CONTENT DISTRIBUTION

POSITION PAPER

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CONTENTS

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1. INTRODUCTION

From the NEM community perspective, "Content Distribution" is a hot topic as the content needs to be delivered before being consumed. The NEM sector is very relevant and covers the entire data value chain, from creation, manipulation, distribution, search, and privacy; and as aforementioned, content distribution becomes the cornerstone to enable the consumption of content, products and services.

The digital revolution has a strong relationship with the area of content distribution, with a series of challenges and opportunities as well as many current and potential technological developments and transformations in business models.

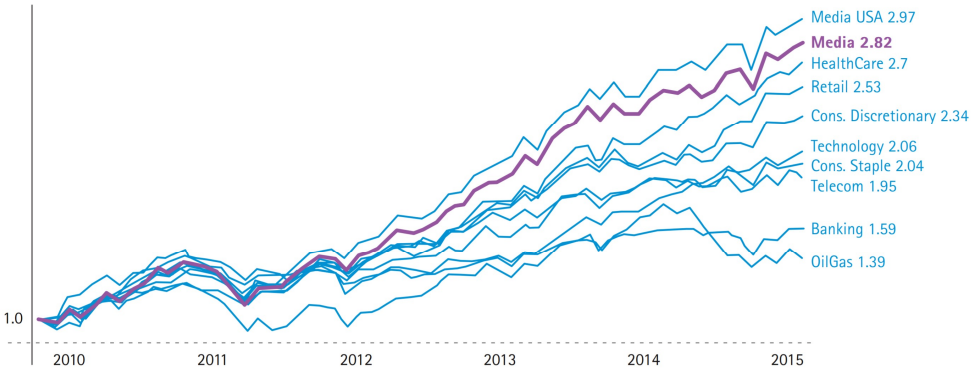
From a technological point of view, many of the future developments will be built upon the evolution of networks, a key element for the content distribution. In fact, for the first time ever, the technologies are available which will transform the way networks are built and services are delivered, to create a global, high performance, scalable, intelligent, integrated IP-IT network [Media5G]. In order to fully achieve this goal, there is a need to insure complete convergence between the different networks (fixed, mobile, satellite, cable) and also to define how content providers will be able to configure the network to meet the specific requirement of an application (bandwidth, latency, security, …)

Technological innovation may be able to break down many of the functional barriers which prevent true compatibility while opening a wide scenario of convergence of broadcasting, internet, and communication services. Convergence will ultimately involve seamless access to content, achieving the idea of ATAWAD (anytime, anywhere and on any device) and attending the needs of transmedia. All the potential combinations of content, networks and devices will provide very different service scenarios, however, all of them should provide an adequate quality.

Sometimes relegated, broadcasting is still the most spectrum-efficient wireless delivery, infinitely scalable (one-to-many architecture and point-to-multipoint), local (capable of delivering geographically local content), timely (provides real time and non-real time delivery of content) and flexible (supporting different business models as free-to-air and subscription services) [FOBTV]. It remains popular and a very widely used means of consuming video and audio content.

In economic figures, the media industry has outperformed other industry sectors in terms of returns generated for shareholders over the past 5 years (2010 – 2015) with technologies related specifically to content distribution seeing an increase in future value [ACC].

The social media explosion has made it a key issue to understand for the NEM world of the future, and as such it will be the NEM community's priority in the coming months.



F ig: Year Total Returns to Shareholders (TRS) 2010–2015 (Source Accenture)

2. EVOLUTION OF MEDIA CONTENT DISTRIBUTION

Never before, have content consumption options been so numerous. The way that media is consumed is changing. Consumers increasingly access media services by means of personal devices such as PCs, smartphones and tablets, and the Internet. There is a real coexistence between live linear viewing, time shifted and on-demand services that are gaining market share. Non-traditional service providers have entered the market and new platforms that use the strengths of online distribution, are competing against traditional TV broadcasting. [EBU Future Distribution]

The use of new technologies, and the new needs in society, has brought an increase in the number of Internet-connected devices. This increment has resulted in an increase of IP network traffic. Managing such amount of traffic has led service providers and ISPs to seek mechanisms to improve services, as well as reduce traffic on the backbone network. For this reason, new methods of content distribution have emerged, trying to reduce adverse side-effects when you have to deliver content to a large number of users simultaneously.

