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Next Generation Networks for Distributed Electronic Resources: Opportunities and Challenges

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ABSTRACT

The changes in the lifestyle of the people, new applications, technological developments and the telecommunication market drive the adoption Next Generation Network (NGN) as the new network architecture. NGN has a service-centric architecture which promotes agile creation of services and then maintenance of these services with end-to-end QoS support. In the current era, every internet user is a potential electronic resource user. Due to the transition from the traditional mode of collections to the electronic resources and the heterogeneity and distributed nature of the electronic resources, a state of the art communication infrastructure is the key component of electronic resource providers. In this regard, NGNs can offer numerous advantages to the electronic resource providers. In this paper the use of NGNs for delivering distributed electronic resources is investigated. The opportunities and challenges are presented.

Keywords: Next generation networks, IP multimedia subsystem, Distributed electronic resources, Opportunities, Challenges.

I. Introduction

Due to unexpected and unpredicted growth of Internet, it is now not only connecting billions of devices to each other from all over the world, but also affecting every single part of our lives today. Although this growth is one of the reasons behind the total mind shift from traditional networks to Next Generation Networks (NGNs), the end-users of the Internet should also be taken into account as the key factors in defining the future road map in this area. Users constitute the main customers of the networking market and the trends in society become more and more important in shaping the NGNs services. The first step was from the companies by launching online services such as banking and governmental follow up.

However, the services that could be easily integrated into the social life such as social network services (SNS) and the weblogs are now becoming popular. Every single user behaves as a server today by sharing photos and videos with other users from all over the world. In addition to this change in user behavior, enterprise users are also moving their daily life over global networks by depending on tele-presence services for meetings and by outsourcing the call-centers to other continents. Technological developments have also been accompanying the society in this journey. First of all, the shift from the circuit switched networks to the packet switched ones was the main innovations in this area. This is further supported by the obsolescence of Time Division Multiplexing (TDM). Next, the broadband technologies became widespread due to emerging access technologies as summarized in Fig. 1. More importantly, in recent years, the mobile broadband subscriptions have overtaken fixed broadband subscribers. As of today, both the Internet connection itself and the capacity of the connection could be thought as "given by default" thanks to the technological developments in the last two decades. In addition to the increase in the number of users and devices connected to the network, the addition of new device types such as sensors, micro-controllers and other electronic devices is also a result of technological developments.

The situation of the telecommunication market and the competitive environment from ISP perspective are the other factors accelerating the realization of NGNs. The major change in the market conditions is the saturation of the network in means of legacy voice services. Combined with the competitive environment, the rates for voice services dropped significantly. Moreover, the number of fixed line subscribers has also been decreasing due to Fix

Mobile Convergence (FMC). Value added services such as Triple Play or even Quadruple Play are now the popular products for providers since neither the growth in demand for bandwidth nor phone calls are yielding growth in the revenue. On the other hand, technological developments led into little progress on reducing operating costs. The NGN services are also imposing new rules to the market, since reduced time to market, reliability, sustainability and flexibility are the new concerns compared to the traditional network services such as voice (Coomonte, Feijoo, Ramos, & Gomez-Barroso, 2013). As a result of the motivations from the society, technology and market, the traffic characteristics experienced a dramatic change. Internet traffic proportions are becoming largely video and real time traffic that does not tolerate latency as given in Fig. 2. However, the traditional best effort model over Internet Protocol (IP) for service provisioning is insufficient for providing carrier grade services such as IP television (IPTV) with real-time characteristics or Voice over IP (VoIP).

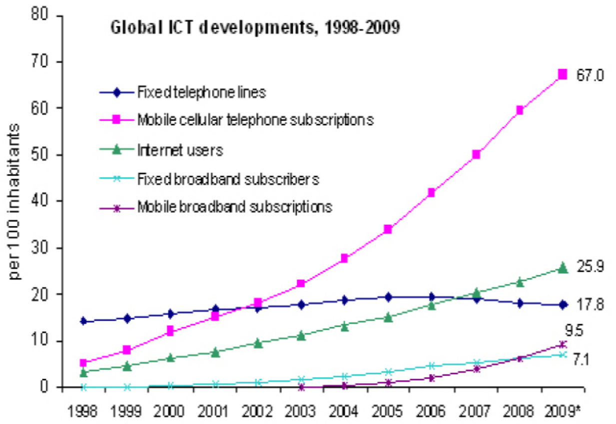

Fig. 1. Global ICT developments 1998-2009 (ICT, 2009)

