A Study of QoS Support, Performance and Pricing of Mobile Data Plans in the USA and South Korea

Ramneek[*, **], Patrick Hosein[***], Wonjun Choi[*, **], Woojin Seok[**]

* Department of Grid and Supercomputing, Korea University of Science and Technology, Daejeon, Korea
** Department of Advanced KREONET Application Support, Korea Institute of Science and Technology Information (KISTI), Daejeon, Korea
*** Department of Computing and IT, The University of the West Indies, Trinidad and Tobago

ramneek@kisti.re.kr, patrick.hosein@sta.uwi.edu, cwj@ust.ac.kr, wjseok@kisti.re.kr

Abstract— **There has been a phenomenal growth in wireless and cellular network technologies since the past few years. This has further led to a rapid increase in the number of mobile subscribers and the amount of data traffic. To accommodate the exponentially increasing data traffic, while optimizing the spectral efficiency, different techniques such as offloading, etc. have been adopted by the network operators. However, the demand is expected to eventually exceed the capacity, and hence, there is a need of more efficient network management techniques. Pricing is now considered as one of the effective ways to regulate the user behavior and manage the network resources, while optimizing the Quality of Service (QoS) and the operator revenue, at the same time. By analyzing the key features and limitations of different pricing plans offered by telecom operators in different countries, this paper attempts to facilitate the better understanding of the implications of pricing strategies on the network performance and the user satisfaction.**

Keywords— **Pricing, QoS, Resource Management, Congestion Control, Network Neutrality**

I. INTRODUCTION

There has been a considerable advancement in the fields of wireless and cellular communication in the past few years. This has led to an exponential increase in the data traffic. As per the forecast by Cisco VNI [1], the global IP data traffic is expected to exceed 1.1 Zattabytes per year and 2.0 Zettabytes per year by the end of 2016 and 2019, respectively. The alarming factor is that more than half of the IP traffic will be generated by the mobile devices such as tablets, smartphones, etc. The main reason behind this is the advancement in network technology and infrastructure (broadband speeds are expected to double by 2019), the increase in the number of connected devices over internet (number of connected devices over the internet will be almost three times the global population by 2019), and the advanced capabilities offered by these smart devices. In addition, the advancement in the network technologies has resulted in the convergence of diverse platforms, allowing the different types of applications such as streaming media applications, voice and best effort data to be supported over the same network infrastructure.

Hence, the network operators are required to manage their network resources efficiently in order to accommodate the ever-increasing data traffic, while providing QoS to the end users.

To accommodate the exponentially increasing data traffic, while optimizing the spectral efficiency, different techniques such as offloading, etc. have been adopted by the network operators [2]. However, the demand may eventually exceed the capacity, and hence, there is a need of more efficient network management techniques. Pricing is now considered as one of the alternatives to regulate the user behavior and manage the network resources, while optimizing the Quality of Service (QoS) and the operator revenue [3]. The users are intrinsically price sensitive, and hence the network operators should adopt flexible data pricing strategies, in order to satisfy the user requirements while optimizing the revenue and resource utilization.

Due to high increase in data traffic and the number of subscribers, and different QoS needs of different users and applications, the flat-rate pricing schemes are no longer suitable. The static pricing strategies that are currently being used by network operators lack the capability of offering any incentives for the end users to dynamically adjust their demand for better utilization of the network. Pricing is an important method of traffic management, as there is a direct relationship between the pricing and the QoS received by the end user. If the users want improved performance, then they must be willing to pay higher price in return. In addition, the pricing plans should be flexible enough to allow the users to choose the plan that is most appropriate for them, based on their QoS requirements and willingness to pay on one hand, and to allow the operators to maximize the resource utilization and revenue, while providing satisfactory service to its subscribers, on the other hand.

In the present work, we provide a brief review about the different pricing plans offered by the major telecom operators in USA and South Korea, and discuss about their potential for supporting QoS in the current and the future network standards. In case of USA, we will discuss about the top four national carriers- AT&T, Verizon, Sprint and T-Mobile,

which account for majority of the market share. In addition, we will consider SKT, KTF and LGU for South Korea. In addition, we will discuss how the current pricing plans should be modified to incorporate QoS, which is an important feature supported by the current 4G networks.

