Study period 2018-2021

Question 2/1
Strategies, policies, regulations and methods of migration and adoption of digital broadcasting and implementation of new services

Annual deliverable 2018-2019

Trends in new broadcasting technologies, services and applications

Executive summary

Trends elaborated on in this annual deliverable include new service scenarios using Integrated Broadcast Broadband (IBB), Ultra-high-definition television (UHDTV) and Virtual and Augmented Reality (VR/AR). The deliverable further highlights some of the work being carried out and underway in the ITU Telecommunication Standardization Sector (ITU-T) and recent events (for example, the Workshop “Future of Cable TV“, organized by ITU-T Study Group 9 in collaboration with ITU-D). Noteworthy economic and regulatory impacts for end-users, stakeholders and regulatory bodies are also shared.

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1. Overview

The migration from analogue to digital broadcasting technologies has been completed in some countries while others are in the process of completing the transition. The Final Report of Question 8/1 from the study period 2014-2017[1] indicates that the transition results in a variety of strategies, plans and implementation actions that achieve a successful process to maximize the benefits. Among those best practices are included actions to accelerate the transition and narrow the digital divide by deploying new services, communication strategies for public awareness on digital broadcasting, and radio spectrum issues related to the analogue switch-off process, among other case studies.

The ITU Telecommunication Development Sector (ITU-D) has been playing a role in assisting Member States evaluate the technical and economic issues involved in the transition from analogue to digital technologies and services. On these matters, ITU-D has been collaborating closely with both the ITU Radiocommunication (ITU-R) and the ITU Telecommunication Standardization Sector (ITU-T), thus avoiding duplication.

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Additionally, the use of the "digital dividend" is an important issue, and continues to be widely debated by broadcasters and operators of telecommunication and other services operating in the same frequency bands. The role of the regulatory authorities

[1] ITU-D Study Group 1 Question 8/1 report on the Examination of strategies and methods of migration from analogue to digital terrestrial broadcasting and implementation of new services (2017), available at: https://www.itu.int/pub/D-STG-SG01.08.1-2017.

in this regard is crucial for balancing the interests of users with the demands of growth in all branches of the industry.

Other issues to consider are the studies from other ITU Sectors, especially taking into account the decisions of the 2015 World Radiocommunication Conference (WRC-15) on the exploitation of the digital dividend in the future. In this regard, it is relevant to take into consideration the maintenance of study topics related to technical and economic aspects involved in the transition from analogue to digital broadcasting.

Finally, another important issue for the future of broadcasting is the emergence of new broadcasting technologies and standards that could be taken into account when developing countries are implementing the digital television transition.

2. Introduction

Broadcasting services are evolving and undergoing transformation. In this context, new broadcasting technologies, services and applications are being provided to users which are enriching user experience.

The broadcasting arena is changing and the offers to users are evolving. New experiences in accessing audio-visual content are being provided and one of the consequences of these new offers is that users no longer have only the traditional media services and applications. The users are instead starting to experience different ways of watching audio-visual content in their broadcasting services.

Currently, emerging media based on the Internet are developing at an extraordinary speed. Thus accelerating the emerging new broadcast technologies, services and applications. At the same time, by means of broadband networks, 4K and Ultra High Definition (UHD), multimedia broadcast TV, mobile TV, interactive network TV (IPTV) and other audio-visual new media services, such as augmented reality (AR) and virtual reality (VR), have gained strong development momentum, which in turn is changing consumer habits and content consumption.

As distribution of video has scaled and become central to the strategies of broadcast operators, telecommunication carriers, and other companies, the broadcast industry is entering a new stage as technology and infrastructure are being deployed to support the enormous growth in demand. This is a critical inflection point in the evolution of video and audio distribution: as demand for all types of new technologies, services and applications grows exponentially, there are huge opportunities and challenges to all of the stakeholders.

It is believed that stakeholders who wish to build a sustainable new video and audio industry – not just for the next two or three years, but for the next fifty – must aggressively assert themselves to define and protect their roles in the ecosystem.

