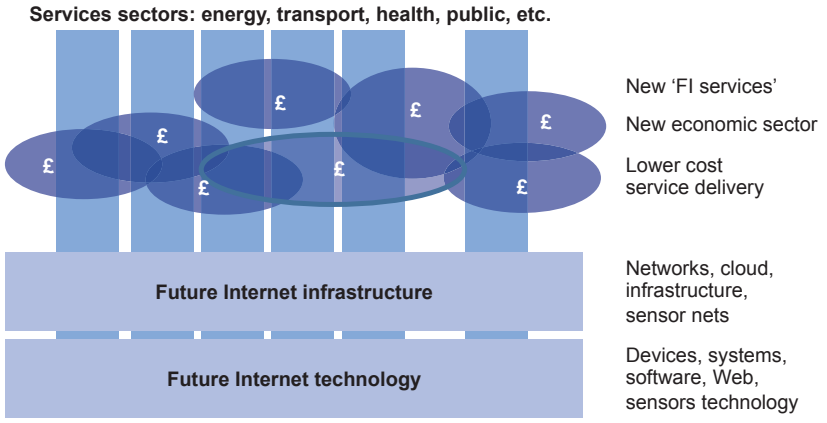
applications market will be open to all types of organisations, but wide-ranging opportunities for SMEs will emerge. This is a similar model to the one operated by Apple and Google today: provide a platform with a micropayment model that allows consumers to pay only for the service they require. The experience of the Apple example is that once the platform and the business model is in place then application developers will move in to develop a whole range of services, thereby creating a market that consumers can access.

There will be multiple platforms, but with a common theme of basic technology in the form of linked sensor arrays, wireless connectivity and systems supporting a cross-sector interface of shared data clouds and networks.

New entrants delivering targeted low-cost services

Enabled by this infrastructure, a new economic sector will emerge with new entrants from industry able to become efficient service providers across multiple sectors creating new revenues and at the same time delivering targeted services to business and the citizen at lower cost (see Figure 6).

Figure 6 Increased revenue from provision of applications



2.3 Efficiency savings across all sectors

Reduced cost of service delivery across all public sectors

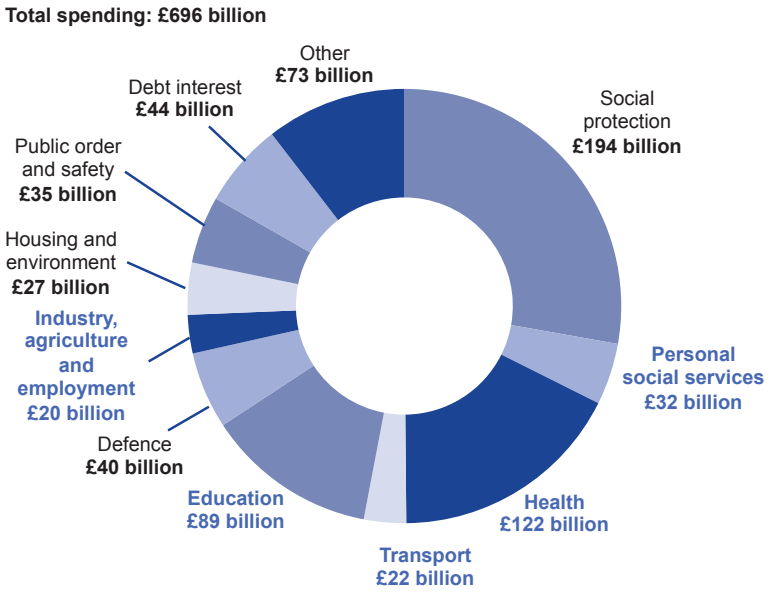
The London School of Economics, Imperial College London and Nottingham University, along with Arup and IBM, have all done considerable work to analyse the potential savings from the Future Internet, with its omnipresent infrastructure and shared data and services. One recommendation of this report is to set up a working group to consolidate this work and construct a plan that covers all public sectors (see Section 8).

Significant savings in Government expenditure …

Government expenditure for 2010–11 in specific areas is set to be industry, agriculture and employment (£20 billion); education (£89 billion); transport (£22 billion); health (£122 billion); social services (£32 billion) – these sectors are highlighted in Figure 7. Even if only small savings in the range of between 5% and 10% could be realised, then the Future Internet environment would deliver between £14.25 billion and £28.5 billion in savings. These savings are savings in public expenditure and do not include savings by citizens in personal transportation and general living expenses.

In addition to the financial return, there will be benefits to the environment through the reduction of transportation CO_2 emissions and more efficient energy usage through the deployment of smart buildings.

Figure 7 Government spending 2010–2011 (Source: HM Treasury[2])



… as well as real social change

These are just a few examples to support the view that the Future Internet could have considerable monetary value to the tax payer and to citizens in terms of personal cost and increased profits and competitive advantage to UK business. A more exhaustive study is required to fully explain the business case for the Future Internet, but if savings in personal transport cost and savings to business through higher efficiency and reduced capital expenditure are added to the above government savings, the value to the UK economy of the Future Internet style approach becomes apparent. Of course, the opportunity is not just monetary. The Future Internet will have considerable social impact through the inclusion of citizens in the delivery of services and the sense of ownership that that will naturally impart.

3 Data

Services will be based on huge amounts of accessible, shared data

A large part of the Future Internet is about data: where they are generated and how they are managed and communicated. The challenge is to enable more data to be made available and shared so that, in turn, more converged services can be created. When talking about data in a global

[2] HM Treasury 2010 near-cash projections. The allocation of spending to functions is largely based on the United Nations' Classification of the Functions of Government (CDFOG). Other expenditure includes general public services (including international services); recreation and religion; public services pensions; plus spending yet to be allocated and some accounting adjustments. Social protection includes tax credit payments in excess of an individual's tax liability, which are now counted in AME, in line with OECD guidelines. Figures may not sum due to rounding.

context, it is important to understand the scale of what is being discussed. Most individuals are familiar with owning videos, photos, emails and documents amounting to several gigabytes (GB) and consider it to be a large amount of data if it totals up to 1,000GB or 1 terabyte (TB). A mid-sized company may hold up to 1,000TB, but there are many organisations that hold a million times more than this.

Much of the data that will be generated in the Future Internet will not be generated by humans, but will emanate from machines or sensors. Therefore, the growth of machine-to-machine communications and the growth of data are interrelated and this section discusses data and sensor growth at a global scale.

3.1 Data growth projections

Digital information is all-pervasive …

Digital information is everywhere: digital bits on HDTVs, audio over the Internet, digital camera pictures. Emailing photographs to friends and family creates more digital bits. YouTube, a company that didn't exist a few years ago, hosts 100 million video streams a day. Experts say that more than a billion songs a day are shared over the Internet in MP3 format. London's 200 traffic surveillance cameras send 64 trillion bits a day to the command data centre. TV broadcasting is going all-digital by the end of the decade in most countries. All this activity results in ever increasing numbers of digital bits.

… and growing rapidly

Key to our understanding of this new environment is knowledge of how much all these bits add up to, how fast they are multiplying and what their proliferation implies. The bullets below indicate the scale of the first two of these issues.[3]

- In 2006, the amount of digital information created, captured and replicated was 1,288 × 1018 bits (161 exabytes or 161 billion gigabytes). This is equivalent to about 3 million times the information in all the books ever written.
- Between 2006 and 2010, the information added annually to the digital universe was estimated to increase more than six-fold, from 161 exabytes to 988 exabytes (see Figure 8).

Images and video are fuelling this growth

- Three major analogue-to-digital conversions are powering this growth: film-to-digital image capture, analogue-to-digital voice, and analogue-to-digital TV.
- Images, captured by more than 1 billion devices in the world, from digital cameras and camera phones to medical scanners and security cameras, comprise the largest component of the digital universe. They are replicated over the Internet, on private organisational networks, by PCs and servers, in data centres, in digital TV broadcasts and on digital projection screens.

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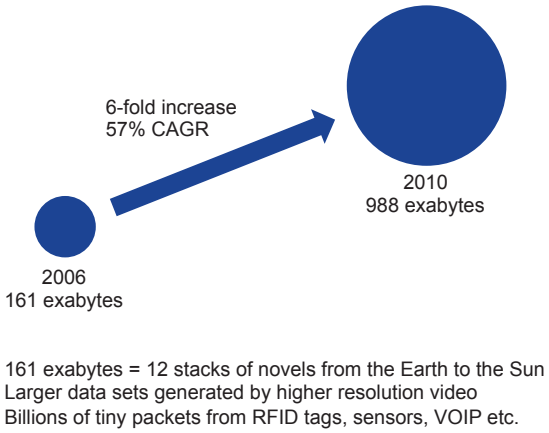
[3] IDC White Paper, The Expanding Digital Universe, March 2007, www.emc.com/collateral/analyst-reports/expanding-digital-idc-white-paper.pdf

Figure 8
Growth in digital data, 2006 to 2010 (Source: IDC, 2010)



Security and privacy will become increasingly important

- IDC predicts that by 2010, while nearly 70% of the digital universe will be created by individuals, organisations (businesses of all sizes, agencies, governments, associations, etc.) will be responsible for the security, privacy, reliability and compliance of at least 85% of that same digital universe.
- IDC estimates that currently 20% of the digital universe is subject to compliance rules and standards, and about 30% is potentially subject to security applications.

This rapidly expanding responsibility will put pressure on existing computing operations and drive organisations to develop more information-centric computing architectures.

Information security and privacy protection will become a boardroom concern as organisations and their customers become increasingly tied together in real time. Furthermore, the community with access to corporate data will become more diffuse – as workers become more mobile, companies implement customer self service, and globalisation diversifies customer and partner relationships and elongates supply chains.

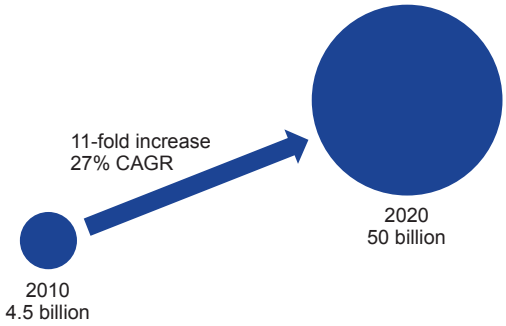
This will require the implementation of new security technologies in addition to new training, policies, and procedures. In particular, IT managers will see the span of their domains considerably enlarged, as voice over IP (VoIP) phones come onto corporate networks, building automation and security migrates to IP networks, surveillance goes digital and radio-frequency identification (RFID) and sensor networks proliferate.

