Multimedia Communications: Technologies, Services, Perspectives

Part II. Applications, Services and Future Directions

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***Abstract*—This survey/position paper gives an overview of the state-of-the art multimedia communications technologies and services, analyses their present significance and expected future role, and attempts to identify development trends. The paper analyses the evolution of networking infrastructure and multimedia services over the last decade and identifies future directions. It consists of two parts. Part I, published in the preceding issue of this journal, dealt with the technologies and systems for multimedia delivery, and covered the dedicated networks such as digital broadcasting systems and IPTV and the technologies of Internet based multimedia delivery. The present paper, Part II, addresses applications, services and future directions.**

***Index Terms*—Multimedia communication, IP networks, Internet, mobile communications.**

I. INTRODUCTION

The survey paper, written a decade ago by Stephen Weinstein and Alexander Gelman [1], was cited in detail in Part I [2] since one of the objectives of the paper was to analyse the state-of-the-art and to see what trends could be observed, after ten years since the paper was published. It was shown how the networking infrastructures and services have developed, and now in this paper we want to show whether the forecasted applications have gained wide acceptance and implementations and what new trends can be identified that were not foreseen that time by Weinstein and Gelman.

The paper is organized as follows.

In Sections 2.1 and 2.2, we come back to digital broadcasting and IPTV, with short comments on the service aspects.

In Section 2.3, the technology as well as service-related issues around the emerging Internet TV and OTT – Over-The-Top content services will be addressed.

The social element is gaining increasing role and importance in media consumption. In Section 3, dealing with "social media" and "social TV", we look into issues around these terms and point out to the importance of social network based interactions among users of multimedia services.

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Section 4 deals with key application areas such as entertainment, e-health and telemedicine, visual collaboration and e-learning, and smart city applications and services.

Our concluding Section 5 outlines some promising directions including multi-screen TV, Free-viewpoint TV and the trend of moving from traditional broadcasting platforms to wireless broadband Internet.)

II. TELEVISION SERVICES PROVIDED OVER DEDICATED NETWORKS

A. Digital television broadcasting

In Part I, we discussed the technologies of digital television systems. While the technical solutions are interesting for engineers, the question is what do they mean for consumers. The short answer is: improved picture quality including HD. This is not too much, given the expenses the customers need to bear by buying a digital TV set or a set-top box that allows for using the existing analogue receiver and a new rooftop antenna. Additional benefit is a greater choice of channels. A digital multiplex as it is called, a package in which TV channels are grouped, usually contains up to 8 TV channels and several radio channels, and is being provided for free. Additional multiplexes are included in a paid monthly subscription.

We should mention the importance of digital terrestrial broadcasting for low-income population groups, living in rural areas, in less developed countries. For them, the digital switchover means that the terrestrial broadcasting will survive in its new form, and thus their only way of accessing news, entertainment programs and taking part in educational programs will remain available in the foreseeable future.

Interestingly enough, the transition from analogue to digital broadcasting paves the way towards replacing this relatively new (since it is digital) but at the same time old (since it uses dedicated broadcasting systems) method by a new one: distributing and consuming TV programs using the public Internet. This is because, as a result of the analogue-to-digital switchover, a considerable amount of bandwidth within the so-called digital dividend has been/will be freed up and will be available for other purposes. There are several applicants for these frequencies, and most likely a great deal of it will be allocated to mobile cellular service providers, which then will use it for expanding their new generation services, and first of all mobile broadband Internet access. This process could eventually lead to the decline of digital broadcasting, although it may be too early to say that. We shall come back to this issue later in this paper.

B. IPTV

In Part I, the technology and architecture of IPTV systems were briefly presented. Although the term IPTV itself denotes TV delivery over any IP network, the most common form is the existing last mile network, the subscriber loop, of the telecom service providers. Thus it is obvious that IPTV is an excellent opportunity for telecom operators to enter into broadcasting business without having to build a new network infrastructure for it. In addition to the original telephone service, and the already provided Internet access over xDSL, TV distribution becomes the third component of their „triple play" – voice + Internet + TV – offering.

C. Internet TV and OTT

Currently we use two distinct ways of media consumption. On the one hand, we have the linear media consumption which is the traditional TV broadcasting, with its edited programmes, that are broadcasted and distributed based on a schedule known in advance. On the other hand, non-linear media consumption has been gaining increasing importance during the last years. Consumers use their desktops or laptops with Internet access to access and download media they choose to watch/listen, whenever they want, repeatedly or in parts if they wish so, very similarly to the old VHS or the recent DVD players. Non-linear way of accessing content is preferred by young generations, although the principle itself should not be unfamiliar also to non-Internet generations: after all books are a non-linear content, too.

