Internet driven convergence – policy implications[1]

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December 2009

Key words: convergence, internet, productivity, policy, telecommunications, spectrum, media, broadcasting, regulation
JEL classification: D20, L86, L96, L98, O47

Abstract

Digital content, Internet Protocol (IP), Moore's law and a move from dedicated hardware to software based systems and rights management are enabling convergence. Convergence can be thought of as occurring in three phases. In the first phase of convergence legacy market players have entered one another's traditional markets and offered a range of services and service bundles to end users. In the second phase internet based applications and content have been offered by non-traditional players in the communications and entertainment markets such as Apple, Microsoft, Skype, Google, Hulu and Spotify. In the third phase, which we may now be entering, applications, services and content delivered via the internet replace existing platform specific services.

Access platforms are likely to change, with fibre replacing copper; and cable (intermediate between fibre and copper), fibre and satellite progressively replacing terrestrial broadcasting. Mobile access will be enhanced, may see consolidation and will compete with copper access. Bundling of services by service providers is likely to give way to device based integration of applications by consumers, with personal devices playing a central role. The internet is at the heart of these transformations, both in terms of demand for enhanced access and "innovation without permission" in relation to applications and content. If these changes become widespread they will fundamentally alter the nature of competition with access to "platform independent" applications and content on the internet replacing competitive models based on access to infrastructure.

In this paper we argue that current communications and media policy is a barrier to the next phase of convergence. Specific barriers to change include: 1) inflexible and inefficient spectrum allocations; 2) platform specific universal service requirements; 3) obstacles to the shut-down of legacy services and networks and the creation of new ones. We propose a number of ways in which regulatory policy needs to change. The long history of legacy networks and services and the institutions that have developed around them – over a century for copper based fixed telephony and over 70 years for terrestrial TV broadcasting – make the required changes challenging. The challenges go beyond the responsibilities of sector specific regulation and involve broader public policy and political choice. They also require a shift of focus from promoting competition within traditional value chains to allowing disruptive innovation. As John Maynard Keynes set out in The General Theory of Employment, Interest and Money the challenge may lie "*not in the new ideas, but in escaping the old ones, which ramify, for those brought up as most of us have been, into every corner of our minds.*"

[1] Acknowledgements: The authors thank the numerous individuals with whom they discussed an early draft of this paper and Britta Glennon of Plum Consulting for feedback on subsequent drafts.

The internet as a primary driver of convergence

The internet is a "network of networks" and therefore facilitates network independence for services and applications. The internet is also a platform for innovation based on open IP and web standards, and a *de facto* rule prohibiting fees for access to end users – known as the "zero-price" rule.[2] Finally, the internet enables services which are personalised, on-demand, 2-way and peer-to-peer.

These characteristics of the internet have led to the explosive growth of online content and applications, the development of global services and locally tailored services, and exponential growth in traffic over fixed, and now wireless, networks. The internet has also seen the creation of new applications that disrupt existing business models including VoIP, advertising sponsored search and free online content. In addition, the internet is leading to disintermediation of existing vertical relationships and the creation of new relationships among applications, content, aggregators, networks and devices. The compatibility of different applications, content, networks and devices has led to a "Lego" world in which innovation is decentralised and new services can be rapidly developed and brought to market.

In this paper we focus on the implications of these changes for telecoms and broadcasting networks, services and policy. Our focus is on the issues traditionally addressed by sectoral regulators rather than on some of the emerging issues in relation to, for example, intellectual property rights and privacy.

Convergence of networks and services

Convergence was initially seen as a cross-over of services across platforms and of players from telecoms and media moving into one another's markets and/or offering service bundles, for example of TV and broadband.

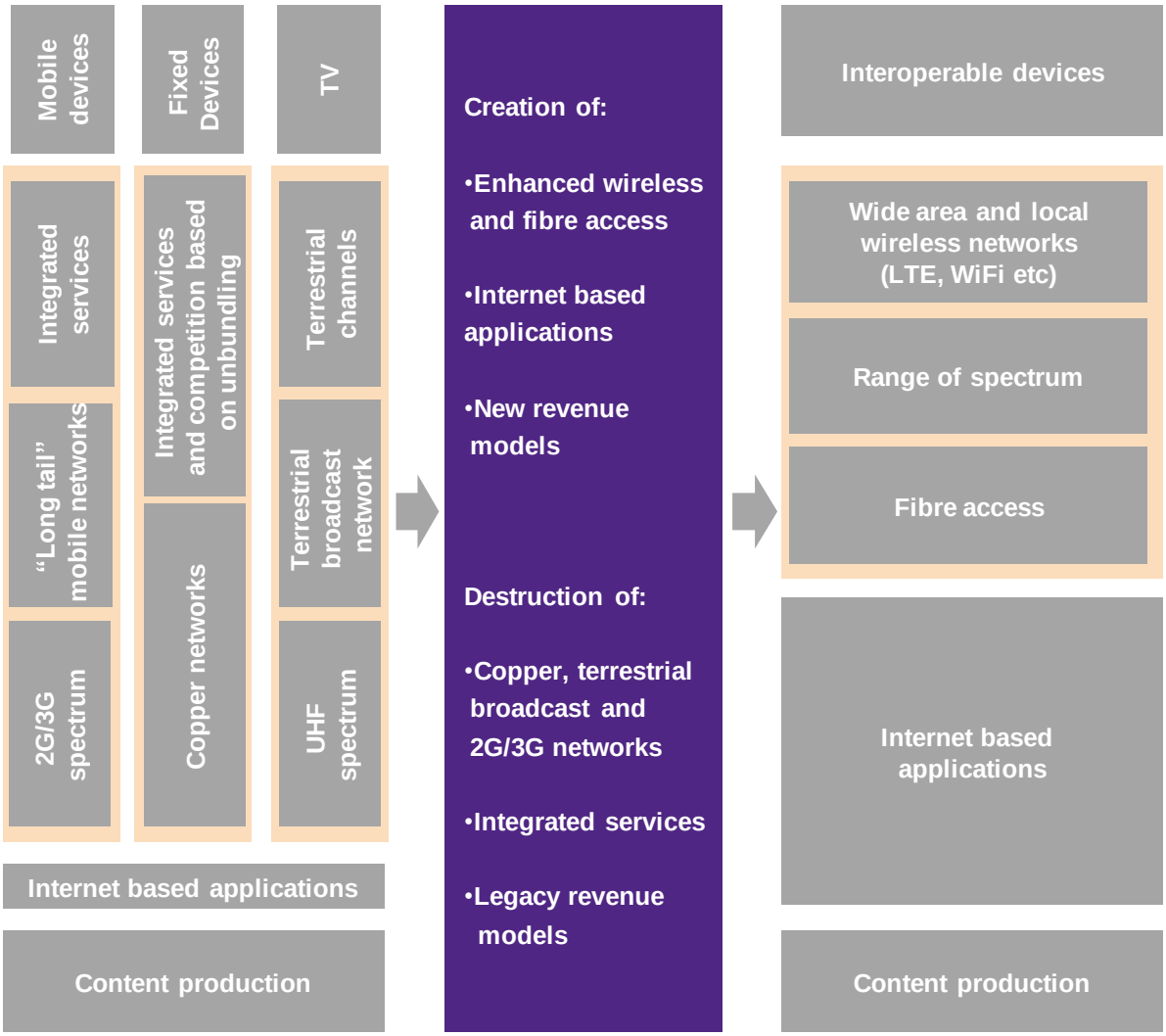
What we are now seeing is something more fundamental with the development of platform independent content and applications, and entry of new and established players from the internet space into the telecoms-media space such as Apple, Microsoft, Skype, Google, Hulu and Spotify. Content may now be delivered "over the top" direct from content producer to end consumer. In addition, the internet has also allowed some services to become global rather than local.