3.2 Growth in machine-to-machine communications

Infrastructure needs to be prepared for rapid increase in M2M communications

Machine-to-machine, machine-to-man and man-to-machine (M2M) communications are expected to grow very rapidly over the next few years, with an anticipated 50 billion devices being connected to broadband connections by 2020 (see Figure 9). To be able to plan and ensure that developments are scalable for the expected increase in data traffic, it is important to have a model for the traffic that will flow through the network.

Figure 9
Projected growth in connected devices worldwide, 2010 to 2020 (Source: Ericsson, 2009)



M2M communications will be disruptive

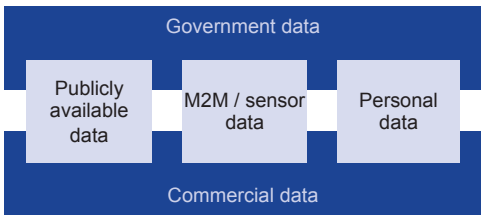
A concept often talked about in conjunction with M2M communications is the 'Internet of People and Things' (referred to in Section 1), where billions of 'smart' objects are connected to the Internet and the data thus obtained can be easily shared and used or reused by many applications. One subfield of M2M communications is sensor/actuator networks that are installed in households, creating automated homes by enabling home appliances to talk to each other and to applications that can be running on hosts connected to the Internet. Such sensor or actuator networks extend the uses of home appliances into completely new and exciting applications, while also potentially making homes more energy efficient by smarter management and operation of these appliances.

3.3 Data types

Converged services will draw on different types of data

Key to this report is an understanding of the different types of data that will contribute to the converged services. These data types are not independent, stand-alone groups; there are areas of overlap, as shown in Figure 10.

Figure 10
Areas of overlap of data types



Reasons for sharing data will depend on the data owner

Irrespective of the source of data, whether entered by people or generated as a result of **machine-to-machine** communications, all data are owned by **government**, a **commercial** organisation or the **individual**. The degree to which these organisations and individuals will share these data so that benefits can be generated will depend on:

- in the case of government, policy and a desire to reduce service delivery costs
- in the case of organisations and individuals, a value case and regulation of what you can share and with whom.

Issues of data protection and active consent have specific relevance.

Data from many sources will be repurposed …

The Future Internet is content-centric as opposed to being communications-centric as it is today. The worldwide data amounting to 988 exabytes estimated for 2010 will not be neatly stored and categorised in a consistent format. Future Internet data will be stored on all kinds of media owned by millions of organisations and individuals across the globe. In some cases, the provenance of these data will be known and tracked but in others it will not. Furthermore, some of these data will have been repurposed several times according to the required use. Information will have been traded rather than the basic data and this in turn repurposed to enable new 'knowledge' to be extracted in support of more services.

… possibly polluted by erroneous data, leading to a degradation of services

The concern is that a sort of 'data soup' will evolve that is polluted by erroneous data leading to a degradation of the services that depend on it. In an environment in which users depend on contextually aware decision support, lack of confidence in the data will lead to a lack of consumer confidence in the service. The opportunity is to provide platforms that can guarantee the provenance of data and trade information generated from these data.

Publicly available data

Can the provenance of publicly available data be trusted?

Data may be published by government or, for example, a city authority, but may also be commercial data released into a shared cloud as part of a contract between organisations as part of the service supply chain. These data will not be directly attributable to a particular individual, but provenance in terms of accuracy is known. Guaranteeing individual anonymity, unless known through active consent, is key to the working of shared data across service sectors. These data and the knowledge drawn from them are used by shared service business models implementing appropriate payment models.

Case study: London data store

The London data store, managed by the Greater London Authority (GLA), is an example of this process taking place and resulting in better decisions on transport.

Machine-to-machine or sensor data

Smart homes will generate data, …

In Section 3.2, the growth of 'things' connected to the Internet was forecast and discussed. DECC is rolling out Smart Meters to every home in the country by 2015, seen as a gateway to the 'smart home', with its access to energy management services and reduction in energy consumption. However, a smart home will have access to entertainment, health care and many other functions in addition to energy.

… as will transport systems …

In transport, communications companies are envisioning the 'Internet on Wheels', where vehicles interact with each other and data points in street furniture, delivering a real-time, accurate picture of road and traffic conditions.

… and other sectors

Energy companies, local authorities, telecommunications companies and entertainment companies, etc. will have to develop business models that allow the 'mashing' and repurposing of data.

However, this category of data presents issues of ownership and integration into what up until now has been an Internet based on human input.

The degree to which the Future Internet can deliver value will depend on the degree to which data can be shared. This in turn depends on:

- the value case
- security
- regulation.

4 The Future Internet challenge and implementation

The Future Internet is about converged services, data and infrastructure that presents an opportunity for the UK …

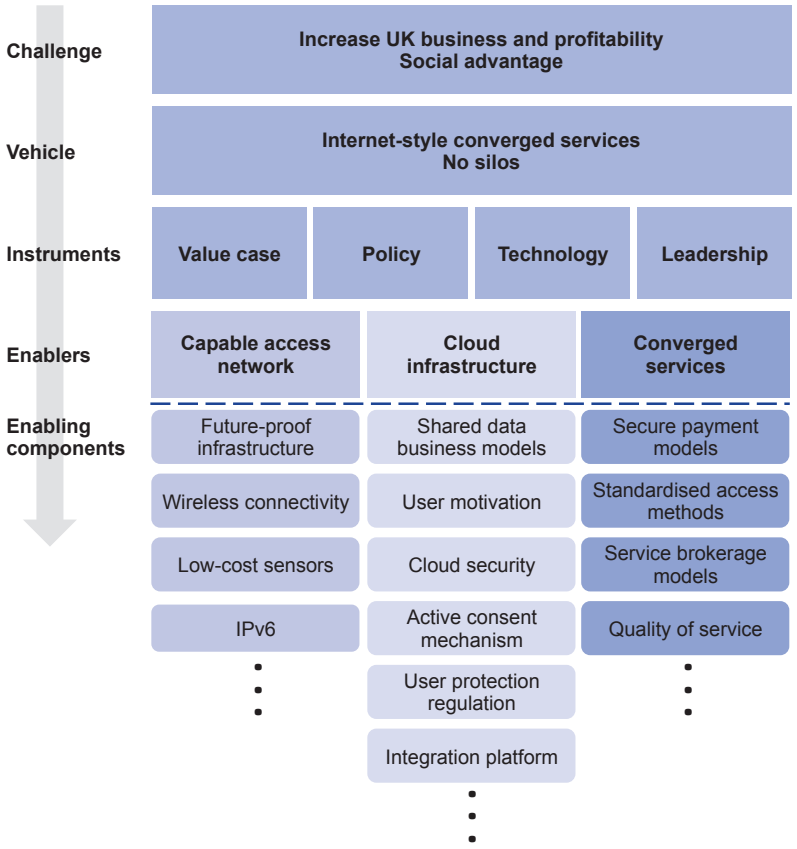
As shown in Figure 11, the overall **challenge** for the UK is to utilise the properties of the Future Internet of converged services, shared data and an always-available infrastructure to increase UK business and profitability, while at the same time enabling major advantage to society. The Future Internet needs to create opportunities for citizens to come together and play a part in the delivery of a wide range of services, rather than accept an open-ended delivery methodology.

The **vehicle** for these changes is new Internet-style converged services and a breaking down of 'walled gardens' in data and service delivery. In effect, this is the removal of the silo approach, with departments at a national and city level operating unconnected systems and databases, moving instead to a horizontal view of service delivery to society and industry, where there is more cross-coordination and massively shared data.

… through putting the necessary elements in place

However, in order for the UK to successfully meet this challenge, it needs to put in place the elements that will enable the Future Internet. This section outlines the instruments and enabler issues shown in Figure 11, while Section 5 considers the enabling components in more detail.

Figure 11
Meeting the challenge of the Future Internet



4.1 Instruments

Various instruments can be used …

As in any change activity, there are instruments that governments and industry can use to effect the required changes. This section outlines the types of instruments, or 'levers', that are available, at both city and national level. Later, Section 4.3 looks at the specific implementation of the Future Internet at a city level in terms of these instruments.

Value case

… value cases for government, industry and data owners

There are different value cases, depending on a commercial or governmental perspective. For example, the city environment requires a value case in terms of reduced service delivery cost to the city, reductions in CO_2 emissions and new services to businesses that will make the city a more attractive place in which to invest – the so-called 'smart city'. From a governmental viewpoint, these factors scale up to a UK value case, but there will also need to be a commercial value case to incentivise businesses to work together in a Future Internet style way. Service revenue will need to flow to infrastructure providers so that real quality-on-demand services can be supported. Similarly, owners of data will need a business case to persuade them to share data with service providers.

Policy

… policy changes to facilitate cross-departmental operation

At a city and national level, there will need to be a change in policy at a most senior level to change the way departments operate, moving from the traditional stand-alone mode of operation to cross-departmental operation. The policy will need to be supported by a jointly developed value case and the implementation of new structures that are design to align service delivery to the Future Internet style. The change will impact on traditional spans of control, demolishing 'walled gardens' and bringing about the advent of cross-departmental shared responsibilities.

On a commercial level, businesses will need to re-examine their corporate structure and cost structures by embracing new ways of delivering output from R&D to operations and support services.

Technology

… technology/platform/ infrastructure integration

Integration of technology and platforms with a capable infrastructure forms the basis of any delivery mechanism. There will be many implementations and it will be necessary to develop architectures to suit each application and service environment.

The technology will encompass the sharing of data clouds, integration of applications with the chosen platforms and all aspects of secure access and payment modalities.

Leadership

… effective leadership with sufficient authority

Without a new organisational structure that can implement the required changes, the full value of the Future Internet will not be realised. It will require a cross-departmental leader position to align the 'levers' and to ensure full implementation of the policy. At a national level, the leadership would need to be at Cabinet level and would encompass not only political leadership but also technology leadership. At a city level, it would mean the creation of a CIO+ role to drive through the required changes and realise the massive opportunities.

4.2 Enablers

Infrastructure must be sufficient to support the Future Internet

As identified in Section 1, the focus of the Future Internet is about a **capable access mechanism** that includes **cloud infrastructure**, massively shared data and **converged services**. There is an underlying need for the infrastructure to keep pace with the requirements set by the new, connectivity-demanding service offerings (discussed further in Section 5.1). Without a capable and omnipresent infrastructure, progress towards a pan-UK Future Internet, available to all citizens and business, will be severely curtailed.

