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A Future Perspective on the 3D Media Internet

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Abstract. The Internet is a living, dynamic "wizard" who is constantly and rapidly evolving, reshaping and transforming and consequently it is changing our social and economic world. However, Internet was designed and primarily used by scientists for networking research and for exchanging information. The current form of Internet cannot efficiently serve future needs raised by the exponential increase of the available cross-modal content and ensure consistency and correctness in terms of media storage, distribution and consumption, along with options to navigate, interact, search and retrieve this content. In this paper we make an attempt to identify the main barriers posed by the Current Internet and analyse major issues and challenges which is expected to be the pillars of the Future 3D Media Internet.

Keywords: Future Media 3D Internet, Future Content Network Architectures, Immersive Environments.

1 Introduction

For many years, the Internet was primarily used by scientists for networking research and for exchanging information. Remote access, file transfer, and e-mail were among the most popular applications, and for these applications the datagram model works well. The World Wide Web (WWW), however, has fundamentally changed the Internet. It is now the world's largest public information network. Many applications—such as video conferencing, Web searching, electronic media, discussion boards, e-commerce and Internet telephony—have been developed at an unprecedented speed. Similar to the explosion of textual content in the Internet, one can easily observe a dramatic increase of network-based audiovisual material (networked media) that has been produced by professional and amateur users.

This explosion has been triggered by the widespread availability of broadband home access, digital recording devices, improved modelling tools, advanced scanning mechanisms as well as display and rendering devices. Today, over one billion of users access the Internet on regular basis, more than 100 million users have downloaded at least one (multi)media file and over 47 millions of them do so regularly, searching in more than 160 Exabytes of content [1]. In the near future these numbers are expected

to exponentially rise. It is expected that the Internet content will be increased by at least a factor of 6, rising to more than 990 Exabytes before 2012, fuelled mainly by the users themselves. Moreover, it is envisaged that in a near- to mid-term future, the Internet will provide the means to share and distribute (new) multimedia content and services with superior quality and striking flexibility, in a trusted and personalized way, improving citizens' quality of life, working conditions, edutainment and safety [2].

In the longer term, the exponential increase of the user generated multimedia content and the number of mobile users will raise many new challenges. In this respect, the Future Media Internet will not simply be a faster way to go online. It will be redesigned so as to overcome current limitations and to address emerging trends including: new network architectures, content and service mobility, diffusion of heterogeneous nodes and devices, mass digitisation, new forms of (3D) user centric/user generated content provisioning, emergence of software as a service and interaction with improved security, trustworthiness and privacy.

In this evolving environment, machine-to-machine communication (including RFIDs and audiovisual sensor networks), rich 3D content as well as community networks and the use of peer-to-peer (P2P) overlays are expected to generate new models of interaction and cooperation. Furthermore, they will be able to support new innovative applications "on the move", like virtual collaborative environments, personalised services/media, virtual sport groups, on-line gaming, edutainment, etc. In this context, the interaction with content combined with interactive/multimedia search capabilities across distributed repositories, opportunistic P2P networks and the dynamic adaptation to the characteristics of diverse mobile terminals are expected to contribute towards such a vision. On the other hand, advances in scalable video coding and 3D video processing, dynamically adapted to the network conditions will give rise to innovative applications such as massive multiplayer mobile games, digital cinema and in virtual worlds, placing new types of traffic demands and constraints on mobile network architectures.

In this paper an attempt is made to collect, review and evaluate the related existing technology with the aim to give research directions towards redesigning the Future Internet, having in mind the obstacles posed by the Current Internet, and the provisioned new applications. Thus, the main contribution of this work is to present, in a coherent way, a view on how 3D Media Internet is likely to look like and which could be its main pillars. Furthermore, the long-term vision is given containing possible research directions which is expected to contribute to the realisation of the Future 3D Media Internet.

The paper is organised as follows: In Section 2 the limitations and barriers of the Current Internet (CI) are analysed while in Section 3 the provisioned characteristics of the Future 3D Media Internet are given. In Section 4 the long-term vision along with possible research directions are sketched and finally, in Section 5 conclusions are drawn.

2 Limitations and barriers of the Current Internet

Since the main parts of the CI were developed 30 years ago for serving research demands (host-to-host communications), it is obvious that it cannot be used with the same efficiency today where new demanding applications rise.. What follows is an analysis of the obstacles and limitations of the CI, with respect to media and network, which put current and future uses at risk [3].