These changes are disruptive. We are seeing a shift from national vertically integrated homogeneous services to global heterogeneous network independent services. Growth in internet use and internet based applications is driving investment in enhanced wireless access and fibre which will ultimately displace legacy access networks including copper, terrestrial broadcast TV and 2G/3G wireless networks. New revenue models are developing, including advertising-supported search and micropayments for apps and content. Payment for access may also grow as fibre and enhanced wireless networks are deployed. We expect other revenue models including advertising-supported linear TV and voice revenues on fixed and mobile networks to continue to decline.

The structure of applications and content is moving from vertical organisation to a horizontal structure where different access networks can support a range of services and applications, and content is not tied to particular access platforms and devices. Figure 1 provides an overview of the transformation that we envisage occurring.

[2] Lee and Wu. Summer 2009. "Subsidising creativity through network design: zero-pricing and net neutrality." *Journal of Economic Perspectives*, Volume 23(3).

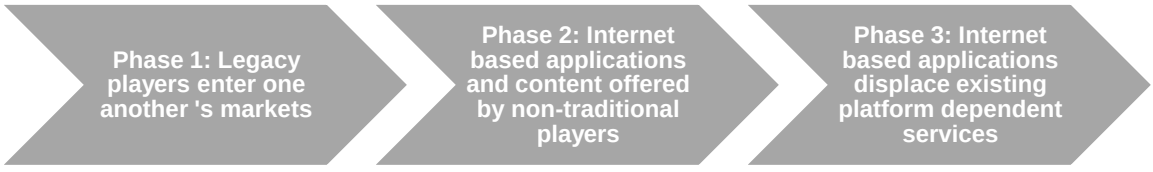
Figure 1: Transformation of value chains towards platform independent applications



Note: radio and satellite TV, which should survive the transition in some form, are not shown.

The transformation in Figure 1 involves three phases of convergence as illustrated in Figure 2.

Figure 2: Phases of convergence



Regulation and policy have tended to focus on the first phase of convergence. In phase two, which is well underway, applications and content are offered by non-traditional players in the communications and entertainment markets. Consumers in the second phase of convergence play a more central role as their preferences drive a proliferation of new applications. Consumers, rather than producers, build their own "bundles" of applications and content.

In the third phase of convergence, platform-independent applications, services and content delivered via the internet replace existing integrated platform-specific service models. Fibre and enhanced wireless will replace copper and fibre, satellite and cable will replace terrestrial broadcasting.

The iPhone and Google Android operating system coupled with the development of Apple and Android Apps stores illustrate these developments. Improved software and touch interfaces have promoted growth in use of advanced mobile devices, services and mobile broadband. They have also decoupled services, including voice (e.g. Skype) and location-based services (e.g. utilising GPS and third party databases of WiFi and base station locations to triangulate a user's location), from network provision.

The development of mobile broadband has accelerated with growth in smartphones, apps and use of the internet on a nomadic basis. Cisco forecasts that global mobile internet traffic will grow 131% per annum through to 2013.[3] Mobile broadband growth will both create demand for fibre access to transmitters in order to carry greater traffic levels and compete with fixed access. Mobile broadband growth is also creating demand for additional spectrum, some of which may reallocated from terrestrial broadcasting. The opening of Apps stores and software development of platforms open to third parties has also resulted in an explosion of Apps. Consumers are able to create "bundles" of applications tailored to their needs, rather than having to accept a bundle of services offered by a single service provider.

The productivity challenge

A key question all governments are facing is: what policy changes are required to reap the economic benefits from innovation in information and communications technologies (ICT)? Historically large variations in the productivity payoff from investment in and use of ICT have been observed across nations and regions even though the technology is tradable and therefore more or less universally available. As Jorgenson and Vu (December 2005) observe:[4] "*Although the surge in investment in IT equipment and software is a global phenomenon, the variation in the contribution of the investment has increased considerably since 1995.*"

Figure 3 shows the estimated contribution of ICT production (the first two bars) and use (the top bar) to overall labour productivity growth per hour worked (shown by the line) for the US.[5][6] A rising absolute contribution is apparent from the mid-1990s accompanied by rising aggregate productivity growth.