Smartphones and tablets are becoming a more common device for accessing multimedia content and services, while mobile networks are becoming increasingly important for the distribution of audiovisual media services. However, it is still a challenge to know the real applicability of mobile broadband for the delivery of broadcast content and services to large audiences. The fast developments in mobile technologies are largely driven by the ever increasing demand for network capacity resulting from the rapid uptake of innovative services, including audiovisual media, and the growing capabilities of mobile devices. [EBU Mobile Distribution].

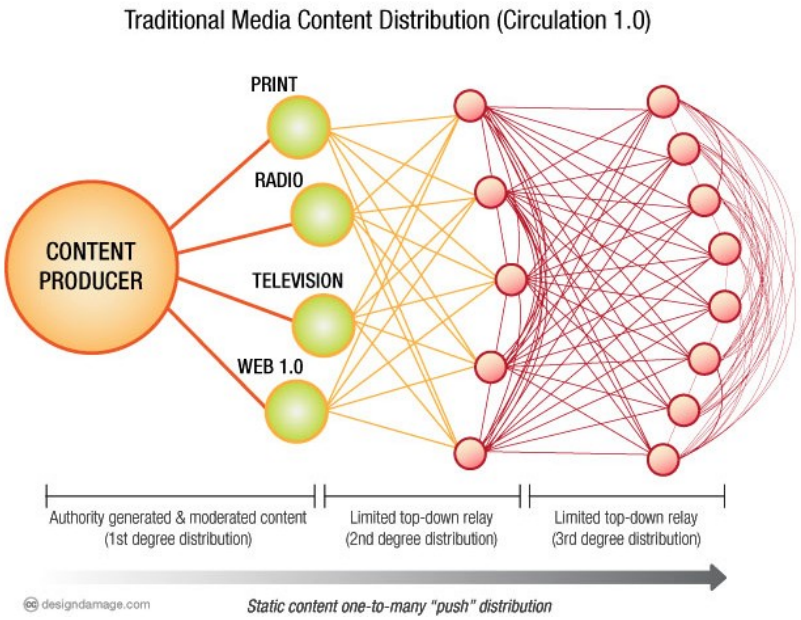


Fig. The evolution of media content distribution I (Source: Tsai)

Traditionally, content distribution has been managed by corporations devoted to the process of distributing to the content consumers. Mainstream content continues to be published by selected providers with large budgets, getting pushed out on a *one-to-many* delivery scheme requiring users to retrieve them (Top-Down approach). The relationship network of contents, providers and consumers can be expressed as in the picture [TSAI].

The Internet blew that model apart. The increasing presence of social media is one of the most important factors in this radical change of the ecosystem [SMI].

Fig: Key statistical indicators of media use (Source We are Social)

The initial Web 2.0 revolution introduced the user-generated content, syndication, sharing and pull models for access to content, and, as a result, social media as a big actor in content distribution. In this model, everyone is a content producer enabling user-generated content to scale efficiently.

The explosion of all new platforms has been great for audiences, but its effects have been more uneven for creators. Today's content creators are aiming at creating direct relationships, putting a lot more effort into building passionate engagement, with audience members by means of niche vertical interest content.

This eruption has led to the current coexistence of the two models in a kind of hybrid model of content distribution as represented in the following picture.