It is believed that stakeholders who wish to build a sustainable new video and audio industry – not just for the next two or three years, but for the next fifty – must aggressively assert themselves to define and protect their roles in the ecosystem. This is a period of significant change, while there are opportunities for each segment of this ecosystem. The critical transition that stakeholders must evaluate and execute in the near term is to pivot from treating their networks as conduits for data and move towards new video technology centric networks.

Evidence of this scenario comes from the report[2] of the workshop on the "Future of Cable TV", organized by ITU-T Study Group 9 and ITU-D, where it was noted that, after observing consumer needs (based on research across multiple countries by Liberty Global), a key trend to adapt from fixed to flexible scheduling and viewing experience was identified. This

[2] Report: Workshop on "The Future of Cable TV", held in January 2018, available at: https://www.itu.int/md/D18-SG01.RGQ-C-0066/.

trend resulted from the fact that customers are always online, including when they are on the go and on holidays, and that binge watching is a new viewing habit, as well as checking what is going on (with the family), switching on devices remotely at home, gaming, tuning (music/smart speakers) and chatting.

In that context, service reliability and security are key, as well as, a comprehensive ecosystem which is boundless. These services would be delivered with a multi-screen user interface (very simple), service orchestration (based on customer profile/data, including parental locking of services), and in the context of the smart home (although the business models/services are still debated on what is best and/or needed). Next generation services are to include voice service activation, predictive (with the use of Artificial Intelligence (AI)) and tailored services (to the different user groups/individuals).

The same workshop also presented some trends in new user viewing experiences, which should include the seamless viewing experience, recommending linear and non-linear content to viewers/customers, and where the delivery method and switching would be transparent to the viewer. Offers should furthermore include appropriate “companion devices” based on technologies such as augmented reality, virtual reality and device synchronization. Ultra High Definition TV (UHDTV) should be explored and enhanced with 360 degrees video and free viewing point capabilities. Enhanced viewer/user interface could further be included by combining of inputs of different kinds, and finally, terminal devices could be connected to sensors and actuators, for example in e-health applications (i.e. Internet of Things (IoT) applications). It can also be argued that system integration is key for the deployment of truly converged services, delivered over multiple platforms (including the mobile platform). Consequently, system integration work should be outsourced and content distribution companies should focus on their content aggregation role.

The broadcasting arena is changing and the offers to users are evolving. The users are starting to experience different ways of watching audio-visual content in their broadcasting services.

In that sense, technology development and standardization efforts in the field are underway, especially in ITU-T inside Study Groups 9 and 16, in areas such as Multimedia Application Frameworks and their possible usage in the broadcasting arena, receivers/end systems (DTT and hybrid set top boxes/receivers/end systems) and Integrated Broadcast Broadband (IBB). For more information on these standardization efforts refer to ITU-D Study Group 1 document SG1RGQ/21 on collaboration on multimedia application frameworks and broadcasting.

Bearing that in mind, the following sections present some trends in new broadcasting services and applications that use these new paradigms to enrich and personalize user experience and provide new possibilities to spectators.

3. Economic and regulatory impacts

3.1 Industry players, regulatory and network impact

Industry

The current status of the broadcasting and TV industry alongside the Internet industry points to three major forces in industry competition in the future, namely: carriers, Internet enterprises, and terminal vendors.

Carriers

Carriers' development strategies mainly rely on the advantages of the traditional broadcasting and TV industry to integrate the upstream and downstream of the industry value chain, provide the best convergent network service experience for users through their networks, and adopt independent R&D (Research and Development), acquisition, merger, and investment support,

provide users with related products and services, such as the Mobile Plus strategy proposed by Vodafone, and establish strategic alliances with Internet enterprises such as Microsoft, Yahoo, eBay, Google, and Myspace to build and improve their ecosystems. Another example is DirecTV, a cable TV operator in the United States, which has launched the “ubiquitous TV” service with Apple to ensure that mobile users can watch more than 60 live TV programs on the TV network.

Carriers can better control the value chain and forcibly form a unified standard. In this way, carriers can reduce the difficulty of application development and share information. In addition, carriers can use their own advantages to promote the development of convergent network services quickly. This is good at the early stage of service development. However, this closed mode is unfavorable to the long-term development of the industry. It limits the development of some excellent technologies and services, and it is also not conducive to the fair and free competition of the whole industry.

