



APPENDIX 3: INNOVATION AND THE EMERGENCE OF NEXT GENERATION NETWORKS

A Discussion Note prepared by BT



INNOVATION AND THE EMERGENCE OF NEXT GENERATION NETWORKS AND SERVICES

1. SUMMARY

Scope of NGNs

There are several industries all of which have a major part to play in the development of Next Generation Networks¹ (NGNs) and services based on them. While there is no strictly defined list of industries, the following is indicative of the true scope of NGNs:

- The broadcasting industry.
- The Internet industry.
- The PC IT industry.
- The enterprise applications IT industry.
- The video and music entertainment industry.
- The electronic games industry.
- The telecommunications industry (historically focussed primarily on telephony service).

Convergence Process

The process of convergence between these industries is dynamic and will include a many transitory stages involving temporary business models. During this period of convergence, which BT believes will be at least 10 years. Convergence is following an emergent path where only the broadest trends are discernable and there is no clear, defined market model either applicable to the current state of convergence or

¹ Annex A gives a glossary of terms

of what might exist at the end of convergence. The “four market” model described by in the 1995 Oftel CD “Beyond the Telephone, the Television, and the PC” describes the possible end result of convergence, however, convergence as a dynamic process, is already happening and is not described by this business model.

Currently, convergence has lead to a limited set of supply side arrangements between the industries and a limited number of retail service bundlings (for example CATV bundling broadcast TV service, telephony, and Internet access).

Given the dynamic nature of convergence, the architecture of NGNs will also be heterogeneous, dynamically changing over time, and emergent rather than constructed.

Collaboration in Service and Network Development

No one industry has the technical skill to develop NGNs by itself and cross industry collaboration is essential. Collaboration between undertakings in the different industries is needed to develop both NGNs and service based on NGNs as well as to manage the financial risks and rewards necessary to finance the investments. However, the nature and rate of technology development is resulting in a succession of disruptive technologies and services, and the timeframe available to recover sufficient income to pay for investment is limited.

Demand Side Positive Feedback Effects

New services based on NGNs have yet to be developed. It should be expected that most of these services will have positive feedback effects when brought to market – those that are successful be become mode successful, and those that are less successful will die quickly. This positive feedback is a necessary feature needed to establish new services.

Technical Standardisation

Different industries have different established ways of achieving technical standardisation. Some, notably in the IT industry, rely of on standards emerging during the course of exploitation – a number of solutions are initially brought to market but ultimately one emerges as a de facto standard.

Innovation

Innovation is essential to the development of both NGNs and services based on it. The important innovation is not primary technology but innovation is needed to create new applications, create and package new service offers to the customers, develop new supply arrangements across industry boundaries, and develop new heterogeneous network architectures.

BT's Position in the Development and Exploitation of NGNs

BT's skills and existing position varies considerable for the different components of the NGN. In many of the important areas of NGNs, BT does not have any pre-existing skills or market position. There are three areas which it might be argued emerge from BT's current telephony network and skills.

Broadband Access – Four technologies appear to be of immediate interest within the UK – DSL, CATV, 3G mobile, and fixed radio/satellite. BT's main interest is in DSL technology based on its copper access infrastructure. In the case of DSL, broadband access includes the CU pair, and the DSLAM (it could also include backhaul and some ATM network but does not need to) and it does not include any IP router. BT's ability to exploit this is already constrained by competition from the other technologies as well as local loop unbundling. For NGN based services, broadband access is infrastructural and as such is not the primary focus of a consumer offer (applications and content are the primary focus). This means broadband access is unlikely to be a source of market power for NGN based services.

Broadband Core Network – The broadband core network includes the IP routers. It may include core transmission infrastructure but this could also be supplied as leased lines. The scope of broadband core networks is global rather than national, and BT is already in strong competition both in the UK and abroad for the provision of broadband core networks. In addition, the development of the technology is generally outside BT's control which generally lies in the US and with vendors.

Voice – Voice on IP networks (VoIP) is in the early stages of development. However, it is already clear it will emerge as a distinct service and a distinct technology from the current PSTN and will have as much in common with Internet technology as PSTN technology. Voice telephony is likely to emerge in NGNs as a CPE capability and not require a traditional switched network and therefore BT is in no better position to offer VoIP services than any other NGN player. BT will be able to provide gateways between the current PSTN and VoIP services, however, current interconnect regulation already ensures any other player can do the same on an equal basis.

2. INTRODUCTION: THE NATURE OF CONVERGENCE AND NEXT GENERATION NETWORKS

Next generation networks (NGNs) and services based on NGNs will emerge as a result of bringing together components from several industries. No one industry has the resources, skills, or consumer credibility to create all aspects of next generation networks and a significant level of cross industry collaboration is essential to develop these new services and the networks on which they are based.

These industries have largely run independently of each other, but there are now clear signs of convergence. At present, this is most often in the form of cross industry supply. The value chain of each industry is still largely intact along with the key end user relationships within each value chain. Undertakings with key end user relationships in each value chain are starting to offer packages of services by contracting from outside the normal industry value chain.

There are also early signs of new industry value chains emerging. An example would be a new industry value chain to supply B2C, B2B gateway, and other enterprise application solutions to corporate customers which draws from the IT industry, the telecommunications industry, and the Internet industry, but is emerging as its own

distinct value chain. Broadband access and high capacity leased lines are also potentially emerging as separate infrastructural supply industries.

The process of convergence between these industries is highly dynamic and will include many transitory stages and temporary business models. During this period of convergence, which could last at least 10 years, the *dynamic process of convergence* is far more relevant to the development of NGNs and their services than any speculation on any possible stable future value chain. Regulation needs to acknowledge this dynamism rather than anticipate and/or assume a static market model.

This process of convergence generates many uncertainties – well beyond those experienced by any one industry. High levels of uncertainty increase the risks in investing in development and infrastructure and profoundly affect the economics of return on investment.

In order to develop new services and invest in NGNs, innovation is necessary. Innovation is needed to create a market in the first place; to create killer applications; to create viable customer offers; to develop innovative cross industry supply; to evolve new network architectures, etc. Technology innovation simply to reduce costs is of secondary importance compared to these.

Each existing industry has its own value chain. There is no reason to believe that any one industry has any greater ability to use its current position to establish NGN services as opposed to any other. BSkyB, FA Premiership, AOL, Microsoft, Cisco, Disney, Nintendo, etc, all have a level of market power today which is more easily transferable to NGN services than any that BT might possess either now or in the future.

However, in this converging world with transitory market models and high levels of innovation, market power itself will normally be short lived. In this environment markets do not exist for long enough, generally, for any position of market power to be exploited, especially as returns are needed to recover the risk in investment. A model of serial competition is emerging – competition which is for the creation of the market. Returns are then achieved for the duration of the market which will disappear as new markets are created.