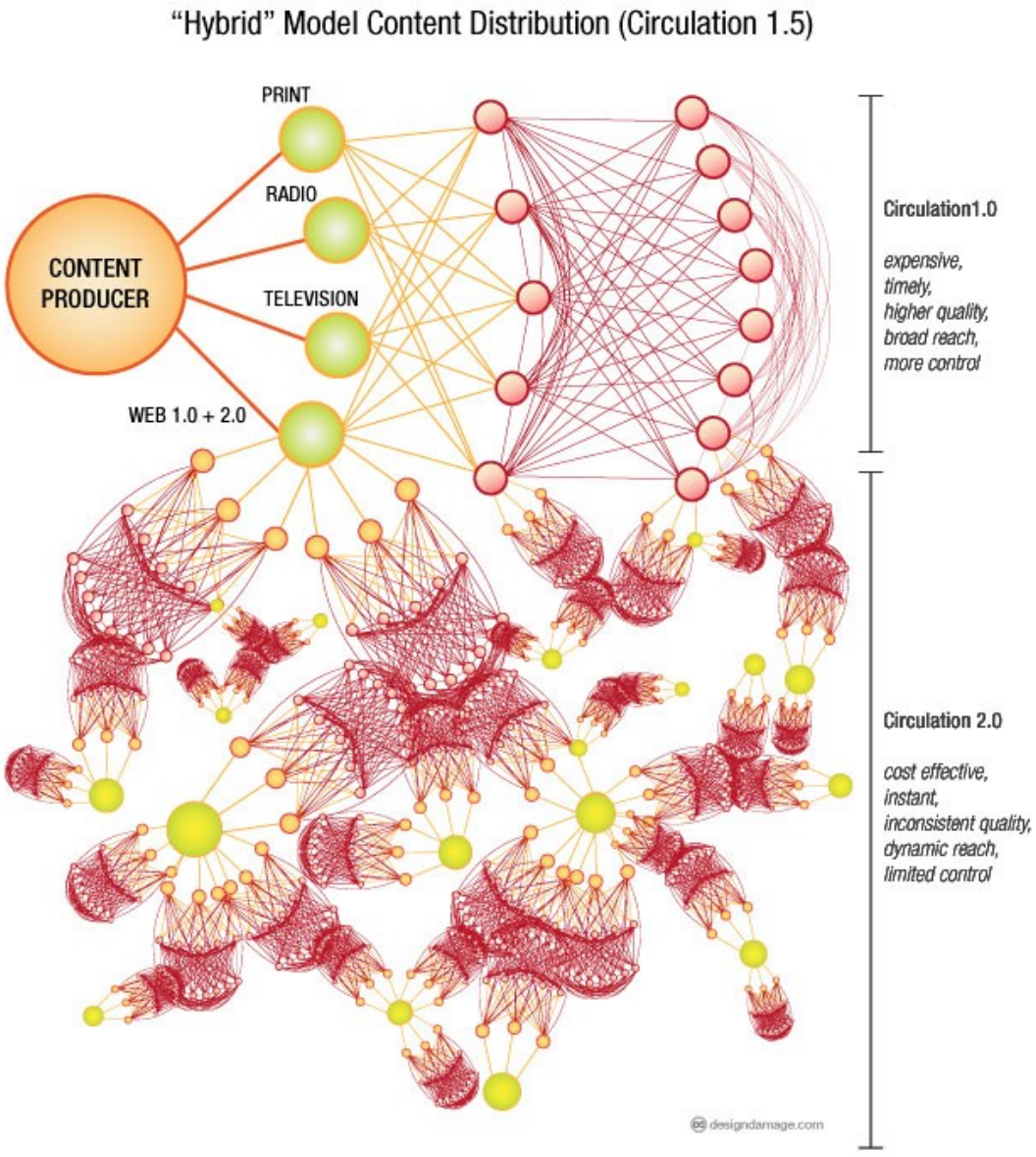


Fig. The evolution of media content distribution II (Source: Tsai)

3. CONTENT DISTRIBUTION ENABLERS AND KEY ASPECTS

3.1 5G CONTENT DISTRIBUTION

The demands of a fully mobile and connected society are characterized by the tremendous growth in connectivity and density/volume of traffic.

5G will not only be an evolution of mobile broadband networks. It aims to bring new unique network and service capabilities. Firstly, it will ensure user experience continuity in challenging situations such as high mobility (e.g. in trains), very dense or sparsely populated areas, and journeys covered by heterogeneous technologies. In addition, 5G will be a key enabler for the Internet of Things by providing a platform to connect a massive number of sensors, rendering devices and actuators with stringent energy and transmission constraints. Furthermore, mission critical services requiring very high reliability, global coverage and/or very low latency, which are up to now handled by specific networks, typically public safety, will become natively supported by the 5G infrastructure.

5G will integrate networking, computing and storage resources into one programmable and unified infrastructure. This unification will allow for an optimized and more dynamic usage of all distributed resources, and the convergence of fixed, mobile and broadcast services. In addition, 5G will support multi tenancy models, enabling operators and other players to collaborate in new ways.