OTT or Over-the-Top Content can be seen as an effort to bridge this gap. Rigid boundaries seem to be ceasing anyway. Non-linear content coming from home media players are being consumed on TV sets. Linear content can be viewed also on desktops, laptops or smartphones. Smart TVs are penetrating, they seem to be the device to combine these two media consumption ways. Smart TVs or connected TVs or hybrid TVs integrate Internet and Web2.0 capabilities into TV sets and set-top boxes. Currently, about 10 percent of the total Internet video traffic is being delivered to TV sets and this number will grow to 14 percent by 2017, according to [3].

What does the term OTT cover? Technically, it is content distribution over the unmanaged public Internet. From the business and service model point of view it is about separating the content provider and distributor/network service provider roles (the latter are the ISPs). This model is fundamentally different from that of the traditional broadcasting companies or of the majority of IPTV providers (who can be called "vertical" service providers). OTT could be called Internet TV as opposed to IPTV that uses a dedicated, managed IP network. On the other hand, it is more adequate not to call it Internet TV, since this term is too general and only refers to the technical side, while OTT is also a service/business model. Table 1 compares OTT and IPTV.

	OTT	IPTV
Delivery method	Over the open Internet	Using a proprietary network
Network ownership by the content provider/ aggregator	No, network provider and content provider roles are separated	Usually the content distributor owns the delivery network
Quality of Service	In general, best effort provided by an ISP, a CDN may be used to improve it	QoS can be guaranteed
Protocol for media transport	HTTP/TCP, adaptive streaming like HLS is emerging	Transport stream over RTP/UDP
Routing topology	Unicast	Multicast

Table 1 Comparison of OTT and IPTV

The components of the OTT "ecosystem" are the following entities:

- Content providers. Example: BBC (UK).
- Content aggregators and distributors. Example: Netflix (USA, UK).
- ISP – Internet Service Providers. Examples: Verizon (USA), T-Home (in many European countries).
- CDN – Content Delivery/Distribution network provider. Examples: Akamai (USA), StreamZilla (The Netherlands).
- Access/core network provider. Examples: most traditional telecom service providers and mobile operators.

Most well known OTT service providers are Amazon, Apple, Hulu, Netflix [4], [5], [6], [7].

How can the service provider ensure QoS without owning the distribution network or having access to it (because the distribution network is the Internet)? Only monitoring and collecting information at the receiver side is possible, without intervention. ISPs cannot monitor the content of the IP packets (otherwise they would violate the "network neutrality" principle). Fortunately, broadband Internet is penetrating, with increasing quality and reliability. In EU countries the goal is to grant at least 100 Mbps access data rate for the whole population by 2020. Also the inclusion of a CDN (Content Delivery Network) provider into the delivery process supports quality of service.

Can we combine IPTV, the TV broadcasting technology over dedicated, managed IP networks and the OTT? It seems yes, the term Hybrid TV refers to a consumer TV set where TV content is delivered by digital television technology (DVB/T/S/C), or, by an IPTV service, and, since the set is connected to the public Internet, all kind of multimedia content, including TV programs, can be accessed. Current hybrid TV platforms of leading vendors (Samsung, LG, Sony) are proprietary ones, thus standardization is a prerequisite for penetration.

HbbTV (Hybrid Broadcast Broadband TV) is a new standard providing an open and neutral technology platform that seamlessly combines TV services delivered via broadcast with services delivered via broadband and also enables access to Internet only services for consumers using connected TVs and set-top boxes. Founders are European telecom and broadcasting companies, TV equipment vendors and other organizations [8]. It is an ETSI standard [9]. As for the current status, HbbTV has been deployed, among others, in Germany, Austria, Switzerland, France, and is being tested in many other countries in Europe. Analysts predict a distribution of 23 million HbbTV-capable devices by 2014 [10]. Nevertheless its future depends on whether it remains a pure European initiative or it will gain acceptance by and support of the US entertainment industry to ensure worldwide penetration.

III. The social element in networked multimedia applications

A. Social media

Social media is exactly what the two words suggest: it is an intersection of social networks and personal media. On the one hand, social networks have become an integral part of our everyday life, we exchange information and communicate to a large extent through FaceBook and similar networks. On the other hand, personal media is becoming more and more social. Let us consider photos as an example. Old ways of collecting and storing of personal photos about ourselves, family events, travels and presenting them to family members and friends are being replaced by doing the same via photo and video sharing sites on the Web. Replacing our paper boxes at home where we used to store photos by „electronic boxes" like the hard drive of our laptop or external storage devices is just the first step. We use new ways of „showing" them to all people who might be interested, and given the enormous amount of photos we take, due to the ubiquitous use of digital cameras, smartphones and tablets equipped with cameras, we really need new ways for the storage and presentation. We can easily select photos we would like to share and upload them to some sharing site, and we can select photos that we want to see from those available on these sites. Moreover, we can use social networks to disseminate information about our personal media, and to search for the desired content on these sites. So, social media is also a new approach to multimedia content search that uses collaborative annotations of the members of social networks.

Ramesh Jain, Univ. of California at Irvine, in his lecture at a meeting of the European project „nextMEDIA" defined the characteristics of social media as follows [11]:

- it is produced and consumed by many,
- production and consumption is democratized,
- sharing plays an essential role,
- media is multimedia content (today: picture, video, voice, data, in the future: smell, tactile info etc.).

