FUTURE MEDIA INTERNET

Theodore Zahariadis *Giovanni Pau* *Gonzalo Camarilo*

The Internet has become the most important medium for information exchange and the core communication environment for business relations as well as for social interactions. Every day millions of people all over the world use the Internet for a plethora of daily activities including searching, information access and exchange, multimedia communications enjoyment, buying and selling goods, and keeping in touch with family and friends, just to name a few. Statistics show (Fig. 1) that Internet usage has achieved a penetration of 77.4 percent in North America, 61.3 percent in Australia, 58.4 percent in Europe, and an average of 28.7 percent of the total worldwide population as of 2010 [1]. This corresponds to more than a fourfold increase (444 percent actually) over a period of 10 years. If we consider that Asia and Africa count together for more than 70 percent of the world's population and have currently the lowest penetration rates with much room to grow as their economies also develop, there is no doubt that many more people will acquire Internet access over the next 10 years.

Moreover, it is a common belief that besides growing, the Internet is evolving toward even richer and more immersive experiences. Advances in video capturing and creation will lead to massive creation of new (user generated) multimedia content and Internet applications, including 3D videos, immersive environments, network gaming, and virtual worlds. Overall Internet traffic is expected to reach an average of 767 exabytes[1] per year in the period 2010–2014, four times the amount of data currently circulating in the Internet [2]. To have an idea of the amount of data this volume represents, this is the equivalent of 12 billion DVDs transferred over the Internet every month at the end of the forecast period.

In this respect, future media Internet will not simply be a faster way to go online. The increasing flood of traffic and the new communication needs will pose many challenges to the network infrastructure. Overdimensioning (adding more powerful routers, more fiber, etc.) is only a temporary solution. At some point in time, structural changes will become necessary. While the extent of the architectural changes can be debated [3], it is not contested that essential elements of the current Internet infrastructure will need to be, to an extent, redesigned. New methods of content finding and streaming, diffusion of heterogeneous nodes and devices, new forms of (3D) user-centric/user generated content provisioning, the emergence of software as a service, and interaction with improved security, trustworthiness, and privacy. In this evolving environment, rich 3D content as well as community networks (peer-to-peer, overlays, and clouds) are expected to generate new models of interaction and cooperation, and be able to support new innovative applications, like virtual collaboration environments, personalized services/media, virtual sport groups, online gaming, and edutainment.

Scientists and engineers worldwide from industry, research centers, and universities are working toward the future media Internet architecture. In this special issue, we have striven to give an overview of the industrial and research community viewpoint by balancing the article selection to include the highest quality papers from both arenas.

We start the special issue with the article entitled "CURLING: Content-Ubiquitous Resolution and Delivery Infrastructure for Next-Generation Services" by Ning Wang *et al.* Apart from an overview of the most prominent content-centric network approaches, the article highlights some of the most important challenges in the future media Internet, such as security, quality of service, scalability, reliability, and network management, considered from a telecom operator perspective.

Solutions based on content-oriented networks (CONs) are among the most prominent approaches toward the future media Internet. In comparison to IP networking, within a CON, hosts identification is replaced by content identification and content file name is independent of the content file/segment location. In IP networking, a user should know which source server holds the content file of interest (spatial coupling) and communicate with that server throughout the content delivery (temporal coupling). In order to support this delivery method, search engines return as results to queries pointers to locations (URL) rather than pointers to the content itself.[2] In CONs, the content generation and content consumption are decoupled in time and space, so that content is delivered based purely on its name (routing by name). Moreover, in IP networking a host address is irrelevant to its content name, which results in phishing and pharming attacks, while in CONs the authenticity of the contents can be easily verified. The next article, entitled "A Survey on Content-Oriented Networking for Efficient Content Delivery," by Jaeyoung Choi *et al.* presents a comprehensive survey on content naming and name-based routing, quantitatively compares CON routing proposals, and evaluates the impact of the publish/subscribe paradigm and in-network caching.