The focus of research into 5G networks to date has been largely dedicated to the advances in network architectures, technologies and infrastructures. Less effort has been put on the applications and services that will leverage and exploit such advanced 5G capabilities. Media is indeed one of the most challenging sectors for exploiting 5G. Media applications are amongst the most demanding services in terms of resources, requiring huge quantities of network capacity for high bandwidth audio-visual and other mobile sensory streams; in addition they demand extremely low latency for truly immersive, responsive and tactile user experiences.

So experimentation should report on this marriage, how innovative media-related applications and the underlying 5G network should be coupled and interwork to the benefit of both: to ensure the applications allocate the resources they require to deliver high Quality of Experience (QoE) while at the same time the network is not overloaded with media traffic.

Thus, it is expected that 5G will offer new capabilities and opportunities to the different actors of the value chain. Topics like decentralisation of network caching, new methodology of media processing and application execution, advanced security, privacy and trust of the content within the network, better QoS/QoE for end-users, improved capabilities and reducing network resources with a flexible architecture, new and enhanced market opportunities for small ISPs and SMEs to join the market of audio-visual content delivery,

are expected to be supported by 5G. Another issue to be solved is the increasing need for higher uplink bandwidth as user-generated-content and the media shared by social networks are changing completely the media flows through the network in a way that has not been previously considered.

3.2 SOFTWARE DEFINED NETWORKS and NETWORK FUNCTION VIRTUALIZATION

In recent years, the complexity of telecommunication networks has increased. More network elements are needed to support the required services, and each network element needs to integrate more functionality.

Software Defined Networks (SDN) and Network Function Virtualization (NFV) present a new network architecture paradigm in the design and management of networking elements. SDN and NFV combine different technological capabilities applied to network functions, network design, and service platforms [JUN].

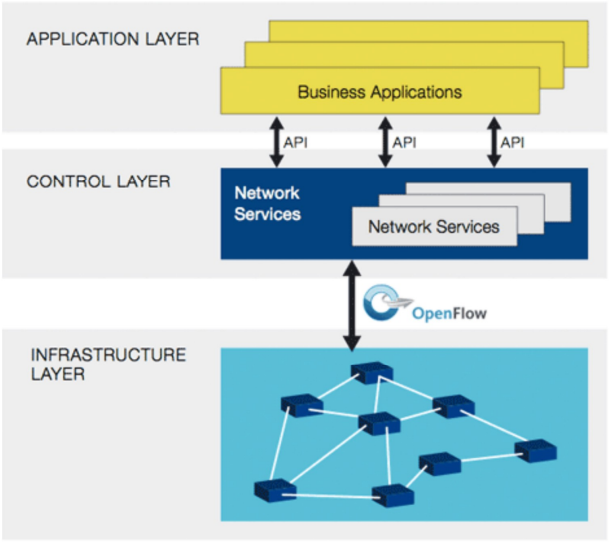


Fig: SDN Architecture (Source: ONF)

Aiming at creating agile, flexible, scalable, and efficient networks, SDN and NFV provide network automation, the separation of control and data plane, taking advantage of the capabilities of cloud computing and virtualization, while lowering capital and operational costs. SDN schemes will change the conception of networks and the way in which they are designed, reducing the complexity and enhancing the possibilities of innovation.

The implementation of SDN provides some benefits:

- Centralization of the FIB ("Forwarding Information Base"): Optimally determined routes deterministically "end to end".
- Dynamic response to application requirements.
- Optimization of network usage and load balancing.
- Security (packet filtering at the edge of networks, redirection of suspicious traffic flows to analysis tools, etc.).
- Better coordination of network behaviour by programming applications that deploy functions on the network.
- Much faster and more flexible evolution; since with this scheme the software does not depend on the hardware. It evolves directly on the control plane.
- Much more predictable networks with controlled behaviours.
- It allows the statistical information of the network to be collected in real time, and be used by the different applications to establish policies and program different configurations and services in the network.

Analogously, NFV provides benefits to network operators such as:

- Reduced operator CAPEX and OPEX
- Reduced time-to-market to deploy new network services
- Improved return on investment from new services
- Greater flexibility to scale up, scale down or evolve services
- Openness to the virtual appliance market and pure software entrants
- Opportunities to trial and deploy new innovative services at lower risk

In this environment it is possible to carry out an on-demand provision of network services by reacting immediately to the requests of the applications. It provides, therefore, flexibility, abstraction, global vision of the entire network (having centralized control plane), isolation between applications, and multi-vendor support. All these features fit very well with the problems of media environments; the increasing content resolution HD, 4K and 8K is facing a pressing problem: massive data transfer and very high volume of traffic in bursts. SDN and NFV can contribute to improve the efficiency of content distribution. [SDX]

Additionally, the use of NFV / SDN can contribute to a decrease in costs compared to traditional technology.