From the technology and network architecture point of view, the development of NGNs will draw together parts from each of the industries. It will not be a monolithic top-down design with a body (e.g the ITU or ETSI) having responsibility for end to end architecture and design, but will emerge and evolve during the process of convergence. For example, while the telecommunications industry may contribute to broadband access, core networking is more likely to emerge from the Internet industry, audio-visual encoding and networking from the broadcast industry and video and music entertainment industry, e-commerce from the enterprise applications industry, and interactive games from the electronic games industry.

The context of convergence for NGNs has been frequently acknowledged however the real implications have not been properly reflected. It may be thought that the market for NGN services is an extension of the current telecommunications market. This may be understandable through a natural tendency of any organisation to see the world relative to themselves, however, the reality of convergence shows this perception is not robust.

This paper offers a picture of the nature and implications of convergence. Section 3 deals with the dynamics and evolutionary nature of convergence including the significance of the different converging industries in the creation of the services based on NGNs. Section 4 discusses the impact of demand side economics on convergence while section 5 discusses the impact of supply side economics. Section 6 looks more closely at the role and importance of innovation to the emergence of next generation networks.

3. DYNAMICS OF CONVERGENCE

3.1 *The Current State of Convergence*

Much has been made of the emergence of a new world of communications based on a next generation of networks. This assumes a general convergence between a number currently separate industries. There is no strict or defined list of industries which are in the process of converging, and indeed distinguishing some of the industries themselves, can be a matter of opinion. For the purposes of this paper, the following industries are identified and part of the convergence process²:

- The broadcasting industry
- The Internet industry,
- The PC IT industry;
- The enterprise applications IT industry
- The video and music entertainment industry,
- The electronic games industry.
- The telecommunications industry (historically focussed primarily on telephony service)

Each of these industries currently has its own business model and value chain, distinct retail and wholesale services, and therefore distinct retail and wholesale markets. It follows that an undertaking with significant market power in one value chain does not automatically have access to market power in another.

² Note – CATV as it is in the UK has not been identified as a separate industry but as a product of convergence and is discussed in section 4.2.

While technology convergence may provide a strong driver, real and practical convergence requires that the business models, value chains, with associated retail and wholesale services also converge.

Currently, convergence has led to a limited set of supply side arrangements between the value chains and a limited number of retail service bundlings. Examples of supply side arrangements include sale of dial access (eg FRIACO) line by the telecommunications industry to the Internet industry, sale of high capacity leased lines by the telecommunications industry to the Internet, broadcasting and corporate services industries, supply of WWW based customer “front doors” by the IT industry to the other industries, and supply of video content by the video entertainment industry to the broadcasting industry. An example of service bundling is the bundling of broadcast services and telephony by CATV companies.

These current supply and service bundling arrangements are clear signs of the convergence process of business models, value chains, and services. The convergence process between these industries will undoubtedly see many transitional business models as undertakings, either solely, or in collaboration with other undertakings, attempt to create new converged services. During this period it is unlikely that there will be any clearly established, stable value chain with which it is possible to identify “upstream” and “downstream” business roles. At this stage, it seems very difficult to estimate how long this transitional period will be. In general, established consumer markets move slowly and it could be at least 10 years before a more stable business model and value chain emerges from convergence.

3.2 The Convergence Process

While convergence has been a subject for discussion for several years now, with a particular burst of activity in the mid to late 1990s, a reality is already emerging. There are some significant differences between some of the original discussion and this emerging reality, notably:

- Convergence is a dynamic process working across many industries and outside the control of any one industry, organisation, or even any governmental initiative;
- The business models of convergence have tended to emphasise a new industry structure which has not yet emerged but left readers with an assumption that NGNs would not emerge until this industry was in place;
- Each industry has very different approaches to issues such as competition, regulation, and technical standardisation.

Convergence needs to be reappraised in light of the emerging reality and seen as a dynamic process where the earlier stages are already largely in place.

The “four markets” model, originally put forward by Oftel in 1995³, is an important case in point. While describing some of the important features of convergence, it does not describe today’s environment. It concentrates on the end point of convergence, seeing a single industry with four roles in the industry value chain – the “four markets”. It does not consider the dynamic processes of convergence, nor does it consider the impact of the current ways of working of the existing industries.

At a similar time, ETSI and ITU developed business models of convergence⁴⁵⁶ in order to understand the role of standards and their role in developing standards. Both organisations, despite initial expectation concluded as a result of these models that they could not set out and manage a standardisation programme. The scope was too broad covering too wide a range of existing industries and existing standardisation processes. Even so, both organisations underestimated the uncoordinated, laissez faire process that has been the reality of standardisation over recent years.

This section sets out a description of the current processes of convergence without directly speculating on the eventual outcome, and is based on the ETSI and ITU models.

3.2.1 Independent Industries

Prior to convergence pressures, a number of industries co-existed, largely in independence of each other as illustrated in Figure 1. Each industry created its own value chain and players took on the roles with the value chain. The final role in each industries value chain is normally retailing to the consumer. Within the value chain are a set of wholesale and component supply roles. In addition, each industry normally requires infrastructure in order to operate.

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³ Beyond the Telephone, the Television, and the PC, Oftel, 1995

⁴ ETSI Special Review Committee on European Information Infrastructure (SRC6), 1995

⁵ European Project on Information Infrastructure, Project 4.1 Report – Principles and Framework Architecture, 1997

⁶ ITU-T Recommendation Y.110, Global Information Infrastructure Principles and Framework Architecture, 1998

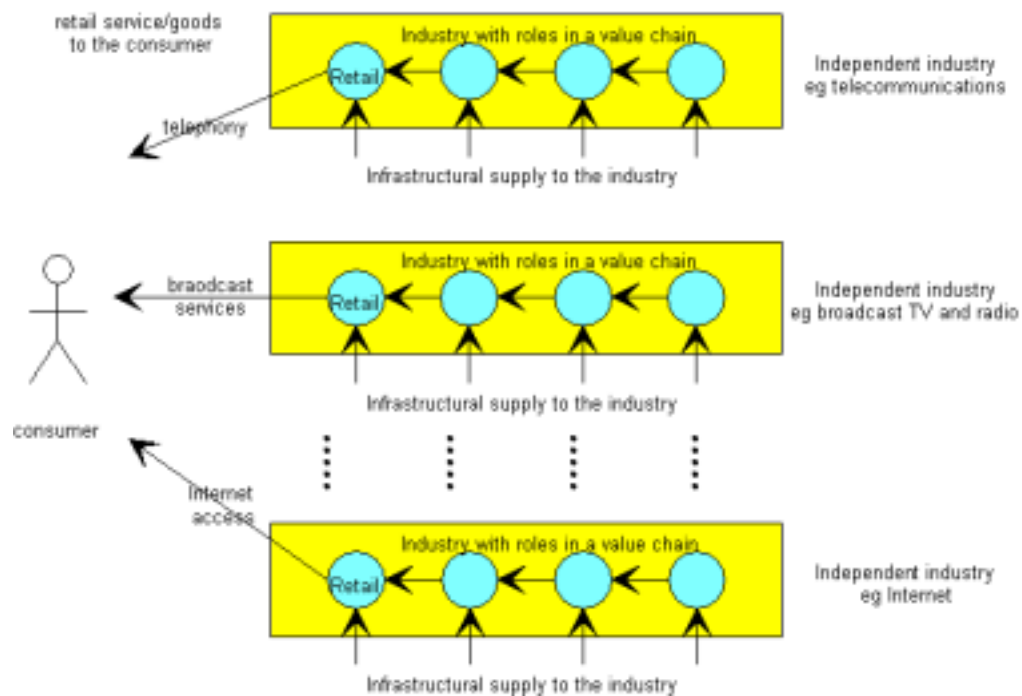


Figure 1 Separate industries prior to convergence

This model identifies three types of supply: retailing the consumer; structural supply within the main value chain of an industry; and infrastructure supply to an industry.