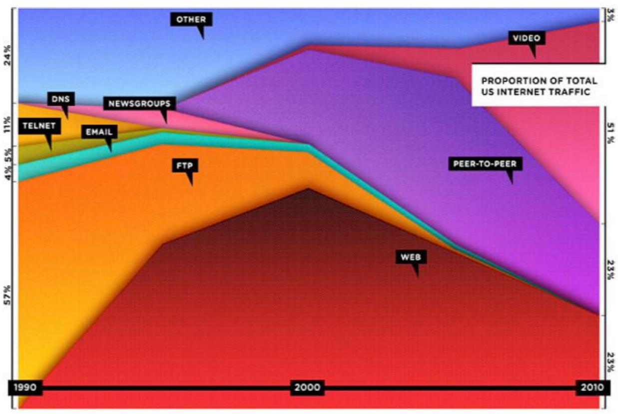

Fig. 2. Change of traffic composition in the last 20 years (WIRED, 2010)

NGNs will network any person, device and resource independent of location, distance, and time, through integrated intelligent interfaces and with enriched media (Crimi, 2000), (NTT, 2008). Currently, the largest network Internet has been connecting billions of people and devices all around the world and has been enabling various kinds of services for their use. The evolution of Internet towards the NGNs will bring additional value to human life by improving quality of life and by enabling new life experiences. NGNs will simply provide a 'playground' for everybody to create and deliver services to others and convey information to all our senses. NGN services can be mainly grouped into three according to the target user as society, business and individuals. Some examples of NGN services for the society are telemedicine, health care, disaster prevention information systems, e-government and distance learning, electronic library services. Enterprise VPN, Software as a Service (SaaS) and telepresence are the major services for the business sector such as enterprise users. Finally, the individuals will be benefiting from NGN over IPTV, home security, gaming and Video on Demand services.

In this paper the use of NGNs for delivering electronic resources is investigated. Due to the huge increase in the number of Internet users and potential users of electronic resources such as e-books, e-journals, and audio books, communication infrastructures of electronic resource providers are heavily loaded. Therefore, the electronic resource providers are constantly looking for alternative technologies to meet this increasing demand. Due to its distinct advantages over traditional computer networks, NGNs can play a key role for the electronic resource providers. The remainder of the paper is as follows. Section II presents the use of NGNs for delivering distributed electronic resources is investigated. Section III presents the opportunities and challenges of NGNs. Finally, Section IV concludes the paper.

II. Next Generation Networks

A Next Generation Network (NGN) is a packet-based network that is able to provide services over multiple broadband, QoS-enabled transport technologies (Zhang & Ansari, 2011). A service layer that is separate from the transport layer provides independence to service-related functions from underlying transport related technologies (Knightson, Morita, & Towle, 2005). The NGN infrastructure is expected to support a multitude of access networks (such as cable, mobile or fixed line access networks) and a broad range of end-devices. The amount and type of the traffic will be unpredictable since more and more traffic will be generated by third party service users. Moreover regular customers will be able to provide customizable services in a user specific way (Blum, Magedanz, Schreiner, & Wahle, 2009). These features of NGN result in a higher complexity compared to the traditional network architecture.

The Telecommunications and Internet converged Services and Protocols for Advanced Networking (TISPAN) (ETSI, 2009) is leading the current standardization activities on NGN design. The resulting NGN functional architecture is based on subsystems. Definition of these subsystems and the relationships between them are still under consideration. The NGN architecture with main building blocks and their functions will be provided in the following subsections. Moreover, the details of the IP Multimedia Subsystem (IMS) framework will be given since IMS is the main building block in NGN architecture for control and management of all services.

The NGN functional architecture is composed of a service layer and an IP-based transport layer. An overall architecture of TISPAN NGN is given in Fig. 3. The service layer of NGN includes the core IMS, the PSTN/ISDN Emulation Subsystem (PES), other multimedia subsystems/applications and common components. The addition of new subsystems over time to cover new demands and service classes will be easy due to subsystem-oriented architecture. Moreover, it also provides the ability to import (and adapt) subsystems defined by other standardization bodies. The transport layer is composed of a transport control sublayer and the underlying transport processing functions in the access and core networks. The transport control sublayer is further divided into the Network Attachment Subsystem (NASS) and the Resource and Admission Control Subsystem (RACS).