Capable access mechanism

A 'fabric' of interconnectivity will enable anytime, anywhere services

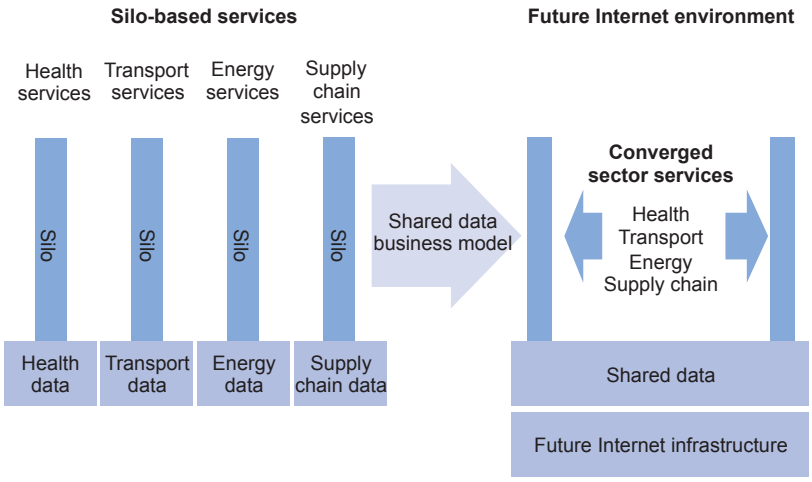
The services will require an 'always-available' environment – not just higher bandwidth, but reliable connectivity anywhere. Increasingly, the services will be ones that support an on-the-move end user and therefore mobile broadband is key to many business models. 'On the move' is not confined to mobile phone calls outside the home or office, but connectivity with a sensor network fabric in all types of locations. The term 'fabric' is used in this context to describe a more advanced network of Internet connectivity, which includes human input and machine-to-machine communications that exist as an integrated part of our living in an eBusiness environment: a ubiquitous, transparent service delivery, available anytime anywhere, combined with situational awareness to provide real-time decision support. An example may be an elderly person being continuously monitored in their own home with personal sensors linked to the mobile infrastructure, to provide health professionals with advanced warning of a potential problem.

Cloud infrastructure

Development of shared data business models is key to converged services

Today's services tend to be narrowly based in industry sectors, driven by databases that are owned by each particular service provider, rather than the vision of the Future Internet in which shared data is used to provide services that cover multiple sectors (see Figure 12). Each service development is currently targeted at a particular business and is unique to that business. Data have high value to their owner, thus an essential element in any progress towards the vision of shared services and data will be the establishment of new business models that recognise this value and return it to data and information providers.

Figure 12 Converging services



Market in data supporting multiple sectors

The change in the way services are provided in this joined-up fashion relies on the ability to share data and information across sectors and organisations. With ever-greater quantities of data being generated by machines or sensors, it will be necessary, simply from a practical and cost benefit viewpoint, to be able to establish a market in data from the sensor fabric. For example, it would not make sense to have sensors in the home

to control energy and another set of sensors supporting health services if they generated the same data. The challenge will be to design environments for business and the citizen that enable the convergence of services.

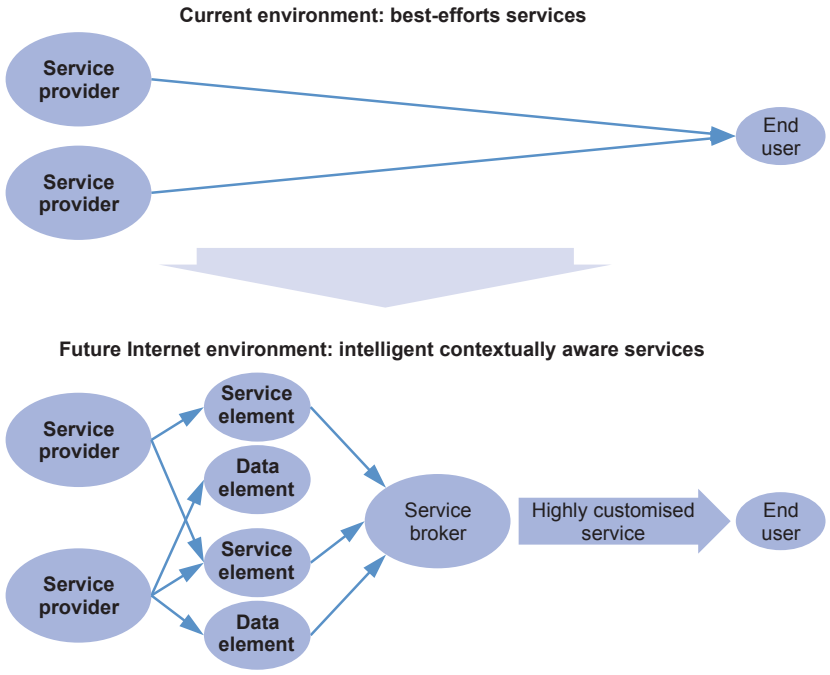
Converged services

The current environment, with its silo-based services, prevents major efficiency savings being made through the provision of shared data and infrastructure. Duplication of resources cannot be eliminated with structures existing in 'walled gardens'.

New service providers will bring diverse contextually aware services at reduced cost

A new class of service provider will emerge that will create and market service elements that can be applied across multiple sectors. These elements will be aggregated together in any number of ways by a 'broker' to provide the end user with contextually aware applications and decision support services (see Figure 13**Error! Reference source not found.**).

Figure 13 The move to intelligent service provision



Cost-effective health delivery at a quality controlled by the GP and patient

Take, for example, a person reviewing their total health requirements with their GP. They may require real-time heart monitoring, and they may also have longer-term mobility issues. The GP will be able to access brokered services from multiple providers to put a package together that precisely meets the patient needs. This will be achieved efficiently and at the lowest cost to a quality of service controlled by the GP and patient. Another implementation could be similar to Amazon or uSwitch, where service and data providers can meet in a virtual environment.

The result will be contextually aware services that can be cost effectively constructed for the individual end user. Efficiency will be increased through always having the correct advice or information available wherever or

whenever it is required: in essence, an information fabric that can be accessed by the end user or a third party at the consent of the end user. From a business perspective, there is the example of Amazon, which started as an online bookshop, but has now developed its business to become a broker for a wide range of products and services.

More choice in service provision

In fact, there is a whole shift away from single service providers. For example, the AA may repair your boiler or British Gas may repair white goods in your home. The Future Internet, with its ability to share data and integrate services, will accelerate this process in all sectors, from manufacturing to health. Ultimately, citizens will benefit from more cost-effective and better-quality services while businesses will be able to market goods and services more effectively.

Rather than services being provided on a 'best efforts' basis, there will be new efficient services enabling people and businesses to do things that are not cost effective or reliable today. Examples range from converged health services with a health package designed for a particular person's need, to highly efficient new forms of companies delivering high value at low cost.

Efficient, highly competitive companies

In the latter case, a small team could effectively leverage cost-efficient and connected services to provide the elements of a company traditionally provided by large numbers of staff located in expensive facilities. Such a company could achieve an economy of scale with a global customer reach (see Figure 14). This model of company enabled by high availability infrastructure would be highly flexible and competitive with traditional companies operating in similar markets.

This approach extends to existing companies that are looking for ways to cut operating costs in a global market, in order to compete with emerging economies such as Korea, which have invested in high performance connectivity. In the second case study in Section 6, a company based in the Netherlands discusses the creation of remote 'hot desk' centres that workers can use to reduce travel costs and company operating overheads.

Figure 14
Increased profits via cost-efficient and connected services

4.3 Putting the theory into practice: the smart city

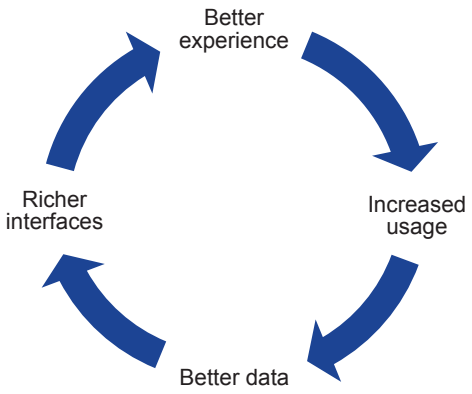
The smart city has high potential for converged services, …

The city can be seen as a potential environment where such joined-up services can most easily be implemented and the benefits most easily measured. The smart city already exists to some extent. Urban infrastructure now includes smart phones, wireless Internet, media facades, sensor networks, smart meters, RFID tags and so on, upon which a rich layer of sophisticated user experiences comprising social media and augmented reality, as well as e-government services, is superimposed.

… building better societies through better experiences

Implementation of a smart environment has a virtuous circle, by first providing a better experience for the citizen, leading to increase use of integrated services, resulting in more data and improved interfaces, giving rise to still better services (see Figure 15).

Figure 15
The effect of implementing a smart environment



Barcelona and San Francisco have a more developed understanding of what is meant by a city as a system. Investing in market awareness, companies such as Cisco, HP and IBM are building a capability that connects all systems together to deliver strategic supply agreements in the city. Companies are making a strategic proposition by saying to the city, 'If you work with us and converge these silos and services, we will be able to deliver more value through reduced costs and an ability to make better decisions.'

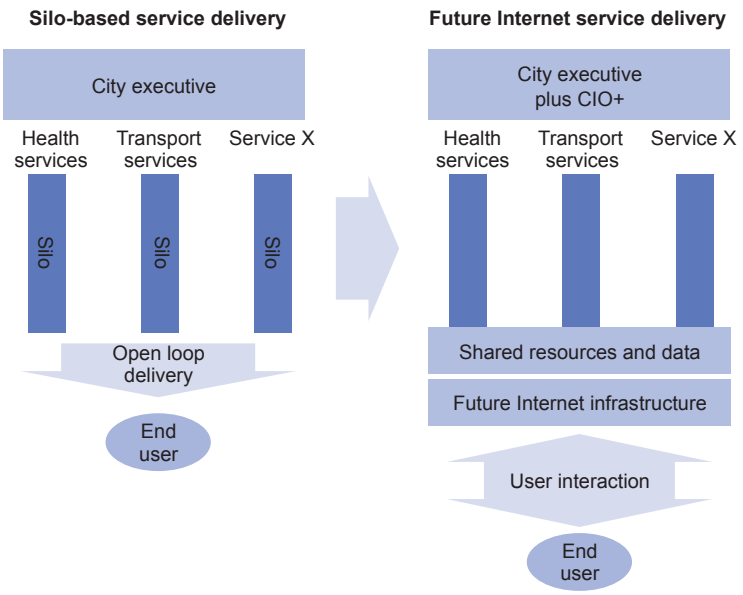
CIO+ role required to change the way services are delivered at a city level

Such supply chain agreements will involve up-front capital investment against future revenue. However, the argument that installing instrumentation in the city environment will deliver the projected returns still has to be won. This has to be done at executive city management level with the involvement of a CIO+ type role, who can engage as an intelligent client with industry and influence policy and budgetary decisions at a city level. That person can then provide the leadership to bring all the silos together. But it has to be a mainstream integrated policy, not a test-bed approach. This is not to say that test beds do not have a purpose, but if the Future Internet is to be implemented on a much wider scale then factors other than technology have to be addressed. These factors are more about policy and the integration of policy into the mainstream of planning and city management than new technologies.