We started to talk about photos as an example of personal media, which is just one kind of UGC – User Generated Content. Another example is digital storytelling, which is a combination of narrative with digital content, including images, sound, and video, to produce a short movie, typically with a strong personal character and usually with emotional component. Who is doing digital storytelling? BBC was pioneering in helping digital storytelling to penetrate, by encouraging and sponsoring people all around the UK to capture videos on local histories and cultures. Another early example is the San Francisco broadcasting station KQED which solicited high school students to shoot stories about how they are living in California. Digital storytelling has a great significance as an educational tool, as well.

It is very little what people need to produce a digital storytelling video: a script and some hardware and software, including a capturing device (video camera, smartphone, iPad etc.) and an editing environment (a desktop or laptop with the necessary inputs and with an editing software, e.g. Apple iMovie, Microsoft MovieMaker).

Since it is so easy to produce some video clips or sound recordings, and, even more importantly, there are always people around when something interesting and surprising happens, UGC is a part of professional media production these days. Mobile users frequently generate content for broadcasters and news portals. Watching a TV news channel, we often see inserts produced by people who were just there where something happened before the TV team could have arrived at the spot.

B. Social television

Today's media consumption is characterized by three independently developed and operated systems/environments/ opportunities [12]:

- *Home living room environment.* It is characterized by large plasma, LCD or LED screens, HD and 3D presentation, with high-fidelity sound system are the main components. Content comes (i) from the Internet and presented on living room equipment (supported by proprietary „media center" type solutions), and (ii) from air or cable as before, and more recently, via IPTV. This set-up can be called a „linear" media consumption environment, with limited interaction possibilities.
- *Desktop environment.* Since people spend long hours in front of the screen of their PCs or notebooks, both in the office and at home, no wonder that this environment is used more and more also for media consumption. Numerous TV and radio broadcasting programs are directly available on the Internet, but content can be acquired from the social sites (Facebook, YouTube) where content consumption is often accompanied by annotation and recommendation services, thus bringing more interactivity than can be achieved in the living room environment.
- *Mobile media consumption.* As we discussed earlier, people use their mobile and portable devices (smartphones,

tablets) for media consumption, production and interactions within their communities. Radio broadcasting receivers are often built in smartphones. TV channels are accessible via Internet, alternatively DVB-H broadcasts can be received where available. Internet connectivity is available almost everywhere at high speed via Wi-Fi and 3G/4G mobile. Interactivity is supported by the inherent communication capabilities: voice calls, SMS, MMS, video calls. Users generate personal content and share it via social networks.

If we combine the three settings and use the social networks for tagging, recommendations etc. we can create community interactions in the context of viewing TV programs. For example, users can collect multimedia information related to the piece of media just being watched/listened to. Another example is collecting and presenting multimedia information related to the geographical location the user is currently visiting. In general, we can make decisions on what to watch based on peers; share programs or edited versions, directly communicate via chat, audio, or video with other peers and comment about a television program within a (possibly) large community, and make available to others what we are watching.

In the yearly publication of MIT, social TV was listed among the „10 most important emerging technologies“ in 2010 [13], see also [14] . The prototype developed at MIT was built around a central database that aggregated video from online sources like YouTube, shares user-specified data with social networks, delivers video to the user's TV, lets users and the people in their networks send comments and ratings via an iPhone app. On social TV, see also [15] and [16].

IV. Main application areas of multimedia communications

A. Entertainment

By 2017, the total spending on online games will reach the amount spent on offline console games [17]. The latter is a huge industry, for global data see [18].

According to Spilgames, a Dutch-based global provider of online gaming platforms, the percentage of online population who plays online games is 44%. [19]. Out of roughly 1.2 billion gaming users 700 million was playing online games in 2013. This activity is on the 2nd place among online activities after watching videos, and before watching TV and radio programs and movies. The share of gaming traffic on the Internet is even more significant if we take into account the time spent on gaming compared with other activities. According to the aforementioned report, the average session duration is 40 min for games, 15 min for YouTube and 5 min for news portals. Cisco forecasts that in 2017, the amount of gaming traffic is expected to be 59 petabytes, compared to around 53 pB of video traffic, around 15 pB of web, e-mail and data traffic and 9 pB of file transfer traffic (data from [3], rounded figures).

Online games on mobile devices is a new but potentially very large market and a fast growth is expected in terms of time subscribers spent on games and the traffic generated. There are technical challenges such as ensuring adequate QoE.

The Entertainment Software Association, ESA, provides data on what people play. About one-third, 34%, is the group containing puzzle, board game, game show, card games, trivia. 26% of games played fall into the category of action, sports, strategy and role-playing. Social games is an increasing group, currently (2013) it constitutes 19%.