[3] Cisco. January 2009. Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update. http://www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/white_paper_c11-520862.html

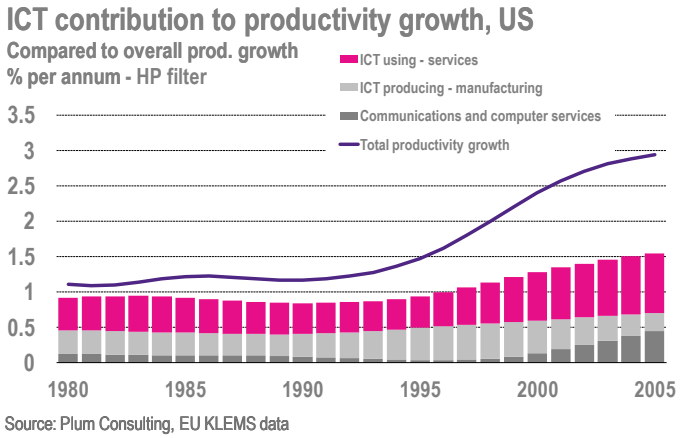
[4] Jorgenson and Vu. December 2005. "Information technology and the world economy." *Scandinavian Journal of Economics*, Vol 107(4).

[5] Based on EU KLEMS project data. http://www.euklems.net/

[6] Labour productivity growth is the only long run source of growth in real income per capita. The focus on labour productivity per hour worked rather than labour productivity per employee reflects the fact that both leisure and income may enhance welfare. The focus on labour rather than total factor productivity (TFP) recognises the fact that TFP is a residual measure in part reflecting incomplete measurement of factor inputs rather than necessarily representing a better measure of long term growth potential.

Jorgenson D., Mun S. Ho and Kevin J. Stiroh. 2008. "A Retrospective Look at the U.S. Productivity Growth Resurgence." Journal of Economic Perspectives, Vol. 22 (No. 1).

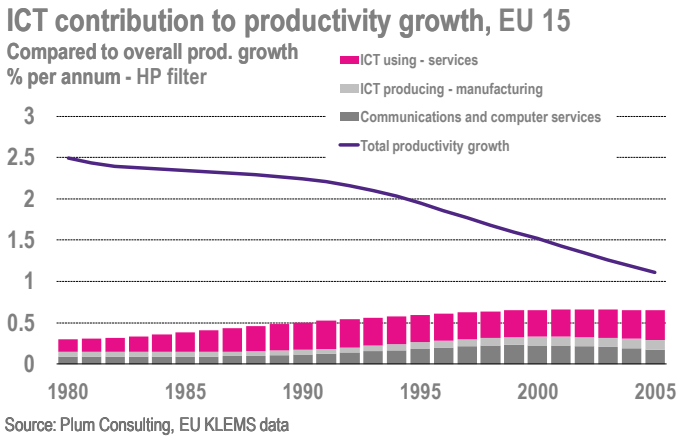
Figure 3



Source: Plum Consulting, EU KLEMS data

In addition to the growth accounting evidence in terms of the relationship between ICT and productivity growth, there is a range of microeconomic evidence that supports the conclusion that the relationship is causal.[7] In contrast Figure 4 shows that in the EU-15 the contribution of ICT to productivity growth increased up to the mid-1990s, but has been static since then and been accompanied by declining aggregate productivity growth.

Figure 4



Source: Plum Consulting, EU KLEMS data

Differences in policy, particularly labour and product market flexibility are thought to be responsible for much of this divergence across regions and nations.[8] It is important to learn from and build on this

[7] Brynjolfsson and Hitt. November 2003. "Computing productivity: firm-level evidence." *The Review of Economics and Statistics*.

Atrostic, Sang and Nguyen. 2005. "IT and productivity in US manufacturing: do computer networks matter?" *Economic Inquiry*, Volume 43(3).

[8] Karel Havik, Kieran Mc Morrow, Werner Röger and Alessandro Turrini (European Commission). September 2008. "The EU-US total factor productivity gap : An industry perspective." Economic Papers. 339.
http://ec.europa.eu/economy_finance/publications/publication13143_en.pdf

European Commission. October 2007. "An overview of the EU KLEMS growth and productivity accounts." Economic Papers 290.

http://ec.europa.eu/economy_finance/publications/publication9467_en.pdf

OECD. 2006. "Regulation, competition and productivity convergence". OECD Economics Department Working Paper No 509.

experience in the next phase of ICT driven productivity growth which requires a transformation of communications and broadcasting networks and services subject to sector specific regulation.

Implications of, and barriers to, the transformation of value chains

Whereas legacy telecoms and TV services involved a small near homogenous set of services the internet and convergence are facilitating an explosion in the range of applications and content available to consumers. This makes measurement more difficult; for example, TV viewing hours no longer adequately capture video consumption and voice minutes over circuit switched fixed and mobile networks no longer fully represent voice communication.

Growing heterogeneity also makes judgement over whether outcomes are good or not more difficult since consumers are consuming different services at different service levels and price points. Benchmark comparisons of price levels and price trends alone are no longer informative regarding changes in consumer welfare. Heterogeneity may also make integration less likely since no single service provider can hope to meet consumers' diverse demands for applications and services (witness the growth of Apps stores). Finally, heterogeneity of service availability and take-up may be viewed as good (consumer choice) or bad (evidence of a "divide"). Initiatives to improve digital inclusion will need to distinguish between the two.

The growth in the number and diversity of applications may also be shifting the underlying economics of platforms towards openness – provided regulation at the access level does not limit profit opportunities unduly. This is because a platform owner seeking to maximise demand for capacity on the underlying platform cannot hope to replicate the level of applications innovation that openness allows. For example, Verizon Wireless and Google have announced a strategic partnership combining the Verizon Wireless network and the Android open platform to deliver mobile applications, services and devices.[9]

The disruption of vertical value chains which had been relatively stable for long periods of time and operated according to distinct and established cultures, norms, contracts and ownership relationships has resulted in a battle over who captures value – or economic rent – in the emerging environment. Uncertainty over outcomes, a lack of guiding norms and a lack of strategic oversight across emerging areas which are "strategic complements" may slow the required transformation.[10]

Uncertainty and a lack of established norms relevant to the emerging environment have also led to debate over issues such as: who should pay for network enhancement and capacity?; who has the right to exploit the growing information about individuals?; can this data be used for price differentiation, targeted advertising and recommendation services? Resolution of these issues by market participants and/or regulators has implications not only for which producers "win", but also for efficiency (the size of the cake) and the balance of gains between producers and consumers. The way in which the market and institutions address these issues may impact on efficiency for several distinct reasons:

- Network and application/content investment will not be efficient and timely unless a degree of price differentiation to reflect end user willingness to pay is permitted.