Internet enterprises

The development strategy of Internet enterprises is to push excellent Internet products and services to the broadcasting and mobile markets by leveraging Internet operation experience and user resources, and fully utilize carriers’ network resources to implement cross-platform interconnection. Internet products are being transferred to the broadcast TV and telecom markets. The stickiness of user groups is extended or even amplified in the corresponding market, however, the business model is the same as that of the Internet. It should be noted that Internet enterprises have begun to launch attacks on traditional broadcasting and television carriers, telecom carriers' services, and industry links. For example, Facebook started to enter the video release field, Google began to operate access services, as well as, the emergence of WeChat, iMessage, and Skypephone.

Terminal vendors

The development strategy of terminal vendors aims to build comprehensive service capabilities around terminals. The features are as follows: development of intelligent terminals to meet users' requirements for audiovisual, network, and data, such as the iPhone; features of terminals to meet specific requirements of users, such as Internet of Things (IoT) games; while further building a self-owned application store, enriching the network applications of terminals, and grasping the entry of Internet services.

While the development strategies and paths of these three forces are different, the final competition focuses on network access entrance and the first contact of users. With the development of the market, new competitive forces may emerge in the future.

3.2 Regulators: Telco video transformation is already under way

With more and more players entering the broadcast and media industry, the regulation of broadcast is facing new challenges.

The vast majority of “traditional” pay-TV services are now supplemented by various IP-based enhancements. While adoption of traditional subscription TV services continues at a steady but relatively moderate pace globally, Over-the-Top (OTT) and mobile video services are emerging as big growth areas for content providers and distributors alike.

Telcos’ expansion beyond their IPTV networks into satellite, cable, and OTT distribution is having a substantial impact on the video industry.

In TV, telcos have made slow but steady progress, accounting for around a fifth of global subscriptions. Telcos’ expansion

beyond their IPTV networks into satellite, cable, and OTT distribution is having a substantial impact on the video industry. Specifically, Mergers and Acquisition (M&A) activity is enabling telcos to accelerate their standing in the TV market, in many cases transforming their competitive position from that of challenger to leaders. Among the recent spate of major telco M&A initiatives in the pay-TV and video entertainment market are AT&T's acquisition of DirecTV, Verizon's purchase of AOL (as well as its imminent takeover of Yahoo's web business), and Vodafone's expansion into the cable and triple-play markets through its ownership of German Kabel Deutschland and the Spanish operator ONO. Some insights were also presented in the report3 of the Workshop "Future of Cable TV", organized by ITU-T Study Group 9 and ITU-D, where regulations to tackle the challenges of the new technological and user experience scenario were discussed.

Keeping this in mind, National Regulatory Authorities (NRAs) should give room for consolidation and co-investment in the industry. As such it seems that there would be a need to reverse previous policies whereby competition was encouraged by promoting new market entrants. Furthermore, the promotion of infrastructure sharing would be required. All these measures are needed as the required infrastructure investments are often too large to be carried by one single (smaller) company alone.

The following standardization gaps have been identified:

(a) open platform for TV program delivery;

(b) a common Set-top-box (STB) for the three different platforms (i.e. Cable, Terrestrial and Satellite);

(c) guidelines for (service and network) implementation;

(d) IBB compatibility; and,

(e) access services.

[3] Report: Workshop on The Future of Cable TV, held in January 2018, available at: https://www.itu.int/md/D18-SG01.RGQ-C-0066/.

Finally, the area of standards for IP multicast was identified as an opportunity where more standardisation work is needed. It was also argued that for better service integration on the STB/PVR (as to deliver the wide range of services) the technology was not the real bottle neck (and consequently technical standards), but rather Intellectual Property Rights (IPR). IPR is a complex matter and its practical application is not keeping up with the rapid technological developments and the many different services on offer.