The retail service is what the end user buys and the retailer, by definition is visible to the end user.

Structural supply is the supply of components *within* the industry value chain and, generally speaking:

- The components are intrinsic to the retail service;
- The end user is normally aware of the component, often including the player who is supplying the component;
- A structural supplier may have effective control of the value chain by supplying a particular component the end user requires.

Examples of structural suppliers are Microsoft and Intel with the PC IT industry, Disney within the video entertainment industry, and the FA Premiership within the broadcast TV industry.

Infrastructure supply is the supply of components which support the main value chain and generally speaking:

- The components are not particular to the industry and are normally supplied to many different industries;

- Even if the end user is aware of the component, they are often unaware of which undertaking is supplying the component (and this may be changed without the end user's knowledge);
- An infrastructure supplier is unlikely to have any significant control of the value chain.

3.2.2 Cross Industry Supply

Currently, convergence pressures are most visible in the form of cross industry supply. This is where components from part of the value chain in one industry are supplied to another industry in order to form new services. There are already several examples of cross industry supply:

- CATV takes components from the telephony and Internet industries in order to supply packaged broadcast TV, telephony, and broadband internet access;
- The Internet industry relies on the availability of a PC and telephone service in order to offer Internet access;
- Radio broadcasters are making their channels available on the Internet;
- The PC industry sources games from the games industry to run on PCs;

These are all examples of structural supply as the components are all integral to the packaged service and visible to the end user.

This process of cross industry supply is illustrated in Figure 2.

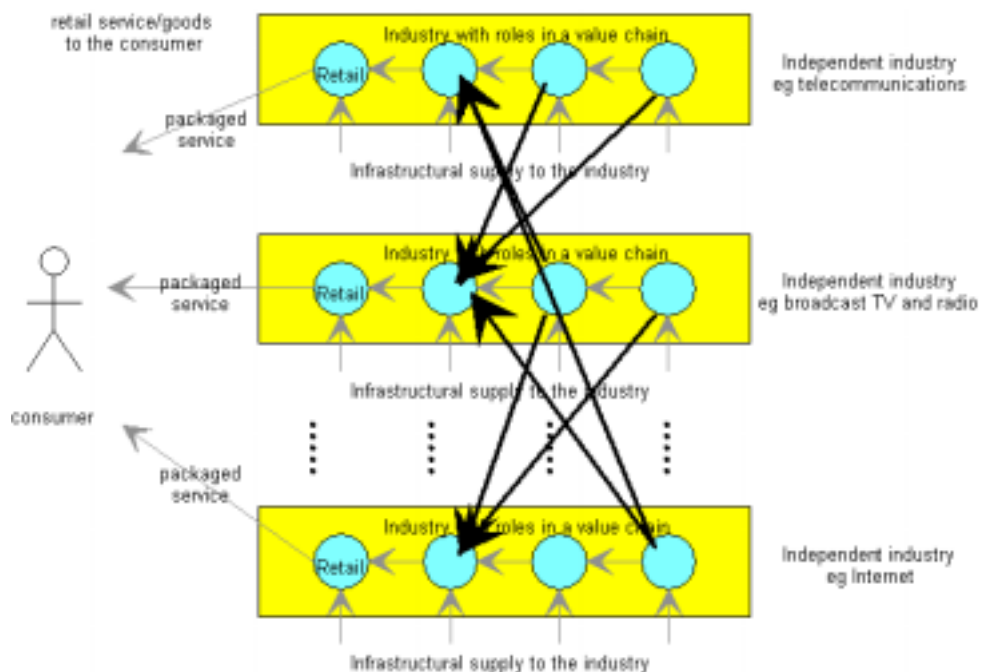


Figure 2 Dynamic convergence through cross industry supply

3.2.3 Development of Common Infrastructure Services

Another aspect of convergence which is already visible is the emergence of common infrastructural services which are applicable to all of the converging industries. The notable examples are the emergence of the following.

- Enterprise application solutions industry which supplies e-commerce, business to business and business to customer (B2B and B2C) gateways, Web portals, and other related solutions which allow a substantial level of automation of customer handling.
- Fixed network broadband access which is starting to provide a more ubiquitous solution of physical access for a number of industries, particularly those using the Internet as a means of distribution.
- The supply of high capacity leased lines for the construction of core networks.

These are illustrated in Figure 3.

