The 2nd Convergence: A Technology Viewpoint

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1 Introduction: What Is Convergence?

Convergence? Why is it popping up in contexts from networking to cuisine? Do we really know what convergence means, when and how it originated and where it is heading? This chapter is going to attempt to define convergence from a technology point of view and will propose that there is not one but many convergences: the current trends in next generation media across the real of human activity are defining the *Second* convergence, that follows the network, device and media convergences of the last 20 years taken together as the *First Convergence* but in fact having developed interdependently.

According the dictionary *converging* means to meet or focus on a common and similar goal, which applies as well to phones as to Asian fusion recipes. In the media and technology context, however *convergence* may be defined in a narrower fashion but with still different interpretations. Henry Jenkins in his article in the (Massachusetts Institute of Technology) MIT Technology Review in 2001 (Jenkins, 2001) defines:

- *Technological Convergence*: The cross-platform digital information flow created by the Internet and how content and our relationship to it are always expanding.
- *Economic Convergence*: The horizontal integration of the [entertainment] industry and the definition of new value chains.
- *Social or Organic Convergence*: The multi-screen multitasking environment created by device ecosystems or the connectivity between different groups of users

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- *Cultural Convergence*: Novel formats and platforms for creativity using various media technologies across different industries and consumer groups.
- *Global Convergence*: The experience of being a citizen of the *global village*

So if indeed we are witnesses to not one but many convergences, we may want to focus on one. This chapter proposes to focus on *Technological Convergence* in its numerous historical and current embodiments. Technological Convergence gave us wired and wireless network integration and the explosion of cellular communication. It created the fixed/mobile integration that lead to ubiquitous Internet connectivity. This in turn produced convergence in devices, the results of which are smartphones, connected televisions and tablets, amongst others. The convergence in our means of communications changed the way we consume content at home, at work and on the road. It redefined how we communicate with one another: not by phone only but via a web of interconnected service and social network applications.

It will be the hypothesis of this book chapter that the convergence in technology drives the economic, social, cultural and global convergences, creating in turn the media convergence of today and the years ahead: the *Second (2nd) Convergence*. This *2nd Convergence* is melding technology, business models, social networks and culture and catalyses media and story telling innovation. It is breaking through traditional design silos and is displacing traditional linear value chains and some the predominant business models and creates a new generation of innovators, users and creators across skill and age barriers.

And technology is pushing forward with the even more diversified *converged solutions*. These include of cloud-based computing and application, content-centric networking and big data, and adding social networking and crowdsourcing to traditional content production to produce novel methods of acquisition and dissemination of content.

Technological convergence was born of the dislocations between the personal and business space and the professional and entertainment realms. It has lead to business model disruptions and maybe to more dislocation in the perception and consumption of media. For example, the smartphone combines elements that were very disjointed (home and business phone, computing device, gaming console, e-reader etc.) in a single platform for which millions of applications were created: this abundance of apps fragments our attention.

In investigating many facets of convergence from the technology perspective, and present successes and challenges, this chapter uses a historical perspective. It presents the evolution from networking hardware and computing devices to current application-centric, mobile and user-centric service and applications. The next section starts this presentation with a cross-section of relevant literature. Technological convergence is a wide field that has generated a large body of academic and industrial publications over the last 10 years. Some important work will most likely be omitted, but the presented works intend to encourage the reader to look further into the field. Section 4 highlights the methodology of convergence research, based on experience and multifaceted investigation. The next three sections present the bulk of the chapter namely the *technological* convergence of the last two decades: from networks, to device and to media. Network convergence, gave us the Internet

of today, by, firstly, combining the data and telephone networks and, secondly, incorporating the fixed and mobile networks. While this is still happening, it will be seen that what at first seemed like a natural evolution essentially entailed a disruption of media business models and the current market frictions between traditional operators and the over-the-top (OTT) community. The device convergence is showcased in Sect. 5. In the undistinguishing set of Internet-connected devices one can ask what will become the differentiation models to keep user loyalty. The multiscreen applications, the ubiquitous Internet and social networking that forms Social media and Social Television are the topics of Sect. 6. These three sections taken together will clearly show that the Internet is now more than a network and a diffusion medium for content: it is morphing into a service and a platform for the latest innovations to be deployed. A personal viewpoint of the future of convergence will be provided in Sect. 7, proposing the 2nd Convergence as encompassing the economic, social and global convergence of media and the creation of new communities. As a consequence, convergence forces a reinvention of the way we communicate and the need for *available and sustainable* connectivity. Finally, we conclude with a reflection on managing convergence and, in view of the previous sections, if it needs to be managed at all: convergence is happening now, continually reinventing itself. With the melding between the social and the physical networks, between locations and real and virtual reality convergence is becoming an *ideation* platform.

2 Technology Convergence: A Literature Review

Convergence has been duly documented, and both glorified or decried over the years. It is disrupting. It engendered dislocation and divergence in the way next generation media dissemination and consumption are perceived and marketed. It fostered creativity and generated economic growth especially in the content and application fields. A number of Media focused Programs including the MIT Media Laboratory were born out the perceived necessity of convergence. And convergence challenged established business model in the media industry, from newspaper to television.

In this section some seminal publications on the convergence will be reviewed. It is not an exhaustive list as the field is vast and it reflects the research and interests of the author. These papers establish a timeline from the strictly network views of the early 2000s to the more media focused recent past and the current revisiting of the business. In subsequent chapters, publications that are specific to the topics under discussion will also be referred to.

In the networking industry convergence started with wireless networks and devices in the early years of the new millennium spurred by the fast melding of the technologies of cellular communication, Internet, television (TV), computers and fixed and mobile phones. The Internet was becoming the converged network of the future to offer all communication services over a common platform. The 3rd Generation Partnership Project (3GPP), the leading standardization body of the wireless industry, standardized the *Internet Multimedia Subsystem* or *IMS* in the

mid-2000s as reported in the book "The IMS: IP Multimedia Concepts and Services" (Paulson, 2010). 3GPP standardized the signalling and the related protocols that enabled wireless communication to integrate into the Internet. The European Telecommunication Standards Institute (ETSI) TISPAN[1] then expanded the reach of IMS into the fixed networks with the *Next Generation Network*s (NGN) seen as the future universal network based on Internet Protocols (IP). The final NGN architecture was published in 2008 (Bulkeley, 2010; Cisco, 2015) and its impacts will be reviewed in the next section of this chapter. In addition, the NGN family of networks and services have and still are been standardized by the International Telecommunication Union (ITU) and the Internet Engineering Task Force (IETF) and the Alliance for Telecommunication Industry Solutions (ATIS) that extended NGN in the television realm (Piokselka & Mayer, 2009).

In parallel to the work performed in the standardization groups, other aspects of technology convergence were also being investigated especially its impact on media and the rising media convergence. The rise of interactive television and its impacts on the broadcasting industry was studied by Arthur Lugmayr and his collaborators in 2004 in their book entitled: Digital Interactive TV and Metadata: Future Broadcast Multimedia (ETSI 2007). Their conclusion, that the use of metadata and technology to enhance the interactivity between the user and the content was creating new opportunities for innovation in the TV industry, rightly predicted the rise of user-centric television models and the use of the social commentary to enhance the television experience. Pablo Cesar and his team further defined "Human-centred television" in their 2008 article where they pushed the concepts of television and human experience to new levels (ATIS 2004).

