

Convergence – A Challenge for broadband development

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Abstract. Convergence is a key concept in development of a broadband infrastructure. The concept of broadband for all is often linked with the idea of one ubiquitous broadband network. But the point of departure for ensuring broadband access for all is however quite different. The existing communication infrastructure is made up by a number of networks, with different architectures and serving different communication needs. This paper discusses the implications and challenges of convergence, which have to be addressed if the vision of broadband for all is to be realised.

1 Introduction

Convergence is a key concept in development of a broadband infrastructure. The concept of broadband for all is often linked with the idea of one ubiquitous broadband network serving all kinds of customers with all kinds of electronic communication services. One reason for this is enormous economies of scope. Broadband networks become more economic viable, if the same network can be used for a wide range of purposes and thereby replace a number of different networks. The point of departure for ensuring broadband access for all is however quite different. The existing communication infrastructure is made up by a number of more or less dedicated networks, with different architectures and serving different communication needs. At least in the short term, these networks and upgrades of these networks will constitute a major part of a future broadband infrastructure e.g. cable TV networks, which are being upgraded to support other types of broadband services as well. Realisation of broadband for all will therefore depend on how this diversified infrastructure can be used to provide a common platform.

This paper discusses the implications and challenges of convergence, which have to be addressed if the vision of broadband for all is to be realised.

Convergence is not only a technical challenge, but involves technical as well as market and regulatory issues, which has to be addressed in order to facilitate the objective of broadband for all. Thus convergence includes at least five different dimensions:

- Convergence of services – the same content are supplied at different platforms
- Convergence of networks – different services supplied via the same network
- Convergence of terminals – multifunctional terminals that can support different services (that might be supplied through different networks)

- Convergence of markets – the same companies supply their products and services in different sectors
- Convergence of regulation – the same regulator and the same set of rules apply in different sectors.

These dimensions include both technical and economic aspects as well as regulatory aspects. The technical development is often seen as the driving force enabling convergence. Although the technology is important this is not entirely true. It was possible to supply the same content at different platforms before the digitalisation, but the technology developments has made this a lot easier. In many countries (e.g. in the US) broadcast and telecommunication have been regulated by the same regulatory authority long before convergence of broadcasting and telecom technologies. On the other hand convergence in technologies does not per se lead to convergence in markets and in regulation. All of these five aspects of convergence will shape development of broadband networks and are described more in detail below.

2 Convergence of services

Convergence in services implies that the same content can be reached from different types of technical platforms (e.g. either through the Internet accessed via the telecom network or through a digital video broadcast (DVB) service delivered through a broadcasting network). This will lead to increasing competition between different platforms. Customers may, therefore, face a convergent market for various types of information services.

Digitalisation of content is one of the major drivers of convergence. In the digital world, the same content can be transmitted across different networks, and different services can be offered based on the same content. The synergy achieved goes far beyond the electronic communication forms and includes among others the printing press. However, in this context the most important content services to consider are: Internet based services, broadcasting services and mobile content services.

Capacity-per-user problems and problems associated with return paths in broadcasting networks will influence the development of data services that will be available in the broadcasting networks. Examples of interactive services offered in broadcasting networks without using a return path include:

Download of software: The broadcasting networks are mostly used in the daytime and evening hours. The transmission capacity during the night-time can be used to download, e.g., new versions of software to set-top boxes.

Download of newspapers: In a similar way, newspapers can be downloaded to set-top boxes.

Internet on TV: Access to the Internet in current TV communication networks is not possible because of capacity-per-user problems of digital TV networks. A partial solution can be to broadcast a limited version of Internet.

TV and radio services offered on the Internet are examples of broadcasting services provided on the Internet. Such services are often taking the advantage of the

interactive facilities of the Internet to provide access to archived radio and TV transmissions and other interactive services.

Mobile content services are developing along with increased bandwidths for mobile services. Mobile services can provide the same content as delivered on the Internet or via broadcasting networks – for instance on-line video of sporting events. However, content will often need to be tailored according to specific demands related to use of mobile terminals and limitations in bandwidth.