[9] Verizon. October 2009. http://investor.verizon.com/news/view.aspx?NewsID=1013

[10] Where changes are strategic complements, in the sense that more of one raises the incremental return to more of another, incremental profit maximising moves do not necessarily lead to a globally efficient outcome.
John Roberts. 2004. The Modern Firm. Oxford.

- A hold-up problem may arise if those who are successful on either side of the market are hostage to others who may seek to exploit them by changing the terms of trade *ex post*.
- Where network integrated services are threatened by new network independent services (such as VoIP) integrated service providers may seek to block or degrade competing services.

Norms regarding terms of trade, agreed explicitly or tacitly by both sides of the market, might reduce these costs. A related question is who owns information by default – the consumer or the producer – and how the gains from exploiting such information are shared between them. If market norms are seen as unjust by consumers they may be overturned by political intervention – even if they are efficient.[11]

Escaping from old ideas and institutions

The shift that is occurring is undermining not only legacy business models, but also current ways of thinking about policy and regulation. A long history of legacy technology, market structures and institutions have led to habitual modes of thought which are an impediment to the next phase of ICT driven productivity growth. To make progress we must escape from the following modes of thought:

- A view that networks are in place and therefore that rewards for network innovation are not required beyond the risk adjusted cost of capital.
- A view that mandated access to infrastructure, particularly via so called "passive remedies" involving access to network elements or "dark fibre", is required to support competition. The existence of vertically integrated single service networks has conditioned this view.
- An approach to universality in telecommunications and broadcasting markets based on cross subsidy and implicit transfers. A lack of competition in telecommunications and broadcasting markets supported this approach historically.
- A view that extensive intervention is required to assure high quality broadcasting. A lack of competition due to the limitations of spectrum to support competing analogue services combined with a lack of developed pay models and the tendency of advertising funded broadcasting to gravitate towards content for the median viewer may have underpinned this view.[12]

Table 1 sets out how thinking may need to change.

[11] Odlyzko. March 2009. "Network neutrality, search neutrality, and the never-ending conflict between efficiency and fairness in markets." *Review of Network Economics*. Volume 8, Issue 1.

Biggar. 2008. "Is Protecting Sunk Investments by Consumers a Key Rationale for Natural Monopoly Regulation?" http://works.bepress.com/darryl_biggar/1/

[12] Helen Weeds and Mark Armstrong. 2005. Public Service Broadcasting in the Digital World. http://129.3.20.41/eps/io/papers/0507/0507010.pdf

Table 1: Transformation in thinking required

Old thinking	New thinking
Economic rent ("excess profits") implies monopoly abuse and such rents should be removed or transferred via regulation. Cost reflective pricing is efficient.	Economic rents may align investor and consumer interests ("information rents") and may simply reflect scarcity (radio spectrum and premium content). Value reflective pricing is necessary for efficient investment.
Vertically integrated telecommunications service providers involving a degree of monopoly have an incentive to discriminate against downstream service providers.	Platform owners want to maximise demand via a diversity of applications.
There is a trade-off between promoting competition and investment in telecommunications.	There may be no trade-off between investment and competition since competition will rely on consumer access to the internet rather than competitor access to infrastructure.
Entrants need access to unbundled network elements to progressively build a customer base and capability for investment (the so called "ladder of investment").	Service entry in communications and video markets occurs via the internet, sometimes via an existing internet brand, sidestepping the need for local access to infrastructure.
Mechanisms for customer switching in relating to integrated service providers are required to support competition.	Interoperable software interfaces in relation to networks and customer rights in relation to the transfer of content and social relationships (the "social graph") embodied in the cloud and web services may be required.
Spectrum must be reserved to support specific social purposes such as public service broadcasting.	Social objectives should be specified in technology neutral terms and all spectrum uses and users should face the opportunity cost of spectrum via trading and/or pricing.
Social purposes (universal service and public service broadcasting requirements) are efficiently delivered via networks and met through cross subsidy.	Social goals pursued via income transfers and/or targeted funding for competitively provided outputs.
National market is natural unit of analysis.	Network access is inherently local whilst services, applications and content are increasingly global.

The economics of innovation in computing and internet markets may now be more relevant than conventional regulatory economic thinking.[13] For example, the conventional regulatory view is that platform owners will discriminate against third party service providers. Whereas in internet markets there is evidence of firms with different capabilities specialising and cooperating with others, and the development of open interfaces even where one firm offers integrated services, for example, third party sellers on the Amazon store.