2.1 Limitations with respect to content

Nowadays we are rapidly moving from a mainly textual-based to a media-based Internet, where rich audiovisual content, 3D representations, virtual and mirror worlds, serious games, lifelogging applications, etc. become a reality. In this environment it is obvious that there is a need to support the *experience* in form of real enjoyment of these media, in the sense of having true *interaction* with both the people and the media. This lack mainly happens due to the restrictions imposed by current limitations in network reliability in terms of bandwidth, as a physical constraint, and the consequent delays that are imposed.

This plethora of media clearly generates the need for algorithms and tools to ease its manipulation (i.e. automatic or semi-automatic media annotation, indexing of media in large databases, visualisation of media in heterogeneous terminals, etc.) and efficient generation, sharing, search and retrieval of media based on both content and context.

Although popular attention has highlighted the phenomena of end-user generated content, it is commonly overlooked that in the majority of existing examples, user activity has typically been bootstrapped and aggregated around a pool of existing, professionally produced, and often commercial content (e.g. YouTube). This reinforces the role of professional content producers and distributors and, at the same time, requires rethinking the role of users and enabling technologies: though users are not the sole or primary source of content, they are active co-creators and participants who need to be integrated in co-creation and exploitation within the media value chains.

Of great importance are also tools able to provide real collaborative environments so as to boost the productivity of the "creative" community and bring together professional and amateur media creators. Nowadays, still in the minds of successful media producers there exist two separate worlds: the amateurs collaborate in the Web2.0 and the professionals compete in the commercial media world. Thus, there is a clear need for a change in the professional work practices and in attitudes and novel networked working environments in future networks in order to collaborate in the professional creative media sector in order to compete on the global content market.

The CI is characterized by a disembodied and non-multimodal access to content. Interaction with content lacks inaction and immersive participation, apart from very specific cases, usually intrusive and not easily accessible to a wide range of users. The role of sound can be strategic to improve immersivity, to enable inaction in the interaction with content and embodied content processing in Future Internet (FI) applications. Sound has an important role in our life: "embodied sound media" and

applications can contribute to improve both novel A/V services (e.g. experience-centric and participative music applications, e.g. future active listening applications) and support applications for industry and also to improve cultural and social (e.g. health, elderly) situation in EU. The lack of embodiment in current Internet could be faced by enhanced support of multimodality, including sound, haptics, visual, gestural, physiological, toward a deeper exploitation and integration of communication and interaction through the physical, non-verbal, full-body channels.

The support to social and emotional communication among users and communities is another aspect that is lacking in the CI. There are initiatives (e.g. W3C, MPEG) to code emotional cues, and to define use cases significant for future developments. However, they are mostly based on the current paradigm of research on emotions, based on emotional labels and explicit modeling of affective states. It is suggested here a widening of paradigms, aimed at empowering the role of emotional interaction in future Internet scenarios: this consists of facing the modeling of non-verbal subtle communication channels, i.e. strongly related to empathy, engagement, synchronization, or, mentioning Japanese culture, "kansei information processing" [4]. As an example, let us consider the emotions and empathy communication between two or more humans standing still in a waiting room (e.g., waiting for a medical treatment). Even without exchanging a single word, they exchange a lot of non-verbal information (emotional, empathic, etc.). This subtle, and at the same time very powerful, aspect of communicating through empathy and emotion should be tackled, modeled, and exploited in future Internet applications, achieving more effectiveness and immersiveness and contact among humans. This also contributes to social networks issues in e2e platforms, and raises important ethical issues. In short, the focus here is towards more "sensible" (and therefore effective in experience-centric and participation of users) Future Internet applications.

To sum up, FI related applications will involve both professional and user generated content able to be used for enhancing interactivity and social and emotional communication between users. To this end, it is obvious that the Future Media which will emerge will require significant research efforts for processing, manipulation and (re)use. This is expected to lead to a new Future Media era in the body of FI.

2.2 Limitations with respect to content delivery networks

The limitations of the current content delivery networks regarding the FI are not based only on the limited capacity or the lacking of IPv6 deployment, but more importantly on the introduction of a new convergent structuring of the networks for 3D media delivery. These content oriented networks should provide adaptation, contextual services and users social and personal network focus, rather than only the service provider orientation.

But which limitations are really in the field today, for content delivery networks? On the one side we can consider the pure network aspects for providing good Quality of Services (QoS) to the final users such as reliability, recovering, convergence time of routing protocols, interruption of the service, etc. It is clear that new applications, based on Future Media, such 3D IPTV, 3D Telepresence or 3D Media applications in general, will need higher bandwidth networks, in mobile or nomadic environments.