The rest of the paper has been organized as follows: Section II describes the characteristics of a good pricing strategy; Section III will provide a review of the pricing plans offered by telecom operators of USA and South Korea; Section IV includes summary and discussion, followed by the conclusion in Section V.

II. CHARACTERISTICS OF A GOOD PRICING STRATEGY

With the deployment of high-speed 3G and 4G LTE standards, capable of provisioning enhanced performance and QoS to the end users, the numbers of users as well as their performance demands have increased rapidly in the recent past. As the spectral capacity is limited, therefore, other traffic management techniques, such as pricing, play an important role in ensuring that the network users continue to receive acceptable performance, while optimizing the operator revenue even when the network capacity is limited.

Therefore, it is important to design the pricing plans carefully. If the prices are set too high, then the customers will not be attracted to the operator, and might also switch to other operators, resulting in a high churn [4]. On the other hand, if the prices are too low, then the number of subscribers can increase considerably, resulting in lack of capacity and failure to provide acceptable performance. Therefore, a good pricing plan should be able to maintain a balance between the user requirements and the operator profit, as schematically depicted in Figure 1. The telecom operators must maintain a balance between these objectives using appropriate pricing and resource provisioning.
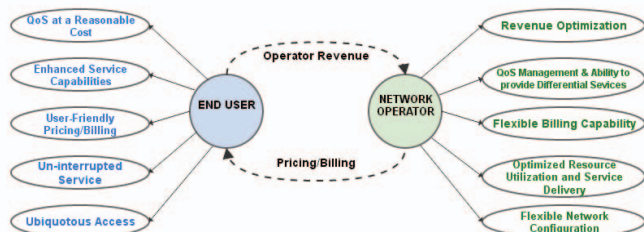

Figure 1. End User and Operator Requirements

The wireless network standards in the past were not capable of supporting QoS, and hence the flat-rate pricing schemes used by the operators were sufficient to provide best-effort service. However, the current pricing plans must be modified to take QoS into consideration. A good pricing plan is one that is simple, flexible, adaptable, fair and network neutral. The plan must be simple, so that the users can choose the most optimal plan with ease. For instance, if the data limit chosen by the user is too small, then the user might have to pay higher for additional capacity, however, if the chosen limit is too large, then he might end up paying for the un-used capacity. In addition, the pricing strategy should be flexible enough so that

it can be easily implemented by the operator, and can be easily adapted to the newer technologies, as they evolve. The plans should be fair to the end users, and there should not be any kind of user-based or application-based throttling or discrimination, leading to the violation of network neutrality principles.

III. REVIEW ON DATA PRICING IN USA AND KOREA

In this section, we will provide a brief overview of the data plans offered by various telecom operators of USA and South Korea, and provide a comparative analysis of their key features.

A. USA Telecom Operators

The top four wireless service providers in U.S. are AT&T, Verizon, T-Mobile and Sprint. All the operators have currently deployed the 4G LTE cellular communication standard in many areas, in addition to the legacy voice service that they provide. These four major cellular operators are responsible for providing the mobile services to the majority of the population in US. We will discuss the pricing plans offered by each one of them in detail, and provide a comparison of the offered data plans and their corresponding prices in Table 1.

1) AT&T: AT&T offers a variety of wireless plans and features including the mobile share value plan, AT&T next, and various other cell phone and device plans [5]. We will focus on the mobile data plans and ignore the device plans for the present work. In case of the mobile share value plan, the subscriber can choose the plan according to their monthly data requirements. There are a number of options, with varying data limits (from 300 MB to 50 GB), that the user can choose from. In addition, the user has to pay a fixed access fee, which is $25 per smartphone for 5GB or lesser data limits, while for 15 GB or higher, it is $15 per smartphone. Apart from this basic access and data price, users can add more devices (smartphones, tablets etc), where data can be shared but additional access fee has to be paid for every individual device. Apart from the basic data, there are some additional features provided to the users of mobile share value plan such as rollover data (valid up to a month), unlimited talk and text, truly shareable data for 1 to 10 devices, unlimited international texting to almost 120 countries, and unlimited call and text to Mexico and Canada for 15GB or higher plans. In case of an overage, the user will be charged $20 per 300 MB plan and $15 per extra GB used for higher plans.