A few years earlier, in his seminal 2006 book "The Convergence Culture" professor Henry Jenkins of the University of Southern California introduced how the different media outlets and available devices increasingly influenced media consumption and changed consumer behaviour. *Transmedia,* the telling of stories across media platforms was made popular by the book that also spawned a successful series of conferences and panels on the *Futures of Entertainment* held every November in MIT.

Hence, the rise of the Internet and in particular the wireless Internet was a catalyst to the technology convergence and in turn to the media convergence. The advent of Facebook created an opportunity to combine the new social networks with other media. This was particularly true in for television, which has always been at the centre of the social discourse. While the idea of combining television with some form of social networking was not new,[2] the facility of creating the social group brought by Facebook (and later Twitter) created the current trends in Social TV or STV. This will be further discussed later in this chapter but research

[1] Combination of TIPHON (Telecommunications and Internet Protocol Harmonization over Networks) and SPAN (Services and Protocols for Advanced Networks).

[2] For a good survey of the history of Social TV see the excellent 2011 presentation by David Geerts and Pablo Cesar (ATIS 2004).

performed as early as 2007 and published in 2008 (Jenkins, 2006) by Mariana Baca of the MIT Media Lab showed the value of the approach to integrate traditional TV and DVR into a social framework. STV was also the case study for a paper from Natalie Klym and the author "Communication at the Edge" also published in 2008 (Cesar, Bulterman, & Gomes Soares, 2008). This paper looked at the converged networks value chain with social television as one example of a converged service. It is also highlighted the increased competition from traditional operators, the new operators and introduced the *virtual operator*, the media consumers themselves. This concept started a pushback against the established TV grid and is now pushed further with channels and programs becoming applications that can be downloaded individually based on personal preferences.

STV has also emerged as the perfect example of convergence from a technology point of view and a next generation IP Television (IPTV). An architecture for such a converged TV system is presented in Cesar and Geerts (2011) with an emphasis on both wired and wireless devices. In this publication, the technology aspects of the move to the Internet from rights management to channel changes are addressed. STV really showed that the future of television was social, mobile and IP based as was proposed by the author and her team in 2010 when the concept was still controversial (Baca & Holtzman, 2008). In a perfectly *converged landscape*, all services should be available anywhere as content consumers, not just their devices, are moving through an ever expanding universe of content. This universe was created by the many convergences that are the focus of the rest of the chapter.

3 Convergence Research: A Methodology and Approach Based on Experience

How does one approach convergence research beyond literature searches? One methodology is actively monitoring the individual elements of a potential converged technology to discover, or predict, where and when they will have enough overlap to become one. For example, the behaviour of Internet traffic has changed greatly over the past years. It is less and less about unidirectional flows moving from a source to a destination over a wire but becoming information disseminated bi-directionally across a large number of nodes most of them wireless. In this environment it is clear that the convergence of the wired and wireless networks happened when cellular networks deployment literally exploded. They created the platform a whole net set of applications that also created a huge demand for even more Internet connectivity of all kind. The experience of the growth of the wireless industry has driven and continues to drive large investments in research and development and provides a large amount of the academic research in engineering and computer science. It is in fact the first convergence that will be described in this chapter.

Another methodology is to be a participant. Experience in network and technology design and implementation is essential to approach convergence. Network convergence emerged from the standardization bodies and resulted from the

work, the common consensus, one would say the converged consensus, of a large number of participants from industry, telecommunication operators and academia. The author having been part of the mobile industry and having been a collaborator to standards got a first hand experience of the process of convergence in networks. This will be important the description of network convergence in this chapter.

Back in 2005 when convergence was a vague concept and as a result of standardization and the design of new mobile phone it became obvious for some leading engineers in a number of manufacturers that a cell phone was very much a TV screen with (then) a keyboard, a TV set was getting a new life as a computer screen and video could be consumed on a laptop. As a result of that early development in converged television were started. The approach there was more experimentation than experience but created some of the early multiscreen applications that are now ubiquitous and the further development of the converged devices because development of these applications on un-related devices was not sustainable in terms of development costs. This chapter will profit from these developments as they defined how television distribution evolved to the Internet and why smartphones, tablets and other converged devices became so popular.

Social Television (STV), the combination of both traditional and over the top content with social networking, has gone from a laboratory concept to a boardroom topic with an incredibly swift pace over the last 10 years. Social TV was the focus of an IEEE Networks feature in 2010 (Montpetit, Mirlacher, & Ketcham, 2010) and was rewarded with a MIT Technology Review TR10 in May 2010 (Montpetit, Mirlacher, & Klym, 2010), as one of the ten (10) influential technologies that will change the way video is consumed. It is now regularly reported on in newspapers and numerous blogs. But in the context of this chapter, STV as a converged service will inherit from the experience of 5 years of the MIT Media Laboratory graduate level class on Social Television. Since 2009, the class, which is multi-disciplinary, has allowed to navigate the evolving landscape of television and its relationship to social media. The students produce one final project every year and these projects have encompassed the evolution and the convergence of the social media and television beyond entertainment. Some of these projects are mentioned in this chapter as they embody some aspect or another of STV from recommendation to metadata.

And finally the methodology and approach to this chapter is just to keep abreast of the technological developments that are happening at an accelerated pace: there was about 450 years between the invention of the printing press and that of the telephone. The last 25 years have seen the personal computer, the Internet, the mobile networks and the cell phones, WIFI, social networks etc. In particular the expansion of wireless networks and of the wireless Internet is exciting: it provides new opportunities for converged services and applications. As can be seen in Fig. 1, adapted from the CISCO Virtual Network Index most recent 2013 predictions, while all type of traffic will increase, video and data services will continue to grow significantly faster than any other traffic type. The Internet is now wireless and video-centric and the combination of wireless and video just confirms that convergence in devices will continue, that new video applications will emerge and that

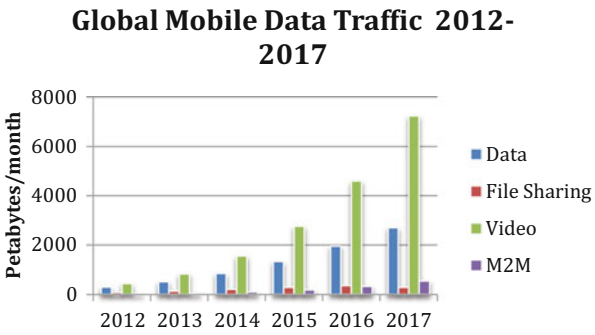

Fig. 1 Predicted growth of mobile traffic 2012–2017 from Paulson (2010)

differentiation in these application will force to rethink the way video is produced and consumed, giving life to more convergence.

4 Network Convergence: The Internet

In the technology world, convergence is often driven by a major innovation creating a business disruption that in turn engenders more innovation. This was first shown by the personal computer in the 1980s with the combination of word processing, spreadsheets and computing on a single convenient platform. Later, in the early 2000s, it was becoming clear that the Internet and its series of innovative services, from the world-wide-web (WWW) information searches to real-time communications, would become the network of the future, connecting all these personal computers together. Traditional voice telecommunication operators were noticing a fast growing application, Voice over Internet Protocols (VoIP). It was suddenly recognized as a mean to reduce operating costs. And the same time, wireless demand, driven in large part by low cost and feature-rich handsets, was growing fast. The new "triple play" offerings were born (voice, video, data) and with need to connect Internet Protocol (IP) services to the wireless handsets for data service like remote access to corporate email. The combination of VoIP and wireless services increased the need for jointly managing all networks.