Real-time citizen involvement in the delivery of services

Figure 16 illustrates the required shift in city management approach from a structure where siloed services are managed through separate departments and city executives to an integrated approach designed to deliver high-quality services at minimum cost. Current services are largely delivered on a standard open-loop basis with minimal real-time feedback from the citizen. The Future Internet promises the facility for citizens to become more involved in the delivery of services, with all the implications that has for e-governance.

Figure 16 Moving to converged service delivery



A survey of forty major cities found that there was an absence of understanding of the potential for such services at an executive level. In areas such as utilities and communities, technology was not seen as a component. Even in areas like transport, it is separated into different areas such as bus information or metro operations and each service is stakeholder related; for example, Transport for London (TfL) will do one thing and National Rail will undertake another part.

Taking a 21st century approach to city governance through ICT

The value case for a true smart city has yet to be made and the suggestion is to create a pathfinder programme involving key people from a number of cities to define a programme of integration, in essence a feasibility study on how to create a real smart city. The value case has to be bottom up in the context of that particular city, but common themes will emerge.

Need to create the value case for a smart city

In summary, there are four instruments at this level:

- **Value case** for the smart city concept: this is a key step to make the transition from today's test beds to a full city-wide implementation. There will be a whole range of benefits, from reduced costs of running the city to a better environment through reduced $C0_2$. From a business perspective a Future-Internet-enabled city will be able to complete with cities in other locations worldwide to attract inward investment and business start-ups.
- **Policy**. Without the adoption of a Future Internet style approach to service delivery then any implementation is inevitably going to be piecemeal and sub-optimal in terms of savings and quality of delivery. There must be a concerted initiative to move away from silo-style service delivery to a Future Internet style of converged services.
- **Technical architecture leadership**. A city-wide deployment will involve many stakeholders and an enormous amount of data. Whatever the implementation, it has to be based on an architecture that is scalable and able to keep pace with the growth in requirement

for services for both citizens and business. There is an example of a 12-month exercise in Norway to bring together city and industry. Such collaboration with effective leadership will shorten the time scale.

- **Leadership**, in the form of executive commitment to the smart city concept and the establishment of the previously described CIO+ role with executive powers to effect change: the city executive has to view services in an integrated way and plan for delivery as a shared operation. The CIO+ role as part of the executive has the power to drive this agenda, backed by a budget but with the responsibility to deliver the projected benefits.

5 Enabling components

Some elements of the Future Internet already exist

Reinforcing the point that the Future Internet is an evolution out of what exists today, not a prophecy of something new in the future, the Future Internet already exists in different areas of the world in various forms. Elements of the future environment can be found in San Francisco, Barcelona, Korea and China, to name but a few. Each of these locations can demonstrate live implementations of the sort of joined-up, converged services that are described in this report.

Enabling components, not barriers

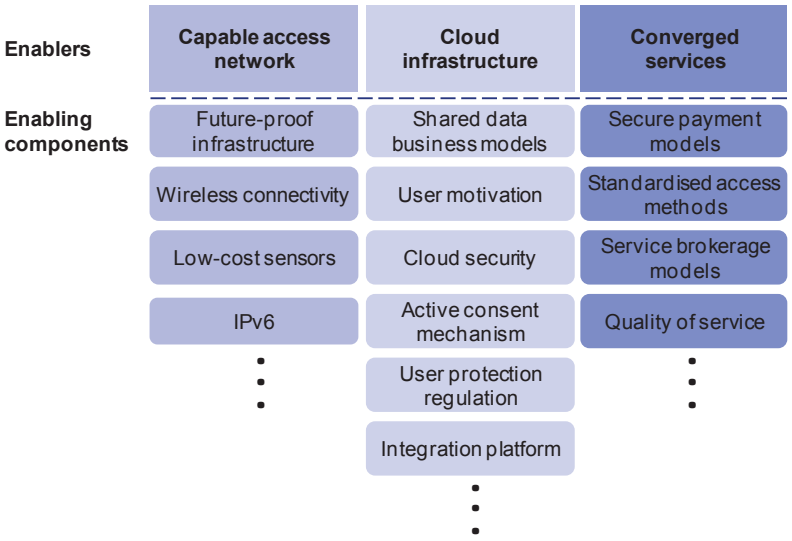
The idea these examples reinforce is that there are enabling components rather than barriers to the Future Internet. A key focus of this report is to identify the main enabling components that will allow a 'market' based on the concept of the Future Internet and the advanced connectivity and mobility features it provides. Many of these enabling components can be implemented today: for example, the technology to share data or to provide wireless connectivity is available; novel payment models are implemented in businesses like Apple and Amazon. There are concerns and this section will highlight them, but fundamentally the main issue is how to bring multiple elements together around a value case that will justify the required investment and result in a market being created.

Figure 17 depicts the enablers for the Future Internet that could bring together all the features described in Section 2 for an environment providing converged, always-available services. The purpose of the diagram is to identify some of the key enabling components of these enablers that have to be in place to deliver the Future Internet vision.

Services, data and infrastructure

This report has identified that the Future Internet is about three things: **capable access network**, **cloud infrastructure** and **converged services**. Therefore the enabling components are grouped under these three headings.

Figure 17 Enabling components for the Future Internet



5.1 Capable access network

0 (overleaf) summarises the enabling components for a capable access network, including their current status. These factors are then discussed in more detail below.

Future-proof infrastructure

Infrastructure must keep pace with developments in services

The Future Internet implements advanced capabilities available to citizens and businesses, enabling people to change work patterns by increased use of teleworking as described in the second case study in Section 6. These new capabilities will only be realised if the UK has an infrastructure that is capable of keeping pace with advancements in video capture and the increased data flows generated by real-time services.

Issue 1: Investment required to deliver an advanced capability.

Wireless connectivity

Wireless connectivity required in the home for sensor and other data

In the UK, wireless connectivity in the home is currently the subject of major focus as part of the DECC Smart Meter roll-out that is planned to be complete to all 26 million homes by 2015. As part of that work, standards are being established to link many diverse devices to a hub that in turn communicates with a wide area network using Internet protocols. A number of solutions are being considered; the point to note is that cost savings can be achieved if sensor and other data can be available to multiple applications and repurposed as required. In reality, the market will offer the consumer competing ways of achieving this objective.

Always available wireless infrastructure is required everywhere to support many services

It is outside the home where wireless connectivity becomes even more important. Support needs to be provided for mobile applications – 'Internet on Wheels' – allowing dynamic management of traffic flows, real-time updates to individuals and route management, with such data being repurposed to aid longer term transport planning and policy formulation.

Table 1 Status of enabling components for a capable access mechanism

Enabling factor	Level of implementation	State of technology	More R&D required?	Issues
Future-proof Infrastructure			✓	• Investment required to deliver an advanced capability
Wireless connectivity			✓	• Resolution of spectrum issues for LTE[4] and improving multiband RF front-end components to utilise spectrum more efficiently
Low-cost sensors			✓	• Development of multipurpose low-cost sensor arrays • Sensor power • Standards for wireless communications
IPv6				• Identify potential opportunities

Key:  = extensive action required, but issues not yet understood
= some action required, but issues are known
= no action required

In terms of improved and reliable connectivity, there are already innovative solutions emerging involving 'mesh' approaches using femto technology, with individuals being offered reduced Internet pricing packages if they give up bandwidth to the 'mesh'. These solutions work well in dense urban conurbations, but rural connectivity will require different solutions.

The frequency and bandwidth of available spectrum are key determinants of how cost-effectively a given level of service can be delivered. However, the portion of the spectrum that is suitable for wireless broadband communications is limited and is also highly valued for other applications such as broadcasting, navigation and radar systems. The evolution of wireless communications from simple voice and text-based services to broadband multimedia at speeds comparable to fixed networks presents a challenge for network operators, technology developers and national regulators to ensure that sufficient spectrum is available to meet future demand and that the spectrum that is available is used to best effect.

The contribution of wireless technologies to the Government's broadband objectives depends in no small measure on the availability of spectrum. That is why the Government is in the process of directing Ofcom to take steps that will accelerate the release of spectrum at 800MHz and 2.6GHz,

[4] LTE stands for long-term evolution, which is the successor to 3G.

spectrum particularly suited to broadband services. That is also why the Government has announced a target to release 500MHz of spectrum, below 6GHz, over the next ten years.[5]

Issue 1: Ensure efficient spectrum usage and improve radio performance as it is a key issue to be solved for Future Internet services.

Low-cost sensors

Sensors will enable new applications

Low-cost sensor networks are a key feature of the Future Internet, with new applications such as infrastructure security, habitat monitoring and traffic control being enabled. Technical challenges in sensor network development include network discovery, control and routing, collaborative signal and information processing, tasking and querying, power and security. This report highlights the issues around the development of such networks and informs R&D prioritisation. Without the ability to build interconnected sensor arrays, it will not be possible to build this 3D virtual picture of an environment that will support accurate decision support. 'Low-cost sensor arrays' and the 'Internet of People and Things' are somewhat interchangeable descriptions of this fundamental requirement.

Issue 1: The development of low-cost, multipurpose sensor arrays that can be used in many types of environments.

Issue 2: How individual sensors will be cheaply and reliably powered.

Issue 3: The development of standards for communication.