2) Verizon: Verizon offers a variety of data plan, ranging from S size (1GB/month) up to XXL sized plan (18GB per month) [6]. Similar to AT&T, it allows the sharing of 4G data between a numbers of devices, with an access price of $20 per month for each smartphone line. In addition to smartphones, the data can be shared with other devices such as tablets at $10/month access fee or other connected devices at $5 per month per device. Since data can be shared among various devices, it also offers higher data plans with up to 100GB per month. All the plans include unlimited talk and text, and in

addition, users are allowed to shift to higher or lower data plans, whenever they want. If the users do not wish to switch to higher plans, then they shall be charged an overage fee of $15 for every extra GB used.

3) Sprint: In case of Sprint, the users can choose from various plans from 1GB to 60GB data limits, for individual use, or for sharing with other devices [7]. Similar to the other operators such as AT&T and Verizon, it also provides unlimited call and text, allows data sharing for up to ten devices, and free international texting from US to more than 180 countries. For 1 GB to 8GB data plans, there is an additional data access fee of $20 (when purchased with Sprint Lease or Easy pay); while for the higher plans the access fee is $15. In all the above plans, unlimited data is provided at 2G speed, after the high speed data limit is exhausted. In addition there is an unlimited data plan for $70 per month for first connecting line, and $60 per month for each additional line.

4) T-Mobile: T-Mobile offers 1GB, 3GB, 5GB and unlimited data plans for the individual users. In addition there are different offers for the shared data plans [8]. In each of the individual data plans, there is a provision of unlimited call and text in US, Mexico and Canada. The user can also increase the high speed data limit, if required. As T-mobile provides unlimited data, the user continues to get the data service at the speed of 2G network, even when the monthly high-speed data is exhausted. It also allows the use of data stash in case of 3GB and 5GB plans, where unused monthly high speed data is rolled over to next month.

TABLE 1. COMPARISON OF BASIC DATA PLANS OFFERED BY AT&T, VERIZON, SPRINT AND T-MOBILE FOR A SINGLE SMARTPHONE LINE. ALL THE PRICES ARE IN $ AND REPRESENTED AS (DATA PRICE + ACCESS FEE) PER MONTH.

	Up to 1GB	*Up to 5GB*	*Up to 10 GB*	*Higher*
AT&T	300 MB: 20+25	2GB: 30+25 5GB: 50+25	10GB: 100+15	20 GB: 140+15 25 GB: 175+15 30 GB: 225+15 40GB: 300+15 50Gb: 375+15
Verizon	1GB: 30+20	3GB: 45+20	6GB: 60+20	12GB: 80+20 18GB: 100+20 In addition there are higher plans from 20 GB - 100GB
Sprint	1GB: 20+20	2GB: 30+20 4GB: 50+20	8GB: 70+15 10GB: 100+15	40GB: 120+15 60GB: 225+15 Unlimited: $70 for 1st line and $60 for each subsequent line.
T-Mobile	1GB: 50	3GB:60 5GB: 70	-	Unlimited: 80

If we consider the current plans offered by different operators, they are similar to each other in the fact that they all offer a variety of plans that differ from each other in terms of the data limit and the prices. In addition, all of them provide the users with unlimited talk and text, data sharing capabilities for up to

10 devices, etc. However, when it comes to choosing the best wireless carrier, both the cost of data plans and the QoS have to be taken into consideration. In addition, these pricing plans should be able to provide sufficient revenue to the operators, while providing acceptable performance to the end users. Fig 2 and Fig 3 provide an overview of the revenue (Average Revenue per User (ARPU)) and the performance (speed in Mbps), respectively, for each of the wireless carriers discussed above [9][10].
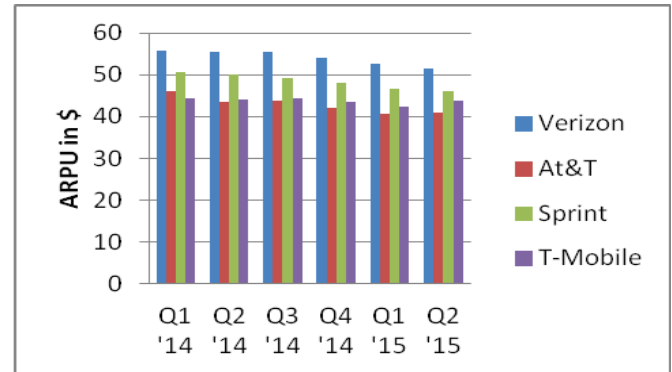