But there was then in essence, four parallel networks: (1) the connected devices supporting the Internet infrastructure, the switches and central office element supporting the telephone system which in turn was divided into (2) fixed services and (3) mobile services and, finally (4) the television networks were totally independent entities with different operators with their own regulatory and business environments. Some television networks like those managed by the cable operators were offering broadband data and phone services but as different services. The only common feature of all these disjoint networks was the fact that they all could support some form of Internet protocols or interconnect at Internet points of presence (POP). Fixed-wireless convergence was greatly catalysed by the wide availability and rapid adoption of Internet technology as will be seen below.

4.1 Wireless Meets Wireline: Fixed-Mobile Convergence

Fixed-mobile convergence (FMC) came to define (1) the joint interconnection and management of traditional fixed (digital voice and data) and mobile services using the general-purpose computers running the Internet and (2) the adoption of Internet protocols to ensure seamless communications between the heterogeneous architectures. The minimization of operational costs and the enhancement of the edge network performance for both consumer and enterprise markets was used to justify the move to these converged networks. But in reality, operators were quickly realizing that the networks of the past could not support the new applications and services of the Internet without some changes to underlying protocols (see Paulson (2010) for a good discussion on the origins of FMC and subsequently IMS).

Hence FMC was born out of the necessity to jointly manage traditional fixed and wireless voice and VoIP over the Internet. FMC started with softswitches [again the reader is referred to Paulson (2010)]. A softswitch is software that allows a telephone call from one phone to another to be connected via the Internet. Softswitches represented a major disruption from the traditional systems that used hardware-based or firmware-based switchboards since they could run on more general-purpose computers. Softswitches became the *convergence point* between the IP world and the traditional telephone services. For VoIP calls the switch connected the calls directly with IP protocols. For traditional fixed and mobile calls the switches were associated to gateways that converted the calls to and from IP protocols, to and from the legacy systems protocols.

Softswitches allowed the management of voice calls across different media. But this is not where the evolution would end. Even feature (mobile) phones could be used for email and web access, and the emerging services like IP Television, moving traditional broadcast to the Internet, was creating further demands for co-management of the heterogeneous networks. Hence softswitches quickly evolved into the Internet Multimedia Subsystem and Next Generation Networks in order to extend the offered services set of the jointly managed networks.

4.2 Legacy Networks Add IP: IMS and the Next Generation Networks

As mentioned in the literature review of Sect. 2, IMS was first developed in the 3GPP to define the wireless elements to support Internet services and the NGN architecture was defined in the ETSI TISPAN to unify the wired and wireless networks. The main NGN features are available in Table 1, taken from the ETSI architecture documents.

NGN supports a set of end-to-end services using IP protocols over a network composed of heterogeneous sub-networks. The main characteristics of the NGN architecture are the uncoupling of services and underlying transport functions, in principle allowing services and networks to be offered separately, to offer different quality of communication and to evolve independently. Provisioning of existing

Table 1 ETSI TISPAN NGN capabilities (Social, 2010; Cisco, 2015)

Capability	Description
Subscriber nomadicity	Decoupling the subscriber from specific access and specific terminal equipment
Application ubiquity	Application availability from any access network. Content 'tuning' to match access and terminal capabilities
Resource control	Authorization and availability Accounting: measuring resource usage, revenue assurance Policing resource usage; fraud prevention
Subscriber identity and authentication	Common model for all devices, access and applications
Service blending	Service brokering enables applications to provide adaptive behaviours based upon subscriber events and states
Billing and settlement mechanisms	Especially beneficial for scenarios crossing multiple providers boundaries

and new services can then be independent of the network and the access technology. Hence NGN relies on a set of physically connected underlying network that use the transport of packetized information in the form of IP packets and share common signalling: the Session Initiation Protocol (SIP) defined by the IETF in the Request for Comment (RFC) 3651 (IETF 2002) with IP protocols to create and control individual sessions. The Internet is extended all the way to the end-user devices allowing photo sharing and television, video conferencing, gaming etc. to become (operator) managed services. To provide these novel services, because of network heterogeneity, network service providers need to perform additional tasks during the establishment of Internet sessions. They include application selection and routing services, session authorization services, session monitoring services, session detail recording and billing, network resource and admission control services. This involvement of the operators in the management of the Internet has generated a backlash from the IP community, as we will see in Sect. 4.3.

4.3 Networks Converge: Business Models Diverge

Fixed-mobile convergence and the development of the IMS and NGN architecture in standardization bodies were pushed by traditional operators and their equipment providers and derived from the needs to *manage* the IP based networks. But by establishing points of contact within the Internet for policy, access control and billing, NGN creates a conflict with a main tenet of the IP community: network neutrality. Network neutrality (net neutrality) is essentially ensuring that all traffic in the Internet is treated equally; hence no traffic flow, in principle, can be submitted to a different set of policies. It is recognized that net neutrality has enabled the recent innovation economy of the Internet from behemoths like Google to small applications development start-ups.

The reaction to NGN/IMS from the Internet community was very negative. For leading members like Scott Bradner of Harvard (Bradner, S. O. (2007). *Private communication*), NGN/IMS can put tolls across the sub-networks of the Internet backbone, the IP islands. Many traditional operators on the other hand welcomed the NGN/IMS because it allows offering better services to applications that pay for it or to users that have requested (and paid for) a better service; NGN created the concept of policy management in the Internet.

The divergence of thinking between the IP community (the application developers and OTT providers) and the traditional operator community is continuing today. Technological convergence contributed to economic and cultural divergence in the way of thinking about the future of connectivity in the two communities. Both camps however want to claim the consumer and the new multimedia applications users request. IMS has been used for consumer services, like television, to offer Web 2.0 services along the traditional broadcast (enhanced television) and to enable IPTV on smartphones. It is also at the heart of new services part of the Rich Communication Suite, n.d. (RCS) recently standardized by the GSM Association (GSMA) that enables real time exchange of content between users (instant messaging, video and picture sharing and some social exchanges) and has already been deployed in many markets notably in Europe. But this is still dwarfed by the growth of the over the top giants like Netflix, Hulu and Amazon, the picture sharing sites like Instagram and the new video clip sharing applications like Vines. It is undeniable that the Internet has changes the communications network landscape and it will not turn back; the friction between managed and unmanaged services will continue.

4.4 A Network Convergence Success: Television Distribution

While the NGM and IMS networks were being defined, the television industry was looking into the Internet protocols in order to distribute content. While traditional cable operators were firmly established in the broadband and voice service delivery, phone operators with the availability of Digital Subscriber Lines (DSL) were seeing television services as a growth area. Internet Protocol Television (IPTV) had (and has) the potential to provide a much richer user experience because of its potential of combining traditional broadcast with Internet services and wider distribution.

A testimony to this is exemplified in an ATIS IIF (IPTV Interconnection Forum) recommendation that defined the IPTV of the future as early as 2004 (Piokselka & Mayer, 2009):

> Going forward, IPTV is seen as a broader application than today's definition encompasses. [. . .] This view of IPTV extends beyond the home delivery model that is the focus of today's IPTV and also includes additional options for distribution of IPTV to wherever the consumer may be.

While IMS or NGN-based television services were hotly debated in standardization bodies, highlighting the friction between legacy operators and

new entrants, the idea of combining traditional television channels with enhanced Internet content got and still has wide appeal.

With network convergence, television can be delivered over any combination of cable, DSL, Fibre to the Home (FTTH), wireless or mobile networks. These capabilities imply that media encoding and transport formats must adaptable to different device types and different access network capabilities and bandwidth. The emergence of the interlinked ecosystem of access networks and end-devices have allowed the creation of services for this *connected television* experience. They form the core of the *multiscreen* viewing experience.