Convergence of services presents new possibilities for end users and new market potentials for producers, but it also presents new regulatory problems that have to be solved. One of the problems is related to the provisions for public service in the broadcast area. Should such provisions be extended to the Internet web, or should convergence on the content level lead to an abolition of public service rules? Another issue relates to the extended access to different kinds of illegal or harmful information, for instance racist propaganda, which the Internet facilitates. What are the possibilities for countries to retain control of this? Yet another problem is related to the provisions for media responsibility that exist today for print and broadcast media but do not apply to Internet media.

3 Convergence of networks

Traditionally, different infrastructures have been used to transmit and deliver specific information and communication services. Examples regularly mentioned in the literature include: dedicated telephony infrastructures for transmission of Plain Old Telephony Services (POTS) and broadcasting networks for casting Plain Old TV Services (POTVS). These infrastructures have been dimensioned and optimised to meet the specific requirements of their respective services.

The technology of information and communication services has, however, been subject to radical changes during the last 20-30 years. Technological developments have resulted in the emergence of new infrastructures and better integration of services across infrastructures mainly due to digitalisation.

Integration and convergence occur at different speeds in different levels of the network. Core networks have other characteristics than access networks resulting in different conditions for their levels of convergence. Convergence has developed more slowly in access networks than in backbone networks.

Telecom networks and broadcast networks differ in capacity offered, switching capabilities and availability of a return channel. Broadcast networks traditionally do not have the return path necessary for interactive services. Digital broadcast networks, however, have a return path, either integrated in the network or using other networks.

Telecom networks have been built to provide point-to-point services resulting in network architectures where the network resources between the user and the first switch in the networks are not shared. This enables the service providers to offer customised services to individual users. However, the cost of operation and maintenance of these networks is high and the increase of capacity at end user sites is developing slowly, making it impossible in the short-term to integrate all kinds of

services. Developments in audio/video compression technology and new access technologies such as DSL make it possible to offer new services in these networks.

Broadcast networks connect users to distribution points in the network and share the network resources. The capacity allocated to a broadcast service is dimensioned to give a good technical quality of the service; however, the Capacity per User (CpU) is very low. These types of networks are not optimised for point-to-point services but are well-suited for services with common interest.

Transmission of broadcast services over switched/routed networks is not necessarily an efficient way of utilising network resources, especially when 'broadcast service' denotes a service that is transmitted to many users and these 'many users' demand the service. All switches and routers in the network will then do a simple job of connecting the same input to many outputs, which is an inefficient way of using a switched/routed network.

To a certain degree, this is in line with the experiments in the UK in the early 1980s, where the cable companies implemented switched cable networks. The cable companies observed that the vast majority of users watched the same kinds of programs for most of the time, reducing the function of the expensive switches to a wire connecting these inputs to all outputs.

A precondition for Internet TV (TV delivered over the Internet) becoming comparable to traditional (digital) TV is an exponential increase in transmission capacity to end user sites. By using a simple assumption that two or three services must be available for a household (different family members must have the opportunity to watch different programs at the same time, and be able to record a program on VCR), the necessary capacity will be about 40-60 Mbit/s in the case of HDTV and 8-12 Mbit/s in the case of SDTV.

For some time to come, the broadcasting networks with their one-to-many structure will be the most optimal way of transmitting broadcasting services to the vast majority of end users. However, when capacity is sufficient to provide broadcasting services over the Internet other parameters like the way services are used can limit the provision of broadcasting over Internet. If a service is used by the majority of people, it is a waste of resources to provide it through a switched/routed network, as it can easily be broadcast to all people using broadcast networks.

One scenario might be that Web-TV (world-wide web pages delivered over broadcast TV) co-evolves with digital TV and exists as a complementary and competitive platform to other delivery networks. As a complementary platform, special types of services that will not be provided on other platforms can be provided on the Internet. As a competitive platform, special narrowcast types of services provided on cable and satellite delivery networks could be provided on the Internet and compete with these infrastructures for some broadcast services.

One of the major barriers for convergence relates to the transport and delivery part (i.e. the infrastructure part) of the value chain. It has been shown that although digitalisation is a major parameter, it is still only one amongst several parameters that influence convergence at the infrastructure level. It is also important, to emphasise that the success or failure of convergence is not directly connected to the capability of one infrastructure to integrate all services.