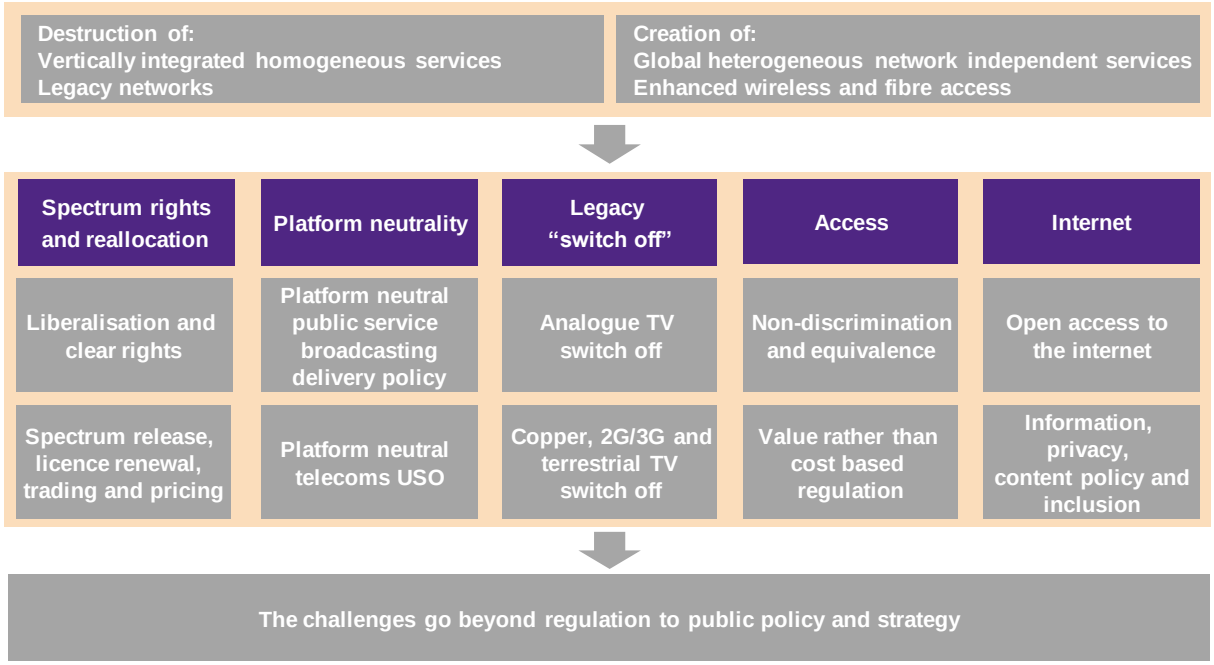
[13] Greenstein. April 2009. "Innovative conduct in US computing and internet markets." Handbook of the Economics of Technical Change, Edited by Hall and Rosenberg.
http://www.kellogg.northwestern.edu/faculty/greenstein/images/htm/Research/WP/InnoEconHandbook-Greenstein.pdf

Joseph Farrell and Phillip Weiser. Fall 2003. "Modularity, vertical integration and open access policies: towards a convergence of antitrust and regulation in the internet age." Harvard Journal of Law and Technology, Volume 17(1). Page 86.
http://jolt.law.harvard.edu/articles/pdf/v17/17HarvJLTech085.pdf

Developing a new paradigm and approach

Figure 5 sets out a number of the high level changes in policy required in the areas of spectrum rights, platform neutrality, legacy "switch-off", access to bottlenecks and policy issues relating to the internet.

Figure 5: Complementary spectrum, broadcasting and telecoms policy reform



These issues are considered below.

Spectrum rights and reallocation

The policy prescription here is simple in principle: namely to create the framework within which spectrum can be reallocated to new users and uses in a timely manner as convergence proceeds. However, for the spectrum utilised by terrestrial broadcasting, this is a radical proposition since existing rights are currently non-tradable and reserved for terrestrial broadcasting on an international basis.

UHF spectrum currently used for broadcasting is particularly attractive in terms of improving wide area and in-building coverage for mobile services. In the US, analogue TV switch-off was completed in June 2009 and some UHF spectrum was made available for mobile broadband. Verizon has begun a test deployment of LTE utilising UHF spectrum and plans to have 100 million customers covered by their LTE network by the end of 2010.[14] LTE deployment is more advanced in the US than Europe, which is not expected to complete analogue TV switch-off until 2012. However, both the US and Europe are now considering further reallocation of spectrum for mobile broadband post analogue switch-off.

[14] Verizon. September 2009. http://investor.verizon.com/news/20090917/20090917_transcript.pdf

In the US, the FCC Chairman has indicated that the FCC will be looking to refarm additional spectrum for mobile broadband.[15] Subsequently the FCC launched a consultation on the incremental value of UHF spectrum for broadcasting versus mobile use and on the possible use of market-based or other incentive mechanisms to enable broadcasters to choose whether or not to make spectrum available for wireless broadband services.[16]

The mobile industry has also indicated the need for up to an additional 800 MHz (in addition to the approximately 400 MHz currently available) for mobile broadband.[17] Further pressure has come from the US Consumer Electronics Association.[18] In a report for the CEA the Brattle Group estimate a market value of $62bn for around 300 MHz of UHF spectrum reallocated from broadcasting to mobile broadband.[19] In comparison the costs of compensating broadcasters or household migration costs are estimated to be around $12bn or $9bn respectively. The authors also estimate that the consumer surplus from reallocating the spectrum would be in the range of $500-1,200bn.

The possibility of a second European sub-band for mobile broadband in the frequency range 694-790 MHz (in addition to the 790-862 MHz sub-band potentially available for mobile broadband post analogue TV switch off) has also been put forward in the context of work for the European Commission.[20] The potential availability of only 72 MHz of UHF spectrum for LTE in Europe, combined with an optimal channel width of 2x20 MHz, can be expected to lead to increased pressure for network consolidation to offer improved service and lower cost, but involving a loss of competition at the network level.

Making spectrum rights clear and tradable could increase their value since new users, such as mobile operators, could offer to purchase such spectrum in competition with others. Whilst spectrum pricing might also incentivise reallocation, particularly in relation to spectrum held by government agencies, it may also discourage efficient spectrum trades.[21]

Platform neutrality and universality

Universal service requirements in telecommunications have tended to be fixed network and voice centric, and typically have focussed on network availability funded via cross-subsidy. As networks are transformed from copper to fibre and wireless, the existing approach of cross subsidy needs to be rethought.[22]

Maintaining voice universality requirements on copper networks may limit the attractiveness of fibre and advanced wireless investment by copper network operators since they will not be able to

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[15] Remarks of Chairman Genachowski. 7 October 2009. "America's Mobile Broadband Future." At International CTIA Wireless I.T. & Entertainment, San Diego, CA. http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-293891A1.pdf

[16] FCC. 2 December 2009. "Data sought on uses of spectrum." NBP Public Notice # 26. http://hraunfoss.fcc.gov/edocs_public/attachmatch/DA-09-2518A1.pdf