Besides, QoS based on dynamic bandwidth allocation or based on Service Level Agreements (SLAs) are simple options when the Perceived Quality of Service (PQoS) comes into play, or the Quality of Experience (QoE). In these situations no simple metrics or mechanisms can be used. But looking further from these simple conclusions, there are limitations which are not only related to pure bandwidth or address limitations.

Furthermore, the users are nowadays creating contents, such as collaborative and user-generated content regardless of the network used (wired, wireless) or the device to produce and visualise the content. The current networks are not adapted to the user–centric media characteristics (especially in the mobile networks) and only some efforts have been devoted (e.g. P4P networks) to address this need. The evolution of the content delivery network should allow new ways of collaborative and 3D applications, also being user context-aware and content aware. Context has been referred in many cases as only as the parameters of the network in the user premises or the user location. User context-awareness should fail more in the QoE of the user combined with the user consumption context and user-generated content creation profiling, isolated and in communities, for a context based on the user context and societal environment, more than extracted from "raw technical network parameters".

Concerning the inter-domain routing, it is currently determined primarily by business relationships between providers and not by technical aspects of the path – e.g. shortest or widest path. As for the multicast protocols, they enable the dissemination of many to many endpoints in a network efficient way. Even though multicast protocols have been deployed by many providers, a lot of problems exist that hinder the inter-domain multicast deployment. One example is the multicast Peer-to-Peer (P2P) IPTV applications which can solve some limitations of the current unicast P2P networks for media services.

Some other limitations are related to content security, rights and trustworthiness of the content networks, which should evolve in the sense of providing enhanced security mechanisms without disturbing the content delivery and affecting less the system as it currently happens. Anyway this will be a long time discussion, as the users not always agree with securing or protecting content.

In summarising, nowadays the network is used mainly to transport information irrespective of the content's carried characteristics using network protocols to distribute the content. However, FM3DI needs a coupling of network and 3D content features to adapt, enrich and optimal distribute the content to the users and their contexts.

3 Characteristics of the Future Media 3D Internet

Taking into account the aforementioned limitations of the CI we present in this section some of the possible characteristics of the FM3DI with respect to both its content and network characteristics.

The content of the FM3DI could be:

- *Intelligent:* able to be adapted to the users with respect to their preferences (personalisation), devices (terminals) and access networks. In order to allow

for a good user experience regarding the media content, this content should be adapted to the user. It should be possible for the user to personalize the media objects by annotating, modifying or creating and sharing it the way they consider appropriate.

- *3D and haptic:* able to be used in many future applications such as realistic virtual/mirror worlds' creation, human representation (avatars), etc. The future media content will be fundamentally 3D (real-time or not) including visual, sound, and other sensorial features such as haptics; it will be able to convey pressure, forces, vibrations and/or motions to the user, as well as physiological or emotional user's state.
- *Interactive* for all different terminals (PC, Set-Top Box, mobile, etc.): The user should be able to interact with the media objects by modifying and/or render them using multiple views and perspectives. Real-time interactivity with other users through the media will be required in order to achieve the maximum level of collaboration.
- *Live or real time (live recording, live performing):* the most attractive media types tend to be preformed or generated in real-time circumstances. Therefore, FIM would need to facilitate live multimodal media, such as video, events in virtual worlds and live music performances to users and in addition, enable collaboration in distributed environments.
- *Cross modal:* Future media would need to be intuitively inter-linked and accessible. Therefore, they need to support cross modal approaches to media creation, retrieval and consumption. Just as the humans easily identify a song with a film, or smell with particular environment and time, FIM needs to inherently facilitate cross modality of the content and its tasks.
- *Iteratively and cooperatively negotiated in communities of professionals and amateurs:* The content of FIM should not be limited to professional producers creating for consumers, but will be created iteratively and cooperatively in negotiations across multiple communities of professionals and amateurs.
- *Publicly opened and controversial:* FM3DI should not be closed, but open for public participation and even be supportive of establishing communities across controversial issues and incorporating stakeholders with conflicting interests.
- *Collaboratively edited/filtered:* In order to have media professionals making maximum use of the internet, the media content should be edited/filtered/written/manipulated in a collaborative way.

Furthermore the content delivery of the FM3DI network should:

- Rely on *Content/service-centric network:* The CI is service location centric, the main drive of the delivery of information relies on the IP addresses of source and destination of a communication, where the IP address acts as locator and identity of the counterparts. A FI should be content and user-centric, stressing the importance of the content and the user versus the service location.
- Be able *to Transport 3D multimodal media:* The FM3DI will rely on 3D multimodal content and should provide mechanisms for signaling and

describing multimodal 3D media objects (including haptic, tactile and smell information) seamlessly and adapted to the presentation terminals.