None of the infrastructures available can integrate all the services in their current state. While integration of the back-bone parts of the networks have had better conditions to evolve, integration of the last mile coverage has been shown to be dependent on many different parameters. However, some infrastructures have better potential to be upgraded to integrate more types of services. Cable TV networks are examples of this. On cable networks, it is possible to offer several broadcasting services of acceptable quality and at the same time deliver Internet and basic telecom services. Also new LAN types of networks in residential areas (and different wireless solutions coming onto the market) can provide acceptable performance levels. However, when upgrading cable TV networks and establishing new networks large additional investments must be made, and it is often not economical to do so.

One way of implementing convergence and delivering 'convergence services' is to utilise the synergy between different networks and consequently to utilise the strength of different networks. In this way, different components of the same service can be transported over different networks. This organisation of heterogeneous networks can be totally seamless for the end-user and function like an integrated network.

There are, therefore, choices to be made between a pure integration model and a heterogeneous network model. This choice depends partly on the characteristics of the types of communication in question and the characteristics of different kinds of networks and partly on the history of network development in different countries. There is a certain path dependency in the possible choices countries make, hinging on the former history of network development. Convergence of networks implies a development where the same services will be offered through different types of networks (e.g. UMTS, FWA and copper-based or optical wired networks).

4 Convergence of terminals

Terminal convergence denotes the coming together of consumer devices such as fixed and mobile phones, the television and the personal computer. Penetration of TV sets is much higher than PC terminals. TV sets are by far the most universal household communication terminal. Providing interactive services, including Internet, on TV can potentially benefit especially the 'information poor' and thus reduce the 'information gap' in many countries. This is an important implication of convergence, as a major part of the population of many countries will only benefit from new broadband services of network economies if it can receive the Internet services on TV.

The PC terminal is developing into a real competitor to the TV set as an access device to broadcast services. Additional low cost TV tuner cards are needed to be able to see traditional broadcast services on a PC. The PC is a well-designed medium for consumption of Internet services and is a good medium for convergence of a wide variety of services. But here also the way of use will be a vital parameter that determines the services for which the PC terminal and TV set will be substitutes.

The development in the past five years shows, however, that the direction of convergence is not only bringing together traditional services provided over different consumer terminals. There is also a trend towards the development of a variety of different access terminals for dedicated services and applications. The trend to service integration is being paralleled by a trend towards a new diversification.

5 Convergence of markets

5.1 Vertical Integration

Telecom services markets were generally highly vertically integrated up to about 1980. The telecom operators focused on delivery of end-to-end services and they either produced their own equipment or had a close relationship with national equipment suppliers. During the 1980s much of equipment production was divested from service operations. This was partly a consequence of the emerging liberalisation of the telecom sector. The equipment manufacturers wanted to sell their products to incumbent operators as well as new entrants. Too strong links with one operator would limit this potential and most manufacturers therefore benefited from a position as independent companies. However, many operators still maintain, substantial R&D departments, mainly in software and service development, in order to create a competitive edge through provision of the most advanced and innovative services. So, for innovation some integration between the production of technology and service production still persists.

For terrestrial broadcasting, equipment production and service production have in general been two separate activities. However, distribution and content production is highly integrated. For satellite and cable there is some vertical integration between content and distribution, as well as equipment production. The basic distribution by cable or satellite may be separated from content production, but most broadcasters act both as gatekeepers and producers of content although they also buy content from others.

Many telecom operators are supplying new content services over their networks. This can be seen as a continuation of the end-to-end philosophy that has dominated the telecom sector, but it is facilitated by new technical opportunities enabled through a wider penetration of broadband or semi-broadband facilities. In addition convergence with other media have drastically increased the market opportunities for delivery of various sorts of content via the telecom network.

5.2 Market convergence across industries

Convergence across industries can take place at all of the three horizontal levels: equipment/hardware, transport/software, and content/services. Each level is related to one of the technical dimensions of convergence:

Convergence in content production is related primarily to *services convergence*;

Convergence in distribution is related to *network convergence*;

Convergence in equipment production is related to *terminal convergence*.

Convergence in equipment production is also related to a convergence between different network technologies, as equipment suppliers produce equipment for use both in production and distribution as well as consumption of content.

5.3 Convergence in markets for content and services

Convergence in markets for content and services does not imply that the different platforms will be used for provision of the same services – a degree of specialisation is likely to remain. But the former boundaries between IT, telecom, broadcasting and other mass media companies are going to be redefined and less visible. Even if a broadcasting company chooses to remain basically a broadcaster, it will be necessary to become visible on other platforms as well. New service integrating elements from IT, telecom, broadcasting or other mass media will continuously be developed. These new services will not always be a source of creation of new companies but will contribute to the blurring of boundaries between the different industry sectors.