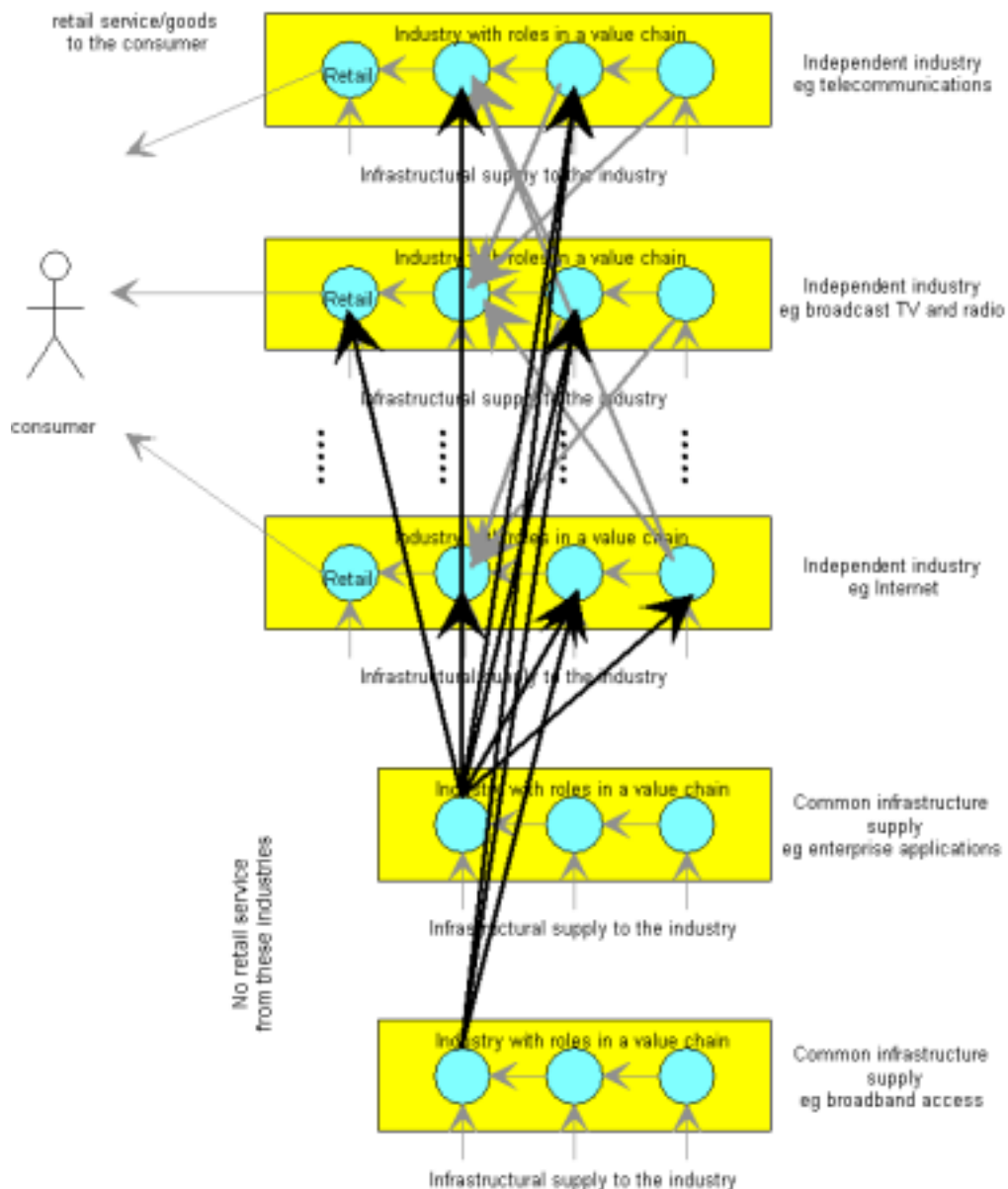


Figure 3 Development of Common Infrastructure Supply Industries

These infrastructure supply industries, by their very nature do not include consumer retailing.

Most of the supply that BT would undertake associated with next generation networks is infrastructure supply. It is also suggested that whatever view may be taken on BT's position within the telecommunications industry, BT would find it very difficult indeed to use such a position, to gain a position in another industry.

3.2.4 Further Stages in Dynamic Convergence

It is possible to speculate on the next steps in the convergence process. The expectation of the four markets model is that the parallel roles within each industry will be the focus for the emergence of new converged roles. However, there are few

clear signs that this is happening. Indeed, even some of the more obvious examples of CPE retailing still shows the strength of specialist PC, telephone, and audio-visual retailers.

It seems that the dynamic processes of convergence are easier to identify than the specific outcomes. Features of the dynamic convergence process include:

- Packaging of service offers;
- Cross industry supply;
- Development of common infrastructure;
- Dynamic creation of markets for new consumer services;
- Transitory collaboration projects across industry;
- Disruption and replacement of existing consumer services.

3.3 *End User Relationships and Market Power*

Currently each industry has an independent relationship with its end users. These relationships are well established and have evolved to suit the characteristics of the industry.

In addition, within each industry, market power has grown up around different parts of an industry's value chain, often reflecting whom the customer has a direct relationship with and/or whom the customer perceives is delivering the prime value within the value chain. More detailed descriptions of each industry and its value chain are set out in Annex B to this paper.

The end user relationships of each of the converging industries are likely to be more enduring than some other aspects, both as a result of the inertia built into these relationships and also since they carry a reasonable proportion of the total value of the industry's value chain.

The result is that end users will probably receive several sources of services based on NGNs as each industry seeks to build on its already established relationships and this aspect of convergence is creating much greater levels of competition for the end user. Even if an undertaking has market power within a market, the process of convergence is creating competition between competing suppliers undermining this market power.

3.4 *Emergence of Next Generation Networks*

The technology and engineering skills required to build the next generation networks, together with marketing skills to develop new services and packages of services do not exist within one industry. No one undertaking, including BT, can contemplate developing such a network and offering services without significant collaboration and/or partnership with players in the other industries. The relevant technologies include the following:

- DSL broadband access
- CATV broadband access
- 3G mobile broadband access
- Fixed radio and satellite broadband access
- Multimedia networking protocols (ie “IP++”)
- Optical transmission
- Packet, frame, and cell based switching and routing
- Enterprise application architecture (eg CORBA, Java enterprise edition, and Microsoft .NET)
- Digital encoding of audio and video
- PCs, STBs, games consoles, and their operating systems
- Portable software client technologies (eg Java, scripting languages, web browser “plug-ins”, etc)
- Home networking (eg wireless LAN, Firewire, etc)

Moreover, the need for collaboration makes it probable that the infrastructure of NGNs will itself be collaborative. Industries which currently own and operate infrastructure are likely to continue to do so. The broadcasting industry will continue to operate contribution and distribution networks, the Internet industry will continue to operate core backbone networks and the telecommunications industry will continue to operate the PSTN.

This means that the overall design and architecture of NGNs will not be a top-down design organised and prescribed within an industry. It will emerge from the complex process of collaboration between the different industries. This is reinforced by the fact that no one industry forum is sufficiently skilled or recognised across all the industries to provide a focus for architectural design and standardisation. Indeed, there is currently some antagonism and “turf wars” between some of the established industry fora.

Neither BT nor indeed any telecommunication player, can expect to successfully lead the required technological development by itself even though BT does engage in significant levels of R&D in the UK. There are three particular areas of NGNs which BT could be seen as having particular ability to exploit – broadband access, broadband core, and voice. These are discussed below. BT does not have a position to exploit the other technologies listed above.

3.4.1 Broadband Access

There are at least four technologies available for broadband access in the UK, namely DSL, CATV, 3G mobile, and fixed radio and satellite. BT has the ability to deploy both DSL and fixed radio and satellite broadband access and has no interests in the other two. The ability of this range of technologies to form a basis of

competition is highlighted in the introduction to the CD. Moreover, current regulation on LLU enables other operators to exploit DSL technology alongside BT.

However, in addition to all this pre-existing competition for broadband access, it is only one component of NGNs, and not one which has a particular importance to the end user, as it has no direct value to the end user – it is only a means of getting to the applications and service which are of interest to the end user. The end user would expect to have their key relationship with the supplier of the broadband application, such as Internet access, video services, gaming applications: the broadband access is *infrastructural* and unlikely to appear of major significance, per se, as far as the end user is concerned.