It is furthermore widely acknowledged that linear TV services should be part of a converged offering with truly integrated (i.e. seamless switching between services for the end-user) and whereby the mobile platform is key (and as argued by some, mobile is even the first platform). However, generally, the role of linear TV would change over time, albeit slowly. Linear TV would be more for event-based content and services. This event-based content is not automatically a domain for traditional content distribution companies to control, as (the larger) OTT providers are starting to buy sport rights and produce event-based content.

3.3 Network technology

The new broadcast technology network is based on the broadcasting and TV technologies. It fully utilizes the advantages of radio and television networks, broadband networks and satellite coverage, comprehensively utilizes mature technology standards and industry chain resources, and constructs a multi-network converged, manageable, controllable, and reliable broadcast TV and broadband media network.

The construction of the broadcast network and broadband media network complies with the following development principles and objectives.

Development principles for broadcast network and broadband media network construction: Convergence; Openness; Security; Technology integration innovation

Development principles

(1) Convergence development principle: Build the broadcast TV and broadband media network with mature technologies and achievements of the broadcast, telecommunication and Internet.

(2) Openness principle: Leverage the advantages of broadcasting and TV networks to ensure the openness of integrated network interfaces, promote the coordinated coverage of wired, wireless, and satellite networks, and unify specifications and interconnection.

(3) Security principle: The network can be managed, controlled, and trusted, including network security, information security, and data security, providing technical support for the rapid development of broadcast and television.

(4) Technology integration innovation: Fully consider the ecological development of the technology industry, promote the application deployment of new technologies, new specifications, and new products, and build a new high-performance converged network infrastructure.

Development goals

(1) Under the overall framework of multi-network integration, based on broadcasting and TV technology achievements, comprehensively utilize the broadcasting and television frequency resources, use the broadcasting TV network, broadband network, and operation platform to make full use of the industry chain resource integration advantages, build a converged broadcast TV and broadband media network.

(2) Optimize traditional broadcast and TV services, gradually provide high-quality new video services, and coordinate wired and wireless satellite traditional broadcast and TV distribution channels to form a seamless network with seamless coverage, providing richer and smoother service experience.

Guidelines

The construction of the broadcast TV network is based on the characteristics of traditional broadcast technology, high bandwidth, high rate, and wide coverage. It uses the mature technology standards and industry chain resources of cable TV, terrestrial digital TV, carrier broadband network, and satellite, with the help of the Internet, wired, wireless, satellite interconnection, and intelligent collaborative coverage are achieved.

The advantages of the Cable TV (CATV) network, wireless broadcast network, and broadband data network are complemented to meet the convergent service experience requirements of individuals, families, areas, and metropolitan area networks (MANs).

4. Trends in new broadcasting technologies and emerging services

4.1 Integrated Broadcast Broadband (IBB)

One of the new paradigms in the implementation of new services and capabilities in broadcasting is the consumption of content from multiple source/networks, more specifically from broadcasting and broadband networks. One of the technologies that are being used to perform the integration of content from both sources in the application layer is Integrated Broadcast-Broadband (IBB) systems.

An IBB system is based on a combination of the technologies of both broadband and various broadcasting, including over-the-air and cable. Various multiple devices are used for effective presentation of content and user interactivity. IBB is being

standardized by the ITU Telecommunication Standardization and Radiocommunication Sectors within ITU-T Study Group 9 (Broadband cable and TV) and ITU-T Study Group 16 (Multimedia)[4], and ITU- R Study Group 6 (Broadcasting service). A wide range of services is enabled by the IBB systems.

Some use cases for the provision of new services with IBB are presented in ITU-D Study Group 1 document SG1RGQ/76. The use cases include the following services: Catch-up TV; Enriched service information; Microsites campaigning; Second synchronized screen; Scalable videos; Push Video on Demand (VOD); and Target advertising.

Some of these new services may have regulatory implications which would need to be addressed in each country. More details in the abovementioned document.

One of the new paradigms in the implementation of new services and capabilities in broadcasting is the consumption of content from multiple source/networks.