3.3 CDN VIRTUALIZATION

Content Delivery Network (CDN) is a set of technical solutions taking into account macro and micro traffic characteristics that aim to provide the best Quality of Experience combined with optimal use of end-to-end infrastructures. [5G-PPP]. As seen in 3.2 Software Defined Networks (SDN) and Network Function Virtualization (NFV) are two paradigms which aim to virtualize certain network functions while adding more flexibility and increasing the overall network performance. [LCN]

One of the most important NFV use cases is deploying virtualized CDN. The main purpose of vCDN is to allow the operator to dynamically deploy on demand virtual cache nodes to deal with the massive growing amount of video traffic. Scaling in/out, caching as a service etc. are also among the key benefits of vCDN.

Virtual Content Delivery Network (vCDN) migration is necessary to optimize the use of resources and improve the performance of the overall SDN/NFV-based CDN function in terms of network operator cost reduction and high streaming quality. It requires intelligent and enticed joint SDN/NFV migration algorithms due to the evident huge amount of traffic to be delivered to end customers of the network.

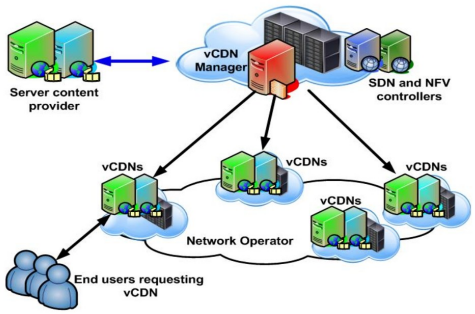


Fig. Virtual CDNs deployment model

This implementation needs to solve issues as the optimal location to migrate a vCDN or to instantiate (place) a new vCDN on demand to satisfy users' quality requirements, or to cope with scalability problems when large scale networks need to be optimized. New approaches aim at integrating the placement algorithms using Information-Centric Networking (ICN) context regarding its ubiquitous and in-networking caching features.

According to research commissioned by Amdocs (NASDAQ:DOX) [BTR] on video content delivery network virtualization, network functions virtualization-enabled multiscreen, 4K video services, combined with revenue from cloud-based DVR upsell, can generate up to $2.1 billion in benefits over a five-year period.

The study indicated that TV Everywhere and the introduction of new HD formats - 4K/8K/high-dynamic range (HDR) - content are driving cable and other video service providers to upgrade their video networks from legacy systems to NFV/SDN cloud-enabled networks.

3.4 4K AND BEYOND

Almost any advance in the world of the contents has been linked to an improvement of the quality of them, typically an increase of resolution. Therefore, UHD TV is at the horizon of the future of broadcasting and content production.

While improving resolution is a huge benefit, UHD enhances other key media features including: [UHD Guidebook]

- Smoother motion by higher frame rates
- Improved contrast by higher dynamic range
- Greater color depth
- Improved audio by high spatial resolution in source localization and an increased sense of sound envelopment.

