TRAFFIC MANAGEMENT FOR MOBILE BROADBAND NETWORKS

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Mobile terminals are becoming the primary Internet devices for most of the people in the world, and smartphone users are generating on average 10 times more traffic than other users. Current forecasts expect mobile data traffic to grow by 300–500 percent over the next 10 years, whereas the capacity of cellular infrastructure only doubles every two years. In order to cope with these challenges, it is critical that telecom operators and Internet service providers adopt smarter traffic management and pricing strategies. By 2020, more than half of the revenue in the global broadband industry is likely to be from two business models: "wholesale" and "two-sided" fees for improved access capacity and quality. These models require enforcement of stringent policy control mechanisms for bandwidth management, quality of service (QoS), and service level agreements.

In this area, several research and technology challenges are still to be addressed, such as:

- How can the network be made service-, state- and/or context-aware in order to apply specific policies to enhance the desired end-user quality of experience (QoE)?
- How is it possible to increase the degree of fairness, in terms of the data volume, among peers and still maintain the desired QoE of all users in the wireless network, especially during congested periods?
- What strategies may be adopted for handling and efficiently offloading mobile data traffic using multiple wireless networks?
- How can different IP flows of the same packet data network (PDN) be routed via different access technologies, and moved from one access to another for seamless offload?
- How can network sharing with a large degree of management flexibility and independence between the shared resources be enabled?

This timely Feature Topic of *IEEE Communications Magazine* brings together key contributions from industry and academia, which address some of the above challenging issues for existing and future mobile broadband networks within and beyond the existing standardization frameworks.

In response to the call for papers, a large number of submissions were received. The papers underwent a rigorous review process, following which five outstanding works were selected for publication. These five articles are in the broad areas of customer service assurance, service/user differentiation for congestion management, strategies for mobile data traffic offloading, IP flow mobility for future wireless networks, and virtualization techniques for efficient network sharing. These articles are expected to stimulate new ideas and contributions within the research community, in addition to providing readers with some relevant background information and viable technical solutions to the main traffic management issues in mobile broadband networks.

The first article of the Feature Topic is by Alessio Botta, Antonio Pescapè, Claudio Guerrini, and Marin Mangri. It is entitled "A Customer Service Assurance Platform for Mobile Broadband Networks" and presents an intelligent customer service assurance (iCSA) platform and related applications to cope with the key issues that telecom operators are facing today in assessing and improving the service quality experienced by their customers. The authors introduce the iCSA platform, its operation and relevant business processes, and present how the solution is deployed using interface probes as the main source of measurements. Several benefits of the proposed platform are illustrated based on experimental results attained for two crucial customer cases: mobility and session management, and root cause analysis of TCP connections. The multidimensional view provided by the iCSA makes it possible to define customer/service-centric data models, aggregate problems in the control and user plane, and perform root cause analyses and troubleshooting with a large degree of automation.

The next article, entitled "Deprioritization of Heavy Users in Wireless Networks" by Joe Zhou, Kevin Sparks, Nandu Gopalakrishnan, Pantelis Monogioudis, Francis Dominique, Peter Busschbach, and Jim Seymour, discusses

the benefits of lowering the scheduling priorities of heavy users (or bearers or applications) in the medium access control (MAC) layer of the (e)Node B (base station for Universal Mobile Telecommunications System [UMTS] and Long Term Evolution [LTE] networks) for congestion management with respect to throttling at the packet data network gateway (PDG) level and the enabling technologies to implement the feature in real networks. The proposed approach of centralized heavy user tagging, by either monitoring tools or offline/online charging servers, and localized deprioritization accomplishes the same goals of a costlier and more complex throttling approach in "closed loop" by allowing for radio access network (RAN)-level congestion sensing and feeding back such information to a central entity (at PGW or gateway general packet radio service [GPRS] support node level), which will then enforce "selective" throttling of heavy user traffic.

In the article entitled "A 3W Network Strategy for Mobile Data Traffic Offloading," Yongmin Choi, Hyun Wook Ji, Jae-yoon Park, Hyun-chul Kimy, and John A. Silvesterz first review various third-generation (3G) data offloading solutions supported by the Korea Telecom (KT) Corporation, including direct tunneling, gateway offloading, traffic policing/shaping-based offloading, and WiFi or femtocell offloading. Then the authors provide a summary of the usage statistics, traffic composition, and growth trends of KT's 3W wireless networks (wideband code-division multiple access [WCDMA], WiFi, and WiBro) in 2010, in terms of number of subscribers and amount of total traffic, clearly showing the effects of the proliferation of smart phones and the introduction of flat-rate pricing. They also present how much traffic a user generates on average in each of the three different mobile networks. The results indicate that strategically deploying multiple different types of wireless networks, addressing different needs/scenarios of mobile users, is an effective way to handle the huge amount of 3G mobile data traffic.