The massively multiplayer online role-playing game (MMORPG) is a specific genre characterized by a very large number of players, usually in the order of several thousands in one server. The most popular ones are World of Warcraft, that has close to ten million subscribers or Star Wars: The Old Republic, which, after its release in 2011, became the world's fastest-growing MMO after gaining 1 million subscribers within the first three days of its launch. Guild Wars is also among the most popular ones.

The business models of MMORPGs are based on monthly subscription fee, or one-time fee, and users have to purchase the client software as well. An increasing trend is to use web browsers as clients. There are different additional fees to be paid for access to extended areas of the game, for example. There are games available free of charge too.

The share of the game traffic on the Internet, although growing, is still and for some time remains to be a small fraction of the total Internet traffic, due to the nature of data transmitted while gaming (as compared with other web applications, file sharing, voice and video applications). Gaming data include the inputs of the players, chats among players, virtual world updates etc. The reason is that most popular games were developed long ago when bandwidth was scarce and access was mostly dial up at low speed. The second generation of game software will make use of the since then dramatically improved access bandwidth and will possibly generate significantly larger data traffic.

As for the technology aspects, most MMORPGs, as other kinds of online games, are based on a client–server system architecture. The server software generates the environment, the virtual world, and players connect to it via client software. A game is usually hosted by several servers in parallel so that the number of players does not exceeds a few thousand, although there are exceptions when a server hosts several tens of thousand users. P2P architecture plays a negligible role and is currently a research issue. Game development technology is about 3D modeling, graphics, animation and games programming.

Finally, let us mention a related area, serious games which have been used for quite a long time as educational tool sin different areas. Currently the majority of serious games applications are being used off-line but the on-line share is growing due to the high demand for flexible forms of education.

B. Health care

The use of information technology in health care, briefly called e-health is another rapidly growing application area these days. It includes telemedicine and home health care services. Telemedicine is about providing health care services to distant locations. According to ATA (American Telemedicine Association) telemedicine is "exchange of medical information by telecommunications means to improve treatment". The first documented telemedicine service dates back to late '60s when a microwave link between the Logan airport in Boston and the Massachusetts General Hospital was installed for transmission of diagnostic data from the emergency room of the airport to the hospital for remote consultation. Already this set-up consisted of the two main components of a telemedicine system: a store-and-forward transmission of diagnostic picture and video and live audio/video communications for medical consultation.

M-health or mobile health solutions are of great importance where wireline communications is missing or of bad quality (there are many such areas and not only in developing countries), and are useful for patient monitoring at home and while the patient is moving (e.g., permanent remote ECG monitoring). Portable screening stations make mass screening possible in remote, sparsely populated areas. Medical services can be provided to disaster areas where the wireline infrastructure is usually damaged.

An ongoing European m-health project addresses scenarios like the following [20]. A young man is jogging in a park. Suddenly he falls down and remains laying, apparently he cannot move, possibly also collapsed. His cellphone (a smartphone) detects the event, searches for mobiles in the vicinity, founds one, sends a message to it, and its owner, a lady runs to the young man. She recognises that the young man collapsed, alarms the emergency service. Contacts the emergency center and using her smartphone, transmits pictures and videos of the patient, and also describes verbally what she sees. Based on this preliminary information, the emergency center decides which hospital the young man shall be delivered. In the emergency car, hearth ultrasound pictures are taken and transmitted to the hospital using a wireless link between the car and the hospital. Then the doctors in the hospital can plan what the best treatment shall be.

An important area of telemedicine where networked multimedia plays a key role is telesurgery. There have been telesurgery experiments for more than a decade. Since the first experiments, the robotic surgery has developed significantly and the Da Vinci robots [21] have become standard technology in developed countries. Telesurgery is just one step from the Da Vinci robotic surgery room: the workstation has to be displaced from the operation room to a large distance. Of course this simple step poses serious challenges in the design and implementation of the communication system: to ensure the required quality of service for video transmission over various telecommunications links, including wireless and mobile systems and services. Space surgery presents additional challenges because of the large propagation times, smaller available bandwidth, and lower reliability.

Some methods, solutions and systems developed for telemedicine purposes have been implemented in a slightly different and highly significant area, namely in providing health care and in general, providing ambient assisted living (AAL) services to elderly people in their homes. According to a EU statistics, the percentage of citizen over 65 years in the 27 European Union member countries is expected to become 25% by 2020 [22]. The majority of elderly live alone at home, thus the various means helping them are of paramount importance. Solutions include regular or permanent monitoring of important vital parameters and transmission of these data to a health care provider site, or monitoring the everyday activity within the homes and outside the homes to detect unusual and dangerous situations such as a sudden fall. Since home health care and AAL are highly important for society, governments and international organizations allocate significant funds for the research, development, implementation and operation of such services. An example is the Ambient Assisted Living Joint Programme of the European Union [23].