4.2 Ultra-high-definition television (UHDTV)

Ultra-high-definition television (also known as Ultra HD television, Ultra HD, UHDTV, UHD and Super Hi-Vision) today includes 4K UHD and 8K UHD, which are two digital video formats that were first proposed by NHK Science & Technology Research Laboratories and later defined and approved by ITU. The Consumer Electronics Association announced on October 17, 2012, that “Ultra High Definition”, or “Ultra HD”, would be used for displays that have an aspect ratio of 16:9 or wider and at least one digital input capable of carrying and presenting native video at a minimum resolution of 3840×2160 pixels.

[4] For more information on Integrated Broadcast Broadband Systems refer to the Intersector Rapporteur Group on Integrated Broadcast Broadband (IRG-IBB) web site: https://www.itu.int/en/irg/ibb/Pages/default.aspx.

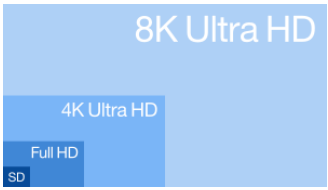


Figure 1: UHD pixel comparison

In 2015, the Ultra HD Forum was created to bring together the end-to-end video production ecosystem to ensure interoperability and produce industry guidelines so that adoption of Ultra-high-definition television could accelerate. From just 30 in Q3 2015, the forum published recently a list up to 55 commercial services available around the world offering 4K resolution.

All TV service providers have to evaluate their positioning regarding the deployment of 4K UHDTV. Currently, 4K UHD deployments are confined largely to IPTV and OTT services; however, there has been a significant proliferation of launches, for example, in the second half of 2016 as European TV providers use the new English Premier League season as a driver for UHD service launches.

Operators face two challenges:

(1) the increased burden on their networks of third-party UHD distribution;

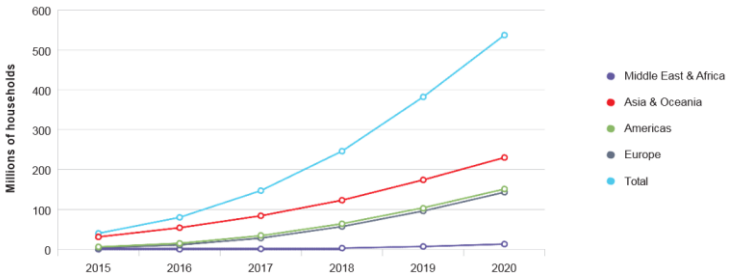
(2) how they wish to incorporate UHD distribution into their own service offerings.

UHD video and TV availability will have a major impact on the market: the emphasis on a differentiated level of video quality may enable higher prices. In order for operators to manage the increased network burden, it is critical that they monetize this additional data burden, not just for day-to-day operations but also to ensure that funding is available to maintain network investments to keep pace with growing audience demand for UHD services.

Despite some constraints – such as high prices for 4K UHDTV sets, limited availability of 4K-native content, and bandwidth limitations – TV operators are demonstrating their commitment to launching 4K UHD services and are promoting them along with set-top-box upgrades. Penetration of 4K UHD is set to increase from just 2.5% in 2015 to 30% in 2020. Over the past five years, 4K UHDTV have become increasingly popular. According to data provided by IHS DisplaySearch, the shipment of 4K TV reached 92,000,000 in 2017. According to data forecasts, the penetration rate of 4K LCD TV will increase to 44.5% in 2018. This accelerates the popularity of 4K UHDTV industry.

Despite some constraints – such as high prices for 4K UHDTV sets, limited availability of 4K-native content, and bandwidth limitations – TV operators are demonstrating their commitment to launching 4K UHD services and are promoting them along with set-top-box upgrades.

At the same time, 4K UHDTV sales exceeded 10% of total TV sales globally. Price decreases and the introduction of new 4K UHD pay-TV services will boost 4K UHD penetration to nearly half of total TV households by 2020. After China and the United Stated, Germany and the United Kingdom will become the world's third and fourth biggest 4K UHD markets, respectively.



Source: Ovum

Figure 2: Global UHD household forecast, 2015–2020

Implementation of 4K UHD outlined in the table below. This development highlights the tendency to remain at the forefront of technical innovation.

