Coverage Impact for Data Traffic Profiling in WCDMA Networks

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Abstract— Nowadays UTRAN is a key data carrier in mobile communications. Serving a majority of customers and processing an enormous traffic quantity it must ensure a sufficient quality of service (QoS) level. QoS reflects how satisfied the users are with the received services. The goal of this research is to ascertain a benefit of QoS for differently profiled UEs. This study investigates HSPA service dependence on uneven radio network conditions for separate users. Users belong to background traffic class and use a data service as other conventional network users. To draw an impact of radio conditions variation, radio signal strength was decreased gradually for a user with a higher priority. The research is performed on heavy loaded commercial network WCDMA cells. The performance of the user experience is analyzed by the metrics — data rate and channel quality, which are provided graphically and reflect the user received gain based on radio environment changes. Customers' prioritization drawbacks in cellular networks are introduced in study also.

1. INTRODUCTION

With rapid development of mobile networks, operators need to continuously ensure the high quality services. Quality of service is a comprehensive reflection of the service capability of a WCDMA system [1, 2]. The goal of study is to discover an impact for user received data services with individual QoS based on uneven network conditions. Therefore study investigates three differently profiled customers which belong to background 3G traffic class [3]. Main focus is paid for evaluation of customers achieved uplink and downlink throughput regarding to variable signal strength. Data rate measurements are carried out in a commercial mobile network. On this study user profile QoS management over core and UTRAN networks has been applied only. It means that QoS profiling over Iub/Iur links was not involved into consideration. Further investigation process consists of analysis of related works on Section 2. Section 3 provides a determination of user profiles and NodeB selection. The rest part of research presents the obtained results and conclusions on Sections 4, 5 and 6.

2. RELATED WORKS

To ensure the end-to-end QoS for each class a bearer service with explicit attributes must be set up. Only when the appropriate core, UTRAN and transport network QoS parameters are determined, a reasonable quality of services can be ensured respectively. Main characteristics of expected QoS are jitter, delay, throughput and signal strength [5]. Usually mean throughput demonstrates an influence for prioritized service of separate traffic class. Many of researches are conducted about non real time services quality assurance in mobile networks. The achievements of better performance and user's satisfaction are obtained by improving resource sharing and utilization [6]. Different QoS management algorithms are implemented in networks for priority based service efficiency improvement [4]. Proposed models comprise sophisticated quality management techniques related to packet scheduling, power allocation and network coordination [7]. Latter management strategy covers multi-domain QoS control between UMTS and WLAN networks. This becomes a relevant topic for majority of Telco, because an increasing data flow force them to introduce small cells and hotspots to carry user plane data with an appropriate QoS [8]. Certainly the investigation of QoS dependence on dynamic radio conditions is relevant.

3. USER PROFILE AND NODEB SELECTION

The QoS is defined during subscription and when a user sends a service request, the CN negotiates with the 3G network in order to provide proper QoS. For ensuring required QoS allocation/retention priority (ARP) and scheduling priority indicator (SPI) parameters are used. Combining the values of these two parameters and setting up other required information users can be classified into three different categories: gold, silver and copper. The priorities of these user categories are organized as follows: gold user has higher priority than silver user twice and the silver is also twice better than copper. This study examines differently profiled customers which use FTP UL/DL services belonging to background traffic class. This class is not very sensitive for delay, but high values of data rate are preferred. The scenario of data collection involves only heavy loaded cells. Analyzed priority users camp on the same cell as other conventional network users and use the services at the same time. Daily load statistics of a typical NodeB which was used in the research are shown in the graphs.

Figure 1 shows the number of served UEs per day. It is observed that the NodeB serve the number of users between 4000–5000 each day. The dotted line indicates the average number of UEs camped on base station for each 15 minutes period over twenty-four hours. Accordingly Figure 2 demonstrates transferred traffic volume of uplink and downlink data which is close to 40 GB for DL and 8 GB for UL. Such a WCDMA base station is held as a heavy loaded and this requires of resources to be scheduled differently for camped UEs. In many cases NodeB's operate with several or more carriers per cell in order to be able to handle the incoming traffic.