Another effect of the wide range and uncertain nature of NGN applications is that broadband access is likely to be relatively “dumb”. This allows core networking and NGN applications to evolve without changing out the investments in broadband access. In addition, optical technology can allow broadband access to be backhauled over large distances to a core network node at little incremental cost to the access, so long as the capacity is being taken to one or two core nodes only. With this, the essence of DSL access is simply a relatively dumb DSLAM with copper pairs on one side, and a fibre pair, maybe two fibre pairs, on the other side.

3.4.2 Broadband Core

The advances in optical technology have meant that the cost of transporting large bandwidths over significant distances between consolidated nodes of a core network, need not be a significant part of overall cost. The impact of the optical technology is to bring about a growing shift in the parameters which control costs in a core network; to reduce the importance of bandwidth and distance, per se, but also to increase the importance of “ports” into the core network. The number, size (i.e. bandwidth), and location of these ports are important to overall network costs. The effect of this is to point towards more consolidated networks, i.e. fatter networks with fewer nodes. Networks become national, continental, and globally structured, rather than regional and national within country. This is already true of most public IP based networks.

With this consolidation of core networks, any player from anywhere in the world is able to set up a core network and compete in the provision of core network services, and many have done so. Indeed, this ability to easily enter the core networking market, can be seen of one of the engines which drove the technology bubble in the second half of the 1990s.

Two other factors which are significant in core networking. First, the economics of networks tend to follow “global reachability” – the number of end points which can be directly reached through a given network. There is, and will remain a strong bias towards North America in the global reachability, which means that all the important core networks are US centric. Second, technology development is largely controlled by equipment manufacturers and not the network operators.

3.4.3 Voice

Voice telephony is a well established service whose basic features such as the service interfacing (e.g the telephone handset) and the pricing structures are well understood by the end users. It has also been, in the UK, the subject of 20 years of regulation.

The fundamental principles of NGNs and their services are very different from those of voice telephony and all the basic features such as the service interfacing and the pricing structures are open to innovation, indeed, most end users do not expect NGN voice services to be a simple extension of the current voice telephony. The expectation has been discussed for several years that NGN voice services will be disruptive to current voice telephony, meeting all the basic conditions for a disruptive technology.

Given this, any player is in a position to develop and bring such a service to market. Indeed, being disruptive, new players are more likely to be in a good position to bring NGN voice services to market.

However, despite some early examples for international voice services, this development has been slower than expected for two reasons.

- As of today, the multimedia networking protocols needed to support a reliable NGN voice service have not yet emerged. The clear expectation is that the basic networking protocol for NGNs will be based on IP, the protocol of the Internet, and has sometimes been labelled "IP++". The slow progress has been a result of many factors and there is still no clear view of the likely solution.
- The NGN voice service is only likely to gain rapid acceptance if it can interwork and interconnect with existing voice telephony service. Interworking has proved so far to be both technically complex (eg with voice delay and echo control) and an expensive part of deploying NGN voice services.

The position of NGN voice service is therefore still very open and a wide variety of players from the converging industries other than telecommunications are looking at NGN voice services as a means of extending their position with the customer. Any incumbent telephony provider, such as BT, faces not just a large range of competition, but also the highly complex task of managing the introduction of a disruptive technology.

3.5 Changed Environment for Innovation

To date, innovation within telecommunications has been within the context of a persistent prime service – telephony, a persistent business model, and a persistent overall end to end network architecture. Innovation has centred on four main areas.

- The use of new technologies to reduce the costs of both the network and service operations. Examples in this category include digitalisation of

switching and transmission and introduction of software support systems in support of automated service operations.

- Service enhancements which enable flexibility in the identification of users and services and the way in which services are charged. Examples include 800 services, premium rate services, and voice VPN services.
- The use of advances in radio technology to enable service to people on the move – i.e mobile.
- The introduction of managed transmission and data networks for wholesale within the telecommunications industry, as well as to facilitate the sale of leased capacity services to other industries.

In all this innovation, the basic service, telephony and the basic architecture of the PSTN has remained.

By comparison, the current round of innovation is oriented towards this emerging world of convergence where:

- The key, commercially viable applications and services have yet to be identified.
- There is no clear view from the consumer, based on existing marketplaces, where they expect to go to purchase convergence services.
- Current supply arrangements between industries are driving several parallel end to end network architectures.

In this environment, the development of new technologies will not lead directly to cost benefits or service enhancements for the consumer unless there is matching innovation to establish new applications and services, new markets, new value chains, and new network architectures.

4. CONVERGENCE DYNAMICS AND DEMAND SIDE ECONOMICS

Compared to most major developments in telecommunications in the past where the end application – telephony – has endured, the current developments require the creation of new applications and services in new markets. This requires a level of customer awareness, customer education, and a customer driven effect in order that a new application and/or service gains general acceptance. It should be expected that these new markets will show strong demand side positive feedback effects. These services will be ones where customer experience is critical for their success and pricing will have to reflect this.

Moreover, given that these markets do not yet generally exist, the demand side positive feedback effects are important factors in enabling the emergence of the market. Without exploitation of these effects, the new markets may not emerge, or may be slow to emerge.

It is also likely to require the development of coherent, integrated offerings to the customer. Putting such offers together will inevitably require either some elements of vertical integration or strong collaboration between undertakings.

The pace of development is such that, in the time it takes for the demand side effects to establish an application or service in the mass market, its technological basis may well be out of date. At this point there is the market opportunity for a fresh set of coherent, vertically integrated offers to enter the marketplace based on new disruptive technologies.

In summary, the combination of the lack of established services and applications, strong demand side network effects, and the rapid pace of technological development, points to a new form of competitive marketplace.

5. CONVERGENCE DYNAMICS AND SUPPLY SIDE ECONOMICS

The supply side of this convergence industry is seeing high rates of technological innovation. These innovations are enabling:

- completely new applications and services;
- existing applications and services from different industries to be delivered on a single network infrastructure;
- cost reductions in infrastructure;
- new, automated interaction with customers for operations processes together with new channels to market.

5.1 *Disruptive Nature of Technology Developments*

Many of the technology innovations are “disruptive” in nature. They do not create any clear cost or feature advantage for an existing product, but do create a new market for a new product and, over time, the new product develops such that it does take over from an existing product. Deployment scenarios therefore do not necessarily follow a pattern of uniform and incremental improvement. This has had a strong effect on who are key equipment and software suppliers at any one time as one set of vendors may be strong with an existing technology while a completely different set develop and grow strong in the disruptive technology.

5.2 *Cost Structure of Next Generation Networks*

The very high rates of development in both optical transmission and packet switching/routing have meant that the capital costs associated with transmission and switching are falling as a proportion of total network costs. Operational costs, while falling, still have a significant human element, and so are not falling at the same rate. Access costs continue to be dominated by the cost of physical infrastructure and are not changing significantly. And of growing importance are the costs of service and technology development and introduction. Access, operational, and development costs have different cost characteristics to transmission and switching costs. This means that even if the argument that prices tend to fall to marginal cost were true, the factors dominating marginal costs are not transmission and switching. The

parameters which were relevant for cost allocation, namely time, bandwidth, and distance, are increasingly irrelevant and misleading in assessing the costs of using networks.