- *Integrate real scalable and self-adaptable mechanisms for heterogeneous devices:* More and more specialised and multimodal devices will appear in the market. The *FM3DI content network*s should be able to adapt the content to the user and device characteristics coping with scalability from low resolution to real 3D video multimodal media formats and allow for creation, modification, search and sharing of the new media objects.
- Be *Real time:* Due to a strong demand for real-time quality of Future Media, it will need to deliver media in real-time throughout the whole pipeline of communication: from the source to the user, regardless of the network architecture. The delivery of real-time applications with the proper network parameters required regarding delay, latency, jitter, is vital in order to enable collaborative editing and creation of media objects or real-time participation and interaction in events.
- *Network content and user context-aware*: User context should go beyond network parameters at user premises to real content aware-networks which can provide real-time adaptation and user context personalization of 3D Media heterogeneous services ranging from simple 3D IPTV to real 3D (multimodal) telepresence. User social profiling, consumption, interaction and historical usage should be combined with QoE for producing real Future Internet services.

The network vision described above, is depicted in Fig. 1

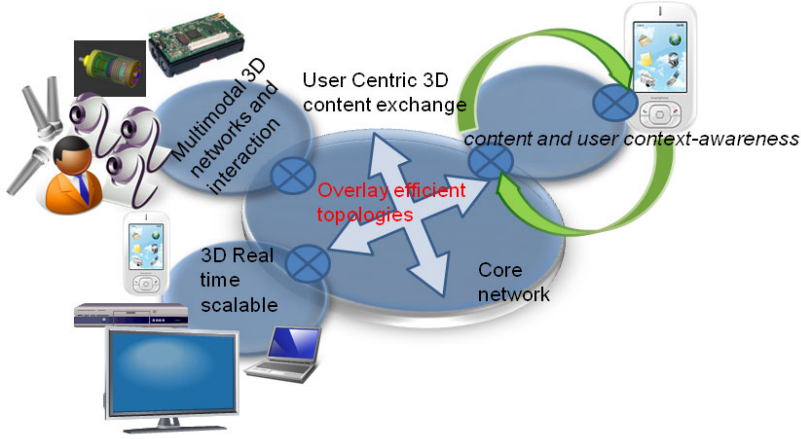

Fig. 1. Representation of the FM3DI network

The FM3DI network should combine the characteristics mentioned above to both network and content to produce a real "Content Centric Network" enabling on-the-fly content enrichment and adaptation of the content to the network, the user and its context, without disturbing the normal content delivery. In summarising, the Future Network should avoid being only a mean of information transport but should also

support FM3DI applications and services which can enable new 3D personalised experiences to the users, adding a support to future concepts after 3D services will become a reality.

4 Long term Vision of the Future Media 3D Internet and possible research directions

The Internet is rapidly transforming into a fully fledged virtual environment that facilitates services, interaction and communication. In order to be able to predict the shape of the FM3DI we should take into account two certainties; that the technology used to build the Internet will change, and that the fundamental (human) needs that it must ultimately serve, will not change dramatically. Our needs include the following: we want to be told (or discover) *stories*, we want to share *our* stories, we need to be part of a social community, but have *identity*, we want to *discover* new 'stuff' for our community and we want to *play* and *escape.* Therefore, the vision of the FM3DI is to be able to realise these needs.

Towards this aim, multiple regional initiatives are currently emerging in view of defining future global networks. Japan (through the AKARI Architecture Design Project) [5] and Korea [6] have made public their ambitious initiatives, China is supporting the domain through an ambitious and integrated industrial policy, in the US the FIND and GENI programmes [7] and facility is a key contributor to the debate on the future of the Internet and with Latin America there are several ongoing initiatives for identification of opportunities for ICT collaborations [8], [9]. These initiatives are not all tackling the issue of the Internet evolution as part of their core objectives, but are certainly related to technological and socio-economic scenarios (ubiquity, connected devices) that will clearly need to be taken into account when addressing the Internet of Tomorrow.

In Europe, the Future Internet Research and Experimentation (FIRE) [10], the Future Internet Assembly and the Future Media 3D Internet Task Force [11] are the main endeavours that are currently taken place in Europe with the goal to have a unique position in the Future Internet research.

According to the outcome of the aforementioned EU efforts [12], specific attention should be given to both main pillars of the FM3DI, namely the content and the delivery of the content. It is envisioned that the FM3DI will include *interactive/proactive autonomous characters*, where a character is any object in a 3D scene with its own opinions and suggestions, able to understand its environment and take decisions and participate in *3D social communities*, which allow people to use 3D environments to communicate and interact with each other using rich communication means similar to those used in face-to-face meetings (gaze awareness, gestures, facial expressions, correct sound direction, manipulation of social signals).