C. Audio-visual collaboration and e-learning

Interactive audio-visual communications is a basis for many important applications including virtual meetings, virtual conferences, and e-learning. The technology is based on the call control protocols. Currently two call/session control protocols co-exist: the H.323 ("umbrella standard"), developed in the telecom world and standardized by ITU [24] and SIP – Session Initiation Protocol, developed almost in parallel in the Internet world and standardized by IETF [25]. (SIP was dealt with in Sub-section 3.2.3 within the context of IMS.) Based on these protocols as well as on sophisticated audio/video compression methods, a large variety of audio-visual collaboration systems (also called video conferencing systems) have been developed, ranging from soft clients for personal computers through the different kinds of conference room systems to multi-screen "video walls". Example is the widely used is TelePresence systems by Cisco [26].

Videoconference systems are the technical means for "virtual classroom"-type distance learning, one of the two main methods used for distance learning. As the name suggests, it is about delivering a lecture to a remote lecture hall or halls. Thus the goal is to bridge large geographical distances. A related application is the "extended" lecture hall, meaning the extension of the real lecture hall, where the presenter gives a live lecture to the participants, to additional (remote) rooms. Examples are conferences with a large number of participants or inter-university lectures.

The other main method, gaining increasing importance, is web-based learning, or e-learning, which is based on hypermedia learning materials accessed over the public Internet or on the intranet of a company or institution. In addition to complete on-line courses, shorter forms such as webinars and webcasts can be used in web-based learning. The advantages are obvious: it provides personalized learning from any place and time. Instructors still play an important role, their active help (e.g., tutoring via e-mail, phone, Skype, video conference) is an integral part of the learning process.

E-learning is a fast growing Internet application area due to strong interests both from the learners as well as from the educational institutions. Learners are interested in flexible forms of learning. They want to obtain additional degrees while working which often requires enrollments in programs of distance universities. Educational institutions can make their programs accessible for a wider population at lower costs.

Online courses are provided either by universities themselves (a well known example is MIT - Massachussetts Institute of Technology - with its OpenCourseWare program) or by independent organizations that are still connected to and based on the offering of a university or several universities. edX is a non-profit organization established by the Gates Foundation and is based on a cooperation with leading US universities such as MIT, Harward, University of California at Berkeley and University of Texas [27]. Another major player in the so-called MOOC - Massive Open Online Courses – business is Udacity, founded by Harvard University [28]. The largest is perhaps Coursera, established by two Stanford professors, with its 22 million enrollments from over 190 countries across 571 courses [29].

Discussing the issues of educational methodology related to open courses is outside of our scope. Let us only mention that providing course materials in the form of video lectures (which is currently the most common format, and, from educational methodology point of view, does not really differ from classroom lectures) is just one component of the learning process. One needs to add tools and create environment for the whole distance or on-line learning process, e.g. consultations with the professors, tutoring, certification of courses and programs, examination, etc. There are also organizational and legal issues such as how the participation in open lectures can lead to degrees, and also what are the suitable business models. Most of these and the like are unanswered questions at the time of writing of this paper.

D. Smart environments

Networked multimedia plays a central role in another emerging application area which can be broadly denoted by the term „smart environments“. Related terms are, in the context of cities: „digital cities“, „digital communities“, „smart cities“ [30], in the context of the citizens‘ immediate environments: „smart homes“ or „intelligent“ homes or „ambient assisted living“, in the context of exhibitions and other mass events: „smart spaces“. In general, we are talking about new applications and services for the benefit of citizens, organizations and businesses. For example, in the context of cities, let us have a brief look at the most important smart city application areas.

Smart metering and control for utility services.

Smart metering or automatic meter reading (AMR) is the technology of automatically collecting consumption, diagnostic, and status data from different utility metering devices such as water, gas, electricity and heat meters and transferring that data to a central database for billing, analysing and troubleshooting. Using an AMR system, failures or misuses can be detected immediately, making possible instant intervention. Billing can be based on near real-time consumption to better control the production and consumption of public utility services.

Parking is a big problem in most modern cities in particular in downtown areas, and many cars are looking for parking lots in every moment, resulting in waste of time, fuel, increasing air pollution and noise load. Assisting drivers in finding parking places is similarly important in parking garages. An intelligent parking assistance system navigates cars to the appropriate available parking lots, navigates drivers back to their cars, and, among other related applications, supports billing.

Let us only list some otherequally important application areas:

- *Smart city transportation*
- *Ubiquitous access to government and community portals*
- *Smart applications for tourists*
- *Meeting the needs of elderly people*
- *Urban safety*
- *Public health applications*

Key technologies for smart cities are (i) a networking infrastructure, mostly wireless, and (ii) sensors installed everywhere, in parking lots (infrared sensing of occupancy), on buildings (e.g. surveillance cameras), in citizens homes (metering devices), just to mention a few examples. Multimedia communications plays a key role on most of the aforementioned applications.

IoT – Internet of Things is a frequently used term to denote the system of networked sensors embedded in physical objects and machines. „Internet“ because this network operates using the same TCP/IP protocols stack as the public Internet, and uses Internet infrastructure as well.