5.3 Availability of Technical Standards

In the past, the telecommunications industry has sought technical standardisation both as a means of achieving interconnection and also as a way of maintaining competitive supply from equipment vendors. This standardisation process has normally taken place *ahead* of the development and exploitation of the technology through a clearly established set of industry standardisation bodies. These bodies have produced standards which are then taken as *de jure* for the purposes of regulation.

Other industries have not followed the same route of technical standardisation and in the process of convergence, no clear converged standardisation process has emerged as yet. Annex C sets out in broad terms, the processes of standardisation currently in operation.

With the wide variety of standards setting processes in the different industries, there is a lack of clear standards setting agenda for next generation networks. Each process is reasonably well suited to its own current industry's needs and also reflect the overall technical complexity of the standards, their longevity, and the time taken to agree standards. API standards, especially, are very complex and both Microsoft and Sun Microsystems have made the strong case that timely and error free development is best undertaken within one organisation.

A clear conclusion is that regulation of next generation networks cannot rely on the availability of technical standards from formal standards bodies which it can apply *de jure* to the marketplace.

Since many of these standards are not created ahead of development and exploitation but may be defined during service development or even after exploitation as a result of "taking off" in the marketplace, NRAs may need to allow a period of proprietary development and exploitation to ensure that a technical specification is both accepted in the marketplace as a technical standard and also has its economic viability assured.

5.4 Investment Risks of Innovation and Service Development

As there is no enduring service with a well understood demand profile for next generation networks, reliable forecasting of revenue resulting from innovations and new service development is difficult.

In this environment, innovation is only likely to be economically justifiable if the following conditions are satisfied:

- The potential returns are very, very much greater than the development costs.
- The innovator can gain a clear advantage over competitors and secure a high market share, at least for a period of time, which can pay back for the development costs.

- The innovator is able to exercise the use of IPR.
- The innovation is potentially usable for a number of services, any one of which may be a high risk, but when taken together give a lower risk investment.

5.5 Management of Innovation Risk Through Network Architecture

Given that most potential revenues are unclear at present, there is an advantage to developing the overall network architecture in a flexible way such that there is a strong chance that at least some of the potential revenue streams can be developed using “reusable” components within the architecture. This is particularly the case for the components of the network which are high cost, and/or take a significant time to develop and deploy. The most notable example is probably broadband access which is both very costly and, by sheer volume, mass deployment may take a number of years.

6. THE ROLE OF INNOVATION IN THE EMERGENCE OF NGNS

Innovation is essential to the emergence of NGNs and services based on NGNs. There are no clearly established applications or markets and any player, to be successful, must innovate to create the applications and markets. There are many areas which are open to innovation, indeed, require innovation. However, there are also two factors which constrain innovation – the time needed to deploy broadband access, and the need for evolutionary interworking. In all of this, technology is only one area for innovation, and as we stand today, one of the less important ones.

6.1 Areas for Innovation

Within the economic and technical constraints where persistence is more likely (see below), innovation is both likely and often necessary for the economic success of next generation networks. The following highlights some of the more important areas for innovation.

6.1.1 Killer Applications

There is a wide expectation one, or possibly a few key new applications will take off in the marketplace and provide the economic basis for the provision of high cost infrastructure. There are already a number of examples of this including I-mode for mobile in Japan and specific gaming applications for DSL in Korea. It would also appear that simple Internet browsing on its own will not be the killer application for the UK as there is insufficient revenue available.

6.1.2 Creation of Consumer Offers

Irrespective of what killer application(s) emerge, there is scope for strong innovation in the way offers are packaged to the consumer. An illustration is the way offers have stimulated mobile telephony.

6.1.3 Upstream Supply

With the required convergence between so many industries, each with its own value chain and way of working, there is great scope for innovation in the way in which the strengths of each can be combined and formed into new value chains for the supply of new offers. It is probable that the consumer will find value in a coherent, single service offer where the “joins” between the industries are not exposed to the user.

An illustration of where this did not initially work well, was Internet dial access where the “joins” between the telecommunications industry parts (telephony and modems), the PC industry parts (configuration of the PC), and the Internet industry part (service support and helpdesks) frequently left the user to sort out complex configuration and incompatibilities (for example disabling network services tones).

6.1.4 Wholesale Pricing Structures

Innovatory new tariffing structures will be expected from the core infrastructure networks underpinning NGNs as a range of services (voice and data) are carried across overlapping infrastructures. Access costs tend to reflect the density of customers in a geographic location and, up to the limits of the physical media, are not dependent on bandwidth, nor are they dependent on the duration of usage.

6.1.5 End to End Network Architectures

Network architecture here implies all the systems required to support applications including all the application hosting systems, B2C and B2B gateway systems, home networking and home appliances, as well as telecommunications networks and systems. Two factors create scope for considerable innovation:

- The significant difference in architecture used by the different converging industries;
- The mix of a few persistent aspects of the network architecture with the rapid pace of innovation in most other areas.

6.1.6 Specific Technologies

While the rapid pace of development of specific technologies has been the main driver towards the next generation networks and innovation will no doubt continue at a similar pace. Innovation here is probably now less significant than the innovation in the other areas described above. Unless there is successful innovation in these other areas, there will not be the applications, services, or markets to exploit the technological innovations.

6.2 Areas of Persistence During Convergence

The development of next generation networks seems certain to be characterised by rapidly evolving business models, services and applications, network architectures, as well as underpinning technologies. Within this, however, there are likely to be a few areas where change is likely to be slower as a result of both economic and technical factors.

As noted above, the deployment of broadband access is both costly and will take a number of years. Probably to a lesser extent than broadband access, networking protocol standards and operating systems standards also need to persist.

Application developers use sophisticated software development tools which include within them all the necessary capabilities for using an operating standard and networking protocols. Unless these are reasonably persistent, these software development tools cannot be developed and application development becomes both more costly and more time consuming.

Even more importantly for networking protocol standards, the application developer needs to know that the ends of the application can communicate with each other necessitating an enduring networking protocol standard. However, as was noted under the discussion on packet switch/routing technology, the current generation of IP standards and Ethernet standards do not robustly support real time services (ie voice/audio and video streams) and some development is needed if a clear networking protocol standard is to emerge.

6.3 *Evolutionary Constraints on Innovation*

Networks, by their very nature, have a value associated with their level of connectivity – the number of potential desirable communications that can take place using the network. Any new networking technology or protocol faces the enormous hurdle of achieving this high level of connectivity.