IPv6 adoption[6]

Move to IPv6 required to underpin UK Future Internet implementation

One of the major challenges for stakeholders in thinking about the future of the Internet is its ability to scale to connect billions of people and devices. One of the objectives of this report is to raise awareness among policy makers of the capacity and limitations of the Internet Protocol version 4 (IPv4), to provide information on the status of readiness and deployment of the Internet Protocol version 6 (IPv6) and to demonstrate the need for all stakeholders, including governments, to play a part in IPv6 deployment.

The consumption of IP addresses will be accelerated by the rapid increase in the number of sensors connected to the 'Internet of People and Things'. One of the key impacts of this explosion will be the exhaustion of the approximately 4 billion IP addresses currently provided by IPv4. This will therefore drive the business need to move the infrastructure to IPv6, which with its 128-bit addressing schema will provide 3.4×10^{38} addresses, amounting to trillions of addresses per person on the planet.

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[5] BIS Britain's Superfast Broadband Future paper http://bis.ecgroup.net/Publications/BusinessSectors/Telecommunicationsbroadband.aspx?LocID=&col=PublishedDate&sort=desc&SubcategoryID=66

[6] OECD, Internet Addressing: Measuring Deployment of IPv6 April 2010, www.oecd.org/dataoecd/48/51/44953210.pdf

IPv4 addresses used up in 2011

There is now an expectation among some experts that the currently used version of the Internet Protocol, IPv4, will run out of previously unallocated address space in 2011, as only 16% of the total IPv4 address space remained unallocated in early 2008. The situation is critical for the future of the Internet economy because all new users connecting to the Internet, and all businesses that require IP addresses for their growth, will be affected by the potential unavailability of IPv4 addresses.

IPv6 provides more than just additional address space

IPv6, on the other hand, vastly expands the available address space and can help to support the proliferation of broadband, Internet-connected mobile phones and sensor networks, as well as the development of new types of services. Beyond additional address space, IPv6 adoption is being driven by public sector procurement mandates, by deployment of innovative products and services and by its better support for a mobile Internet, as well as by the decreased network complexity that it allows.

Today, the latest versions of new popular end systems (e.g. Microsoft Windows Vista/Server 2008, Apple Mac OS X, Linux) fully integrate IPv6, as do parts of the core of the Internet. However, progress in actual usage of IPv6 remains very slow to date and considerable challenges must be overcome to achieve a successful transition.

Table 2 UK ranking

IPv6 address allocation	Top IPv6 networks	ISP's offering IPv6	Operating systems supporting IPv6	Native IPv6 users
United States	Germany	Germany	Japan	France
Germany	Netherlands	United States	United States	China
Japan	United States	Japan	Taipei	Sweden
United Kingdom	China	United Kingdom	Korea	Netherlands
Netherlands	United Kingdom	France	China	United States
Australia				Japan

The key issues relating to IPv6 deployment are shown in **Error! Reference source not found.**:

- **Allocations of IPv6 address space** show interest in potential IPv6 deployment, since obtaining IPv6 address space is a first step in deploying IPv6.
- The IPv6 global routing tables show the **top IPv6 networks** that are to some extent capable of handling IPv6 traffic.
- As key infrastructure to exchange local Internet traffic, Internet eXchange Point (IXP) support of IPv6 is a prerequisite for fast and inexpensive IPv6 connectivity. Having **Internet Service Providers (ISPs)** and transit providers offer IPv6 is also key to enabling IPv6 connectivity.
- The penetration of **operating systems** that support IPv6 by default

indicates the number of Internet computers/devices ('end-hosts') that could potentially run IPv6.

- End-user systems that chose IPv6 when given the choice (dual-stack) and end-user systems that have IPv6 connectivity are two very important indicators of **IPv6 uptake by users**. They are particularly important for content providers.

Organisations are reluctant to make the investment to move to IPv6

The figures show a very small percentage take-up of IPv6 compared to the installed base of IPv4 (fractions of a single percentage in most cases). IPv6 is not backwards compatible with IPv4 and a significant investment will have to be made to move everyone onto the new protocol. There has been a perception that IPv4 can be made to continue to serve the needs of Internet users and in the present financial climate organisations are reluctant to make the investment until they really have to.

Delay in IPv6 is a limiting factor to UK development and risks loss of skills

However, other economies in South East Asia, and in particular China, are making the transition to IPv6 and this process will continue leaving the UK disadvantaged in terms of business in general and also in its ability to grow new sectors based on the Future Internet. The UK will not be viewed as a world leader in terms of Internet technology development and Internet service provision. This in turn will mean a loss of skills in the industry and will restrict growth.

The UK Government therefore established a policy and provided some seed investment in promoting the change over to IPv6. 6UK (www.6uk.org.uk) was formed in early 2010. 6UK is a not-for-profit membership organisation founded to help the UK and UK organisations secure every competitive advantage available from the rapid adoption of the new protocol.

Issue 1: Work needs to be done around the cost to business and loss of competiveness in the event of the UK failing to take a lead.

Issue 2: From a positive perspective, commission a study of potential opportunities for the UK in developing technologies, applications and business models.

5.2 Cloud infrastructure

Issues around security, access and business models

It is worth noting that while the Future Internet will provide advanced services to citizens and businesses, as discussed in this report, the capabilities of the Future Internet will also provide alternative infrastructures for companies needing to reduce operating costs to capture new business in the face of competition from emerging economies that are well advanced in the provision of capable infrastructure. In order to create an infrastructure of shared data clouds, a number of enabling components need to be put in place.

Table 3 summarises the enabling components for shared data, including their current status. These factors are then discussed in more detail below.

Table 3 Status of enabling components for cloud infrastructure

Enabling factor	Level of implementation	State of technology	More R&D required?	Issues
Shared data business models				• Now a question of application design
User motivation			✓	• Confidence • Psychological and value case
Cloud security			✓	• Security across organisational and national boundaries
Active consent mechanism			✓	• Legal and regulatory issues coupled with R&D into more robust and transparent methodologies
User protection regulation			✓	• Regulation at UK, EU and global level
Integration platform			✓	• Build platforms that will allow applications to be created and marketed (e.g. Apple)

Key:  = extensive action required, but issues not yet understood
 = some action required, but issues are known
 = no action required

Shared data business models

Recognising the value of data at each element in the value chain

Data has value, shared data and information have even greater value. Value can be monetary or it can be a benefit we are prepared to accept as the price for releasing personal data or allowing sensory information relating to our own environment to be pooled.

Converged services can only be possible with shared data and therefore businesses and individuals will have to share the benefits and profits that result from those services. For example, train companies and bus companies will share data if that sharing results in increased passenger levels as a direct result of a more efficient and user-friendly transport system.

Issue 1: The means to develop new business models is already being pioneered by Google, Facebook, etc. The technology exists and the issue is one of extending these principles into the way general services, both public and private, are sold and delivered to end users and organisations.

User motivation

End users need to be persuaded of the value versus perceived risk

There are studies underway in the area of Smart Energy, in particular the means by which consumers will adopt change to enable energy reduction targets to be met. The output of this work can inform the debate about overcoming user resistance in the Future Internet sector.

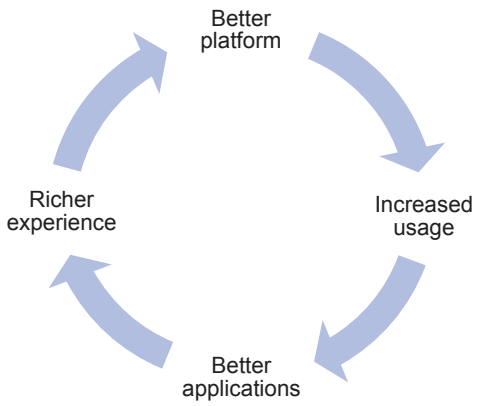
A service usually gains acceptance if a value case is made and/or the service provides an improvement as measured by the end user. This may be something of really significant value, for example better and more responsive health care, delivering education to a wider audience, or simply providing better ways of managing personal travel. Each example has a value to the consumer. If this value is allied to low investment on the part of the user, then risk is taken out of the equation. For example, Apple or Android applications are generally low cost or even free, so the decision point is made easy. If there is high obvious value, then the consumer will be prepared to invest more.

Much is made about the security aspects of the Future Internet, but consumers are already using the Internet to impart personal data and an extension of security methodologies will overcome any concerns.

Users may be 'rewarded' for data by gaining access to shared services

If user data has a value and an organisation can create profits from analysis of these data, then the provider of the data has a right to expect some form of compensation for it. The 'payment' for data may not be simple monetary: taking the example of BT FON, giving up bandwidth allows access to the service. In a similar way, a data-sharing business model may be devised that allows access to shared services. Once the platform is established and applications created, then users will experience value, leading to a virtuous cycle of revenue generation and improved services (see Figure 18).

Figure 18 Enhancing user services and experience



Issue 1: Confidence in the security of data, market psychology and value case as measured by the user will be a major factor in the overall aspect of user motivation and Future Internet take-up. Any lack of confidence is not confined to individuals, but also applies to public and private organisations. What will motivate a city to change its management strategy to become a smart city?

Cloud security

Users need to feel their data are secure, …

Microsoft Windows 7 offers a private cloud facility, where documents, photos and data files can be stored. The facility allows the sharing of such data with other specified individuals. The Future Internet with its omnipresent fabric takes this to another level, with data being added to our own cloud without necessarily our intervention.

… that they can control use of their data …

But security is not just about preventing others from accessing data. Security of course involves confidentiality, but also has to address confidence, confidence in the user's ability to control the use of data. A security protocol that is going to have to control access by multiple third parties must deliver the appropriate level of confidence in relation to the type of data being secured. Users need to have confidence that their data is not going to be inappropriately accessed, used or passed on. For example, bank details will require the highest level of confidence, whereas energy usage patterns are less of a concern. The collected data must be kept secure, and must ensure prohibition of uses (or misuses) of the data not compatible with the user's wishes. Its integrity must also be maintained throughout the many iterations of storage technology that will inevitably take place.

… and that they can access their data as long as they need

The second element in security is that of availability. To entrust critical personal data to a cloud hosted by a third party is to trust that the data are going to be available whenever it is required for as long as it is required. This is a broad assumption as companies change ownership or even go out of business. They may also see the data as an asset to be traded.

Issue 1: As data are shared across sectors and by different organisations, how is that secured when the organisations hosting the data may not be in the UK and may not always be financially viable?

Active consent mechanism

It is easy to grant consent, harder to withdraw it

How can giving consent on line be made to be as reliable as turning on a tap and revoking that consent as easy as turning the tap off again? The challenges relating to the collection, storage, use and onward sharing of personal data are wide ranging, encompassing regulatory, business, end-user and technological issues.