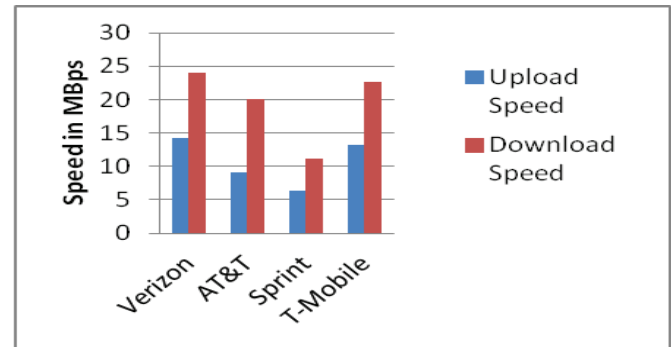**Figure 2.** ARPU from 2014 (1st quarter) up to 2015 (2nd quarter)
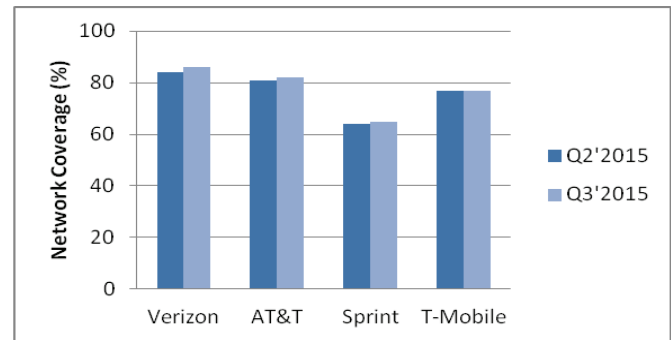

Figure 3. Upload and Download Speeds

Figure 4. Network Coverage (%)

All the operators offer a wide range of data plans from as low as 1GB to as high as 50-100GB, and even unlimited data plans in case of Sprint and T-mobile. If we talk of shared data plans, Verizon's XL plan offering 12GB for $80 per month, along with an access fee of $20 for each device, is the most attractive one, as the amount of data the user gets is much more than what AT&T has to offer at the same price. In

addition to the cost benefit, Verizon's network has the best performance amongst the four carriers, as shown in Fig 3. While Verizon offers reasonably priced shared data packages on a fast, reliable network on one hand, T-Mobile provides a large amount of data for a lower price, on the other hand. In addition to the basic data plans, AT&T offers the rollover of unused data from one month to the next, and this data has to be consumed by the end of next month's billing cycle. Similarly, T-Mobile's data stash rollover plan adds unused data from the current month to the next month, reducing the probability of data overage. While AT&T and Verizon charge high overage fees in case the user data limit exhausts before the end of the month, Sprint and T-Mobile offer unlimited data at 2G speed after the monthly high-speed 4G data over.

In addition, most of the operators offer zero-rated applications. For instance, T-Mobile also offers streaming of music without the use of 4G LTE data for some selected services such as Pandora, iHeartRadio, etc. Such zero-rated applications can drive up the network usage, causing congestion and degradation for other users, who might not be using such apps. Another issue is the network management policies adopted by various operators. For instance, the Sprint users with the unlimited plan will be de-prioritized at those times and places where the network is constrained, when their monthly usage exceeds 23 GB. In addition, the terms and conditions (usage limitations) clearly state that in order to improve the data experience for the majority of users, they can reduce or vary the throughput on the network. Misuse of such network management practices can lead to the unfair QoS degradation for certain users by the operators.

B. South Korea Telecom Operators

Three major telecom operators in South Korea are Korea Telecom (KT), SK Telecom, and LG Uplus. We will discuss in brief about the various data plans offered by each one of them and provide a comparison of the offered data plans in Table 2. We will mainly focus on the post-paid data plans and exclude the prepaid and device plans for the current study.