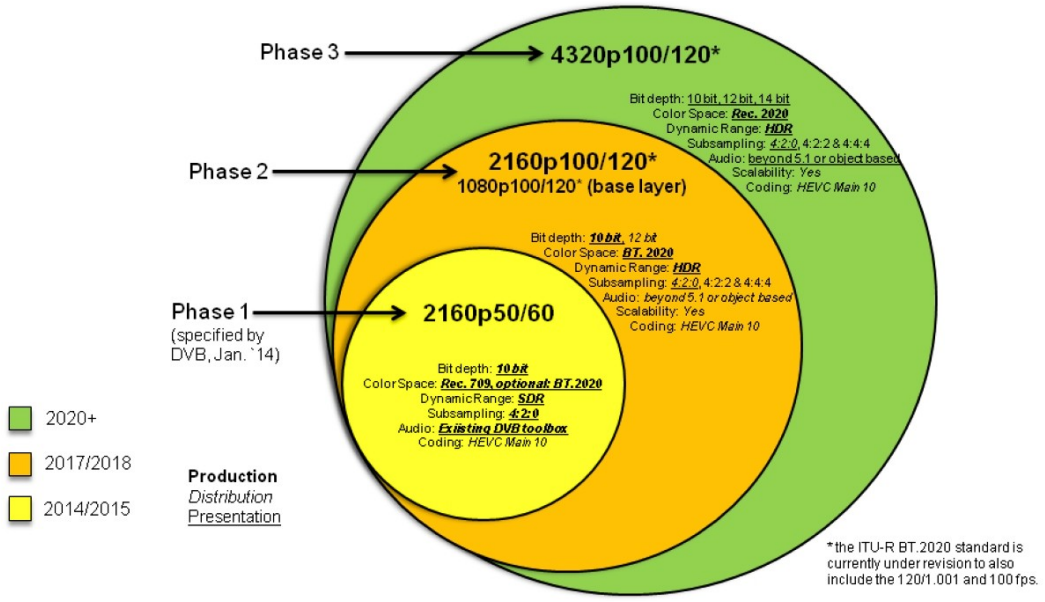


Fig. UHD phases timeline

On the other hand, UHDTV demands four times the bandwidth of HDTV requiring greater storage and transport costs. These two issues are addressed by the improvement in compression mechanisms, currently, through the use of H.265 coding standard.

The successive changes in production formats and the temporary coexistence of several, lead to market fragmentation. This issue makes backward compatibility a key problem to be faced. There are different approaches to tackle this topic, especially in the broadcast case, which are under evaluation by DVB. OTT models are more flexible, so the potential solutions can be applied easily, although the costs of transcoding, storage and (CDN) delivery are meaningful.

UHD TV is progressively consolidating, but content is always going a step further. NHK is aggressively testing 8K in the TV broadcasting environment with public tests having begun in association with the 2016 World Cup Soccer Tournament, and the eventual goal to provide 8K broadcasting feeds for the 2020 Tokyo Summer Olympics. However, beyond technical advances, it is necessary to find a response to how the production in higher resolutions can be cost effective.

Despite 3D TV having been substantially reduced, services with improved immersivity are proposed and under evaluation. Tele-Immersive (TI) applications enable real-time, multi-party interaction of users spread around the globe, by placing them inside a virtual world. With the ongoing Virtual Reality revolution, specialized hardware entering the consumer market and significant funds coming to VR related technologies, these next generation communication applications are now starting to emerge and are expected to take the networking world by storm. Quality of Service (QoS) and Quality of Experience (QoE) are top priorities in immersive media whereas availability and interaction between users are considered critical challenges that need to be met as they ensure a smooth user experience. High quality 3D reconstructions of users are created, usually in the form of time-varying meshes (TVM), which produce large volumes of heterogeneous data, thus, creating a challenging networking scenario. [5G Networld]

All the open issues need ambitious R&D programs in Europe on those questions that can stimulate the industry to study the technological and economical challenges. They should provide answers to the migration to new methods of production empowering transmedia, on how to produce innovative multi-channel sound, to integrate accessibility to TV and movie content (Audio description, subtitles ...), and improve standardized metadata in new file systems in order to promote new tools and solution that facilitate the use of publishing metadata to create more interactivity between viewers and works; and to help share and organize streamlining the exchange of content from production to distribution and archiving.

3.5. OTT MODELS

Over the Top (OTT) services can be defined as those video, audio, voice or data services that are transmitted over fixed or mobile internet platforms and are generally not provided by traditional telecommunication operators.

These type of services include the distribution of associated audio and video, videoconferences, audiovisual content on demand, messaging services and communication through social networks. In all of them media is of extreme importance.

The provision of content in traditional networks such as free-to-air and pay-tv has spread easily to the Internet, as this platform is very attractive to consumers because of its convergent (through any devices), anywhere (ubiquitous) access features, and anytime. Thus, an OTT platform may offer considerable advantages over traditional television services where content is received at pre-set times, in the same location and through a single device.

These services require a terminal device with internet access, such as the computer, smartphone, game console, tablet or smart TV. The attributes of the service offerings depend exclusively on the OTT provider, but the perception of quality received by the user is also influenced by the quality and capacity of the internet access of the network that provides the infrastructure.