Services convergence implies that content providers will become cross-sectional in the sense that they provide content to more than one sector. Most content providers are, however, still rooted in one sector and their new activities are mainly in the new sectors. This is seen most clearly in content provision to the Internet. Both newspapers and TV broadcasters have developed their own web-sites, where they exploit the economies of scope related to provision of the same content to different platforms.

These activities may expand in such a way that this will lead to a convergence between providers of content to the Internet and either newspapers or broadcasters. But it is also possible that provision of news services to the Internet will develop into separate entities that may be spun off as independent companies. Or the market will be taken over by completely new companies that have content provision for the Internet as their core business.

An important barrier to the development of cross-sectional content providers is that it is not enough to provide the same content on different platforms. In order to remain competitive, content must be designed in a way that takes the potentials and limitations of each platform into consideration. As long as the technical capabilities vary across platforms and networks, there will always be scope for development of content designed for a particular platform.

Another trend is the entry of telecom operators into the broadcasting sector. In Denmark, for instance, the incumbent operator TDC (formerly TeleDanmark) tried to establish its own TV channel in the mid 1990s; Telecom NZ has bought a stake in Rupert Murdoch's Sky Network Television; and British Telecom has recently applied for a broadcasting license.

These examples deal both with horizontal and vertical integration. The philosophy is to ensure content to the networks. For example, BT (formerly British Telecom) seeks to distribute its broadcasting service via its own broadband network. However it is not yet clear whether these attempts at convergence will be successful. BT has yet to make its broadcast service profitable.

5.4 Convergence between distributing companies

The most important trend in convergence of distribution networks is between the telecom networks (which also provide the infrastructure for many IT services) and the broadcasting networks. The telecom networks are used for telephony as well as data, and now Internet services. Broadcasting services are still mainly distributed over

separate networks, but some broadcasting can also take place via the Internet. On the other hand, cable-TV networks can offer telecom services as well. In the UK, US and some other countries, cable operators have upgraded their cable networks to provide telephony, and cable modems are used to offer Internet access in many countries.

In some countries, the incumbent operators have from the very beginning been among the major cable-TV operators. This has tended to slow down convergence as telecom operators have been hesitant to introduce new services in the cable network (such as cable-modem access to the Internet) that compete with services delivered in the telecom networks. In the US, through its acquisitions of leading cable operators TCI and MediaOne, AT&T became one of the two major cable-TV operators. Since its divestiture from its local operating companies in 1984 AT&T has lacked a direct network access to its customers. Through this acquisition it sought to regain direct access.

Another trend is convergence between communication network operators and operators of other types of networks. In particular electricity companies have been active in rolling out communication facilities in conjunction with their power lines. This has in many cases proven to be a cost effective way to provide fibre to the home (FTTH).

5.5 Convergence between equipment manufactures

Convergence in equipment production is not a new phenomenon, but is essential to achieve in particular terminal and network convergence. Many industrial corporations such as Philips and Siemens are involved in many different industrial activities in most of the ICT and media sectors. The reasons for this relate primarily to strategy of conglomeration and the synergies between equipment production of different types of electronic equipment that existed before the digitalisation opportunities arose.

During the past decade, convergence has been most visible in the IT and telecom sectors. The liberalisation of the telecom sector has made it possible for new entrants from IT hardware, software and consumer electronics to start up production of telecom equipment. At the same time, the technical convergence between IT and telecom equipment has made it economical to enter the telecom market. One prominent example is Cisco which supplies routers to private data networks as well as public telecom networks (in particular IP-networks).

Convergence is not only a matter of utilisation of synergies in development and production. It is also a question of developing new types of equipment with features originating from different industries. This is clearly seen in the development of terminals for digital TV. These terminals not only combine broadcasting and IT technologies in their technical design. The services they provide are also a result of the convergence between the different industries.

6 Divergence of markets

There is, however, also a trend towards divergence. Mobile communication, for instance, has emerged as a new sector. The largest player on the market for mobile

communications, Vodafone, is an independent company with a focus on mobile businesses. In addition, some of the fixed operators are divesting their mobile activities. The explosion in mobile services around the world has been driven by independent competition made possible by the separation of mobile from fixed network operators, not its integration.