1) KT: KT offers a variety of LTE data plans ranging from 300 MB to unlimited plans [11]. All the data plans are accompanied by unlimited voice and text messages. For the basic data plans (300 MB to 6 GB), the users have access to limited channels on the Olleh mobile TV service, while for the unlimited plans (10 and 15 GB), they have access to all the channels. In addition, the highest unlimited plan (30GB) subscribers have access to the mobile TV service VIP pack. The user is just required to choose the data limit that best suits his monthly requirements. An important feature offered by KT is that if the amount of data from the chosen data plan is insufficient, the user can pull ahead some data from the upcoming month. Similarly, if there is some leftover data in the current month, it can be added to the next month. In case of the two unlimited plans of 10GB/15GB and 30 GB, 2GB data per day at the speed of 3Mbps and 5Mbps respectively, is provided when the data limit is exhausted. It also offers various bundles such as LTE bundle and family packs where

members of a family can get special offers and discounts if they all subscribe to the KT for their internet plans.

2) SK: SK Telecom offers eight different categories of plans known as band data plans, based on the amount of data per month and the additional services [12][13]. Band data plans 36, 42, 47, and 51 have a data limit of 1.2 GB, 2.2GB, 3.5GB and 6.5GB respectively. In addition, there are unlimited data plan, where 11GB, 20GB and 35 GB per month is given for the band data plans 61, 80 and 100 respectively. After the monthly data cap is exceeded, these users get an additional 2GB per day at a speed of 3 Mbps. In addition, value added services are provided to all the band data subscribers, including the video streaming of 'B TV Mobile', and other different types of services such as TV, games, sports, etc. under their 'T Freemium Plus' offer. In addition, the members of Happy Family Plans who subscribe for band data are given additional data and other benefits, free of cost.

3) LG: LG Uplus offers two different kinds of data plans; one with unlimited voice and messages (basic data plans), and the other with unlimited voice, messages and video (video data plans) [14]. Both of the plans offer data limits from 300MB to 6.6 GB, and the unlimited plans. The speed is throttled to 3Mbps after 2GB data has been used in case of the unlimited plan users. In case of unlimited video data plans, the users can use 1GB data per day for video. In addition, the subscribers of the video data plans can use 1GB of video streaming when in subway/metros, without any additional charges. The users of basic data plans have access to LTE Video Portal (with a monthly data limit depending on the basic data plan). The subscribers of unlimited data plans in both the cases have additional benefits such as unlimited and premium access to video portal, Asiana airlines mileage points, and various other offers.

TABLE 2. COMPARISON OF BASIC DATA PLANS OFFERED BY KT, SKT, AND LGUPLUS (VIDEO PLANS SPECIFIED IN BLUE COLOR). ALL THE PRICES ARE IN KOREAN WON (KRW) AND INCLUSIVE OF THE VAT.

	Up to 1GB	*Up to 5GB*	*Up to 10 GB*	*Unlimited*
KT	300MB:32890 1GB:38390	2GB:43890 3GB:49390	6GB:54890	10GB:65890 15GB:76890 30GB: 109890
SKT	300MB:32890	1.2GB:39600 2.2GB:46200 3.5GB:51700	6.5GB:56100	11GB:65890 20GB:88000 35GB:110000
LG	300MB:32890 300MB:41800	1.3GB:39490 2.3GB:46090 3.6GB:51590 1.3GB:48400 2.3GB:55000 3.6GB:60500	6.6GB:55990 6.6GB:64900	11GB:65890 11GB:74800 20GB:88000 35GB:110000

Due to the decrease in the popularity of voice and sms, and the growth of mobile data usage, there has been a paradigm shift in the plans offered by various operators. Most of them have adopted the pricing strategies and plans based on the data instead of talk time or text, in response to the change in the usage patterns of its users. All three operators provide a wide range of data plans from as low as 300 MB data limited to as

834

high as unlimited data plans. Although there is a nominal difference between the prices charged by the three operators for different tiers of data, there is difference in the special services and discounts that they offer. For instance LG U+ provides LTE Video Portal service that allows the subscribers to access wide range of video content. For the LG unlimited data plans, it includes services such as the cloud service U+Box, navigation service U+Navi, U+HDTV, etc. In addition, it provides special offers such as 1GB of free video data per day for use in the local subways. Similarly, KT provides many offers such as Olleh mobile TV, music streaming service, etc. In addition, it also offers the *data push and pull service* that allows the user to pull some data from the next month, if the data limit for the current month is over, and also allows pushing the remaining data from one month to the next month. In case of SK telecom, a number of multimedia applications are provided to the end users, including live video streaming using B TV mobile service (free of cost), and access to many different contents such as games, TV, cartoons, etc for subscribers of higher data plans.