[17] CTIA. September 2009. "Wireless Crisis Foretold: The Gathering Spectrum Storm…and Looming Spectrum Drought." http://files.ctia.org/pdf/filings/2009_09_29_Spectrum_Demand._FINAL.pdf

[18] Wall Street Journal. 28 October 2009. "FCC Considers Shifting Some TV Airwaves to Broadband." http://online.wsj.com/article/SB10001424052748703574604574499730302393274.html

[19] The Brattle Group. 23 October 2009. "The Need for Additional Spectrum for Wireless Broadband: The Economic Benefits and Costs of Reallocations." http://www.brattle.com/_documents/UploadLibrary/Upload809.pdf

[20] Analysys Mason, DotEcon and Hogan and Hartson. September 2009. "Exploiting the digital dividend – a European approach." http://www.analysysmason.com/EC_digital_dividend_study

[21] Marks and Williamson. June 2009. "Is spectrum pricing compatible with spectrum markets?" http://www.plumconsulting.co.uk/pdfs/Is%20spectrum%20pricing%20compatible%20with%20spectrum%20markets.pdf

[22] Ministry of Transport and Communications Finland. 2008. "A phone for everyone – from fixed to mobile services." http://www.lvm.fi/web/en/publication/view/278177

rationalise their networks. The viability of operators with universality commitments tied to legacy networks might also be threatened by competition.

Policy makers are now proposing measures to ensure that broadband is universally available. Proposed approaches around the world differ widely but can be classified into the three categories shown in Table 2.

Table 2: Categories of approach to universal broadband

Category	Illustrative example/s
Near term universality via wireless and satellite	In Finland a minimum (defined statistically) of 1 Mbps universal broadband will be available to all from 1 July 2010.[23] In Ireland "3" are providing 1.2 Mbps minimum down and 200 kbps with 100% coverage by September 2010 utilising fixed wireless and satellite.[24]
Fibre in the "middle mile"	The second phase in Finland focuses on the middle mile with the aim of ensuring 99% of premises is within 2 km of fibre by 2015 and with approved government funding of €66 million and with customers paying for their own wireless or fibre connection, though tax credits will be provided.[25] The FCC has also issued a consultation in October 2009 on an approach which would focus on "anchor institutions" and the middle mile.[26]
Fibre in the last mile	Singapore is investing in fibre to all premises at a cost of S$1 b with state funding of S$750 million.[27] Both Australian and New Zealand are also focussing on approaches which would see fibre to the premises deployed widely.

In relation to the above, there may be merit in specifying any near term universality objective in a way that allows mobile broadband to play a part. In order to achieve this, objectives in terms of speed should not be too ambitious (particularly prior to the release of UHF spectrum from analogue broadcast switch off) and should be specified in probabilistic terms. Giving mobile broadband greater prominence on the supply side may also improve take-up, as discussed later in this paper under digital inclusion.

In relation to broadcasting, requirements in relation to quality, national content and to "free to air" availability have been implemented in different ways in different countries. These approaches emerged in an environment in which terrestrial broadcasting capacity and therefore competition and choice were limited by spectrum availability and analogue technology, and in which subscription

[23] Ministry of Transport and Communications. 16 October 2009. "Access to a minimum of 1 Mbit Internet connection available to everyone in Finland by July 2010." http://www.lvm.fi/web/en/pressreleases/view/920100

Some variation will be allowed in the universal service connection speed to enable mobile services to fulfil the requirements. The average speed of downstream traffic must be at least 75 per cent of the required speed in a measuring period of 24 hours. In a four-hour measuring period the speed must be at least 59 per cent of the required speed.

[24] DCENR. National Broadband Scheme.
http://www.dcenr.gov.ie/Communications/Communications+Development/National+Broadband+Scheme.htm

[25] Ministry of Transport and Communications Finland. 2008. "Making broadband available to everyone

The national plan of action to improve the infrastructure of the information society." 50/2008.
http://www.lvm.fi/web/en/publication/view/821179

[26]FCC. 8 October 2009. "Comment sought on cost estimates for connecting anchor institutions." DA 09-2194.
http://hraunfoss.fcc.gov/edocs_public/attachmatch/DA-09-2194A1.pdf

[27] Citigroup Global Markets. 30 January 2009. Telstra Corp Ltd at the Crossroads.

models were limited by available technology. In this environment a number of "market failures" existed which state intervention was designed to overcome.[28]

For TV and radio services digital terrestrial TV, satellite, cable and internet based services have opened up greater choice and competition including access to globally available content. Further, software based protection (DRM) and interfaces are supporting innovative subscription and advertising funding models, and the protection of content independent of the network/device.[29] In light of these developments, a fundamental question is to what extent the market might meet objectives of public service broadcasting, and how should public service content be funded and procured (to the extent that they are not met by the market). Further, how should universality requirements on "free to air" evolve in a multiplatform environment where terrestrial TV broadcasting may contract as content moves to other platforms and as mobile broadband competes for UHF spectrum.

Legacy network switch-off

Fibre, advanced wide area wireless (WiMax and LTE) and local wireless hotspots will displace copper networks and existing 2G and 3G wireless. Fibre and LTE deployment will not only allow, but would be facilitated by, the "switch off" of copper telephone networks, thereby reducing network operating costs and improving investment returns.

In high density locations fibre and wireless networks will to some extent be complements.[30] As William Webb (2007) put it: *"The extent to which fibre cables are brought within 100-300 metres of people's homes will determine the viability of massive upgrade of wider area mobile radio data speeds."*[31] LTE – which is expected to offer a 5-fold reduction in cost per bit, a 10-fold improvement in speed and a 10-fold reduction in latency compared to 3G - can be expected to substitute for copper in areas where fibre is too costly to deploy and for those customer segments with more limited broadband demands and/or lower willingness to pay for fibre.[32]

Terrestrial broadcasting will come under pressure from cable, fibre and satellite TV, which offer greater scope for on-demand, interactivity and multichannel HD. In parallel with these competitive pressures, mobile broadband growth will create increasing pressure to reallocate spectrum utilised by terrestrial broadcasting. This could lead to the "Negroponte switch" whereby the roles of wireless and fixed networks switch.