In practice, any development is heavily constrained unless it is backwards compatible with existing networks. The development and ongoing technology costs associated with backwards compatibility are often considerable. However, this is still frequently small compared to the costs achieving a critical mass of deployment in order to gain acceptance. The backwards compatibility between Windows 3.0 and MS-DOS was almost certainly a major factor in its success. The incompatibility between B-ISDN and any other deployed network technology was probably a major part of its failure.

The need to engineer backwards compatibility is often considered as secondary in the consideration of next generation networks, however, it seems likely that it gives the strongest indicator to successful innovations. Within the context of next generation networks, “disruptive technology” analysis should give strong attention to the needs of backwards compatibility which enables immediate high level of networking connectivity.

Glossary of Terms

Next Generation Network – an emergent and evolving collection of components originating from several different industries which, when brought together, can offer a wide range of new services and applications.

Industry – a cohesive set of business relationships (both customer/supplier relationships and competitor relationships) which are targeted at the delivery of an identifiable end user good or service. An industry will have an established way of working including industry wide bodies and mechanisms for establishing technical standards.

Value Chain – the set of primary supply relationships within an industry. All the supply, even upstream supply is generally directly visible to the end user and is seen by the end user as important to the delivery of the industry's end user goods or service.

Structural Supply – supply within an industry value chain

Infrastructural Supply – supply to an industry which is not part of the primary value chain but underpins the operation of the industry. Infrastructural supply is generally not directly visible to the end user and is seen by the end user as coincidental to the delivery of the industry's end user goods or service.

Packaged Offer – a retail offer which brings together several goods or service components from different industries into a single, coherent consumer offer.

New Service – a new retail offer which goes beyond packaging of existing components. This could be a wholly new application or an innovative way of offering and delivering an existing application.

Common Infrastructure – infrastructure which is applicable to and used by several industries and may give opportunities to creation of new services.

Convergence – a dynamic process by which a number of industries enter each other's markets. The convergence process can be driven by packaged offers, and the development of common infrastructure. In addition, the dynamic convergence process is likely to involve cross industry supply, dynamic new service creation, transitory cross industry collaborations, and disruption and replacement of existing consumer services.

Broadband Access – the infrastructure needed to connect an end user to the NGN and to make use of NGN based services. The supply of broadband access is infrastructural supply to other industries.

Innovation – the creation of novel new services, package offers, network architectures, cross industry supply arrangements, wholesale pricing structures, as well as the introduction and use of new technologies.

Standards – a set of technical specifications on which an industry come to agree and use. The standards may result from pre-development collaboration, collaboration during development and deployment, or may emerge, de facto, from a particular development's success in the marketplace.

Structure and Competition in Each of the Converging Value Chains

Broadcast TV and Radio Industry

From the consumer's point of view, there are two principal markets for broadcast TV – terrestrial free to air service⁷ and subscription services⁸.

For terrestrial free to air service, there is no service retailer (although there is a strong CPE – ie TV – retailing role). The principle role in addition to the end user role, is the broadcaster role which provides the broadcast channels (currently BBC, ITV companies, Channel 4, and Channel 5). These have structural suppliers of programming content as well as infrastructure suppliers, including the supply of contribution and distribution communications networks. They have end user customers as well as advertising customers (with the exception of the BBC).

For subscription services, the consumer can buy retail service from one of two service providers – BSkyB or the local CATV company, assuming the consumer is in an area covered by CATV. In each case, the undertaking has content providers, either supplying complete broadcast channels, or supplying specific programming (e.g sport), or supplying packaged content (e.g films). It also happens that these undertakings provide their own distribution communications network. There is a limited infrastructure supply market for contribution networks.

Broadcast radio is generally split into channels with national coverage and channels with only local coverage. Generally all channels are free to air being either BBC or commercial radio stations funded by advertising and/or donation.

In neither case, does the end user have any visibility of BT, and any components which BT may supply are within a highly competitive marketplace. BT's is largely coincidental to this value chain.

The use of next generation networks could allow the consumer a greater choice of channels (which for TV, current experience suggests is of limited value) and a greater level of interactivity within services. One affect which is already available with Internet, is that local radio stations can make themselves available world-wide. Any decisions on the deployment of next generation networks for such services will be

⁷ Free to air normally is taken to include BBC services paid for under the licence fee.

⁸ Also normally including pay per view and other minority payment methods.

taken by the broadcast service providers who are also likely to control all the associated technology, with the possible exception of the broadband access.

Internet Industry

There are currently three main structural roles in this value chain of industry – the Retail Internet Service Provider (ISP), Wholesale ISP, and the Internet backbone operator. In addition there are two main infrastructure supplier roles – access supplier and leased line supplier.

The retail ISP takes on packaging and retailing service to the end customer. The wholesale ISP takes on the operation of the component parts of the ISP service – for example, access, authentication, and authorisation (AAA) of customers, running of email and WWW servers, peering with other ISP and with backbone operators, etc. Many ISPs integrate both wholesale and retail roles.

The access supplier provides the connectivity between the customer's premises (currently supplying either a telephony service, a leased line service, or a broadband access service). The leased line supplier supplies leased line service between the nodes of the ISP's network.

BT has an ISP, Openworld, with a modest position in the marketplace.

BT has a backbone network in the UK and in Europe, however, in neither case are they even the largest in their areas. Moreover, the important backbones are the "Tier 1" backbone networks (which make no outpayments for any peering) which are all US based and BT does not have an ownership stake in any of these. With strong levels of competition between backbones and the current development of the market where most end users are unaware of any backbone undertakings, a backbone is not currently a likely source of market power.

BT is an infrastructure supplier of access and leased lines and this is discussed in more detail under the telecommunications industry. However, it is clear that whatever view may be taken on BT's market position in telecommunications, this has not lead to any position of market power in the Internet industry.

PC Industry

While the personal computing industry started by supplying stand alone computing solutions, in recent years networking of PCs has become an increasingly important aspect, especially in the business environment. The PC provides an number of applications which have grown up with the industry, for example document and presentation production and mathematical spreadsheet modelling, however, the PC is now an important piece of infrastructure for many of the converging industries,

There are four main roles in the PC industry value chain – retailing (eg PC World and online retailers), PC hardware supply (eg Dell, Compaq, Toshiba, Apple, etc), PC

hardware component supply (eg Intel), and PC software supply (eg Microsoft). BT has no substantive involvement in the PC industry.

Enterprise Applications Industry

This industry supplies IT solutions to corporate customers including supply chain management systems, accounting systems, customer contact management systems, ordering tracking systems, personal management systems, email systems, internal information systems, external information systems, etc. Increasingly, these applications are making use of distributed “client-server” architectures and use a PC to host the client end of the applications.

The two main roles in this industry’s value chain are the systems integration role and the component supply role. BT has a systems integration business (Syntegra) but does not play in component supply. Syntegra is not the biggest player in UK which is increasingly a global market.