As a result in recent years, video consumption has changed radically. Multi-screen television is delivered over triple-play (voice, video and data) or quadruple-play (by adding mobile) broadband access networks and managed and unmanaged WIFI. For example, a viewer with a subscription to fixed-line IPTV service may access subscribed content for display on a TV set, a Personal Computer (PC), a smartphone or tablet (3-screens), delivered over a DSL access network into the home and distributed within over WIFI. Convergence is shaping the TV experience.

Many companies such as Intel (Bourdonnec, 2010), with its television experience group, have dedicated entire teams to evaluate the user experience and dramatic changes to video delivery when it becomes multiservice. In addition, improved transmission performance is needed over any network in and out of the home to ensure consistency across viewer groups. With content moving to the cloud for easy access everywhere, the viewing experience no longer conforms to pre-defined broadcast schedules or channels. Instead, content is personalized, reflecting the viewer's individual content and display preferences, access permissions and session status, and mobile, reflecting the consumers change of location during the day. The use of social networks for video distribution and recommendation also figures prominently in this evolution. *Converged television* is nowadays associated with a television service offered on a diverse set of devices and augmented by ancillary services such as widgets or web content over a combination of wired and mobile wireless networks, managed and public. While providing a familiar and simple user interface that masks this aggregation, converged television requires a reliable and comprehensive system and network architecture for content management and device interoperability.

The challenge of TV in the next decade necessitates a comprehensive end-to-end and top to bottom strategy that continues to moves away from the current design silos, a systemic approach that defines the needs for better user experience and interaction. Figure 2 presents a simple overview of a solution to this challenge from the distribution chain point of view. What is highlighted by this architecture is the combination of operator controlled services with public Internet information, the distribution over many possible networks to a variety of end-points and the fact that while the content providers still mostly deal with operators they could themselves use the Internet for distribution (the dotted line) and become their own OTT. It is interesting to reflect on the fact that this converged TV network seems more complex than the TV of the past where content provision, operation and (over the air) distribution was done by a single entity.

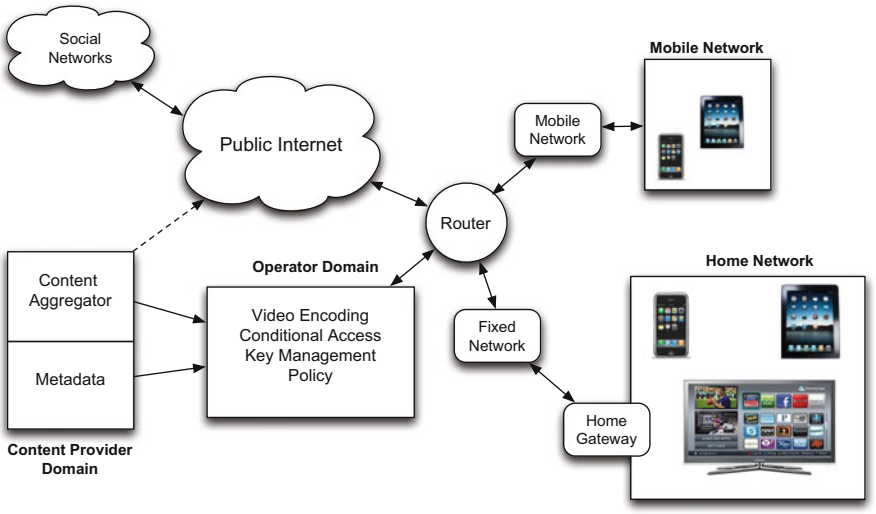

Fig. 2 Converged video delivery network

In addition, the wireless portion of Fig. 2 should not be ignored. A phenomenal growth in mobile video is predicted in the next few years reported in the CISCO Virtual Networking Index (Montpetit & Klym, 2008) already introduced in Sect. 3. In standardization circles video is considered the *killer application* for the Long Term Evolution (LTE) networks. In response there is a flurry of activity to ensure that the network infrastructure will meet the demand.

While some critics have declared that television was more or less in decline, television content provision has become an active innovation area and testament to the power of convergence to create new opportunities: the commoditization of the TV set is a consequence of device convergence but the Internet has allowed innovation in creation, distribution and consumption of TV concept. Not content to just deliver content some OTT providers have started creating it with Netflix leading the way. With more and more platforms available for content consumption, wireless (IP) distribution and the plurality of content sources, TV is becoming a personal video delivery system, available everywhere and curated by the users themselves.

The TV set of the 50s has cut its cords and antennas and moved to cyberspace.[3] This move in turn is spearheading a content convergence: a combination of real-time, on-demand and user-generated content of many forms including context and location specific information for museums, tourist sites, smart-city and art projects as will be addressed in Sect. 4. The opportunities provided by the Internet demonstrate that the *balkanization* of devices and networks is soon to be over. Television

[3] It is interesting to note that the US service Aero uses dedicated user antennas to provide real-time television services over the Internet to circumvent regulatory aspects.

is being redefined: the unidirectional broadcast from an operator to a device is now a diverse service offering and *television services* of today are truly the children of network convergence.

5 Device Convergence: Access, Services and Applications

In the days when computing hardware was very expensive it made sense to minimize functionality and develop highly optimized devices: music players, books (before and with e-readers), wireless access, television, voice etc. Even when they were physically co-located they were still discrete entities. This is not the case anymore: convergence in devices is the result of developments in microprocessors, Moore's law and user interfaces. Driven by applications and services offered by traditional operators and new entrants alike smartphones, tablets and connected televisions are starting to look the same. The Internet has created a "blank" network platform that allows concentrating much functionality on a single device, for home, enterprise and industrial uses, since in the end they all transit through a common network. From the user point of view this allows single points of contacts to the operators and simpler billing. The device convergence in turn creates a convergence of the means of acquisition, creation and dissemination of content: movies are directed using cell phones[4] and news events are captured on smartphones and distributed on Twitter feeds[5] (more in the next section).

The move of web experiences onto the converged device ecosystem has become one of the great innovation catalysts of the past few years: widgets appear everywhere and more on more on laptop and desktops; the wireless in a reversing of roles now drives the wired network. Users are now enjoying live interactions with content, other machines and ancillary devices and of course other users. User interactions are transforming the design, implementation, and use of those devices. As we move through our busy days, our devices coordinate and link to maintain the continuity of our communication events. For example as a consequence of both network and device convergence, the seamless video experience is born: it allows to start watching the Olympics on a computer at work, switch to a tablet for the commute to home, and finish watching on a web-enabled television all the while be connected to social commentary and ratings.

Converged devices are more and more video and rich-media centric. And they provide the platforms for innovative services and applications that are socially engaging with operator-based, over-the-top, and user generated media. In this section, the converged device ecosystem is reviewed from three points of view: access, services and applications.

[4] www.directr.com

[5] www.stringwire.com

5.1 Access: Communications in a Box

It is still usual to deal with multiple accounts for fixed and cellular services and with extra fees for services like texting and mobile data or international calls; his is what the triple and quadruple-play offerings are trying to reduce to a single bill. But it is even more common to use different equipment for cable or IP television, for wireless phone, for broadband access and wireless (WIFI), for Digital Video Recorders (DVRs) and for game consoles; we all know the resulting in the device clutter in the living room. To counter this trend, device convergence is happening in the home network: there is convergence toward the *box*, the home communication and media gateway, that aggregates services and provides connectivity within and outside the house and that is being adopted by many operators and equipment providers and wished for by the cluttered consumer.