Most Internet traffic is due to video content; thus, efficient video coding and streaming is significant. Contrasting the conventional client-server model, in peer-to-peer (P2P) distribution models, video is delivered to the end users not directly from the server but in a fully distributed fashion by converting users to content redistributors. This may result in a major economy in scale, espe-

[1] *1 exabyte = 10^{18} bytes = 1000 petabytes = 1 million terabytes*

[2] *One approach to decouple the search engines results from the content location is provided by the EC FP7 project COAST, "Content Aware Searching Retrieval and Streaming" (http://www.coast-fp7.eu)*

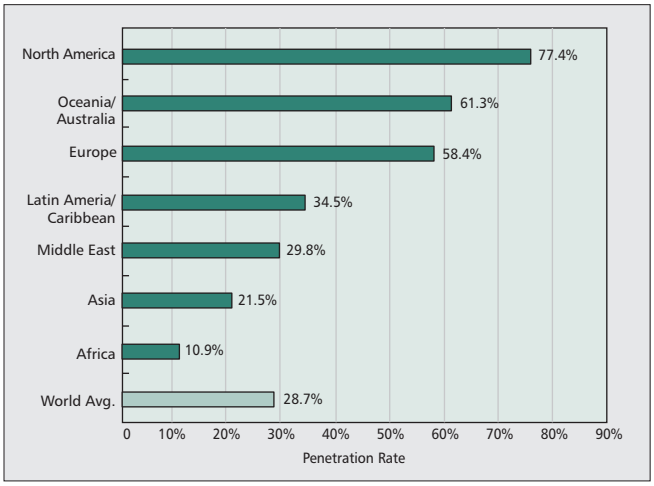

Figure 1. *World Internet penetration rate, 2010 (source: Internet World Stats [1])*

cially in cases of highly popular videos and proper selection of peer nodes. Furthermore, content needs to be displayed on a variety of devices featuring different sizes, resolutions, computational capabilities, and Internet access. If video is encoded in a scalable way, it can be adapted to any required spatio-temporal resolution and quality in the compressed domain, according to peers' bandwidth and end-user context requirements. The next article, "Peer-to-Peer Streaming of Scalable Video in Future Internet Applications" by Toni Zgaljic *et al.*, presents a fully scalable extension (scalable video coding, SVC) of the latest H.264/MPEG-4 AVC video coding standard, and describes successful experiments of streaming SVC encoded videos over P2P networks.

Many researchers envision that the future networked media applications will be multisensory, multi-viewpoint, and multi-streamed, relying on (ultra) high definition and 3D video. These applications will place unprecedented demands on networks for high-capacity, low-latency, and low-loss communication paths. The next article, "Improving End-to-End QoE via Close Cooperation between Applications and ISPs" by Bertrand Mathieu *et al.*, advocates the development of intelligent cross-layer techniques that, on one hand, will mobilize network and user resources to provide network capacity where it is needed, and, on the other hand, will ensure that applications adapt themselves and the content they are conveying to available network resources. Aiming to improve the quality of experience (QoE) and optimize network traffic, the article presents an architecture based on cooperation between the application providers, users, and communications networks.

The high volumes of content create specific trends for efficient information mining and content retrieval. In the near future, search engines should not respond to a user query by just finding the most popular content, but what the user is actually seeking. As such, personalization and contextual issues should be taken into account. The next article, "System Architecture for Enriched Semantic Personalized Media Search and Retrieval in the Future Media Internet" by María Alduán *et al.*, describes a system architecture that handles, processes, delivers, and finds digital media by providing the methods to semantically describe contents with a multilingual-multimedia-multidomain ontology, annotate content against this ontology, process the content, and adapt it to the network and network status. The article presents the architecture, and the modules' functionalities and procedures, including the system application model, to the future media Internet concepts.