V. OUTLOOK AND SUMMARY

In this paper, we gave an overview of the state-of-the art networked multimedia technologies and services.

As for the future, it is impossible to identify a single unified direction where multimedia services are developing. Instead, in this concluding section, we briefly address some interesting and promising approaches, including solving challenges in providing broadband access, novel multimedia technologies, and new business models for providing multimedia services.

A. Multi-screen TV

While until recently the term multi-screen denoted different kinds of video walls with several screens, for example displaying the participants of a video conference plus presentations and videos delivered by participants, different stakeholders of the TV and mobile industry gave it a different meaning. For TV service providers, it means extending the viewing experience of customers from smart TV sets to a second device such as a table PC or a smartphone, basically adding tablet and smartphone participation to classical TV viewing. The terms “Companion TV“, „second screen TV“ refer to the same thing.

In general, multi-screen TV means enabling the service providers to deliver any content to any screen via any network within the framework of a single integrated system (“TV anywhere“). It seems that while smart TV offers a combination of traditional broadcasting content and interactive content accessible from the Internet, there is a significant demand for an application where second-screen or multiple-screen viewing can be delivered and customized via a mobile handheld device, as a flexible extension to the primary large-screen TV set.

As an example, WatchON™ of Samsung [31] allows for accessing content across different Samsung devices. With WatchON, a mobile smartphone or tablet PC can be paired with the main smart TV, and the selection of content and device is controlled via a smartphone application. In addition to multi-screen viewing, this application provides intelligent program search, personalized recommendations, complementary content and social network sharing.

Ericsson claims that "TV consumers today demand a seamless way to consume any content, on any screen, anywhere. They want to have a social experience while watching TV. They want personalized and rich experience across devices." [32] Ericsson's „Multiscreen TV Solution" is a complete system consisting of Multi-screen clients and Multi-screen Core Platforms. The core functionality includes content management, middleware, VOD backoffice, digital rights management among others. The client functionality includes common client framework, SDK and portals.

B. Future 3D Media Internet

As it was discussed in Part I, there have been important research initiatives on both sides of the Atlantic to support research of Future Internet network architectures. Several directions have been listed in which new solutions were required to meet the new demands. Perhaps the most important challenge is to support 3D media delivery on the Future Internet, and the solutions embedded in the Future Internet to meet this challenge are denoted by the term „Future 3D Media Internet" [33].

Requirements toward the Future Media Internet, listed and analysed in [34], [35], and [36] include coding, transmission and presentation of 3D audio/video + additional sensorial information (pressure, vibration, smells etc.), interactivity with 3D media from any user devices, inclusion of 3D handling capability in browsers.

The main challenge is transmission and delivery of 3D information while meeting the desired QoS and QoE requirements. There are several directions in which the current Internet should evolve to become Future Media Internet. Just to mention one: 3D media transport. The current protocol stack of RTP/UDP/IP will most likely be replaced by RTP/DCCP/IP. TCP is usually not an option in most media applications (streaming, interactive media, online games) because fast delivery is needed and the reliable transport mechanism of TCP causes unaffordable delays. On the other hand, UDP lacks a congestion control feature which is important for the transmission of large amounts of multiview 3D video. DCCP or Datagram Congestion Control Protocol seems to be a solution. DCCP provides congestion control for datagrams in bidirectional unicast connections. The transmission of datagrams occurs unreliably just as with UDP.

C. Free viewpoint 3D TV

As it was noted earlier in this paper, current 3D stereoscopic technologies, used in cinemas and blue-ray players, are not attractive enough for 3D television due to the reasons mentioned above. Besides some limitations of the current technologies, such as specific glasses or the limitations of the current displays, it seems that viewers are not enthusiastic enough just about some depth experience, rather many prefer 2D viewing but with increased resolution. The main reason maybe is that these technologies provide only a single 3D view and the viewers cannot control their viewpoint.

A breakthrough technology could be free-viewpoint TV, a multiview system where the user can freely choose the viewpoint he/she wants to watch a scene from. The basic technology is the free viewpoint video, or FVV, which has been around for several years as a novel production and reproduction technology. In FVV, the scene is recorded simultaneously by several cameras. The recording is controlled by the master camera and the operator, who selects a part of scene to focus on and all other cameras are directed to the same part of the scene, but each from different location/angle, in a computer controlled way. The resulting multiple video stream is processed by appropriate coding technologies, transmitted to the receiver side, where it is decoded and rendered to a special display. So far this technology was commercially utilized mainly on the production side, examples being the stop-motion animation in the movie "Matrix" or in the "Eyevision" system for sport effects [37].

According to [38], the world's first real-time free-viewpoint TV system, including the complete chain of operation from image capture to display, was constructed by Masayuki Tanimoto and his team.

Part of this complicated chain, namely, the multiview coding, has been already standardized. The Multi-view video coding (MVC) standard is an extension of H.264/AVC, and is based on exploiting the redundancies not only between frames of a given view but also between frames of different views [39]. MPEG is now (in 2013) engaged in the third phase of FTV standardization, with the objective of establishing a new FTV framework. The first document [40] deals with use cases and requirements. There are important developments in the other elements of the FTV chain, e.g. in multiview 3D displays, so one can expect the appearance of the first commercial TV applications in the near future.