Table 1: 4K UHDTV services: Chronology of launches

4Q13	Netflix** adds first 4K titles to its online streaming library
1Q14	UHD pay-TV trial by Japanese NTT* (STB-based; vendor: Sumitomo)
2Q14	KT Corporation* (South Korea) launches the world's first UHD pay-TV service, called "Olleh GiGA UHDTV"
3Q14	DirecTV (US) launches its first non-STB RVU (Remote Viewing)-based 4K UHD pay-TV service
	China Telecom* Sichuan launches the first commercial 4K UHD STB service in China (developed with Huawei)
4Q14	Comcast becomes the second US pay-TV operator to launch a UHD pay-TV service (non-STB, Samsung app)
	Amazon** and M-Go* launch 4K UHD offers
1Q15	Dish Network (US) launches the first 4K STB service among US pay-TV operators
2Q15	Free* (France) launches its first "Mini 4K" STB

3Q15	BT* launches YouView box, the first UHD STB in the UK
	DirecTV unveiled its first 4K STB, the Genie Mini
	Videotron (Canada) launches a 4K UHD commercial service
	Totalplay* (Mexico) launches the first UHD STB in Latin America
4Q15	SFR* (France) launches a UHD gateway, La Box Fibre Zive
	UltraFlix** launches its 4K offer on Roku 4
1Q16	Etisalat* (UAE) launches the Middle East and Africa region's first UHD 4K IPTV service
2Q16	Swisscom* launches its TV UHD Box 2.0
	Vodafone* Portugal launches TV Box 4K

Note: *Telco; **OTT player. *Source:* Ovum

The infrastructure impact of UHD

Attention should also be drawn to the potential of video delivered over broadband networks. There is growing adoption of UHDTV and video across the entire visual entertainment value chain. Studies also point out that consumers enjoy video on mobile devices but not streaming video over cellular networks. This is because of a "lack of clarity over the amount of data used […] and how much data does an hour of video use?'"

There is growing adoption of UHDTV and video across the entire visual entertainment value chain.

While bill shock has historically constrained mobile video volumes, 4G increasingly addresses this with significantly larger data allowances. However, until there is sufficient penetration of such data service offers in a given market, video consumption over cellular will remain constrained and the willingness of

companies to undertake the necessary experimentation to identify viable business models will not occur. There is a significant opportunity but operators are exercising caution in rightsizing mobile video investments until there is a clear indication of a viable and sustainable commercial model, particularly when new network technology investments, such as 4G and 5G, are considered. Some operators are investigating the potential of a separate tariff or commercial model for video data entirely.

UHD's potential for network operators lies in the significant uptake in data volumes required to deliver higher-resolution video. The quality of the video user experience, however, does not end at resolution: several other factors such as video quality (blocking) and responsiveness of interactive functionality (requires very low round-trip time (RTT)) also contribute to the level of user experience, which justifies relatively high price points.

4.3 The emergence of virtual reality (VR) and augmented reality (AR)

Virtual reality

VR is short for virtual reality, which was created by Jaron Lanier, a founder of VPL, in the early 20th century. The connotation is as follows: Virtual reality (VR) is a computer simulation system that can create an interface to experience the virtual world. It uses computers to generate a simulated environment, and uses the interactive 3D dynamic view and entity behaviour simulation system to immerse users in the environment. As early as 2014, virtual reality technology has just emerged. Oculu, a virtual reality start-up, was bought by Facebook for USD 20 billion, which mainly made virtual reality helmets. Facebook wanted to be able to apply virtual reality technology to a more vertical new area, including media, education, medicine, and so on. In 2016, virtual reality has penetrated into many application fields, including tourism, driving, indoor design, and real estate. Virtual reality technology has a three-dimensional, vivid, all-directional

immersion feeling, which makes the past technical means incomparable.

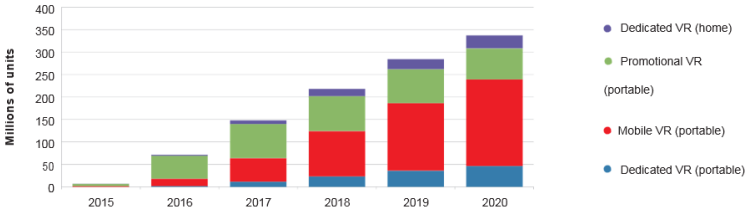
Traditional broadcasters have begun to strategically position themselves in new media markets.