Video and Music Entertainment Industry

This industry is focussed on the production and retailing of film and music content. It is possible to see a number of roles in this industry – experiential retailing (eg cinemas and concerts), durable media retailing (ie CDs, DVDs, audio and video tapes), promotion and distribution, production, and the “stars” themselves.

Linked with, but separate to this industry, is the manufacturing and retailing of consumer equipment for the replay of content. In addition, an important outlet for content over and above direct experience retailing and durable media retailing, is through the broadcast industry.

Critical to this industry is the ownership of rights. This can take many forms as it is passed down the value chain, normally changing form as it goes, and includes rights and restrictions on the end user (ie an end user normally cannot make and resell copies of content, or similarly, a person attending a concert is not allowed to make a recording or it).

BT, currently, has no direct involvement this industry.

Games Industry

Three main roles can be identified in this industry – retailing, games production, and games console production.

Retailing of games is now frequently joined with the retailing of video and music durable media. While games consoles have been specific for games (eg from Nintendo and Sega), the PC is also an important platform for games. Like the video and music industry, the games industry is concerned with content rights. The Internet gives rise to the opportunity for an additional form of game – the interactive game, which adds a new dimension to the management of rights.

ISPs, including BT's Openworld, have started taking an interest in both the retailing of games and in facilitating interactive games. This is a very small part of the current games industry.

Telecommunications Industry

For the current purposes, we describe the current telecommunications industry in three sectors, based on end user services. First is the sector supplying telephony and derivative services, second is the sector supplying leased line and data services as infrastructure to other value chains, and third, the emerging sector supplying broadband access.

While the forerunner of BT was a nationalised utility service provider, the UK telephony sector has now been the subject of intense regulation for nearly 20 years with the goal of creating effective competition at all points in the value chain. OFTEL recognises the strong position of infrastructure competition in the UK.

The leased line and data sectors have only grown into a significant part of the industry relatively recently and leased lines has been a prime focus for regulatory intervention by OFTEL.

Broadband access is not a consumer service in its own right, but is an *infrastructure* service which is potentially of interest to a number of other industries. So far, the Internet industry is the only one which developed a sufficiently viable consumer offer to prompt deployment of broadband access. However, without consumer offers from other industries⁹, ie converged offers, it seems unclear that an offer of just Internet access will be sufficiently profitable to any participant.

BT's market position with respect to the first two sectors is not the primary focus of this paper which is about next generation networks. The two key questions of relevance to next generation networks are:

- Does BT have market power in services based on next generation networks or in their development;
- Could BT exploit any position it might have in either of the other two sectors for services based on next generation networks or in their development?

Many of the critical parts of next generation networks do not naturally emerge from the telecommunications industry. Core networking is more likely to arise from the Internet industry, CPE from the PC industry, applications hosting infrastructure from the enterprise applications industry, and the applications which are the real value to the end users come more naturally from the broadcast, video and music, and games industries.

⁹ The cable sector in the UK has clearly been able to innovate in this manner.

Broadband access, which does naturally arise from the telecommunications industry, but not exclusively, is only one part of next generation networks. Moreover, unlike telephony, broadband access is not the end application which the end user values. The customer value is in the Internet, broadcast channels, video and music entertainment, games, etc. BT's current position concerns one part of next generation networks, and not the part of intrinsic value to the end users. BT, does not control access to the end-users in that they can form contractual relationships with third parties.

The opportunities for linking next generation services with telephony services, while possible, also does not give rise to any significant ability to leverage into the market for next generation services. Any other undertaking in any of the other industries clearly has the opportunity to innovate in the same way, and given that the current offers from the Internet, broadcast, video and music, and games industries are of more immediate relevance to end users, any linkage with telephony is co-incidental. Leased line infrastructure supply is even more co-incidental and normally wholly invisible to the end user.

Current Processes Of Standardisation

Internet Industry

The Internet industry has used a principle of “rough consensus and running code” which effectively results in standardisation *during* development and exploitation. The main standardisation body, the IETF, was constituted before the commercialisation and huge expansion of the Internet. Its governance structure now struggles with the commercial interests, especially of vendors, and the inability to give commercial weight in voting mechanisms. Despite highly effective and rapid standardisation in its early days, development of the latest generation of networking standards to support real time services and QoS in IETF has been slow. The overall scope of IETF activities has also been a subject of much recent debate.

Within this, vendors, undertaking increasingly proprietary developments which become the de facto standards for the industry irrespective of work within IETF (vendors often illustrate the interoperability of their equipment by referencing interoperability with a particular Cisco Systems implementation). Standards for the WWW are now developed within the WWW Consortium (W3C). These standards are now developing well beyond the simple display of text and graphics with hyperlinks to other pages of information, and the latest standard, XML, is capable of interfacing to many sophisticated enterprise application features in support of business to business (B2B) and business to customer (B2C) gateway interfaces.

Broadcast Industry

The broadcast industry has a similar standardisation process to the telecommunications industry with a set of formal de jure standardisation bodies as well as a set of less formal but often highly active industry fora, eg DVB. As a result most standards are established *ahead* of development and exploitation.

Video and Music Entertainment Industry

The video entertainment industry standardisation process makes use of some aspects of broadcast standardisation. In addition, there is a history of informal industry collaboration ahead of development and exploitation (eg CD, DVD, and VHS) and some proprietary developments (eg mini disk).

Electronic Gaming Industry

Standards for electronic games are currently proprietary (owned, for example, by Sega, Nintendo, Microsoft, and Apple). These standards are the operating system

APIs on which the games software runs and include the operating systems of dedicated gaming consoles as well as the operating systems for PCs (see IT industry below).

PC Industry

Standards in the PC part of the IT industry are best described by reference to the particular cases. The "IBM PC" is now defined by a set of hardware and firmware standards some of which are developed through informal industry collaboration (eg PCI bus) while other are proprietary developments whose interfaces are published (eg the Intel Pentium instruction set). Microsoft currently dominate the operating system market for the IBM PC with Windows which presents the Windows API for applications to run on. The Windows API is open and freely available and Microsoft actively promotes a community of third application developers to exploit the API. Apple's MAC bundles the PC hardware and operating systems (the interface between the two is proprietary and closed). However, the operating system API is open in the same way that the Microsoft Windows API is open. More recently the Linux and FreeBSD operating systems for the "IBM PC" which are Unix based have gained popularity. These are available under an open software licence which required that all technical developments are published and publicly available. As a result standardisation takes place during development and exploitation but openness is enforced by the licence conditions.

Enterprise Applications Industry

Standards in the enterprise applications part of the IT industry are beginning to converge on three sets of standards. Each of these specifies a set of utility applications which enable distributed components of an application (for example an order processing system) to communicate as well as a set of standards to which interfaces between components must conform. The three sets of standards are CORBA (standards developed in the industry forum OMG), Java Enterprise Edition (proprietary development of Sun Microsystems but Java standards have been adopted by both ISO and W3C), and DCOM (a proprietary development of Microsoft, also branded as .NET).