Another divergence trend is the increasing separation of supply of telecom services and operation of the physical network structure. Today a number of telecom operators base their operations in part on access to other operators' networks through leasing and interconnection agreements. In addition, a number of infrastructure providers have emerged. These are often public utility companies, which are in possession of their own telecom infrastructure but do not have any intentions of entering the retail market for telecom services. The financial crisis following the UMTS auctions may be an additional factor prompting this development, as some of the incumbent operators may be forced to sell off their infrastructure in order to reduce their debt. Among others, BT has received offers for their infrastructure from at least two different consortia. Although these offers have been rejected, analysts observe that BT (as well as other debt burdened telecom operators such as KPN, Deutsche Telekom and France Telecom) must decide whether they want to be pure network operators or service providers in the future.

6.1 Convergence of regulation

From a policy and regulatory perspective, convergence trends in the ICT and media areas raise a number of issues, which are relevant for development of broadband infrastructures. These issues include the general societal importance of a convergent broadband infrastructure, access to networks and content, technology neutrality, problems of network and media concentration, and issues related content regulation. At the content level, there are a large number of issues to be resolved, including the question of whether all content areas can be treated in similar ways regarding, for instance, what it means for public service provisions in the broadcast area and what it means for media responsibility rules. Other questions deal with privacy protection, security, consumer protection, intellectual property rights, and illegal information.

6.2 General Societal Importance

The general societal importance of convergence policies lies in the growing importance of ICT and media industries in terms of size of the industries themselves and the broader social implications. ICT elements are integral components of products and services in many sectors, and information and communication systems constitute infrastructures for many functions in society. Information and communication infrastructures are, for instance, crucial in importance for the many services activities that play an increasing role in social developments. Many countries have, therefore, devised information/network society visions and plans to take advantage of the potential applications of the new information and communication technologies and services, and many countries strive to establish the best possible economic and

regulatory framework conditions for the development of a broadband infrastructure and innovative applications.

6.3 Access to Networks and Content

Access to networks and content has become an increasingly important issue. Many countries have some form of universal service rules in telecom, or are in the process of developing such rules. Many countries also have provisions for access to public service broadcasting, even though in some countries there is an unfortunate conflation of public service and government propaganda broadcasting. The policy question is whether and to what degree such access provisions should be extended to broadband networks and services, reflecting developments relating to convergence, Internet, public information services, etc.

The arguments in favour have centred on the issues of overcoming the social divides and the economical and social advantages of a broad take-up of new technological possibilities, including both democratic aspects and the industrial growth potentials made possible by a broad diffusion. Arguments against have been concerned primarily with creating a situation where the mass of users are forced to support the most advanced early adopters of new technologies, and the dangers and inefficiencies of subsidising technologies that are quickly made obsolete by new and more powerful technologies. However, some countries have gone beyond the mere provisions for universal service in basic telephony and there is generally open-mindedness in relation to the possible inclusion of some sort of universal access provision, e.g. broadband access.

6.4 Technology Neutral Regulation

With respect to information and communication infrastructures, there is a general trend in policy discourse towards uniting the regulation of the different infrastructures. Most countries have operated with different rules applying to fixed networks, mobile networks, and broadcast networks. But with the technical convergence developments and the increasing possibilities for conveying similar services over different networks, the foundation for differences in regulatory rules are being questioned. The principle is here that regulation should not favour use of a particular technology for provision of broadband services.

Many countries, therefore, are seeking to harmonise regulatory frameworks of different communications infrastructures based on the principle of technology neutrality. However, there are some problems attached to this approach. There are for instance a number of special rules protecting users of fixed telephony, which do not apply for similar services provided via the Internet. Also, the levels of competition in the different infrastructure areas may differ, for instance, with greater competition in mobile services than in fixed.