While the overall prices for different data caps are comparable in case of the three operators, however, they differ from each other in terms of their download speeds and the value added services they offer. The variation of ARPU, download speed and network coverage for each of the operators is shown in Figs. 5, 6 and 7, respectively [11][15]. While KT offers the highest download speed of 34 Mbps, LG has highest network coverage of approximately 99.6%. In addition to the LTE plans, these operators also offer the GiGa Internet service, which allows the users to access internet at high speed (approx. 1Gbps). Although these carriers provide efficient network services, the increasing popularity of the zero-rated streaming and other applications supported over them raises a serious concern about the network neutrality violation. By providing such applications free of cost, or at subsidized rates, they can discourage the use of other rival applications, leading to the neutrality violation.

IV. SUMMARY AND DISCUSSION

In recent times, the popularity of voice and sms, and the growth of mobile data usage, has lead to a paradigm shift in the plans offered by various operators. Due to the evolution of the IP networks, many service providers now support the real time applications such as interactive multimedia and video conferencing as well as best effort services such as VoIP, email and other web-based applications, over a common IP-base network. It is important for the operators to support the premium services such as video on demand, gaming, video streaming, voice over IP (VoIP), etc., as such applications have gained popularity with the availability of high-speed networks and smart devices, and can potentially increase the ARPU for the operators, as most of these are data intensive and have high performance requirements. However, best effort service is not adequate to support such service offerings and there is a need of QoS support. In addition, the operators must make sure that they do not violate the network neutrality

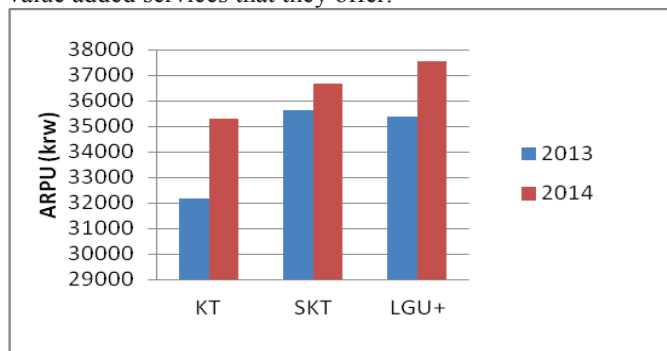through their traffic management policies, or through the value added services that they offer.
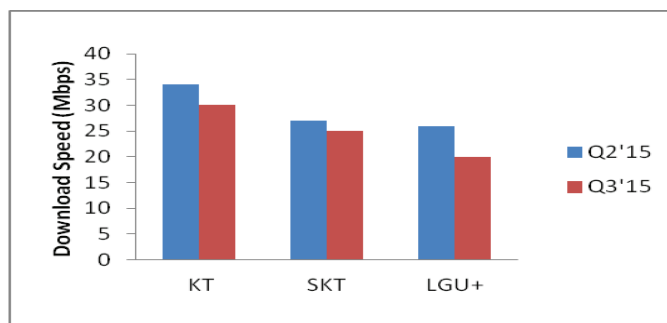

Figure 5. ARPU (2013-2014)

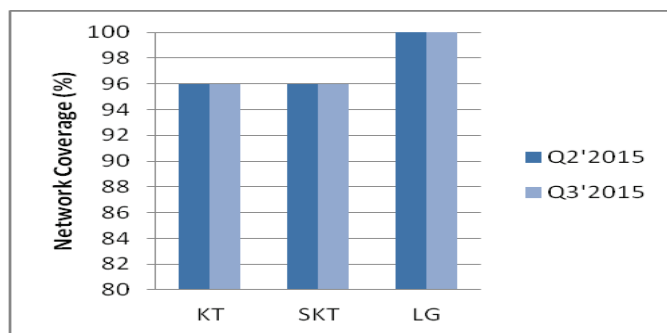**Figure 6.** Upload and Download Speeds

Figure 7. Network Coverage (%)