Ultimately, users must have confidence in both their ability to know what data are held that is traceable to them by full disclosure backed by regulation, and their ability to ensure data are withdrawn on request. It is the ability of the users to make the right choices and not just blindly continue to hit the accept button. Ways need to be found in which citizens are more involved and empowered to have more control and rights over usage of their own data. Business models need to reflect an active participation by the citizen or organisation and to have security and privacy built into them. The FIA Ghent report[7] describes a 'data deluge' and

[7] FIA Ghent report. Future Internet Assembly, December 2010, www.future-internet.eu/uploads/media/r-fia-ghent.pdf

questions why all these data are needed. It would appear that data are often collected simply because it is technically possible to do so and as a result there is a growing loss of control by data managers.

Issue 1: Legal and regulatory issues coupled with R&D into more robust and transparent methodologies.

User protection regulation

Data knows no boundaries and international regulation will become a major factor

EU data regulation is currently under review and any development and deployment of the Future Internet will need to comply with the outcome. However, the Internet knows no boundaries and issues around competition from different parts of the world are recognised.

Privacy policy needs to be developed as part of the design of the Future Internet

One of the most sensitive aspects of consent is around the use of location data and this is especially relevant to the Future Internet with its promise of contextually aware decision support services. Current regulations limit creativity, as authorities do not want people to share their location. With the development of the Future Internet, there are a number of challenges to build privacy policy:

- Individuals must know what happens to their data.
- Individuals must gain control over the processing of their data.
- There is a need for greater transparency on data processing.
- There is an urgent need to clarify what 'informed consent' means and when and how it should be obtained. In addition, clarification on what 'implied consent' means, which may be inferred by an action or inaction of the user, should be addressed urgently. The way in which consent is given should be unambiguous and there should be no doubt about whether the individual has consented. The legal regime should ensure that consent is full and there need to be new ways of informing people 'up front'. For example, there are some cases where expressed consent should be required.
- There is a need for more proactive approaches to data privacy and integration at a practical level.

Building the right data protection framework goes hand in hand with technological developments. When dealing with privacy and citizenship, a clear view of what data is applicable is required, including all information on individuals and on objects that could have an impact on the individual. This has consequences, in particular, on new technologies. Privacy in the Future Internet is only effective if it is part of the design: building data minimisation and processing of the minimum sets of data required into the systems.

Issue 1: Ofcom's ability to regulate data use and ownership when the data are hosted in the UK. Then what controls are practical in the prevention of data being transferred out of UK jurisdiction and misused?

Integration platform

Enabling a Future Internet environment that many organisations can participate and invest in

The point has been made repeatedly in this report that many of the individual technologies and business models already exist in one form or another. For example, cloud technology is being implemented across many sectors, payment systems that allow consumers to pay only for the elements they want are already in place. Security is a concern, but there are already significant advances in user protection. For the Future Internet to take off, a key element will be a platform that will allow application creators to make use of the shared data and combine service elements.

The Apple and Android platforms for smart phones are an ideal example. A simple platform was created and that in turn created a market in applications relying on a variety of business models. The platform has a set of standards and exposes APIs. Anyone is then free to develop an application and generate revenue. The market then makes a judgement on whether that particular application has value.

While it is possible to draw examples from other sectors, a platform that would initiate a similar scale of growth in the adoption of the Future Internet is not understood and requires urgent R&D.

Issue 1: Risk investment to develop a standardised platform that will allow applications to be created and marketed.

5.3 Converged services

0 summarises the enabling components for converged services, including their current status. These factors are then discussed in more detail below.

Payment models

Easy access to a multiplicity of services

There has been an increase in the development of micro payment models for services similar to the business models developed by Apple with its iTunes application. The emphasis is on ease of access to accurate, contextually aware, decision support services that can be purchased for only the time they are required. Once the service capability is in place through converged content and fabric infrastructure, there is nothing to prevent a business launching services with this payment methodology.

Issue 1: No real issue, now a question of application design.

Table 4 Status of enabling components for converged services

Enabling factor	Level of implementation	State of technology	More R&D required?	Issues
Secure payment models				• Now a question of application design
Standardised access methods			✓	• Development of advanced identity methodologies
Service brokerage models				• Business model to demonstrate value across a wide range of services
Quality of service across the network			✓	• Implementation of QoS across the Future Internet • Developing a capable infrastructure

Key:  = extensive action required, but issues not yet understood

 = some action required, but issues are known

 = no action required

Standardised access methods

Access needs to be easy but secure …

Mechanisms for gaining access are necessarily complex, but represent a barrier to the world where we can use any service, any time, anywhere. To the average user it is a mess, with different passwords and user ids to remember, to a point where for practical purposes people use the same password for multiple applications. There are multiple solutions, some strong, some weak. They tend not to be user friendly and there is no agreement between service providers on what levels of authentication will be required. Security and therefore access should be appropriate to the context.

The user of Future Internet services should not have to worry about how the content is delivered. It should be available through any appropriate device when and where it is needed. The communications medium should be completely transportable and the user should not have to search for a 'hot spot'.

However, although a Future Internet user should be able to access services as required by means of a method that is universally recognised on the Internet, it must be more sophisticated than a single identity that once breached would be disastrous for an organisation or individual. In other words, access should be secure, but simple in the sense that in a converged services world the user is accessing a single fabric, not individual unconnected services.

… and users need to have confidence in its security

It all depends on confidence and in order to provide this there is a requirement to create a demand for secure, safe and reliable software products that meet certain standards. This will become an increasing issue with the proliferation of new applications.

The UK Government and even the EU Commission could regulate, but the Future Internet is global in nature.

Issue 1: Development of advanced identity methodologies.

Service brokerage models

Depends on the ability to build business models that provide a return on investment

Some long-established business models used in the physical world have been adopted on the Internet, with varying degrees of success. Among these are mail-order, advertising, free-trial, subscription and direct-marketing models. Other business models are native to the Internet and e-commerce and focus heavily on the movement of electronic information, including digital delivery, information barter and freeware models.

One business model that has transferred to the Internet is the brokerage model. At the heart of this model are third parties known as brokers, who bring sellers and buyers of products and services together to engage in transactions. Normally, the broker charges a fee to at least one party involved in a transaction. While many brokers are involved in connecting consumers with retailers, they may also connect businesses with other businesses or consumers with other consumers. A wide variety of different scenarios or business configurations fall under the banner of a brokerage model. These include everything from websites posting simple online classified ads and Internet shopping malls (websites that sell products from a variety of different companies) to online marketplaces, online auctions, aggregators and shopping bots.

Issue 1: Developing a business model to demonstrate value across a wide range of services.

Quality of service across the network

Users will pay only for the required level of service

The Future Internet comprises an environment of converged services based on shared data and delivered via an omnipresent infrastructure to provide advanced services that are in most cases contextually aware. Service providers will charge for applications on the basis of delivering a standard of service, and consumers will expect to receive the requisite quality of service at all times.

Consumers are used to receiving a ‘best efforts’ service on a fixed subscription basis. However, once it is possible in real time to invoke an application that requires a specified service delivery, then the best-efforts approach no longer works. For example, a person may wish to hold a high-definition videoconference and pay for the additional bandwidth for that service, but only for the period of time that it is used.

Quality of service is therefore about the implication for the network infrastructure and its ability to respond to service requests from users and

their applications. Videoconferencing, for example, has not only a quality aspect but also a real-time aspect requiring the prioritisation of data packets to meet a user-specified quality criteria.

This model then needs to scale to millions of consumers accessing services through the omnipresent web and paying for only the services they consume.

Issue 1: Implementation of quality of service across the Future Internet based on a network infrastructure that will support it, combined with application managed service level agreements (SLAs).

Issue 2: Developing an infrastructure capable of delivering this quality of service.

6 Sector case studies

Case study: A telehealth system

A Technology Strategy Board supported project is allowing patients with long-term conditions to undertake video consultations with secondary care in their own home using a domestic broadband connection. In West Yorkshire, The Advanced Digital Institute brought together Airedale NHS Foundation Trust Hospital, an SME technology company called Red Embedded Design and a small content house called BTL to deliver this Internet-enabled solution. Based on consumer electronics and using the patient's own TV, a set-top box delivers video experience that improves with the quality of the broadband connection. The approach opens up a range of service propositions for delivering care including:

- early discharge from hospital with patients supported in their own home through virtual ward rounds
- outpatient consultations in the home
- links between primary and secondary care with the potential to shorten patient pathways and waiting times
- potentially a single point of access to both health and social care.

A patient using the system wrote, 'The telemed literally brought tomorrow's technology into my living room today: without any need to travel I can talk to a specialist! The system puts me in control of my diabetes care instead of my illness governing or interfering with my lifestyle. There is no expensive journey to and from hospital (2 bus journeys each way!), no reorganising of work commitments to then spend time sitting around in waiting rooms and no stress and frustration: simply a live link-up where I can talk freely and we can swap ideas as to how to improve my life. Talking in this way makes me feel I am being treated as a person with a life beyond my diabetes – not just an illness with a patient attached! The consultation is an active two-way process. In turn, this gives me the confidence to ask questions and try out suggestions knowing that problems can be swiftly addressed. It makes a huge difference to how I feel about my diabetes and therefore about myself!'

By improving quality and access to broadband these new ways of working with patients have the potential to transform health and social care improving people's lives.

Case Study: Smart Work Center Amsterdam Bright City opens first public Cisco TelePresence suite in the Netherlands[8]

TPEX Offers subscription and pay-as-you-go collaboration services

AMSTERDAM, 14 October 2010

Today the first ever public telepresence service has been launched in the Netherlands. Public Cisco TelePresence™ service is being offered by TPEX Netherlands and is already available to the public in the Smart Work Center Amsterdam Bright City. This facility is part of the Double U Smartwork, a network of Smart Work Centers throughout the Netherlands. Smart Work Centers offer high-end working facilities and aim to address modern urban challenges by measures such as reducing travel and promoting efficient and sustainable ways of working.

Public Cisco TelePresence suites operate on a subscription or pay-as-you-go service that can be booked online by virtually anyone through TPEX Netherlands. The TPEX Telepresence Network is connected to a number of other rooms around the globe through Tata Communications' Global Meeting Exchange. The Exchange enables business-to-business meetings between any public rooms or customer-owned private rooms on Tata Communications' services; as well as rooms on the networks of Tata Communications' Intercarrier-Exchange partners, BT and Telefónica, and the National Lamda Rail network, which links leading US universities. This network reach makes Public Cisco TelePresence a truly global collaboration tool.