The regulatory environment that allowed newcomers to enter the broadband market spurred the box paradigm. For example, in Europe it was the opening of the local loop that created competition in DSL services; in the US it was the offering of the voice and data services by the cable operators. As a result for example, the French service FREE came on the market in 2002 as new DSL offering, with triple and quadruple play bundles and very low prices to the consumers possible by the integrated Freebox.[6] Once a single operator can offer a number of services there is an incentive to provide a more integrated equipment offering.

But that was just the beginning. Gaming consoles, like the Microsoft Xbox, are now becoming the main entertainment hub for the house and are moving into the multiservice provision and seamless integration with the Microsoft tablets and phones. WIFI access points combine direct broadband access as well as embedded backup and home data storage; operators are adding home security features these existing broadband equipment and allow connection and personalization via smartphones or tablets. Apple TV offers video services but also efficient mean to transform a large television screen into a business projector. Connected televisions (large screen TVs with direct broadband access) are now at the centre of the connected home entertainment ecosystem. These integrated devices are dislodging the home computer as the main communication and computing hub and the traditional television set as the centre for all entertainment.

It does not stop there: whole new ecosystem of personal connected devices is starting to appear that use the smartphones as gateways. These like Fitbit or Nike Fuel and the new smart watches from Samsung and others extend the capability of the phones to provide, for example, better health care monitoring but also other lifestyle services from personalized workouts, diet tips and meal suggestions.

[6] The Freebox combines an Internet Protocol Television (IPTV) set-top box with recording capabilities to voice over Internet Protocol (VoIP) and WIFI access as well as gaming. This reduces operational and provisioning costs for the operator and provides a single entity in the consumer's home.

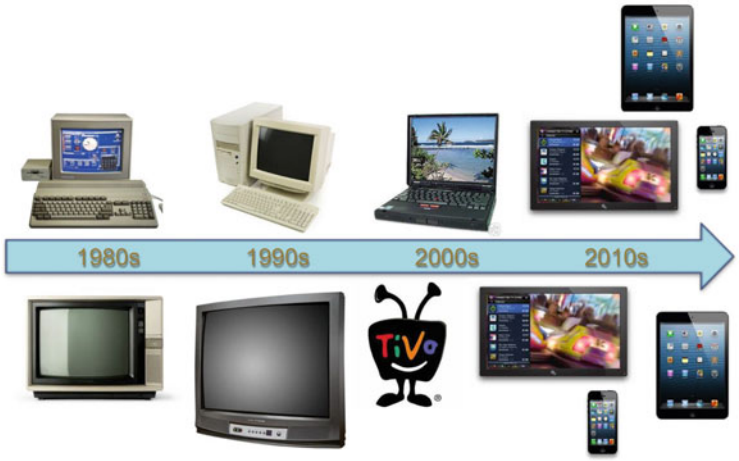

Fig. 3 Device convergence: the *top timeline* shows the computing evolution and the *bottom timeline* the entertainment evolution—they become the same devices even if their usage is still different

5.2 Services: Morphing Computing and Entertainment

How have our home devices evolved over the last 30 years? We get a graphical overview of this evolution in Fig. 3. Information and entertainment used to use vastly different platforms. The computer was in the office at work, the den or the home office (with little connectivity besides disk copies and dialup). We had a "business" relationship with it: it was work. The television, a more convivial device, was in our livingroom, bedroom or kitchen. Phones were apart and often in every room since they were fixed.

Then services like Skype appeared and the computer became the phone; laptops moved the computer into the bedroom and the kitchen and outside the house. A Digital Video Recorder (DVR) like TIVO liberated the TV content from the traditional scheduling grids. While it allowed skipping commercials and it also created a demand for TV everywhere, a TIVO in the cloud. With smartphones, the web services moved to the mobile networks and tablets moved the video experience away from the livingroom and the bedroom or even the house. We now phone people on our laptops, read books on our tablets, videoconference on our TV and buy dinner on our phones. It is now common that content of any kind is created and consumed on an ever evolving but at the same time very much look alike set of "screen": TVs, laptops, tablets and smartphone are sharing similar user interfaces and common widgets. The device convergence has evolved into the n-screen. While the 1st screen is often associated with the television, more and more the true 1st screen is the one we carry and look at first. Television is not a device anymore; it is a service and, even, a set of applications. Computers well are now phones and web access device much more than software development platforms. Smartphones and tablets are applications delivery engines.

In particular, a smartphone is becoming our main interface to the Internet. Nowadays, teenagers everywhere and many users in developing economies forgo the computer/laptop entirely, relying on their phones for all their data and media services. We all have now have a variety of Internet access devices in our lives, but the cell phone has become the primary means by which 25 % of those in the ages of 12 to 17 access the Internet. Among teenage smartphone owners, 50 % said they use the Internet mostly through their mobile and smartphones, according to the study.[7] These teenagers are now gaining a behaviour that they will most likely keep in the future because smartphones fulfil most of the requirements of the typical users: texting, email, connecting with friends on social networks, listening to music, reading books, accessing the web for information and for using cloud applications for document management, myriads of lifestyle applications and of course phoning.

The phone also provides a controller for navigating the media space and receiving or creating relevant information to be displayed elsewhere. The smartphone is used both as the remote and as the viewing screen. While continuing to watch videos on a TV-set or computer, a user can interact with friends, share opinions and ratings, and look up related information on the smartphone (or tablet). In addition, the phone can provide information and interactions that are contextually related to one's activity from mapping to sports statistics to smart city services. A large number of adults are also now connected to Internet via smartphones and the popularity of e-readers and tablets is growing.

Media offerings and delivery are adapting to the converged devices. Personalized services require interactive User Interfaces (UIs) and fine-grained information models to capture and manage viewer preferences. Instead of only managing access or *subscriptions*, which are based on business relationships, this enables personalization based on individualized preferences. Because of both user and device mobility, delivery is not localized to the consumer's home or service-provider's network. Content and applications can be accessed from any location that has Internet connectivity. As a consequence, advanced security capabilities for security, Digital Rights Management (DRM) and protection of viewer identity (privacy) have become major concerns for content providers, operators and users alike.

Because content of any kind can be consumed anywhere on converged devices, the experience is not limited anymore to entering an address and wait for the content to be displayed in a uniform manner. Instead, the device UIs and application widgets enable interactivity and allow viewers to customize displays, banners and the arrangement of information. The new devices like Google Glasses offer capabilities for advanced interaction and ubiquitous connectivity. Intelligent gateway devices (combining network facilities and home gateways) can handle message exchange between user-controlled device and the larger networks to provide

[7] http://www.networkworld.com/news/2013/031313-pew-teen-smartphone-use-soars-267647.html

in-home and outside the home services like home security. These transformative capabilities combined with Social Networks enable social interactivity at the device level; take a picture from your glasses and post it on your Facebook. Our devices are *social*: media can be delivered anywhere to other members of the same social group on any combination of devices the members prefer.