Most of the operators have adopted the pricing strategies and plans based on the data instead of talk time or text, in response to the changes in the usage patterns of its users. The key features of various pricing plans offered by telecom operators in USA and South Korea have been summarized in Table 3. Although the network operators have expanded their spectrums and adopted the latest network technology (4G in most of the cases), however, they still have to rely on traffic management practices and pricing plans for efficient management of their resources. As observed in the previous section, the current pricing plans offered by various operators in USA and Korea are data oriented (prices differ based on data cap), however none of them focuses explicitly on guaranteeing QoS to the end users. In addition, the pricing plans should be more flexible, allowing the users to choose their QoS requirements based on the applications they use. Charging based on level of QoS guarantee can not only help to

save the cost for those users who might have to pay higher in case of the current plans, although they might not even need the 4G speed, but also optimize the resource utilization and revenue for the operator. This is so because the users would be encouraged to pay less and opt for lower QoS plans, if they do not use real-time applications very often. In addition, congestion management and admission control policies should also take the QoS and differentiation into consideration.

In addition, the network operators offer a number of zero-rated or free of charge applications such as video streaming applications, mobile TV, etc, with the basic pricing plans, as discussed in previous section. Although they claim that they provide such applications to enhance the customer experience, however, providing such applications can violate network neutrality principles, as the real motive behind providing such applications for free could be to compete against other service providers who charge for such similar applications, or to earn more revenue by attracting more users [16].

TABLE 3. KEY FEATURES OF DATA PLANS OFFERED BY VARIOUS OPERATORS.

Operator	Pricing Plans and Key Features
AT&T	Pricing based on data limit; Additional device access fee; Unlimited talk and text; Shared value plans; Extra overage charges; Data roll-over, Offers zero-rated applications and services.
Verizon	Pricing based on data limit; Additional device access fee; Unlimited talk and text; Shared data plans; Users can change plans dynamically; Overage charges if not shifted to higher data plans; Offers zero-rated applications and services.
Sprint	Pricing based on data limit; Additional device access fee; Unlimited talk and text; Shared data plans; Offers unlimited data plans (speed throttled to 2G speed when certain limit is exceeded); Unlimited data at 2G speed after high speed data is exhausted; Offers zero-rated applications and services.
T-Mobile	Pricing based on data limit; Additional device access fee; Unlimited talk and text; Shared data plans; Unlimited data plans; Data stashing; Unlimited data at 2G speed after high speed data is exhausted; Offers zero-rated applications and services.
KT	Pricing based on data limit; Unlimited talk and text; Unlimited data plans included (2GB per day at 3/5 Mbps after certain data cap is reached); No device access fee; Data pull and push; Offers zero-rated applications and services.
SKT	Pricing Based on Data Limit; Unlimited Talk and Text; Unlimited data plans included (2GB per day at 3 Mbps after certain data cap is reached); No device access fee, Special offers for family plans; Offers zero-rated applications and services.
LG U+	Pricing Based on Data Limit; Two different kinds of data plans: one with unlimited voice and messages (basic data plans), and the other with unlimited voice, messages and video (video data plans); Unlimited data plans included (speed is throttled to 3Mbps after 2GB data has been used in case of the unlimited plan users); No device access fee; Offers zero-rated applications and services, special video data offers.

V. CONCLUSION AND FUTURE WORK

Due to large increase in data traffic and the number of subscribers, and different QoS needs of different users and applications, the flat-rate pricing schemes are no longer suitable. The static pricing strategies that are currently being used by network operators lack the capability of offering any incentives for the end users to dynamically adjust their demands for better utilization of the network. Hence, there is a need of dynamic and flexible plans that allow the users to choose the QoS level and data volume based on their usage requirements. In addition, it should help the operators to manage the network resources effectively by encouraging the users to choose what they need, thereby reducing the probability of over provisioning and under utilization of network resources as in case of fixed plans. As a part of the future work, we plan to propose a pricing scheme that will take both the data volume and QoS into consideration.

