Computer Standards & Interfaces 36 (2014) 412–422

Contents lists available at ScienceDirect

Computer Standards & Interfaces

journal homepage: www.elsevier.com/locate/csi

Smart Ubiquitous Networks for future telecommunication environments

Chae Sub Lee [a], Gyu Myoung Lee [b], Woo Seop Rhee [c,*]

[a] KAIST, 291 Daehak-ro, Yusong-gu, Daejeon 305-701, Republic of Korea
[b] Telecom SudParis, 9 rue Charles Fourier, 91011 Evry Cedex, France
[c] Hanbat National University, 125 Dongseo-daero, Yusong-gu, Deajeon 305-719, Republic of Korea

ARTICLE INFO

Article history:
Received 7 November 2012
Accepted 20 August 2013
Available online 29 August 2013

Keywords:
Smart Ubiquitous Networks
Future networks
Context-awareness
Smart resource management
Fine granularity of traffic

ABSTRACT

In this article, future communication environments have been derived from the analysis of impacts of information communication technology and social service aspects. From the concepts of "Smart Ubiquitous Networks (SUN)" as a short-term realization of Future Networks in ITU-T, this article presents frameworks of the SUN with context awareness and smart resource management. As challenges, we propose methodologies and operational processes to support context awareness and new fine granularity of traffic for smart resource management. Finally we illustrate a use case of SUN considering a smart city to show how SUN capabilities contribute to build smart and ubiquitous communication environments.

1. Introduction

Telecommunication infrastructures have been changed significantly during the last two decades, vastly impacted by the use of IP, the development of mobile and the deployment of broadband. IP has been used for realizing a connected world by providing end-to-end connectivity over any transport networks. Mobile technologies provide connectivity to anyone at any place over the air, using wireless accesses. Broadband development is providing transport pipes for the delivery of information, over fixed or mobile networks. Combining these three developments is becoming the most important elements for building today's communication infrastructures, which form the basis of the information society.

Today, people live in the fully connected environment: most people are connected using mobile as well as fixed devices, without restriction from time, place and devices; most information available on-line, and therefore accessible over the networks also at any time and any place with any devices [1,2]. Combining these with mass deployment on broadband over fixed and mobile networks, the quality of on-line information is being developed in diverse ways: higher quality multimedia with higher resolution of videos (including 3D), personalization to fit individual's requirements and preferences, and finally information formed as knowledge and provided to the consumer. In addition, higher quality multimedia information over the huge number of fixed and mobile devices with various networking technologies such as broadcasting and peer to peer places requirements for operation of networks as well as effective and efficient delivery of services considering investments to the telecommunication infrastructures.

The information society resulting from Information Communication Technology (ICT) developments places demands for better features of information infrastructures, especially considering the diversity of various services, applications, end user devices through personalization with knowledge rather than just delivery of information. Recently "Smartness" by smart devices, smart networks and smart services is becoming an important subject for further enhancement of the information society.

ITU-T Study Group (SG) 13 [3] is developing global standards for telecommunication network infrastructures of the information society with a title "Future Networks (FNs) including cloud computing, mobile and Next Generation Networks (NGN)". SG13 has been involved with the developments of standards on various telecommunication networks and services such as IP-based networks, NGN [4], fixed mobile convergence and IPTV [5]. One of the main subjects in SG13 has been NGN since 2004 initiated by the first ITU-T Focus Group on NGN (FG-NGN) [6]. While NGN kept a major stream until the 2010, new initiatives have come to SG13, such as "FNs [7–11]", "Internet of Things (IoT) [12–14]" and "Cloud Computing [15]".

Considering emerging trends and requirements for smart telecommunication networks, this article introduces the key concepts of "Smart Ubiquitous Networks (SUN)" and provides a high-level architecture of the SUN with relevant capabilities. SUN is a new initiative being developed by ITU-T SG13 since 2011 covering limited parts of FNs but those expect to be realized soon. This article highlights on context awareness and smart resource management for smart telecommunications networks. As challenges for SUN development, we propose methodologies and operational processes to support context awareness

* Corresponding author. Tel.: +82 42 821 1749.
E-mail address: wsrhee@hanbat.ac.kr (W.S. Rhee).

0920-5489/$ – see front matter.
http://dx.doi.org/10.1016/j.csi.2013.08.012

with other networking capabilities and new fine granularity of traffic for smart resource management. Finally we illustrate a use case of SUN considering traffic accident management in a smart city to show how SUN capabilities contributed to build smart and ubiquitous communication environments.

The remainder of this article is organized as follows. Section 2 identifies future telecommunication environments impacted from ICT developments and telecommunications operations. Section 3 introduces SUN as a telecommunication infrastructure for providing a solution for the environments identified in Section 2. Thus, Section 3 presents a framework of SUN covering requirements, capabilities, functional architectures and relevant key functions. In Section 4, we present further challenges for smart telecommunications networks in the course of SUN developments focusing on new fine granularity of traffic for smart resource management. Section 5 introduces how SUN capabilities are applied to telecommunications through a use case. Section 6 provides a conclusion.