Finally, in the future media Internet users will request new methods of communication and interaction, with much better QoE, well beyond today's communication forms. It is expected that voice over IP, videoconferencing, IPTV, email, instant messaging, and so on will be completed by virtual environments and 3D virtual worlds, where friends and colleagues will meet, chat, and interact in more natural ways. The last (but not least) article of this special issue, "Automatic Creation of 3D Environments from a Single Sketch Using Content-Centric Networks" by Theodoros Semertzidis *et al.*, describes an innovative core application that provides an interface where the user sketches in 2D the scene of a virtual networked world, and the system exploits dynamically similarity search and retrieval capabilities of the search-enabled content-centric network to fetch 3D models that are similar to the drawn 2D objects. The retrieved 3D models act as the building components for an automatically constructed 3D scene.

Before we leave you to enjoy this special issue, as guest editors we would like to thank all authors, who invested a lot of work in their really valuable contributions, and also all reviewers, who dedicated their precious time in providing numerous comments and suggestions. Last but not least, we would also like to acknowledge the enlightening support of the Editor-in-Chief, Dr. Steve Gorshe and the publication staff.

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BIOGRAPHIES

THEODORE ZAHARIADIS [M] (zahariad@synelixis.com) received his Ph.D. degree in electrical and computer engineering from the National Technical University of Athens, Greece, and his Dipl.-Ing. degree in computer engineering from the University of Patras, Greece. Currently he is associate professor at the Technological Education Institution of Chalkida, Greece, and chief technical officer at Synelixis Solutions Ltd. From 1997 to 2003, he was with Lucent Technologies, first as technical consultant to ACT, Bell Labs, New Jersey, and subsequently as technical manager of Ellemedia Technologies, Athens, Greece, while from 2001 to 2006 he was also chief engineer at Hellenic Aerospace Industry. Since 1996 he is involved in various EC funded projects and currently chairs the EC Future Media Internet Architecture Think Tank (FMIA-TT) and the EC Future Internet Architecture (FIArch) Group. He is a member of the Technical Chamber of Greece and ACM. His current research interests are in the fields of broadband wireline/wireless/mobile communications, content-aware networks, and sensor networking. Since 2001 he has been a Technical Editor of *IEEE Wireless Communications* and has served as principal guest editor of many special issues of magazines and journals.

GIOVANNI PAU (gpau@cs.ucla.edu) is a research scientist at the Computer Science Department of the University of California, Los Angeles. He obtained a Laurea degree in computer science and a Ph.D. in computer engineering from the University of Bologna. He served as Vice Chair and secretary of the ComSoc Multimedia Technical Committee and as Vice Chair for North America. He served as Technical Program Committee Vice-Chair for IEEE ICC '06 General Symposium, Technical Program Committee Co-Chair for IEEE International Workshop on Networking Issues in Multimedia Entertainment (NIME '06), and Technical Program Committee Co-Chair for NIME '04) in conjunction with IEEE GLOBECOM, He is Associate Editor-in-Chief and co-founder of *IEEE Communications Society Multimedi*a and a Steering Committee member for IFIP MedHocNet Mediterranean Ad Hoc Networking Workshop since 2002. He serves as Associate Editor of the Elsevier *International Journal of Ad Hoc Networks* and Springer *International Journal on Peer-to-Peer Systems*. His current research interests include mobility, wireless multimedia, peer-to-peer and multimedia entertainment, vehicular networks, and future Internet archtectures.

GONZALO CAMARILLO (Gonzalo.Camarillo@ericsson.com) works for Ericsson Research in Finland. He received M.Sc. degrees in electrical engineering from the Stockholm Royal Institute of Technology, Sweden, and Universidad Politecnica de Madrid, Spain. His research interests include signaling, multimedia applications, transport protocols, and networking architectures. He has authored a number of RFCs, books, patents, and scientific papers on these areas. He has co-authored, among other standards, the Session Initiation Protocol specification (RFC 3261). He has served on the Internet Architecture Board and has chaired a number of Internet Engineering Task Force (IETF) working groups. Currently, he is director of the Real-Time Applications and Infrastructures area at the IETF. He is also IETF liaison manager to the Third Generation Partnership Projects.