Antonio de la Oliva, Carlos J. Bernardos, Maria Calderon, Telemaco Melia, and Juan Carlos Zuniga in the article entitled "IP Flow Mobility: Smart Traffic Offload for Future Wireless Networks," present and compare two possible approaches to IP flow mobility offloading: client-based and network-based. The former relies on an IP host-centric solution, which makes use of a mobility client in the host (mobile node) and a mobility agent in the core network. The latter relocates the IP mobility client functionality from the mobile node to the network, thus making the mobile device agnostic to any IP mobility signaling. The technology is currently being standardized by the Internet Engineering Task Force (IETF) and has been adopted by the Third Generation Partnership Project (3GPP) as a technique for seamless 3G offload.

Finally, the article entitled "Network Sharing in Next Mobile Network: TCO Reduction, Management Flexibility and Operational Independence" by Ashiq Khan, Wolfgang Kellerer, Kazuyuki Kozu, and Masami Yabusaki, introduces a new network architecture for flexible and dynamic network sharing among multiple network operators. The proposed architecture model for fourth generation (4G) and beyond next mobile network (NMN) is based on an end-to-end physical infrastructure, which can be fully shared with the help of network virtualization technologies. The isolation properties of the proposed virtualization technology makes it possible to expand the scope of current network sharing, increase the operators savings in terms of total cost of ownership (TCO), and address the requirements of future resource sharing solutions.

In closing, we would like to thank all the stakeholders who have made this Feature Topic possible: colleagues who spread the Call for Papers around, the many authors who submitted papers to our special issue, and the team of reviewers who helped us to select and further improve the outstanding papers published in this Feature Topic. We are especially grateful to the Editor-in-Chief of *IEEE Communications Magazine*, Dr. Steve Gorshe, as well as to the members of the editorial board for their invaluable help and for hosting this Feature Topic, and to IEEE ComSoc's editorial staff who produced the final material. We hope that this endeavor will meet the readers' expectations, for whom this Feature Topic on Traffic Management for Mobile Broadband Networks has been prepared.

BIOGRAPHIES

DAVID SOLDANI (david.soldani@huawei.com) received an M.Sc. degree with maximum score and cum laude approbatur in electronic engineering from the University of Florence, Italy, in December 1994; and a D.Sc. degree in technology with distinction from Aalto University, Finland, in October 2006. He has been in the ICT industry for more than 15 years. From 1997 to 2007 he was at Nokia in various technical and research management positions. From 2007 to 2009 he was a research director and head of Customer Networks & Solutions and Solutions & Services Innovation functions, Research Technology & Platforms (RTP) at Nokia Siemens Networks (NSN), Munich, Germany. In this role, he was responsible for driving the alignment between the RTP research portfolio, the NSN network architecture vision and technology strategy, and future customer needs, and driving innovative research projects for improving professional services and solutions. Prior to joining Nokia, he was a graduated officer in the Italian Military Navy, Livorno, Italy. He is currently vice president of the European Research Centre and head of European Network Solutions R&D at Huawei, Munich, Germany. In his current role, he is responsible for driving the alignment between Huawei All-IP E2E solutions and future customer needs, taking a holistic view of both service requirements and how these requirements affect the structure, technology, and network components of the optimal solution for each part of an operator's network. His areas of technical expertise include wireless mobile networks (TETRA, GSM, EDGE, WCDMA, HSPA+, LTE/SAE, and WiMAX), QoE and QoS, policy control and charging, CEM, network planning, troubleshooting and optimization, transport network layer technologies (IP/MPLS/Ethernet), and wireline broadband access technologies (xDSL, xPON). He has been selected seven times to receive special awards in recognition of his role, commitment, professionalism, and outstanding contribution at Nokia, Nokia Siemens Networks, and Huawei Technologies. He has published or presented numerous international papers, contributed to the publication of many books, and holds several international patents. He has been a Guest Editor of *IEEE Network* and *IEEE Communications Magazine*, and he has taken part in a number of IEEE Technical Program Committees for international conferences, journals, magazines, and workshops in areas of mobile broadband networks.

SAJAL K. DAS [SM] is a University Distinguished Scholar Professor of Computer Science and Engineering and the founding director of the Center for Research in Wireless Mobility and Networking (CReWMaN) at the University of Texas at Arlington. His current research interests include resource and mobility management in wireless networks, wireless sensor networks, mobile and pervasive computing, smart environments and smart heath care, security and privacy. He has published over 500 papers and over 37 invited book chapters in these areas. He holds five U.S. patents in wireless networks and mobile Internet, and coauthored three books: *Smart Environments: Technology, Protocols, and Applications* (Wiley, 2005), *Mobile Agents in Distributed Computing and Networking* (Wiley, 2011), and *Handbook on Securing Cyber-Physical Critical Infrastructure* (Morgan Kaufmann, 2012). He is a recipient of the IEEE Computer Society Technical Achievement Award (2009) for pioneering contributions to sensor networks and

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