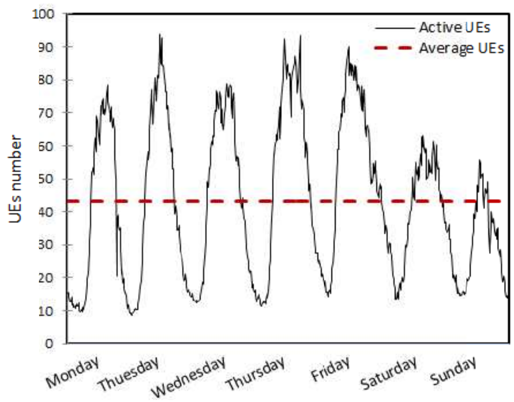


Figure 1: Number of active packet switch UEs per NodeB.

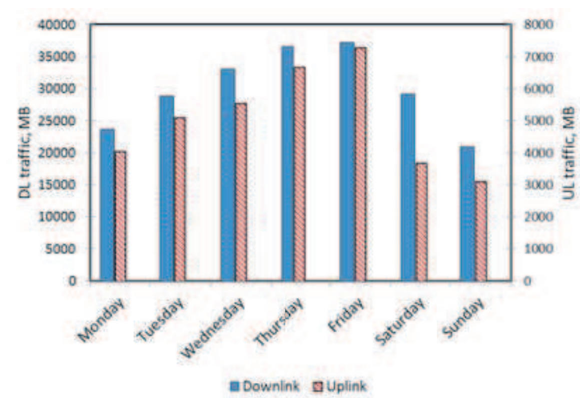


Figure 2: Daily traffic volume of uplink and downlink in heavy loaded NodeB.

4. HSDPA USERS PROFILING

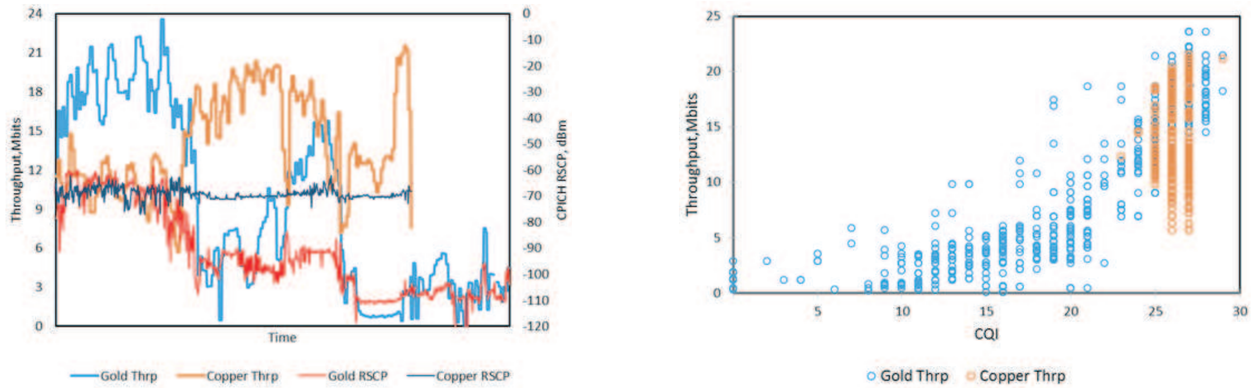
The basic results obtained over the research are provided in this section. First we will discuss the data related with HSDPA QoS profiling. Results presented below cover differently profiled users experience based on received data rate when radio signal is uneven. To draw an impact of radio conditions variation, a radio signal strength changes for a user with a higher priority gradually.

In Figure 3(a) it is seen that UE with higher priority achieves better DL rate when radio signal is more less equal. Scheduled transmission time is frequent compared with copper user. The difference amongst attained throughput is close to double. However when a channel quality begins to deteriorate and the signal strength starts to fade the NodeB scheduling algorithm reassess the scheduling of resources for next TTI. In this way a resources are reallocated to UEs that are able to take advantage of them. This means that channel quality evaluation is an important part of ensuring best QoS. Figure 3(b) shows the user obtained throughput rate when CQI decreases. Despite the superior priority of gold user the received service quality is getting worse depending on RSCP. The same trend is observed when gold versus silver or silver versus copper users are investigated.