REFERENCES

[1] "Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2014-2019", Cisco Whitepaper, www.cisco.com.
[2] "Mobile Broadband Capacity Constraints and the need for Optimization", Rysavy Research, February 2010.
[3] G. Song and Y. (G). Li, "Cross-layer optimization for OFDM wireless network: part I and part II", IEEE Trans. Wireless Commun., vol. 4, no. 2, pp. 614-634, March 2005.
[4] P. Hosein, "Pricing for QoS-based wireless data services and its impact on radio resource management", GLOBECOM Workshops, Miami, USA, 6-10 Dec. 2010.
[5] "AT&T – DIRECTV, Wireless, Cell Phones, U-verse & Internet", Available: http://www.att.com.
[6] "Cell Phones, Smartphones & the Largest 4G LTE Network – Verizon Wireless", [online], Available: http://www.verizonwireless.com.
[7] "Cell Phones, Mobile Phones & Wireless Calling Plans from Sprint", [online], Available: http://www.sprint.com.
[8] "Mobile Broadband Unlimited Data Plans w/ No Annual Contract | T-Mobile", [online], Available: http://www.t-mobile.com.
[9] "ARPU wireless carrier United States 2013-2015 | Statistics", [online], Available: http://www.statista.com.
[10] "The State of LTE September 2015 - OpenSignal", [online], Available: http://www.statista.com.
[11] Product.olleh.com, [online], Available:https://product.olleh.com/wDic/productDetail.do?ItemCode=1037.
[12] SK Telecom, [online], Available: https://http://www.sktelecom.com/en/
[13] T world, [online], Available: https://www.tworld.co.kr
[14] "Mobile>Personal Services | LG U+", [online], Available: http://www.uplus.co.kr/en/
[15] "KT defeats competitors in subscriber revenues", [online], Available: http://koreajoongangdaily.joins.com/news/article/article.aspx?aid=3000427&cloc=joongangdaily|home|newslist1
[16] Ramneek, P. Hosein, Wonjun Choi and Woojin Seok, "Disruptive network applications and their impact on network neutrality", 2015 17th International Conference on Advanced Communication Technology (ICACT), pp.663-668, 1-3 July 2015.

Ramneek received B.Tech (Computer Science and Engineering) and M.Tech (Information Technology) from Guru Nanak Dev University (G.N.D.U) Amritsar, India in 2010 and International Institute of Information Technology (IIITB), Bangalore, India in 2013 respectively. She is currently a student researcher at Korea Institute of Science and Technology Information

(KISTI), pursuing Ph.D. at the University of Science and Technology (UST), Daejeon, Korea. Her research interests include Networking and Communication (Congestion Management in Wireless and Cellular Networks, QoS and Pricing for Cellular Networks, Network Neutrality) and Cloud Computing (Openstack, IaaS, Cloud federation, Cloud Networking, SDN).

Patrick Hosein attended the Massachusetts Institute of Technology (MIT) where he obtained five degrees, a BSc degree in Electrical Engineering and one in Mathematics, an MSc degree in Electrical Engineering and Computer Science, an Engineer's degree and a PhD in Electrical Engineering and Computer Science.

He has worked at Bose Corporation, Bell Laboratories, AT&T Laboratories, Ericsson and Huawei. He is presently a Professor of Computer Science at the University of the West Indies, St. Augustine, Trinidad. He has published extensively with over 75 refereed journal and conference publications. He holds 38 granted and 42 pending patents in the areas of telecommunications and wireless technologies. His present areas of research include radio resource management, QoS and pricing for 5G cellular networks.

Wonjun Choi received his Bachelor's degree in Mathematics from Wonkwang University in 2006. He is currently enrolled in the integrated course in Grid and Supercomputing in the Korea University of Science and Technology. His research interests include Network Engineering, Network Communication, TCP, Cloud Federation, CCNx, NDN, SDN, and Computer Science.
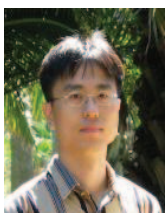
Woojin Seok, received B.E, M.S, and Ph.D. from Kyungpook National University, University of North Carolina at Chapel Hill, and Chungnam National Univerysity, respectively. He currently works for Korea Institute of Science and Technology Information(KISTI) Advanced KREONET center. He is also adjunct professor of University of Science and Technology(UST). He is a society member of KICS and KIPS, and also committee member of Future Internet Forum (FIF) Korea and Asia Pacific Network Operation and Management (APNOM). His interesting research areas are network testbed, federation, SDN, and so on.