5.3 Applications: Abundance and Scarcity

Both Apple and Google are leading providers of converged devices. More and more these are becoming application delivery devices. The developer ecosystem has proven to be a very effective model for Apple and Google. Close to 90,000 applications are available on the Apple Store and Google Play claims closer to 1 million. Hence while the networks and devices are converged, the applications are following a complete different pattern of use. Seemingly there is more than one application for about any activity ranging from the serious (like remote medial diagnostic) to the completely frivolous (the large number of zombie "detectors" and cute cat pictures). As the World Wide Web (WWW) and the wireless multiscreen screen are becoming equivalent, questions about the infrastructure of the new Internet remains: can the current wireless protocols and networks support the quality of the wireless experience that are not only required for the development of new services and the ubiquitous connectivity required by the users but also to provide reliability, privacy and secure connections? The major applications like Facebook, Twitter or YouTube still generate the most traffic but the sheer number of applications is pushing the limits of the converged networks and require new approaches to ensure the Quality of Experience (QoE) of the users.[8] And the companion devices ranging from lifestyle monitoring to home security are exacerbating the trend: there are 10 billion connected devices today to become 20 billion in 2020.[9]

In particular, the abundance of always on, video and other rich media on the wireless Internet is becoming a challenge to the QoE, creating indeterminate performance especially in homes and public areas alike. There are strong incentives to investigate novel solutions to improve the wireless experience. The wireless industry has known for over 20 years realized early the impact of errors on wireless performance. This includes not only the throughput, the bits delivered to the device, but also the goodput, the bits delivered to application, and the consequences of directly applying wireline solutions in the wireless domain. Interruptions and delays are providing a poor and unwanted quality of experience. In reaction, the users

[8] For the purpose of this book chapter we will define Quality of Experience as the subjective evaluation of a service by its users. QoE encompasses measurable parameters like delay when playing a video or opening an application, service interruptions and overall application availabilities but also user interface inefficiencies, poor screen layouts and more and more application overload.

[9] http://techcrunch.com/2013/05/09/internet-of-everything/

disconnect: this is not what content providers, user communities and advertisers wish for.[10]

Novel approaches, from bandwidth sharing with device-to-device (D2D) or peer-to-peer (P2P) architectures and application layer error corrections mechanisms and application accelerator like the Google SPDY,[11] Qualcomm Raptors[12] and QFactor's Dynamic Packet Recovery[13] are being developed and deployed. P2P in particular offers the promise of creating local consumption groups that take into accounts the availability of close-by resources like storage to create the community networks described in the Innovation at the Edge paper already mentioned in the literature search of Sect. 2. P2P video on demand has been studied extensively in academic circles as a replacement for centralized remote disk farms and taking advantage of hyper-local video preferences; one such solution, a push-to-video system was described by the team from University of Massachusetts and Technicolor in 2007 (Suh et al., 2007) and the author presented architectural improvement to P2P to make it more acceptable in the wider content dissemination community by adding mechanisms to ensure content protection (Montpetit, 2008).

And finally infrastructure and bandwidth are only two aspects of the device convergence impacts. Another one is sustainability. Upgrading a converged device is becoming a frequent event (yearly for some) with the impact on the environment due to the recycling of these electronics. Compared that with the life of an old telephone or television, which could be repaired. The environmental consequences of device convergence, beyond the scope of this chapter, could spur a return to more focused devices, but this is still to come. In the mean time however their immediate impact is on media consumption, which has experienced dramatic changes in the last few years. It is the topic of the next section.

6 Media Convergence: Content meets Social Networking

The WWW were initially used as a one-way communication system. Viewers consumed static content from the content providers and couldn't interact beyond selecting which hyperlinks to follow. And this is very much what is still the model followed by a number of websites today. But starting with e-commerce sites and now social networking, the one-directional model now allows to incorporate, commenting, micro-blogging and user generated content. Interactivity enables new models for content consumption and it impacts the whole content industry

[10] http://gigaom.com/2012/11/09/online-viewers-start-leaving-if-video-doesnt-play-in-2-seconds-says-study/?utm_source=General#43;Users&utm_campaign=81ff9e61ba-c%3Amob%2Ctec%2Cvid&%2343;d%3A11-10&utm_medium=email

[11] http://www.chromium.org/spdy/spdy-whitepaper

[12] http://www.qualcomm.com/solutions/multimedia/media-delivery

[13] www.qfcomm.com

including newspapers, books, movies and television. Social Media is another phenomenon made possible by the convergence of networks and devices.

6.1 Social Connectivity: A Result of Convergence

Social networks have greatly impacted many areas from personal communications, becoming less personal when posted online, news-gathering with real-time commentary and micro-blogging from newsworthy events, to advertising and its focus on micro-blogging to provide audience measurements. Social networks are reshaping the way people find and consume content of every kind, providing major disruption in the media industry: the question is still open about its positive or negative influence.

User and business communities now create and engage in digital social innovation using platforms from Facebook to Twitter, Instagram and Pinterest. These are essentially social platforms combining social networking systems, cooperative creation software and mechanisms for the sharing of knowledge and real-time gathering of content. Applications range from more traditional gaming and micro-blogging to social video consumption, fundraising such Kickstarter,[14] distribution and rating, the health and well-being, environment and sustainability such as energy monitoring programs and smart grid applications, always-on traffic monitoring and directions, home security systems and controls and the emergence of the connected do-it-yourself (makers community).

Social media applications require that the members of the communal experience be connected via some Internet technology. But inherently, social connectivity should not imply physical connectivity, but instead should allow changing the physical connectivity to offer the best quality of experience. Our need to connect socially should drive our physical connectivity; we should be able to enable social connectivity it on demand independently of the actual platform, device or network being used. One answer is to define *content as a service* leveraging current cloud computing. This is very much aligned with content delivery networking and content-centric concepts being proposed for the next generation Internet. And of course it defines the Social Television experience.

6.2 Social Networks and Video: Social Television

As web-based social networking is becoming more and more prevalent with more than half a billion Facebook users, its impact of the TV experience is huge and barely starting to be measured. Most television programming now includes some links to the social networks either directly from the programmer or via companion application.

[14] www.kickstarter.com

Video on the web dates back to the mid to late '90s with the first versions of Apple's QuickTime and Real Networks RealPlayer. It really took off as a streaming service of decent quality with the availability of broadband and the development of better devices with cameras and powerful graphical engines. YouTube became the video archive of humanity in just a few years. And of course the mobility of both the users and their devices liberated the content from the network: crowdsourcing provides live video information from virtually anywhere, at any time. Online communities and social networks have shown that the most efficient way to create and ensure the quality of user-generated content is to leverage social capital.

The use of social networking with traditional television linear or on demand programming is creating a tremendous opportunity for a paradigm shift for TV viewing. Commentary, video sharing and multimedia interaction can be added to the TV shows to promote content, encourage viewer loyalty and measure engagement. According to Yahoo and the Nielsen Company,[15] 86 % of mobile Internet users (and 92 % of the 13–24 year olds) are using their mobile devices simultaneously with TV. Updating/reading social networking sites while watching a show are the most popular activity; the goal of programmer is to encourage this activity to be centred on the show being watched. Micro-blogging activities are now considered the best way for content producers and advertisers to promote shows, gather commentary and measure audience and their reaction to programming. Activity on Facebook about popular shows and show-specific group are both growing; promotion of upcoming programming on social media is now the norm, not the exception.

With end of the traditional TV channel brought by converged television architectures, the gates to the social channel and the re-discovery of TV and video viewing in general as a shared social experience are re-opening. The living room of the 50s is being replaced by the "global" and "cyber" living room where content is consumed together or recommended by the group. The water cooler is also moving to cyberspace: activity in social networks encourages viewing and the creation of communities around television content. One's social network allows specifying peers with whom to share video experiences: common viewing, sharing comments, posting ratings, discussing content etc. Cloud-based content, aggregation sites, OTT and broadcaster applications ensure the availability of the same content on different devices and at different times that suit the individual viewer while enabling social interaction. The TV experience moves from a single person, to a family, to a friend group and finally the wider the social network. Social TV is not just the result of aggregating social networking streams around television content but it is creating communities and social engagement around television content.