What can be highlighted is that the gap of throughput between the G vs S or S vs C users is lower compared to G vs C. This is due to combination of ARP and SPI parameters which weight is significant when radio signal fluctuates approximately at the same level. Otherwise the data rate is mostly dependent on CQI value and reallocation of scheduling. This is also confirmed by the fact that data rate of UE with a poor radio signal remains low even when other UE stops downloading. Consequently a higher priority against the other consumers does not guarantee better quality services in any case.

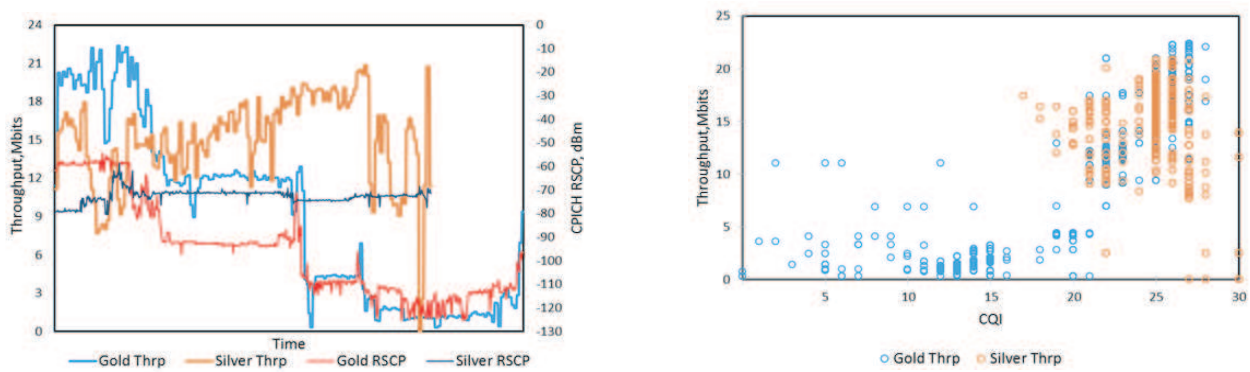
5. HSUPA USERS PROFILING

In the uplink a pure time division scheduling does not provide a comparable benefit as in downlink. It is limited by the power of UE which means that full uplink channel capacity can't be utilized



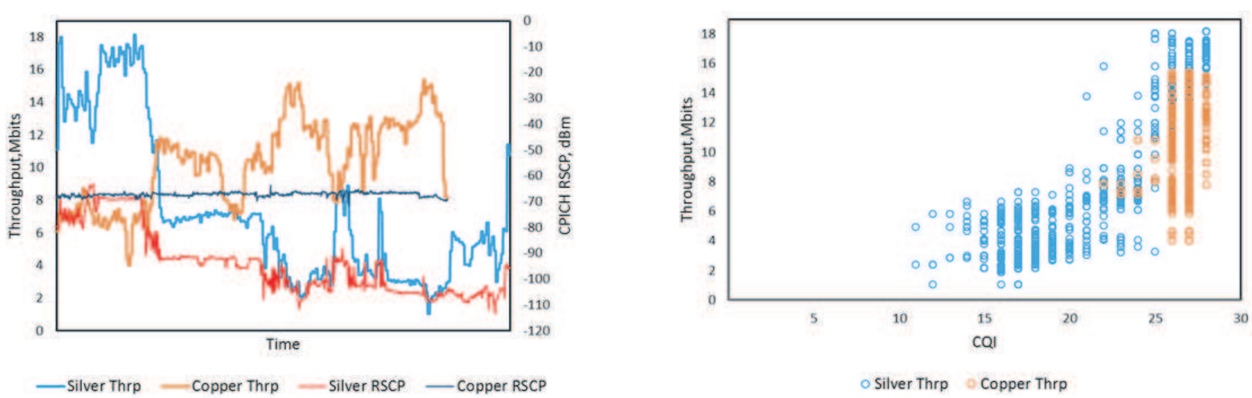
(a) (b)

Figure 3: (a) Gold versus Copper user HSDPA throughput related to radio signal changes. (b) CQI corresponding throughput distribution.