Also, the FM3DI will allow for *personalised* entertainment supporting *interactive*, and *senses* to be engaged in an *immersive* experience (participation in - or bringing theatre, movies, games) leading to the coexistence of virtual and real worlds maintaining perceptual coherence.

In order for the aforementioned vision to become true the following network characteristics should be fulfilled: higher bandwidth needs to be coupled to new traffic patterns, content adaptation in the network and the terminals that enable the availability of media for a range of heterogeneous devices, new models of content distribution that consider not only the protocols involved but also the social characterization of the nodes and the data, and new network management modules and mechanisms to provide and monitor QoE, trust and privacy (Fig 2).

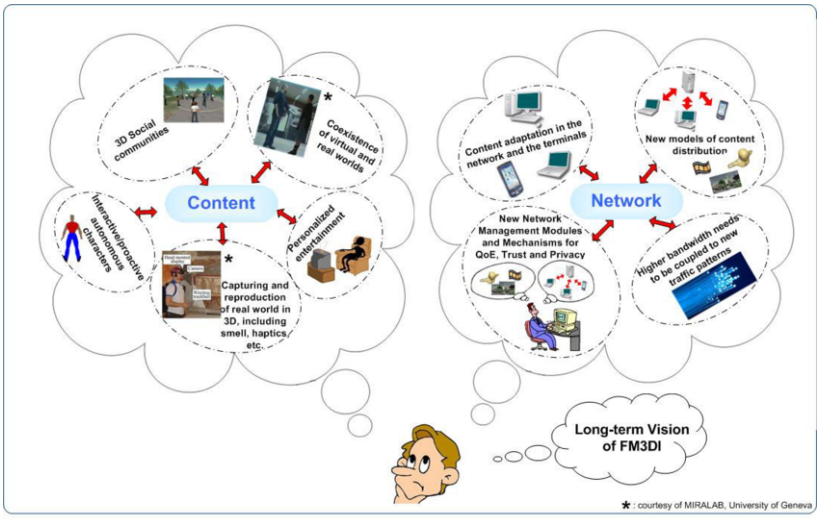

Fig. 2. Characteristics of the FM3DI [12]

These concepts require extensive research endeavours on finding optimum methods for capturing the visual appearance of the real world, including 3D/multiview, high dynamic range and high frame rate. Further, efforts should devoted on developing rich interfaces allowing for multimodal interaction 3D navigation and strong personalization, on the extensibility, scalability, distribution and availability of the content anywhere, anytime and in any terminal and on new mechanisms for native searching.

5 Conclusions

The main goal of this paper was to present our vision for the 3D Media Internet with respect to its two main pillars: the Future Media 3D Internet content and the Future Internet Network Architectures needed for supporting the content advances.

After an in depth analysis of the current technologies and limitations posed by the CI we concluded that more research efforts should be devoted to realise the vision of the FM3DI for both the content and the networks. It became obvious that we need to think “out of the box”, in a more creative way so as to redesign things from a clean slate. Short-term endeavours, like for example the Next Generation Networks, seem not to be adequate for serving the demanding applications of the Future. .

Also, by reporting the envisioned research directions and by sketching the long-term vision for the FM3DI, based on the efforts of the EU and worldwide, we believe that there is a long path to be walked until reaching a real FM3DI complete development. Significant research investment and cooperation between non-EU and EU countries are needed in order a European FM3DI can be in a leading position.

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References

1. IST SAPIR "Large Scale Multimedia Search & P2P", http://www.sapir.eu
2. Zahariadis, T., Daras, P., Laso, I.: Towards Future 3D Media Internet. In: NEM Summit 2008. Saint-Malo, France, October 13-15 (2008)
3. White paper on "Future Media Internet", European Commission, Networked Media Unit, Information Society and Media, January 2008
4. http://www.infomus.org/Research/Kansei.html
5. http:// akari-project.nict.go.jp/eng/overview.htm
6. http://mmlab.snu.ac.kr/fiw2007/presentations/architecture_tschoi.pdf
7. http://www.nets_find.net and http://www.geni.net/office/office.html
8. http://www.solar-ict.eu/
9. http://www.salamas.eu/
10. http:// www.cordis.europa.eu/fp7/ict/fire
11. http:// www.future-internet.eu/
12. White paper on "Research on Future Media and 3D Internet", European Commission, Networked Media Unit, Information Society and Media, October 2008