Network consolidation and replacement will raise difficult issues in relation to legacy network switch-off. The reason that network switch-off raises public policy questions is that copper, 2G and 3G wireless and terrestrial broadcast networks variously support services that have explicit universality requirements, that involve replacement of legacy consumer equipment and/or where there are political and consumer expectations of service continuity. Whilst the analogue to digital transition for mobile

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[28] Mark Armstrong & Helen Weeds. 2005. "Public Service Broadcasting in the Digital World." http://129.3.20.41/eps/io/papers/0507/0507010.pdf

[29] However, in the hybrid broadcast video on demand environment, software implementation of content protection may be limited by regulation in some markets, potentially slowing convergence. Farncombe. October 2009. "Towards a replacement for the DVB common scrambling algorithm." Farncombe White Paper. http://farncombe.eu/whitepapers/FTLCAWhitePaperTwo.pdf

[30] Fibre optics and wireless utilise electromagnetic spectrum on an unshared point-to-point basis and a shared omni-directional basis respectively. According to Cooper's law wireless traffic increased 1 million-fold in 45 years: predominantly from increased transmitter density (1,600x) rather than technology (25x, perhaps with potential for a further 5x increase) or additional spectrum (25x). A high density of radio transmitters and high traffic volumes will ultimately drive demand for wide area fibre networks.

[31] William Webb. 2007. "Wireless communications: the future." John Wiley. Page 209.

[32] Verizon. 10 September 2009. "Verizon at Bank of America Securities Media, Communications & Entertainment Conference." http://investor.verizon.com/news/20090910/20090910_transcript.pdf

networks was in general managed by market players, future transitions and legacy system switch off will occur with near universal take-up of mobile, and so public policy considerations are more likely to arise. In Finland, policy makers have recognised the need to plan for copper network switch-off with proposals to re-specify voice universality in terms of mobile and for allowing fixed switch-off subject to one year's notice.[33]

Access

Telecommunications competition is currently thought of in terms of competitive service provision supported by regulated access to incumbent infrastructure (where infrastructure competition is judged insufficient). These regulatory arrangements were developed assuming that incumbent infrastructure providers wish to remain vertically integrated and have an incentive to discriminate against third party providers (an assumption that rests on experience rather than on theoretically unambiguous results).[34]

The growing diversity of applications, from voice historically to a multiplicity of internet-based applications today (across all of which the platform provider cannot hope to be competent), will tend to diminish or eliminate the incentive for a vertically integrated provider to discriminate against third party application providers. Many web services are now open to third party innovation, and platforms such as the iPhone OS, Android and the Symbian operating system allow third party applications.

Existing policies should be reappraised in the transition to next generation broadband for the following reasons.[35] First, efficient and timely investment requires value reflective, not cost reflective, pricing. Second, competition is shifting from integrated service provision based on network access to the provision of applications over the internet. The latter requires that end users have access to the internet, not that service providers have access to networks.

An important qualification to the above argument is the distinction between consumer and multi-site business markets. Global businesses often demand a one-stop shop across many markets and this requires network connectivity. Incentives for integration, and potentially for discrimination, may therefore persist in this market segment. Ubiquitous access products are required and might ideally be provided via "active" access products which lower the transaction costs of service provision and allow for consistent service provision across a diversity of underlying access networks.

Net neutrality

Innovation in terms of internet-based applications and network transformation via investment in fibre and advanced wireless are complementary. Both are required to maximise gains to consumers and society. *De facto* and formal policy rules governing access to networks by service competitors and consumer access to internet based applications will shape the evolution of these complementary developments.

Rules are required that allow value creation to drive investment and innovation decisions. Cost reflective network access distorts incentives for efficient investment due to mis-alignment of incentives and end user interests. Denial of consumer access or discriminatory terms of access to internet-based applications would limit the development of internet applications – in turn reducing demand for advanced network services.

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[33] The Ministry of Transport and Communications. 2008. "A phone for everyone – from fixed to mobile services." http://www.lvm.fi/fileserver/a%20phone%20for%20everyone%20–%20from%20fixed%20to%20mobile%20services.pdf

[34] David Mandy. 2000. "Killing the golden goose that may have laid the golden egg: only the data knows whether sabotage pays." The Journal of Regulatory Economics, 17:2.

[35] Brian Williamson. September 2009. "The regulation of next generation access networks and the draft Commission Recommendation." In NEREC. Monitoring EU Telecoms Policy. http://www.nerec.es/wp-content/files/NEREC_report.pdf

The US and Europe have pursued contrasting approaches to these challenges: the US has deregulated network access and is focussing on net neutrality principles whilst Europe has placed primary emphasis on competition supported by mandated access to bottleneck infrastructure with less emphasis on net neutrality. However, two European countries, Norway[36] and Sweden[37], have promulgated net neutrality guidance.

In the US, the FCC has proposed strengthening the original network neutrality principles published in September 2005 that focused on ensuring that "*...consumers are entitled to run applications and use services of their choice...*"[38] by translating them into legally-binding rules with additional transparency requirements and an additional requirement that *"broadband providers cannot discriminate against particular Internet content or applications";* noting that *"this principle will not prevent broadband providers from reasonably managing their networks."*[39]

On 24 November 2009 the European Parliament formally approved the EU's telecoms reform package which includes a provision relating to net neutrality. This provides for national telecoms authorities to have powers to set minimum quality levels for network transmission services so as to promote net neutrality, transparency requirements to ensure consumers are informed about the nature of the service to which they are subscribing and a political commitment by the Commission to keep the neutrality of the internet under scrutiny.[40]

The key issue is what set of *de facto* and/or formal rules is required to maximise innovation and consumer benefits in relation to network access and internet applications considered together. Price differentiation is required to support efficient investment in networks, but discrimination in favour of integrated services and/or *ex post* opportunism[41] by either internet service providers or networks could harm investment, innovation and consumers. In considering this issue, two distinctions should be made: first, between access and core networks and second, between mobile and fixed access networks.