At present, traditional broadcasters have begun to strategically position themselves in new media markets. Some radio stations have been digitally transformed successfully. If the video live broadcast and new media video displays are the second screen of the broadcast feed, the virtual reality may become the third screen of the broadcast content. Some TV stations have used virtual reality technology to combine with live TV, which is more vivid and intuitive than ever before. Technical innovation, providing users with “most immersive” reports. For example, the front reporter uses the 360-degree panoramic camera. The image and sound are recorded without dead angle, so that the user is like a person on site. If you wear virtual reality glasses, you can experience the full immersion of the virtual effect.

VR was also cited as a driver of data revenues, though the timing was deemed uncertain. Early deployments have relied on data rates in the region of 10 Mbps; however, this can rise exponentially as higher resolutions are used, depending on broad market adoption of the technology. VR is expected to shine as video game makers, in particular, embrace the medium, and the combined effect of high-end headsets becoming available, content creators getting on board, and virtually any new smartphone provides the technology. VR also has a potential role in a number of industry verticals, where it will provide enhancements to existing video communications solutions. The health sector in particular can benefit from VR applications that may be used for various functions, such as surgery simulation, remote surgery, and tele-medicine.

Ovum projects that the total VR installed base will grow from 71

million to 337 million devices between 2016 and 2020. With disposable experimentation devices predominating before consumers shift to mobile VR, which will contribute 65% of sales by 2020. Dedicated VR device volumes will remain small with 19-21% market share between 2018 and 2020.



Source: Ovum

Figure 3: VR installed base (consumer only), 2015–2020

Augmented reality

Augmented reality (AR) is an interactive experience of a real-world environment whereby the objects that reside in the real-world are "augmented" by computer-generated perceptual information, sometimes across multiple sensory modalities, including visual, auditory, haptic, somatosensory, and olfactory. The overlaid sensory information can be constructive (i.e. additive to the natural environment) or destructive (i.e. masking of the natural environment) and is seamlessly interwoven with the physical world such that it is perceived as an immersive aspect of the real environment.

In this way, augmented reality alters one's ongoing perception of a real world environment, whereas virtual reality completely replaces the user's real world environment with a simulated one.

The primary value of augmented reality is that it brings components of the digital world into a person's perception of the real world… through the integration of immersive sensations that are perceived as natural parts of an environment.

The primary value of augmented reality is that it brings components of the digital world into a person's perception of the real world, and does so not as a simple display of data, but through the integration of immersive sensations that are perceived as natural parts of an environment. The first commercial augmented reality experiences were used largely in the entertainment and gaming businesses, but now other industries are also getting interested in AR's possibilities, for example in knowledge sharing, educating, managing the information flood and organizing distant meetings.

Augmented reality is also transforming the world of education, where content may be accessed by scanning or viewing an image with a mobile device. Another example is an AR helmet for construction workers which display information about the construction sites. The most significant mobile AR app is Pokémon GO and its global success may kick-start this segment. Pokémon GO relies on data over cellular networks, because the basic premise of the game is that the player must play while walking.

Telcos are likely to start incorporating VR and AR components into the video communications solutions they already offer to enterprise and industry customers. The success of VR and AR in the enterprise will be highly dependent on the strength of the ecosystem developed in support of the hardware, and 360-degree cameras are one example of this ecosystem starting to build out. Enterprise is far more likely to embrace the less-bandwidth-intensive AR apps than the consumer segment, which will gravitate significantly towards VR gaming scenarios. Coming with the option of a VR headset accessory is translating into to lots of industry excitement, media coverage, and early adopter demand.

VR and AR service provider

Telcos and infrastructure providers will focus on reliable network access with advanced networks outlined as described above. VR and AR applications that rely on OTT or mobile data will

have the most significant impact on operator networks. This due to the fact that one of the use cases for VR is in enabling people to communicate. It is likely that the adoption rates of consumer VR will be significant in determining the data demands of VR.

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