One of the original goals of STV back in 2002–2005 was to enable viewers in different locations to socialize around television content using Internet technologies. By allowing people to synchronously communicate with others while watching TV, early applications wanted to remediate to the social dislocation of modern families and provide a familiar environment to engage family and

[15] http://advertising.yahoo.com/industry-knowledge/mobile-shopping-insight.html

friends. For that reason, pioneer work on social TV focused in linking separated living rooms and create virtual viewing rooms with embedded cameras and microphones, where remote users could communicate with others, while watching television content together. While those were valid experiments they suffered from both technical issues like maintaining synchronicity across different locations but also from the fact that it was disruptive on the overall viewing experience. Hence user acceptance was fairly low but still showed a need for the togetherness created by television.

The newer implementations of STV are much more associated with direct social and community interactions via microblogging and annotation tools. They benefit from the deployment of IP connected set-top boxes and connected television. The use of smartphones and tablets for interactivity has generated a number of companion applications that provide interaction features complementary to Twitter microblogging. Popular applications use audio fingerprinting or recognition to synchronize to the watched show and applications like Zeebox[16] or Viggle[17] allow to link extra content directly to what is being watched.

To be successful STV also needs to take the viewing behaviour into account. In "Convergence Culture" already mentioned in Sect. 2, Professor Jenkins discusses the fact that:

> Different genres of entertainment provoke different degrees of social interactions. (ETSI 2008)

Hence the current reliance on real-time micro-blogging to measure social engagement is insufficient: a lot of commentary happens before of after the show especially drama that is very poignant or action-filled sequence that need attention. For these shows the successful social interaction will include interactivity before or after the show. From Professor Jenkins comments it is easy to realize that a *one size fits all* approach to STV does not satisfy cultural and artistic goals. There is still a need for a comprehensible framework for how media pieces will be combined together to create a seamless user experience, containing the right mix of social connectivity and content. The current direction toward *shows as applications* could provide customized STV that is specific to maintain the immersive television experience and provide the right amount of socialized information to enhance that experience. The use of metadata could be used for these purposes. In her paper, entitled "CommenTV" (Hwang et al., 2012) Jee Yeon Hwang suggests that metadata could be used to interact with viewers especially when they watch at different times.

There is also a need to keep some of the accepted viewer behaviour when designing STV. Many STV applications favour the *lean forward* mode of television associated with the web experience. Many viewers appreciate getting more

[16] www.zeebox.com

[17] www.viggle.com

information from their extended social network as well as ancillary information about their show. Groups of viewers can exchange comments while watching the same show or leave messages on screen for later viewing (such as provided by the viki application[18]) and suggest related content. However, some of these applications tend to create an information overload: many times microblogs are not properly filtered and as a result, viewers are exposed to all the comments, which in most of the cases are irrelevant for them or could even be interpreted as breach of privacy. The curation of the commenting via the social group is still in its infancy and will improve, as better tool are developed to take advantage of social graphs and personal preferences.

But one should not forget the *lean back* mode. One criticism that is common when discussing STV experiences is that one may just want to enjoy a show without distractions. This is a good argument for moving the interaction to the personal space of the phone and tablet or at a minimum to allow a back and forth between lean back and lean forward. In their project named NeXtream published in 2010 (Martin, Santos, Shafran, Holtzman, & Montpetit, 2010) Reed Martin and his team devised an ingenious use of the iPhone accelerometer for moving between active and passive mode: when the phone is on the table and in the horizontal position the main screen is in the non-interactive mode, when the phone is held vertically (in the user hand) it triggers the interactivity menu on the screen for commenting and recommendations.

Content recommendation is probably the most popular application linked to social television. Interactive guides like the NextGuide[19] use media related posting from a social group to promote content one could be interested in watching. Social features in applications and in self publishing sites like YouTube become virtual operators or curators that suggests the content friends should be watching, enables ratings and creates content lists influencing the group's viewing behaviour. Tablets also provide the perfect screen to create joint viewing and commenting areas in the personal space. This has the advantages of ubiquity but also of leaving the main television screen for the more public experience, the one involving other people. More recent research projects have also looked into cross-media, using what you buy or the music you listen to, as a means to recommend related video content. Cross-media is different from transmedia in the sense that it does not relate to storytelling but to media consumption in general. Freely available profiles are valuable assets for content distributors and aggregators like Netflix or Amazon, since they can use social interactions for providing more accurate content recommendations. Cross-media recommendations were utilized in the Tubely project in 2012 (Chan and Narula, 2012) (Fig. 4).

STV is also now viewed as a game changer in the way the content itself is produced and consumed to promote an immersive experience and increase user engagement. Even in the age of convergence, producers have not taken full

[18] www.viki.com

[19] www.dijit.com

Fig. 4 NeXtream: multidevice STV experience (Martin et al., 2010)

advantage of the opportunity to radically affect television content production using converged technologies. Some forays in academia have attempted to integrate television in its environment favouring the whole-room experience and the use of ambient elements; the evolution of such approach is described in Lugmayr and Zheng (2012) as a feature for the future. Some shows allow television viewers to vote off contestants (e.g., American Idol) in an aggregated manner but while this is possible for reality shows it remains limited overall. Other more interesting experiments include a television drama created in Finland, Accidental Lovers where viewers could influence in real-time by sending text messages (Ursu et al., 2008), but they are still very scarce because of their potential disruption over the show's storytelling. While there is an obvious opportunity in using STV in the creative process it remains to be seen how professionally produced content will address it. For the moment YouTube and other user generated content site are starting channels and promoting commercially produced content around social commentaries and the boundaries between the commercial and personal spaces are starting to meld and to provide a rich base for the creation of future programming.

But STV is not and should not be only using a linear process from content production by one to content consumption by many. Crowdsourcing on mobile phones is used to create a new form of content acquisition and distribution for journalism. It creates a large amount of data to be filtered for authenticity, privacy and lawfulness. The previously mentioned Stringwire new gathering application,[20] recently acquired by NBC provides curation by real journalists and a rating

[20] www.stringwire.com

mechanism for the contributor to filter the received information and ensure truthful reporting. The applicability of such approaches to TV drama is still under question but the relative success of the MySpace teenage series Freak in 2009 is promising: its viewers were asked to participate in the show's plots and tapings as well as providing personal content relating to the show and they reacted very positively.

The growth of STV is a testament to the power of convergence in changing traditional media to take advantage of the new technologies but also a reflection of social trends. Most current Social Television implementations combine social interaction and personalization features but in fact STV can be much more: it can promote the creation of community around the viewing experience. And convergence can be seen as the creator of communities: networks, devices, content and of course people.

7 A Viewpoint on Convergence: Disrupting the Content Consumption Experience

At the end of August 2013 a meeting in Montreal was held to discuss the different aspects of convergence under the theme of "community, audacity, authenticity: managing the convergence of media" (f.&co 2013). The goal of the meeting was to position convergence into the media creation process focus and emphasize the emergence of new means of connectivity to achieve community building. The meeting also wanted to re-enforce the idea that convergence and its associated technologies are creating opportunities for not just the end of the mass media experience. Too many traditional providers, from broadcasters to newspapers to book publishers continue to deliver content constrained by antiquated regulations, artificial programming schedules and single platforms, rather than tailored to the individuals and taking advantage of connectivity. In the innovation circles this state of mind is changing fast. The large variety of available content and delivery mechanisms has disrupted the industry status quo. Hence convergence in Technology, which was discussed throughout this chapter:

> Has now moved the media discourse from the simple transposition of similar content from one platform to the next, the notions of transmedia storytelling have opened a vast array of creative expressions in cable and web television, adding to the creations of app developpers, authors and video game producers to create entire new universes (f.&co 2013).