In relation to core networks, bandwidth costs are anticipated to fall rapidly, with an estimate of approximately a ten-fold reduction between 2008 and 2012.[42] Core networks have also seen progressive upgrades in capacity to meet demand, and traffic management services including priority links and local caching are offered competitively by a number of third parties, for example, Akamai. There does not seem to be a problem here.

In relation to access networks, mobile and fixed networks have fundamentally different cost functions: in mobile networks traffic volumes drive the need for additional spectrum and/or base stations whilst in fixed networks access costs are independent of traffic volumes (though they are a function of speed in relation to fibre versus copper). To preserve reasonable quality of service and cost in mobile access

[36] Norwegian Post and Telecommunications Authority. January 2009. "Network neutrality: Guidelines for Internet neutrality." http://www.npt.no/ikbViewer/Content/109604/Guidelines%20for%20network%20neutrality.pdf

[37] PT. February 2009. "Network neutrality – guidelines for internet neutrality". Version 1.0 http://www.pts.se/upload/Rapporter/Internet/2009/natneutralitet-2009-6-eng.pdf

[38] FCC. September 2005. FC-05-151. http://fjallfoss.fcc.gov/edocs_public/attachmatch/FCC-05-151A1.pdf

[39] FCC Chairman Julius Genachowski. 21 September 2009. "Preserving a Free and Open Internet: A Platform for Innovation, Opportunity, and Prosperity." http://openinternet.gov/read-speech.html

[40] European Commission. 24 November 2009. "European Commission welcomes European Parliament approval of sweeping reforms to strengthen competition and consumer rights on Europe's telecoms markets."

[41] Joskow. 1985. "Vertical Integration and Long-term Contracts: The Case of Coal-burning Electric Generating Plants." *Journal of Law, Economics and Organization* 1(1).

[42] Analysys Mason. November 2008. "Delivering high-quality video services online." http://www.ofcom.org.uk/research/technology/research/emer_tech/hqvs/

networks, some form of traffic management via rules or pricing policy will therefore be required; whereas in fixed access networks higher traffic levels do not impose incremental costs at the access level. However, price differentiation in relation to fixed access may be required to support timely upgrades.

A way forward would be to allow price flexibility and service and price differentiation on the basis of access network characteristics (for example, bandwidth or traffic levels) but to limit the scope for discrimination or *ex post* opportunism between access platform and application and content providers. The *de facto* "zero price" rule in relation to the internet has contributed to innovation[43] and does not appear incompatible with efficient forms of price differentiation for access. Access providers and internet-based application and content providers may therefore have a mutual interest in agreeing terms of trade along these lines.

Digital inclusion

In addition to a focus on broadband availability, growing attention is focussed on ensuring people are able to access services available through the internet. Whilst there has been substantial growth in broadband availability and take-up in developed countries, growth in internet adoption has been more limited.[44] Further, cohort effects – the ageing of those who already use the internet – explain a share of the growth in internet adoption by older people.

There is evidence of persistent low levels of internet and broadband adoption by some segments, particularly less well educated older people.[45] [46] Cross-country variations in internet use appear correlated with differences in the overall ICT intensity of the economy and differences in basic levels of educational attainment and labour force participation. [47] [48]

Looking at the experience in relation to mobile voice, a diversity of devices, marketing backed by the presence of retail stores and innovative tariff structures such as pre-pay have driven near universal take-up. Mobile broadband, new devices and interfaces and mobile broadband tariffs which enable consumers to better manage their costs may also facilitate growth in internet adoption by bypassing the need to acquire PC skills and contract for fixed broadband. Specialist devices and associated services such as eBook readers may also provide some with their first taste of the internet, without needing to consciously adopt broadband or go online. In devising policy interventions in relation to network coverage and demand side stimulation measures the above changes in terms of modes of access, devices, services and tariff models should be taken into account.

Conclusion

We suggest that network independent applications and content delivered via the internet are likely to displace network-dependent services. Policy makers seeking to promote consumer welfare will need

[43] Lee and Wu. Summer 2009. "Subsidising creativity through network design: zero-pricing and net neutrality." *Journal of Economic Perspectives*, Volume 23(3).

[44] Comparing data on household broadband versus internet access from the OECD broadband portal. http://www.oecd.org/document/54/0,3343,en_2649_34225_38690102_1_1_1_37441,00.html

[45] Pew Internet & American Life Project. "Trend data - usage over time". http://www.pewinternet.org/Trend-Data/Usage-Over-Time.aspx

[46] Eurostat Information Society Statistics. "Computers and the Internet in households and enterprises." http://epp.eurostat.ec.europa.eu/portal/page/portal/information_society/data/database

[47] OECD. 2009. "Society at a glance". Self-sufficiency indicators – Employment. http://www.oecd.org/document/24/0,3343,en_2649_34637_2671576_1_1_1_1,00.html

[48] OECD. 2009. "Education at a glance." Indicator A.1.2. http://www.oecd.org/document/24/0,3343,en_2649_39263238_43586328_1_1_1_1,00.html#4

to adapt to this transformation by facilitating rather than inhibiting the necessary process of creative destruction. Old services and networks will need to be phased out as new applications, fibre and advanced wireless networks replace them.

While networks and services will be transformed, the pace, extent and benefits of such transformation are dependent on a change in the way policy makers think about communications and media markets and the nature of intervention in such markets. A fundamental shift is required, from promoting competition within traditional value chains to allowing disruptive innovation.

Underlying drivers may also lead to greater government involvement in areas traditionally left to independent regulators. Competition is reducing the scope to pursue public policy goals via cross subsidy or privileged access to spectrum, platform switch-off may require political management (analogous to the processes adopted for analogue TV switch off), new networks raise fresh issues related to universal access and global internet-based services may be difficult to regulate nationally.

The challenges of achieving convergence and a timely transition in terms of services and networks therefore go beyond the scope of existing national regulatory agencies and require engagement by government, cross border initiatives and potentially greater reliance on co and self regulatory approaches with industry.