D. OTT vs digital broadcasting

We noted earlier that the transition from analogue to digital terrestrial broadcasting has been recently completed in most countries worldwide. Analogue TV distribution in CATV networks will be terminated also soon. But what will be the future of digital TV broadcasting? As we also mentioned, the bandwidth savings due to digital switchover will help the penetration of wireless broadband Internet access which is going to be increasingly used by customers for enjoying TV content as opposed to using traditional digital broadcasting and distribution services. Many think – and the authors belong to them - that the days of DVB-T are numbered. This service will probably continue to grow in the next few years but then a decrease will likely start. IP-based TV distribution over dedicated networks – IPTV - will remain significant in the next few years. And mobile broadband Internet access will grow due to reuse of the digital dividend and later due to freeing up new bands. Consequently the share of the non-linear media consumption will grow. In the near future, customers will use a multiplicity of platforms, interfaces etc., no universal worldwide standard is expected to be established. As we already noted, the future of HbbTV is unclear.

This trend was recognized by the Communications Committee of the British Parliament. In their recent document [41], it is stated: "We recommend that the Government, Ofcom and the industry begin to consider the desirability of the transfer of terrestrial broadcast content from spectrum to the Internet and the consequent switching off of broadcast transmission over spectrum, and in particular what the consequences of this might be and how we ought to begin to prepare."

The development in the mobile broadband technologies seems to be supporting this trend. Existing HSDPA and LTE technologies already offer significant download speeds as compared with 3G services. And the move to the next generation is underway. Ericsson, one of the market leaders in mobile system technology, a company investing a lot in related research, is talking about 5G as evolution of existing standards plus complementary new technologies. They say "5G will enable the Networked Society and realize the vision of unlimited access to information for anyone and anything. This vision will be achieved by combining evolved versions of today's radio-access technologies (RATs), including LTE and HSPA, with complementary RATs for specific use cases, not by replacing existing technologies. Future mobile broadband users will expect "unlimited" performance from the network." [42]. Moving to new generation mobile broadband services is also in the focus of the recently launched program, 5G PPP, within the new Horizon 2020 framework program of the European Union. According to [43] the 5G PPP will deliver solutions, architectures, technologies and standards for the ubiquitous next generation communication infrastructures of the coming decade. It will provide such advancements as 1000 times increase in wireless capacity serving over 7 billion people (while connecting 7 trillion "things"), saving 90% of energy per service provided, and creating a secure, reliable and dependable Internet with zero perceived downtime for services.

To sum up what was outlined in this concluding section, it is likely that we will be witnessing dramatic changes in networked multimedia to take place in the near future: a move from the present digital broadcasting to mobile broadband Internet, at the same time a transition from linear to non-linear media consumption, and the commercial introduction of novel 3D technologies that will provide unprecedented viewing and listening experience.

References

[1] S. Weinstein and A. Gelman, "Networked Multimedia: Issues and Perspectives", IEEE Communications Magazine, Vol. 41, No. 6, pp. 138-143, June 2003.

[2] L. Chiariglione and Cs. A. Szabo, „Multimedia Communications: Technologies, Services, Perspectives. Part I. Technologies and Delivery Systems". Infocommunications Journal, Vol. VI, No. 2, pp. 27-39, June 2014.

[3] Cisco Visual Networking Index: Forecast and Methodology, 2012–2017. Cisco White Paper, May 29, 2013. Downloaded from http://www.cisco.com/c/en/us/solutions/collateral/service-provider/ip-ngn-ip-next-generation-network/white_paper_c11-481360.html, on February 24, 2014.

[4] www.amazon.com

[5] http://www.apple.com/hu/appletv/#tv-overview

[6] www.hulu.com

[7] www.netflix.com

[8] www.hbbtv.org

[9] "Hybrid Broadcast Broadband TV" ETSI TS 102 796 V1.1.1 (June 2010).

[10] S. Arbanowski, "Hybrid-, connected-, Smart-, TV? Was steckt hinter der neuen Medienwelt." Universitaet Potsdam, 2013. http://www.medienengineering.de/Ringvorlesungen/WS20122013/Arbanowski15.1.2013.pdf

[11] Social Media: Creation, Distribution and Access. Ramesh Jain, UCI. Presentation at the 1st Spring School on Social Media Retrieval (S3MR), Interlaken 2010. Accessible on http://videolectures.net/s3mr2010_jain_cda/.

[12] L. Galli, R. Guarneri, and J. Huhtamaki, "VERTIGO: Find, Enjoy and Share Media Trails across Physical and Social Contexts", Digibiz, London, 2009.

[13] TR10: Social TV. Relying on relationships to rebuild TV audiences. „10 most important emerging technologies", MIT Technology Review, May/June 2010, downloaded from: http://www.technologyreview.com/printer_friendly_article.aspx?id=25084.