2. Future telecommunication environments

2.1. Impacts from ICT developments

The feature-rich capabilities provided to customers are the result of end-user devices, networks and services benefiting from ICT developments. To maintain the pace of technological change, telecommunication infrastructures have been continuously improved to extend capabilities and functions. In this section, we show that impacts of ICT developments featured "Smart and Ubiquity" which is an important phenomena in emerging trends.

2.1.1. Emergence of smart end user devices

An important emerging trend of end user devices can be represented by "Smart capabilities using ubiquitous connectivity". Devices labeled "smart" are examples of such trends and many of them are already available. As the first example, Smart Phones are very popular and widely available today, providing an integrated personal communication and service platform taking advantage of connections over mobile and other wireless accesses utilizing separate as well as integrated manner (i.e., the multiple-connection capability). Recently, Smart TV equipped with smart capabilities to provide bi-directional service features such as receiving TV programs and content from servers as well as providing content. It is expected that Smart TV will evolve into a smart home gateway to communicate with various devices inside the home. Finally, Smart Small Devices (e.g., sensors and actuators) enable connections to all manner of consumer devices to provide status information.

2.1.2. Enhancement of networking capabilities

Smart end user devices require more complicated, sensitive and differentiated treatment of communication requirements. For example, a specific content would be delivered to the Smart Phone in abstracted resolution but delivered in very high resolution to the Smart TV in the case of supporting seamless mobility. For proper delivery of service, several issues should be considered.

First consideration should be given to various types of media (e.g., video, audio, different codecs) with different Quality of Service (QoS) and Quality of Experience (QoE). The differentiated delivery of content according to the delivery policy should be considered as well as taking into account seamless handover among different devices. Finally another important issue for networking capability is processing of data traffic, from tiny bits to large volumes and from short to very long connection time. While handling various different types of traffic, network operators are seeking to find solutions for efficient and effective management of resources and to provide fair treatment of end user service requirements for all users — including avoiding heavy users monopolizing network resources.

2.1.3. Upgrade of social services

Telecommunication networks and services are essential infrastructures for the operation and evolution of the information society. Information society will evolve and update through further evolution of ICT such as over "Smart City". This would direct a highly advanced information society, characterized by two key features, "High security" and "Advanced convenience".

High security provides more than traditional security with its on-line vulnerabilities such as spam, viruses, hacking etc. High security should be extended to protect human life, for example, Child Online Protection (COP) [16] from inappropriate on-line content. Information regarding content will be used to protect children from in-appropriate on-line content with minimum intervention. Information regarding the context of the end user will be used to identify the situation of that child to monitor, warn and identify any incident.

Advanced convenience will be based on the knowledge about the communication environment. Smart end user devices allow collection of personal preferences or habits of service usage to facilitate advanced convenience for communication taking into account economic considerations such as the price of communications and services. In addition, networks and service-related functions should have capabilities to monitor the status of resources already assigned and reserved. Consequently they provide best connections with proper QoS/QoE to the end users and prevent traffic congestion or network failure by automation of networks and service operations.

2.2. Impacts on telecommunications operations

The roles and responsibility of telecommunications networks in terms of information infrastructure have been continuously increasing. Concerns are on the remaining security and extending effective and efficient operation of the networks to include fair provision of services. "Network neutrality", "Investments to the networks versus revenue sharing of the business" and "Fairness of the services" are critical examples which require different roles and responsibility of the telecommunication networks. This section presents impacts of ICT developments into network operations and vice versa.

2.2.1. Efficient and effective telecom operation

Many new emerging services such as Smart TV, HDTV, 3DTV, video streaming, etc., require networks to allocate more resources to support more bandwidth and various service features such as real-time, non-real-time, store-forward and others. This shall require additional network resources needing huge investments. A few zealots (users and providers) for specific services/applications generate quite large amounts of traffic at specific time, which has the potential to monopolize large amounts of network resources [17]. As shown in Fig. 1, this monopolization of network resources (bandwidth and number of sessions etc.) by few users (10–20% of subscribers occupying more than 95% of traffic) prevents proper usage of relevant network resources by other users. This monopolization of resources (including data explosion) potentially may degrade service quality and, in addition, prevent further development of smart devices and their services. In the case of mobile (wireless) environments, also the developments of smart end user devices such as Smart Phones are made available through various broadband multimedia services previously used in fixed environments. Examples are Web-TV, multimedia services including mobile networked games, video-phone and others. The trend of mobile (wireless) services usage of bandwidth is causing issues of traffic congestion, reducing number of users in mobile (wireless) access networks. In general, most of service traffic (from servers) are transported over fixed environments and are delivered to the end user devices over mobile (and wireless) access which are constructed with quite limited resources comparing with fixed access in terms of bandwidth, number of users, etc. Therefore it is noted that incoming traffics from fixed network environments to the mobile (wireless) access environments