7 Promoting UK Future Internet innovation

7.1 The role of firms

With a favourable business and regulatory environment, businesses will be motivated to invest in R&D

There is an opportunity for high-growth, service-provision technology. The question is how industry, both large and small, together with research organisations and the Government, can devise a combination of policy and stimulation.

There are opportunities for SMEs to collaborate by building virtual clusters, sharing intellectual property and working with larger companies. For example, Cisco and IBM are among a number of large multinationals that value the work agile and innovative SMEs bring to R&D and are engaged in setting up clusters of SMEs to create engines for innovation. Also, by involving academic institutions, they are able to create highly innovative and creative environments, which can often produce results quicker than large R&D organisations.

SMEs need to be encouraged to embrace the opportunities

SMEs will play a large part in the Future Internet and through highly available and reliable services be able to access niche markets not always of interest to larger organisations. Large firms will consolidate on the infrastructure and they will also have a role in the adoption of new business models.

The problem the UK has to address is that of scale and integration. The USA has the scale, Asia has the vertical integration. However, the UK has

[8] http://newsroom.cisco.com/dlls/2010/prod_101410b.html

a strong SME community that will develop innovation once it sees the policy; this is an area where the knowledge transfer networks (KTNs) and the Technology Strategy Board can stimulate growth and innovation. SMEs also need to be open to the opportunities presented by the Future Internet, understanding the value of R&D and the potential for exploitation, supported by increased venture capital funding. A UK-based Network of Excellence has been suggested. Large multinationals play a pivotal role in attracting inward investment by demonstrating the advantages of working in the UK and also through their own internal investment and sourcing decisions.

Issue 1: Lack of a national strategy as exists in other countries.

7.2 The role of the public sector

Infrastructure roll-out is important, …

Just as with private investment, there is a role for the public sector in the implementation of the different aspects of the Future Internet. Developing policies for the roll-out of capable infrastructures that can support the advanced services promised in the Future Internet environment is the first enabling objective, and the Government's drive to roll out broadband to all citizens is a valuable contribution.

… but regulation and innovation support can stimulate investment

However, there is more that the public sector can do to stimulate and enable the Future Internet, which in turn will deliver the opportunities described in Section 2. Although the Future Internet is an evolutionary process, it will require the enabling components to be integrated together to move to a new value-added environment. In particular, there is an early adopter stage where regulation and support for innovation can stimulate significant commercial investment and activity.

Support for innovation

R&D tax credits could be extended to include new technology

A number of large companies such as IBM and Cisco are developing technology clusters involving SMEs in working on innovative projects, from technology to the supply chain. Extending SME support in the form of tax credits from just R&D to the implementation of new technologies will enable small businesses to create new products and services supported by larger organisations. These clusters could in turn link together to form 'innovation communities', focusing on a particular technology or industry sector.

The Government needs to develop understanding of the benefits of the Future Internet

Innovation is also about finding ways of encouraging businesses and citizens to take up the opportunities offered through new services and ways of structuring and running businesses. There is a place for the Government to engage with people and develop awareness of how the Future Internet can provide benefits to a wide range of people and organisations. Lack of awareness and innovation leadership down to the individual level will impede take-up and slow the development of new markets that can then be exported. A fully engaged society supported by a capable infrastructure allowing business to adopt lowest cost methodologies will also attract inward investment.

Providing light touch regulation

Proactive regulation can encourage innovation

Providing light touch regulation that is aligned to a Future Internet environment will allow UK business to complete with other deregulated economies. Regulation should also be proactive rather than reactive; the proposal is that the regulator should take on additional responsibilities to promote innovation, something it is not currently mandated to do. Government bodies do not regulate in this area and are not enablers; in fact, the Government is seen as tending towards being risk averse. A consultation is required to establish exactly how this would be implemented.

Public procurement taking a lead

A critical mass of business could put the UK in a leadership position

Public procurement could select key sectors that can deliver new growth and maximum GDP, such as health, transport, energy and education, as flagship areas where procurement organisations could work together to provide an early critical mass of business that would enable UK industries to be in a leadership position. For example, if a local authority purchases 20 electric vehicles it has no effect of the electric vehicle industry, but if all local authorities placed a combined order then that investment would fuel R&D and export potential as the industry achieves a critical mass.

8 Recommendations

To accelerate the evolution of the Future Internet in the UK, areas of technology, business models, security, consumer psychology, leadership and regulation will all have to be addressed. To do this on a national scale will require the involvement of government, industry and academia working together to devise scalable solutions and to establish a market in the Future Internet sector. There is the philosophy that if a valued capability is provided people will use it, but this report has identified a number of factors that would currently prevent the roll-out of a scalable capability that could be taken up by early adopters and kick start the 'benefit–adoption–benefit' cycle.

Reflecting the way the technology and its implementation was categorised in the report the recommendations have been prioritised in a similar way. (= extensive action required, but issues not yet understood; = some action required, but issues are known)

The report's main recommendations are as follows.

Structural/ strategic

1 In order to maximise the penetration of Future Internet style services to business and citizens, the UK requires a coordinated strategy that will bring together cross-departmental priorities and initiatives towards this objective. The recommendation of this report is the formation of a high-level cross-governmental Future Internet Advisory Board working in conjunction with the Treasury-led Infrastructure UK initiative that will inform UK Government policy in the areas of interdepartmental priorities to drive innovation and bring together a Future Internet ICT strategy

2 A strategic activity needs to be created around a smart city agenda to drive Future Internet change in the way services are delivered through Future Internet style applications and systems. The activity will lead to creation of a

smart city Centre of Excellence that will provide a template for city managers.

Capable access mechanism

3 Future internet services will run on 'cloud infrastructure', a global system of shared communications, computing and storage on a global scale provided by cloud operators from the most appropriate geography taking into account scale, connectivity, costs and jurisdiction. The UK needs security of supply, capacity for services operating under UK jurisdiction, with performance to offer new and interactive services across the whole country. The recommendation of this report is that 'cloud' should be considered as 'critical infrastructure' by the Future Internet Advisory Board with a long-term plan that addresses barriers and accelerators to adequate and appropriate cloud capacity for the UK.

Wireless connectivity

4 Releasing spectrum is a major technology challenge in terms of ensuring the outgoing service is moved into new spectrum and the new service can coexist with the adjacent users of the allocated spectrum. Major technology challenges have to be solved to design radios that can meet these requirements. Compounding the issue is that poor radio frequency (RF) performance increases the demand for spectrum (radio network density). Recent studies have shown a large variation in radio performance for equipment and in recognition of this challenge the ICT KTN Wireless Technology and Spectrum Group voted this as a 2011 priority to address the longer-term R&D challenges to improve radio front-end technology. The working group is working closely with a newly formed Cambridge Wireless Radio Technology special interest group (SIG)[9] to address this challenge. It is strongly recommended that the Technology Strategy Board and the Engineering and Physical Sciences Research Council (EPSRC) have future R&D competitions to address this major technical challenge.

Shared data

5 Shared data is a transformational element of the Future Internet and the foundation on which new and valuable services can be built. However, there are issues around personal data security, data provenance, user confidence, motivation, consent and access mechanisms that will require a high level of innovation before we can use these valuable resources to deliver innovative services. The Technology Strategy Board must initiate project work, inviting research to address this whole area. Applications in areas such as smart cities would be an ideal context.

Converged services

6 To enable the delivery of real-time contextually aware services anywhere anytime to a specification, research must be conducted into system architectures access methodologies and payment models that will stimulate an ecosystem of services that have a built-in quality-of-service element. The work should encompass investment already made at a European level.

[9] Cambridge Wireless Radio Technology SIG http://cambridgewireless.co.uk/sigs/radiotechnology/

9 Conclusions

This report has focused around the key components of the Future Internet: converged services, shared data and an always-available infrastructure. It has also reviewed the main enabling components from a technology, business model and regulatory perspective and, in essence, the main conclusion has to be that for the most part, the individual technologies already exist. Individual business models and payment systems are already implemented in some sectors, particularly in the creative industries. Cloud technology and product offerings by major companies enable new methodologies in personal and business computing.

There is some R&D required to greatly increase security and enable ease of access to services wherever and whenever they are required. There is also a major international issue around the need to make the investment to move to IPv6 to remove the barrier of the IP addressing issue, but the main thrust of effort, intervention and investment is in integrating the three elements into services that are based on informed knowledge founded on data of known provenance. The UK Government's initiative to roll out a universal broadband capability will underpin much of what has been discussed, but further investment to make available a wireless fabric connecting people and machines is an absolutely fundamental requirement. Without this, the promised societal and business changes will not be realised and the cost savings will not be achieved.

Much of what has been discussed is exemplified in the 'smart city', where the value case can be made at a more or less local level. The smart city also highlights the need for a change in executive structure, embracing the idea that services can be improved and delivered more efficiently and at lower cost through the implementation of ICT all levels.

Innovation plays a significant part in developing new business models, integrating technology and building an awareness and acceptance on the part of citizens and businesses. Major companies such as HP, BT, Cisco and IBM are working in the UK to lead clusters of SMEs and universities based on particular technologies. The Government's Technology Innovation Clusters (TIC) will extend and strengthen innovation and provide the UK with research 'instruments' in a similar way to the Fraunhofer in Germany. However, the Future Internet is a cross-cutting strategy, so each TIC should understand how the Future Internet is implemented in its area, i.e. Future Internet in ICT, Future Internet in health, Future Internet in transport, Future Internet in energy, etc.

The UK has an opportunity to develop new economic growth and make vast improvements in society and business if the Future Internet vision in this report can be delivered. Other countries in Europe and Asia are already making advances at a national and city level. Leadership and investment is required now to ensure that the UK does not simply fall behind, but actually capitalises on its strong capabilities in individual areas to take a world leadership position in Internet capability.

APPENDIX A
THE UK FUTURE INTERNET STRATEGY GROUP

The UK Future Internet Strategy Group (UK FISG) has been established by the Technology Strategy Board and its Digital Communications Knowledge Transfer Network, with endorsement from the Department of Business Innovation and Skills and the Engineering and Physical Sciences Research Council.

The Group looks from a UK perspective at every aspect, from underlying technologies to high-level applications, which will contribute to the development of a Future Internet – where more users will be attracted to new services requiring greater speed, mobility and interactivity.