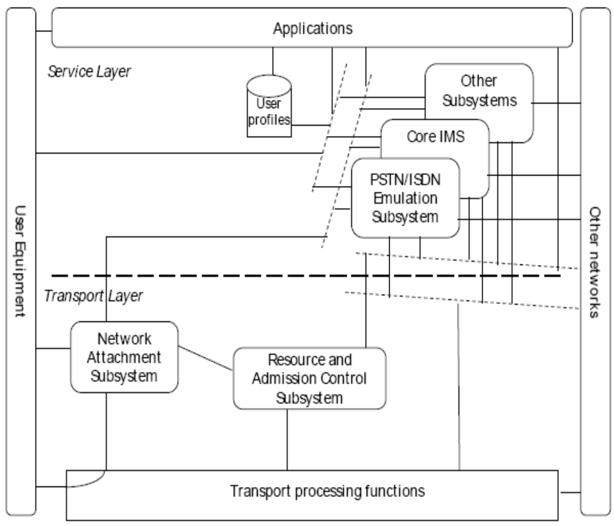

Fig. 3. TISPAN NGN overall architecture (ETSI, 2009)

The functionalities in NASS are dynamic provision of IP addresses and other terminal configuration parameters, authentication taking place at the IP layer in address allocation procedure, authorization of network access based on user profiles, access network configuration based on user profiles and location management taking place at the IP layer. RACS implements procedures and mechanisms handling policy-based resource reservation and admission control for both unicast and multicast traffic in access networks, core networks and customer premises networks. In addition, RACS is also responsible for the setting and modification of end to end quality of service, traffic policies, and transport-level charging.

IMS framework is the main building block in NGN architecture for control and management of all services. The NGN IMS, also known as Core IMS, is a subset of the 3GPP IMS defined in TS 123 002 (ETSI, 2005) which is restricted to the session control functionalities. Some IMS entities such as Application Servers (AS) and transport/media related functions such as the Multimedia Resource Function Processor function (MRFP) and the IP Multimedia Gateway Functions (IM-MGW) are considered to be outside the Core IMS. The NGN IMS supports the provision of SIP-based multimedia services to NGN terminals and the provision of PSTN/ISDN simulation services (Camarillo & Garcia-Martin, 2004). NGN IMS functional entities might exhibit minor variations compared to the 3GPP IMS entities due to differences in access networks and user equipment. The location of IMS in the overall NGN architecture and interactions with other NGN components are shown in Fig. 4. During the standardization efforts, each functional entity (FE) in NGN architecture is defined with multiple reference points. Each reference point stands for an interaction between two FE and the specifications for them such as protocols to be used for communication on an interface are left as open issues. Similar to the sub-system based architecture, this abstract reference point based interfacing concept enables current NGN architecture to be flexible for future adaptations and requirements.

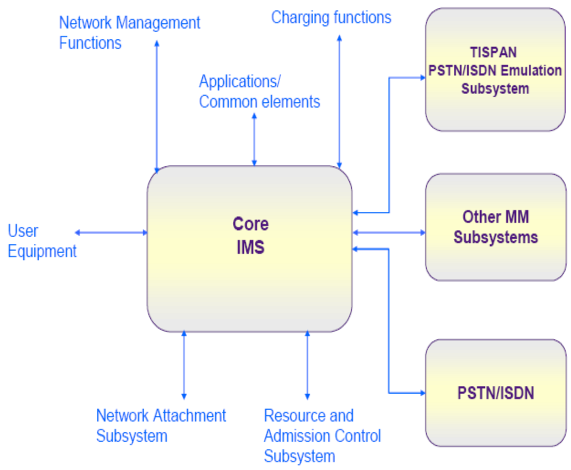

Fig. 4. TISPAN IMS and its environment

IMS is adopted in the core of NGNs to make network management easier by separating the control and the transport planes. On the one hand, this separation brings significant benefits in terms of new service creation and operational savings. On the other hand, the coordination between the different layers becomes a challenge for NGNs management. A real time resource control engine enabling access technology-agnostic interaction with the underlying network infrastructure is identified as a solution for this challenge (Rothenberg & Roos, 2008). Standards Development Organizations (SDOs) have been specifying policy-based resource management functionalities for IMS to ensure that QoS requirements of users are supported at the transport plane. Such functionalities are defined as the key factors in NGN operation, in order to deliver quadruple play services, data, voice, video and mobility, over Fixed and Mobile Converged (FMC) networks in a profitable way. Moreover, an NGN equipped with such resource management functionality is expected to ease the service set-up and provisioning the network and service delivery elements. The specific service provider requirements such as authorization, billing, accounting and control capabilities should also be taken into account during management.

III. Opportunities and Challenges for Delivering Distributed Electronic Resources via Next Generation Networks

For both telecommunication operators and content providers, NGNs bring several advantages including reducing the operational costs of multiple services, speeding up the development of new services and helping protect operators' businesses from cable and other service providers. The key advantages of NGNs for content providers can be listed as follows.