[14] M.-J. Montpetit and M. Medard, „Social Television: Enabling Technologies and Architectures," Proc. IEEE, Vol. 100, No 5, May 2012, pp. 1395-1399.

[15] Pablo Cesar, David Geerts, "Understanding Social TV: a survey". http://nem-summit.eu/wp-content/plugins/alcyonis-event-agenda//files/Understanding-Social-TV-A-Survey.pdf

[16] P. Cesar, D. Geerts and K. Chorianopoulos: Social Interactive Television: Immersive Shared Experiences and Perspectives. IGI Global, 2009.

[17] "Global Online Gaming Market 2014" YStats report, February 2014, downloaded from http://www.ystats.com/uploads/report_abstracts/1064.pdf?PHPSESSID=3656a3c0b0e2afdb46fab3740e414327 on March 2, 2014.

[18] Sales and demographic data, ESA – Entertainment Software Association, 2013.

[19] "State of the online gaming report 2013." Spilgames, http://www.spilgames.com/press/2013-state-online-gaming-report-released-spil-games/

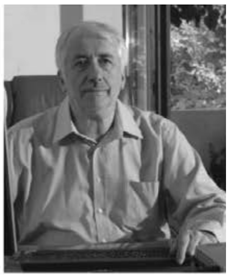
[20] A. Takács, L. Bokor, A Distributed Dynamic Mobility Architecture with Integral Cross-Layered and Context-Aware Interface for Reliable Provision of High Bitrate mHealth Services., Lecture Notes of the Institute for Computer Sciences, Social-Informatics and Telecommunications Engineering 61: pp. 369-379. 2013.

[21] http://www.davincisurgery.com/da-vinci-surgery/

[22] European Commission "2009 Ageing Report: economic and budgetary projections for the EU 27 Members States".

[23] http://www.aal-europe.eu

[24] http://www.itu.int/rec/T-REC-H.323-200912-I/en
[25] http://www.ietf.org/rfc/rfc3261.txt
[26] https://learningnetwork.cisco.com/docs/DOC-8096
[27] www.edx.org
[28] www.udacity.com
[29] www.coursera.org
[30] Magnus Boman: Digital Cities. White Paper. EIT ICT Labs Innovation Radar, 31 December 2012, downloadable from: http://www.eitictlabs.eu/fileadmin/files/publications/130426_wp_digital_cities.pdf
[31] http://www.samsung.com/us/watchon/multi.html, downloaded January 23, 2014
[32] http://www.ericsson.com/ourportfolio/media-industry/multiscreen-tv
[33] Future Internet and NGN Design requirements and principles for a Future Media and 3D Internet Created by "Future Media and 3D Internet Task Force". Coordinated and supported by the Networked Media Unit of the DG Information Society and Media of the European Commission. February 2009. Available at ftp://ftp.cordis.europa.eu/pub/fp7/ict/docs/netmedia/20090220-fid-rp-3-dg_en.pdf
[34] P. Daras and F. Alvarez, "A Future Perspective on the 3D Media Internet", in: G. Tselentis et al (Eds.), "Towards the Future Internet". IOS Press, 2009.
[35] Position Paper on Networked 3D Multimedia. Accessible on www.nem-initiative-org.
[36] T. Dagiuklas, "3D Media over Future Internet: Current Status and Future Research Directions", International Journal of Computer Science Issues, Vol. 9, No 2, January 2012.
[37] A. Smolic, "3D video and freeview point video - From capture to display." Pattern Recognition 44 (2011) 1958 -1968.
[38] M. Tanimoto, M. P. Tehrani, T. Fujii, and T. Yendo, "Free vievpoint TV. A review of the ultimate 3DTV and its related technologies." IEEE Signal Processing Magazine, January 2011, pp. 67-76.
[39] ITU-T and ISO/IEC JTC 1, "Advanced video coding for generic audio- visual services", ITU-T Recommendation H.264 and ISO/IEC 14496-10 (MPEG-4 A VC), 2010.
[40] M. P. Tehrani, S. Shimizu, G. Lafruit, T. Senoh, T. Fujii, A. Vetro, M. Tanimoto, "Use Cases and Requirements on Free-viewpoint Television (FTV)". ISO/IEC JTC1/SC29/WG11 MPEG2013/N14104. Geneva, Switzerland. October 2013.
[41] Broadband for all - an alternative vision - Communications Committee of the British Parlament, 2011. Available at: http://www.publications.parliament.uk/pa/ld201213/ldselect/ldcomuni/41/4106.htm#a18
[42] Ericsson Labs Research Topics, downloaded from http://labs.ericsson.com/research-topics/5g, 17 February 2014.
[43] 5G Infrastructure PPP: The next generation of communication networks will be "Made in EU". Downloaded from http://ec.europa.eu/research/press/2013/pdf/ppp/5g_factsheet.pdf, 17 February 2014.



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