6.5 Network and media concentration

The balancing of benefits and problems in relation to complementarities and market power is not a new issue. Public policies have been seeking to strike such balances in many areas for a long time, and asymmetric regulation has been used to increase competition between telecom operators, and incumbent telecom operators have been forbidden to offer cable TV services and have been requested to divest such activities. On the content side, many countries have for years had regulations limiting cross media ownership. However, technological developments including digitalisation of different media content, policy developments in the direction of increasing liberalisation and a less stringent view on economic power concentration, and increasing business internationalisation leading to larger corporations and political support for such tendencies, have altered the former balance points between the benefits and problems associated with common ownership of broadcasting and telecom networks and with media concentration. Network competition needs to be ensured also on a converging market for broadband services and there is still a need to ensure plurality in media. There is today a widespread political trend toward loosening the restrictions on media concentration, including cross media ownership provisions, in order to take advantage of the new complementarities between media. However, the policy issue is still there and just as important as it ever was. New balances have to be struck in view of benefits and drawbacks in loosening and restructuring regulations on media concentration.

6.6 Converging Content Regulation and other content issues

Adaptation of content regulation is crucial for development of broadband. In some areas for instance broadcasting existing regulation may pose barriers towards development of converging services, and users may be reluctant to use services if consumer protection is inadequate. Both issues may hamper service development and demand, and delay roll-out of a broadband infrastructure.

It is an open issue as to the extent regulation in the different content areas should converge. In the broadcast area, many countries have public service provisions of some kind, though they may be very different from one another. Some broadcasters have responsibilities for providing services under certain quality obligations but have, at the same time, a number of privileges in terms of, e.g., frequencies for terrestrial transmission. In other media areas, for instance print media, there are no such arrangements. And when content can be used across different infrastructure platforms, the question is what the implications will be for the specific public service provisions in the traditional broadcasting area. It will surely be more difficult to maintain a central position for public service broadcasters, but will public service provisions necessarily disappear? Conversely, is it possible and desirable to extend public service provisions to the Internet web in the sense that public service broadcasters become obliged to develop web pages with a public service type of content?

Another example of a similar question relates to the media responsibility rules for print and electronic mass media. Authors/journalists and editors are in most countries responsible for what is printed and broadcast. However, such rules seldom apply to information on the web, and the issue is whether it is possible and desirable to uphold

such rules in a situation with a growth of information spread over the web, or whether it is possible and desirable to extend rules for content responsibility to new media platforms at all.

Privacy protection takes on a new dimension in a converged Internet environment. Not only is it much easier to transmit files with personal information, it also becomes much easier to collect information about people, their interests and buying habits by means of automatic registration. Security problems involve both the security of information transmitted on networks, i.e. that personal information is not disclosed or tampered with, for instance, and the security of payments made on electronic networks. Consumer protection is also an important issue. When buying goods and services on networks, consumers must be protected against shoddy quality products, late delivery or simple fraud. In some countries, there are actually stricter rules protecting customers in e-commerce than ordinary commerce, but this does not apply to the great majority of countries where consumer protection is less, and there are certainly special problems in relation to international transactions.

Intellectual property rights constitute another area where a converged Internet environment creates many new problems. The Internet provides new possibilities for spreading cultural products – which is a great advantage. But for the holders of intellectual property rights, these new possibilities create new problems with respect to protecting their rights against infringements. Finally, illegal information such as racist utterances and child porn can be spread much wider on the Internet, and the question is how to protect citizens against such information and how to hinder people from spreading it in an international Internet context.

These issues are not new. They have not been created by the development of convergence in the media and Internet areas. However, convergence and the Internet create a new environment in which these known issues acquire major new dimensions.

It follows that convergence pose a number of issues of technical, economic and regulatory character, which needs to be taken into consideration in defining policies for promotion of broadband. Actors active on this market must realise that borders between various market segments are being redefined, and regulation must be reshape according to changes in technology and market conditions in order to facilitate development of converging infrastructures and market.

7 Conclusions

It follows that convergence pose a number of issues of technical, economic and regulatory character, which needs to be taken into consideration in defining policies for promotion of broadband. At least in the short term, a variety of existing networks and upgrades of these will constitute a major part of a future broadband infrastructure. Realisation of broadband for all will therefore depend on how this diversified infrastructure can be used to provide a common communications infrastructure.

Actors active on the communications market must realise that borders between various market segments are being redefined, and regulation must be reshape according to changes in technology and market conditions in order to facilitate development of converging infrastructures and market.

The emergence of broadband networks, which in principle are able to provide all types of communication services previously provided through separate network infrastructures, does not seem imply creation of converged market actors present in all parts of the value chain and delivering all types of services. But borders between existing industries will be redefined and new business models will emerge. The ability of the industry to adapt to this new environment will be crucial for development of broadband infrastructure and applications.

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