One of the most popular OTT services has been the provision of content on demand. This new audiovisual attraction involves broadband service providers in terms of infrastructure and capacity, due to the quality of connection demanded, and OTT content providers, due to the high standards in video definition that clients are used to consume and require.

Convergence and market trends lead to providers of pay-tv having integrated content options on demand and even the possibility of playing content outside the programming time and on devices other than the television. Globally, the pay-TV market has grown as much as the market for OTT platforms for audiovisual content.

The development of OTT services will be the result of the implementation of commercial strategies such as the packaging of services, as well as the exclusivity of content as the main attraction for users, and above all, the growth in penetration and quality of broadband.

Nowadays, new emerging business models for over-the-top (OTT) services are testing the market; however, there are many open issues regarding market policy and regulation with a potential high impact for OTT. Several studies aim to identify costs and barriers to European online service development including OTT while analysing the regulatory environment for online services in Europe, contrasting it with the environment for

traditional telecom and media services, as well as the environment in some of Europe's major trading partners. [OTT policy].

4. STRATEGIC IMPORTANCE OF CONTENT DISTRIBUTION

Content delivery has been constantly evolving to scale better, accommodate new workloads, and incorporate new actors, new protocols, and new algorithms trying to accommodate the increasing needs from video exchange.

Annual global IP traffic is expected to reach 3.3 ZB (ZB; 1000 Exabytes [EB]) by 2021. Globally, IP video traffic will be 82 percent of all consumer Internet traffic by 2021, up from 73 percent in 2016. Immense growth is due to the number of Internet-connected devices, which already surpassed the number of humans on the planet in 2011, while the number of mobile connected devices is increasing fast, too; Cisco forecasts that there will be 11.6 billion mobile-connected devices by 2020, including M2M modules—exceeding the world's projected population at that time (7.8 billion). [CISCO]

Media content needs to be delivered so efficient technologies and services which improve the way media content is transported are always welcomed by consumers.

A big boost can come by creating a unique value proposition through convergence of 5G systems with NFV/SDN paradigm; thus, it is expected that it will yield significant revenues for involved stakeholders and boost the competitiveness of the EU industry in the mobile media revolution, brought by rich media industries, e.g. virtual reality (VR), augmented reality (AR), etc.

With the emergence of popular video-streaming services that deliver Internet video to the TV and other device endpoints, CDNs have prevailed as a dominant method to deliver such content. Globally, 70 percent of all Internet traffic will cross CDNs by 2021, up from 52 percent in 2016. Globally, 77 percent of all Internet video traffic will cross CDNs by 2021, up from 67 percent in 2016 [CISCO]. Any significant improvement on CDN's is, therefore, critical for the scalability and sustainability of the content ecosystem.

Lastly, work to create technical and regulatory framework that allows for the stable growth and deployment of different solutions and their convergence and interconnectivity will have a crucial impact on the competitiveness of the EU industry for the coming years.

5. CONCLUSIONS

The media sector is looking for new business opportunities as its current business models are being reshaped by challenging technology and market trends. Media is moving to concede more power to users, to achieve higher levels of personalization, and aims to get them engaged by powering emotional and social connectivity with the content.

These paradigms need to be addressed by consolidating new networks capabilities with an improved management. Content distribution strategies need to be supported by technological advancements driving more appealing user experience within the entertainment & media industry. User-generated-content and the media shared by social networks are completely changing the media flows through the network, leading to a need for a higher uplink bandwidth.

Important pan-European initiatives as Big Data PPP and 5G PPP, especially when referring to content distribution, are taking into account media and content singularity. Content and media are, on the other hand, exceptionally useful material to assess the real potential of both technologies and can really bring European innovation horizon at their maximum performance. Since currently the majority of Internet exchanged data is media and content, it is of utmost importance to include and promote content technologies in the new developments for both commercial and research purposes in Big Data and 5G domain.

Content distribution should be the cornerstone of the so-called New Generation Internet which should take content and media experience to a new era. In the way of offering an answer to this reality, content distribution must go beyond improving technical capabilities such as bandwidth, intelligence, scalability and performance. The integrity of content and the confidentiality, authenticity and integrity of private data of the users managed within content services are key to the deployment of successful use cases.

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