The group was set up in the context of global recognition of the importance of continued investment in Internet technologies. For example, the European Commission has made the Future Internet a priority for research investment,[10] including a proposed €300 million public–private partnership initiative due to start in 2010.[11]

Members of the UK FISG include leading figures from UK-based business and academic organisations involved in activities related to Future Internet development, with observers from the public sector. The Group is currently chaired by Nick Wainwright, Director of Open Innovation at Hewlett Packard Laboratories Europe.

Commenting on the role of the new group, Mr Wainwright said 'The Internet already plays a major part in our lives today and will do so even more in the future. We are bringing together world class UK expertise to ensure that UK business benefits by developing and applying the next generation of internet technologies, applications and services.' Dr Maurizio Pilu at the Technology Strategy Board, which was instrumental in establishing the new group, commented: 'The UK is extremely well placed to be a leading player in the future of the Internet, provided we work together. The new strategy group will have an important role to play in this coordination.'

The UK Future Internet Strategy Group met for the first time in December 2009. It held a public launch event on 26 February 2010, addressed by leading speakers from the UK and Europe. The aims of the UK Future Internet Strategy Group are:

- to give a voice to actors in the UK Future Internet sector:
  - a forum to express views
  - a means to encourage consensus
  - a meeting point for collaboration
- to offer advice to the UK Government on Future Internet policy, while respecting the positions of individual members
- to contribute to EC initiatives on the future of the Internet:
  - influencing and shaping policy
  - encouraging UK participation.

[10] www.future-internet.eu/

[11] http://ec.europa.eu/information_society/activities/foi/library/docs/fi-communication_en.pdf

APPENDIX B
LIST OF CONTRIBUTORS

The people and organisations listed here have generously given their time to contribute to the content of this report. These inputs have been collated together to form the complete report and in doing so does not seek to represent in their entirety the views of any single contributor or organisation.

We would also like to acknowledge the contribution from Richard Foggie and Lee Vousden (Business Innovation and Skills) and Maurizio Pilu (Technology Strategy Board) for their strategic guidance to the group.

Contributor	Position	Company
Dr David Brown	Technical Manager Network & Maritime Communications	QinetiQ
Volker Buscher	Director	Arup
Dave Carter	Head of Manchester Digital Development Agency	Manchester Digital Development Agency (MDDA)
Chris Chambers	Head of Media Network Integration Laboratory Research & Development	BBC Future Media
Carmel Dickinson	Programme Manager	Manchester Informatics, University of Manchester
Tony Dyhouse	ICT KTN Cyber Security Director	ICT KTN QinetiQ
Richard Egan	Technical Manager	Thales UK, Research & Technology
John Eaglesham	CEO	Advanced Digital Institute
Professor Alex Galis	Visiting Professor	University College London
Paul Jenkins	Head of Strategic Programmes	BT Innovate & Design
Ian Kennedy	Senior Director	Cisco
Jonathan Legh-Smith	Head of Partnerships & Strategic Research	BT Innovate & Design
Antony Manuel	LTE New Business Models Program Director	Alcatel-Lucent
Ian Osborne	Project Director Director	Intellect Digital Communications KTN (now ICT KTN)
Dr Mark Parsons	Executive Director Associate Dean for e-Research	EPCC The University of Edinburgh

Stuart Revell	Chair, ICT KTN Wireless Technology and Spectrum Working Group	ICT KTN
Dr Mike Short	Vice President Chair, ICT KTN Steering Board Deputy President	Telefonica Europe ICT KTN IET
Dr Walter Tuttlebee OBE	Chief Executive	Mobile VCE
Dr David Snelling		Fujitsu Laboratories of Europe Ltd
Dr Colin Upstill	Managing Director	IT Innovation Centre
Nick Wainwright	Director of European Projects	HP Labs

APPENDIX C
SAMPLE QUESTIONNAIRE

The Digital Communications Knowledge Transfer Network and the UK Future Internet Strategy Group, with the endorsement of the Technology Strategy Board and the Department of Business Innovation and Skills, are undertaking an activity to identify key future developments in Internet technology, infrastructure, service provision and adoption in the UK.

The purpose of the report will focus on the Future Internet as a techno-social system involving the engagement of people and businesses. The activity will look at the current state of UK in these key areas and discuss barriers to the necessary investment in and adoption of new Internet technologies, infrastructure and services, essentially analysing the factors that will make the UK a good place to do business, resulting in wealth and job creation. Although the report will identify infrastructure fabric limitations, these will not be the main focus. Finally, it will make recommendations for the steps the UK should be taking now to ensure it is positioned for a thriving Internet sector in the next decade.

A report will be prepared summarising the key findings. The report's focus will be as much about barriers to investment and enabling new business models as to the underlying technology. The objective will be to identify the means to secure UK competiveness and to show how the Future Internet will contribute to this goal. The report will start by outlining a vision for the Internet over a 10-year period and will focus on a wider global view. With a global view in mind, the report will place the UK in terms of its position with regard to other leading and emerging economies, especially those that are investing in leading edge infrastructure. The overview of the UK landscape will seek to determine where we are leading and where we are lagging in terms of R&D, and new business models, particularly in the area of infrastructure and services.

The next section entitled 'Infrastructure' is a deeper examination of the technologies and business models involved in the infrastructure. By infrastructure we are concerned with all levels up to, but not including applications. The report will examine enabling infrastructure capability beyond basic bandwidth requirements that are already well understood. Examples may be, but not restricted to enabling augmented reality, real-time processing and advanced automated SLAs.

Data generation is growing at a rapid rate and its storage, accessibility, security, latency and management are likely to be an increasing factor with the introduction of new business models. The data is owned largely by industry (commercial applications including the entertainment industry), domestic users, government and academic or research institutions. The report will examine barriers to commercial adoption of business models that create and manage Information from data.

Most studies identify SME organisations as playing a key role in economic growth, so the report will have a section with particular focus in this area and its dependence on the Future Internet. We will seek to identify any unique factors that relate to this industry sector.

In any endeavour there is always risk and investors will look for key risks to be identified as part of the work. The report will examine risk from the perspective of technology, business and investment.

Finally, there will be a section on investment in the sector, both private and public in terms of the role of the Government. We will also look specifically at the methodologies and structure that will enable the UK to maximise its effectiveness in the FP8 consultation process.

The primary input for the report will be face to face or telephone interviews using the questionnaire below, supplemented by additional research to identify supporting evidence and sources.

The Future Internet

Q1 What do you think the most important objective of the Future Internet should be over the next 5 to 10 years?

(a) How can it impact on businesses?

(b) How can it especially impact on SMEs?

Q2 What is the most important thing the Future Internet must deliver to help sales, R&D, service, start-ups, etc. over the next 5 to 10 years?

Q3 What do you believe to be the main disruptive Future Internet technologies over this period, and why?

Q4 What do you believe to be the main disruptive Future Internet business models over this period, and why?

Q5 What do you believe to be the largest potential for economic, social or environmental benefit of the Future Internet over this period, and why?

Q6 What are the barriers to provision and adoption of such technologies and business models and how could they be addressed?

Overview of the UK landscape

Q7 How would you position the UK in the global Internet landscape? Where are we leading and lagging?

Q8 What are in your views the biggest opportunities ahead for the UK in the Future Internet that can act as an engine for economic growth and what groups of organisations would the main driving force to achieve that?

Q9 What are in your view the best-in-class examples of Future Internet technologies or deployments in the UK? *(*Please describe any UK initiatives you are involved in that can be used as case studies.)

Q10 How does the current level of infrastructure limit UK competiveness in terms of:

(a) international services

(b) new business models

(c) bringing new products and services to market

(d) scientific and technology R&D?

Infrastructure

Q11 What do you identify as transformational Future Internet infrastructure(s) over the next 5 to 10 years with the biggest potential?

Q12 What do you see as being the main barriers to the development and/or deployment and/or adoption of such infrastructure(s) and how could they be overcome or progress accelerated?

Q13 Where should investments be focused in the UK?

Services

Q14 What do you identify as transformational Future Internet services over the next 5 to 10 years with the biggest potential? And in which sector?

(a) What new things will we be able to do?

(b) What will be the innovations to services?

Q15 What are the UK industry sectors that will experience growth as a direct result of implementation of the Future Internet?

Q16 Taking the sectors identified in the previous question and imagining advanced Future Internet capability being available, what further barriers would we expose in those industries?

Q17 What economies of scale are anticipated and how can they be achieved?

Q18 What do you view as being the most important development in service-orientated architectures in the UK over the next 5 to 10 years?

Content

Q19 What is the anticipated growth in the amount of data generated?

Q20 What is the anticipated growth in traffic flows (bandwidth required?)

Q21 What are the main drivers for this increase in data?

Q22 How will the Internet intelligently handle the increase in global data flows and storage?

Q23 What are the barriers to the adoption of new content management models, e.g. Cloud?

(a) Industry

(b) Domestic

(c) Government

(d) Academia

The role of firms

Q24 What role can large firms (ICT and non-ICT) play in Future Internet innovation, adoption and/or wealth creation resulting from adoption of Future Internet technologies and services?

Q25 What role can SMEs have in Future Internet innovation, adoption and/or wealth creation resulting from adoption of Future Internet technologies and services?

Q26 Do SMEs have the channels to investment that will enable them to deliver new products and services?

Role of the public sector

Q27 What are the major risk factors?

(a) Technology

(b) Business

(c) SMEs

(d) Investors

Q28 How can the government and the public sector facilitate Future Internet adoption and wealth creation other than through financial interventions?

Q29 Where should tax payer's support/investment be focused (other than funding broadband)?

Q30 What is the role of policy?

Q31 How can public procurement drive Future Internet adoption, and what are the most likely areas?

Q32 How could knowledge transfer activities and UK-wide open innovation help?

EU collaboration and investment

Q33 How does the UK Future Internet landscape relate to the Future Internet programme in FP7 Work Programme in terms of relevance and alignment?

Q34 What is lacking in terms of support infrastructures in the UK compared to other EU leading countries that could increase UK participation in EU programmes?

Q35 How could UK SMEs get more engaged in EU programmes?

Q36 How do you think the UK should approach the consultation process around FP8?

Q37 What structures could the UK set up that would make us more effective in the consultation process?

Q38 What priorities should the UK be pursuing in the FP8 consultation process?

ICT KTN
Russell Square House
10–12 Russell Square
London WC1B 5EE
Email: info@ictktn.org.uk
Website: www.ictktn.org.uk
Telephone: +44 (0) 20 7331 2056