- NGNs build up coordination among multiple diverse resources.
- NGNs enable groupware and collaborative computing and support interactivity among multiple parties sharing data, voice and video.
- NGNs offer advertising and information delivery based on behavior patterns and personal preferences.
- NGNs offer many value added services including bandwidth on demand and call admission control.
- NGNs enable electronic transactions, verification of payment information, and trading.
- NGNs enable voice calls and e-mail messages through queue system, electronic access to catalog, stock, ordering, and customer information, and communication between customer and agent.
- NGNs offer added security and network features for virtual private networks.

Although NGNs can offer many advantages over traditional wired and wireless networks for providing electronic resources as mentioned above, they have still been under focus of standardization efforts. On the other hand, a general understanding of NGNs is now clear with the release of architecture and functional architecture of main components by European Telecommunications Standards Institute (ETSI). The three main aspects characterizing the NGN design are the packet-based networking, end-to-end multi-service QoS support and the separation of service and transport planes (Ganuza & Viecens, 2013). Replacement of circuit switching with packet switching enables NGNs provide services over multiple broadband transport technologies. This is also closely coupled with the QoS support for a wide range of services with different traffic types such as voice, data and video with different Service Level Agreements (SLAs). Finally, the separation of transport and service layers provides independence to service-related functions from underlying transport related technologies (Knightson, Morita, & Towle, 2005). Resulting in integration of existing infrastructure, this independence provides open interfaces that can be used to be interconnected by all providers to jointly create and manage NGN services. The current NGN design is shaped by the requirements of both the users and the providers.

The requirements imposed by the trends in society, the pattern in the technological developments and the market conditions focus on transforming the traditional network into a customer-driven and service-centric network. On the one hand, it is desired that the services are customizable in a user specific way (Blum, Magedanz, Schreiner, & Wahle, 2009) while providing complete independence from the underlying access, aggregation and core networks. On the other hand, end-to-end QoS requirements specified in SLAs are expected to be met by these networks without any performance degradation during the service life times (Stojanovic, Kostic-Ljubisavljevic, & Radonjic-Djogatovic, 2013). Furthermore, users are expecting to get these services in a cost effective way, while the providers aim to increase their profits.

NGNs could meet these requirements from different sources by applying a service-centric management framework. Such a framework should concentrate on service set-up, network and service delivery elements, provisioning and service accounting while taking the service provider and society needs into account. In other words, the NGN management should deal with designing the service properties, required network resources, required components and their behaviors, communication protocols among components for the purpose of control of the service, redundancies and security features. Moreover, the service has to be maintained until it is terminated while preserving the agreed QoS, security and robustness of the service.

Although there exists an overall agreement on the need of the functions for controlling resources in an NGN, a consistent implementation of solutions offered by different SDOs is far from reality. Convergence of different networks such as access, aggregation and core is one of the main ideas behind NGN. This will bring different operators into game who own parts of these domains with different transport technologies. This also requires a common understanding of NGN service management by all parties. The rapid development and deployment of NGN services will be possible, once the impact of new service to the existing infrastructure and the services being given is known beforehand. Therefore, a service composition and management system should exist over a resource control system. Both systems should be compatible to achieve convergence aim of NGN while satisfying the changing QoS requirements of the next generation services. The challenges on this existence are coordination in vertical level by providing correct binding of different transport and service level semantics and coordination in horizontal level by achieving end-to-end resource control across heterogeneous domains. Accordingly, we list the requirements for the service-centric NGN management as follows:

1. It should enable verification of the available network resources and facilities for setting up and carrying out the service such that QoS requirements of the new service are met without disrupting the QoS of existing services.
2. It should respond rapidly to the changing traffic patterns and requests for new types of services. Hence should facilitate an algorithmic implementation to enable automatic service creation and maintenance.
3. It should be modular that is management will be distributed over multiple devices as well as

operators due to the convergence in transport technologies.
4. It should be scalable to support for a variety of devices, users, locations, connections and QoS requirements.
5. It should enable "Horizontal Coordination" that is achieving end-to-end resource control across heterogeneous domains.
6. It should enable "Vertical Coordination" that is providing correct binding of different service level and transport level interfaces in an access technology-agnostic way (Rothenberg & Roos, 2008), (Li & Sandrasegaran, 2005).

In addition to the abovementioned management related issues, although NGNs bring several benefits to electronic resource providers, they require huge investments in infrastructure. This creates significant financial risks for the electronic resource providers as well as the telecommunications operators serving them.

IV. Conclusion

Although, in recent years, the number of traditional library users has decreased, there has been a huge increase in the number of electronic resource users. This trend necessities the use of new communication technologies and/or management techniques. In this paper, the use of NGNs for providing distributed electronic resources has been investigated. Though NGNs offer several advantages and opportunities over traditional wired and networks, they have some drawbacks that need to be addressed. These have been investigated in the paper, as well.

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