The media experience is becoming richer and more exciting as our media becomes available on an increasingly diverse set of multi-purpose devices as was described throughout this chapter. The move to the cloud allows users to choose online content they're interested in, and even share content recommendations through online social networks. But coincidentally these many options introduce complexity and frustrations for some users. Access to broadband connectivity at an affordable price is still not universal; while free municipal WIFI is appearing in

many communities it is more the exception not the rule. The fragmented and confusing experience the abundance of applications widens the generational and technological gaps. Divergence emerges from convergence.

But does it have to be that way? The challenge for developers is clear: how to navigate this diverse ecosystem of content and devices while providing a satisfying user experience? For example, traditional TV viewers usually expect a passive, lean-back interaction as was described previously. Mobile device and computer users are used to more actively seek out online information. So while interactive viewing may be an advantage, it is also more complex for viewers accustomed to the traditional experience. So for truly building communities convergence must allow for diverse behaviour to not only being accommodated but to become part of any new offerings. This requires a re-thinking of existing architectures for networks, new creation and distribution models for content and novel user behaviour metrics; it is happening.

Convergence encourages a reinvention of content acquisition as we saw in the preceding sections as devices are now capable of recording and transmitting a large variety of multimedia content almost from anywhere an Internet connection is available. While its impact of movie making is still to be assessed it is easy to see how smartphone could contribute not only images and sound for the movie but via social networks a direct interaction between the characters and the viewers. This is already being used in some TV programming. The biggest impact of convergence according to his author is its changes to person-to-person communications and its promise of forming virtual communities. To communicate with one another we can now use our device of choice, at our location of choice and at our time of choice. We can use voice, especially when dealing with older people used to the phone, we can use text with our teenagers, video and pictures with our friends and often all of those together when hosting online events. Our connectivity is not defined by anyone but us. Convergence allows us to get together in an un-precedented manner.

And convergence continues to, well, converge, moving to new domains. It profits from the Information Ecology[21] and the interdependencies between users, application development, and the availability of appropriate networks as well as underlying cultural trends. These forces will shape the future of convergence. The *power of convergence* consists in:

> The integration of disciplinary approaches that were originally viewed as separate and distinct. This merging of technologies, processes and devices into a unified whole will create new pathways and opportunities for scientific and technological advancement. (MIT News, 2011)

Convergence is truly talking advantage of the *authenticity* of human interaction and the *audacity* of technical and media innovators to create the *community* of tomorrow.

[21] Thanks to Henry Holtzman of the MIT Media Lab for coining the word.

8 Conclusion: A Note on Managing Convergence

In "Convergence is King" (Cass, 2011), Stephen Cass proposes that companies like Apple have been the winners of the convergence economy because since the iPod in 2001 it has managed to "deliver all kinds of content to you in a way that is so seamless that you cannot pass it up" hence creating a lucrative market out of their converged platforms.

The impact of the wireless (converged) Internet in on the economy is huge. Smartphones, themselves the result of convergence are one of the reasons, along with the emergence of tablets as the communication platforms of choice, why landlines are being cancelled as was first reported in the Business Insider in 2010.[22] And the new leaders of large operators like AT&T and Verizon in the United States are now being selected from their wireless carrier subsidiaries, not from their wireline businesses. Convergence has shifted the balance in strategy to the wireless business.

A key challenge in the next decade will be for the industry to follow a comprehensive strategy to end-to-end and top-to-bottom systems to move away from the remaining silos, and to encourage innovation across networks, devices, and services; combining content and social interactions is a goal. Convergence has given us the anywhere/anytime/any device immersive world. The challenges of convergence are to move from closed devices and independent departments into a more interdependent and open ideas environment where the technology, the services, the applications and the user interface merge. In the business area this creates in the words of Andre Hagiu of Harvard a true *multisided application*, one that results for these many inputs and in turn profits from its diverse component.

As defined in the Introduction, this *2nd Convergence* about technology, business models, social networks and culture. It has moved beyond entertainment and mass media to provide comprehensive solutions from medicine to smart cities as is reflected in the wide range of applications available in app stores. The innovative use of devices and soon of the augmented reality of Google glasses for example add to these application to create immersive experiences. The human skills are evolving and are being combined, another convergence? Artists are now technology-savvy, technologists are discovering the needs of end users and we are all becoming involved in sustainable development and *living laboratory*. The new convergences is moving away from basic functionality into a richer set of interdependent elements of hardware, software, content and user interaction. Hence the managing of convergence means a return to the engineering principles of the past: the realization of the need of the different fields involved to collaborate and interact at all points in the realization of a common project. Can the second convergence lead to convergence of skill and a new Renaissance enabled by technology? The future may tell.

[22] http://www.businessinsider.com/chart-of-the-day-almost-a-third-of-us-households-have-cut-the-landline-cord-2010-8

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Appendix

Acronyms

3GPP	3rd Generation Partnership Project
AF	Access Function
ATIS	Alliance for Telecommunication Industry Solutions
D2D	Device to Device
DRM	Digital Rights Management
DSL	Digital Subscriber Line
DVR	Digital Video Recorder
ETSI	European Telecommunication Standards Institute
GSM	Global System for Mobile (Communications)
GSMA	GSM Association
IETF	Internet Engineering Task Force
FMC	Fixed-Mobile Convergence
IEEE	Institute of Electrical and Electronics Engineers
IIF	IPTV Interoperability Forum
IMS	Internet Multimedia Subsystem
IP	Internet Protocol
IPv4	Internet Protocol version 4
IPv6	Internet Protocol version 6
IPTV	Internet Protocol Television
ISP	Internet Service Provider
MAC	Medium Access Control
MIT	Massachusetts Institute of Technology
NGN	Next Generation Network or New Generation Network
OTT	Over the top
P2P	Peer to Peer
POP	Point of Presence
QoE	Quality of Experience
QoS	Quality of Service
RACS	Resource and Admission Control Subsystem
RFC	Request for Comments
SIP	Session Initiation Protocol
STB	Set-top Box
STV	Social Television

TISPAN	TIPHON (Telecommunications and Internet Protocol Harmonization over Networks) and SPAN (Services and Protocols for Advanced Networks)
TV	Television
VoIP	Voice over IP
XoIP	"Anything" over IP

Definitions

Architecture:	abstract representation of a communications system
Control plane:	plane that has a layered structure and performs the call control and connection control functions; it deals with the signalling necessary to set up, supervise and release calls and connections
Flow (of IP packets):	traffic associated with a given connection-oriented, or connectionless, packet sequence having the same 5-tuple of source address, destination address, Source Port, Destination Port, and Protocol type
Goodput:	the number of bits delivered to an application
Forwarding:	process of relaying a packet from source to destination through intermediate network segments and nodes
Management plane:	the management plane provides two types of functions, namely Layer Management and plane management functions
Throughput:	the number of bits delivered from a network to an attached device
User plane:	plane that has a layered structure and provides user information transfer, along with associated controls (e.g. flow control, recovery from errors, etc.)

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