(a) (b)

Figure 4: (a) Gold versus Silver user HSDPA throughput related to radio signal changes. (b) CQI corresponding throughput distribution.

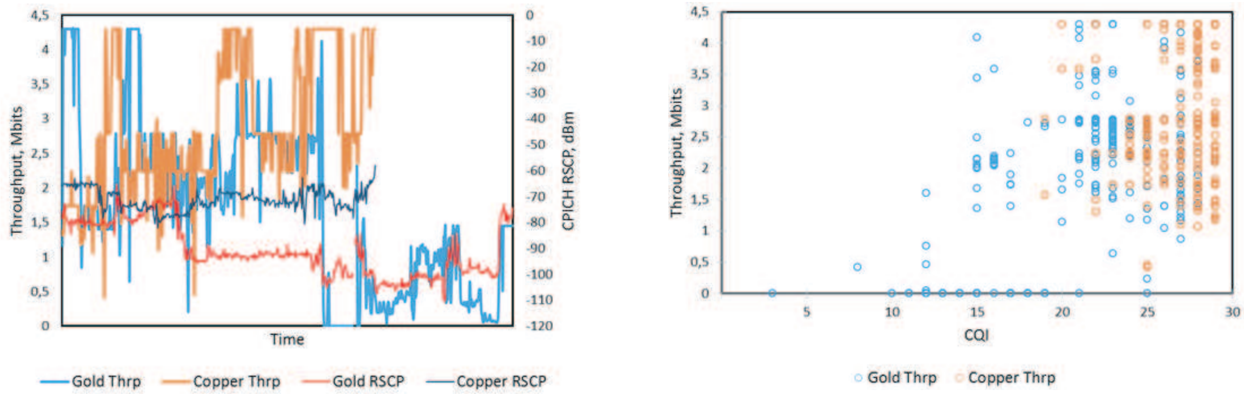


(a) (b)

Figure 5: (a) Silver versus Copper user HSDPA throughput related to radio signal changes. (b) CQI corresponding throughput distribution.

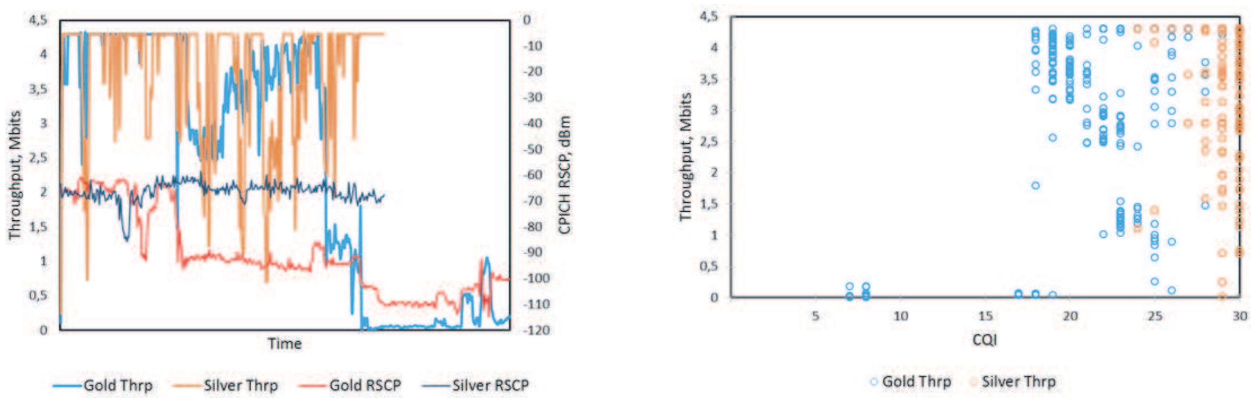
efficiently by single transmitting UE. The obtained results of HSUPA performance over this research confirmed a limited availability to serve prioritized services on uplink channel. It can be seen from the graphs below.

Charts named as (a) contain the results of data throughput related to signal strength for uplink transmitting UE. Practically it does not matter which pair of profiled UE's would be compared. Because as it can be seen data rate is more less equal mutually and a given profile is irrelevant. Nevertheless when the RSCP decreases to the bound of −90 dBm of one the UE, data rate diminishes



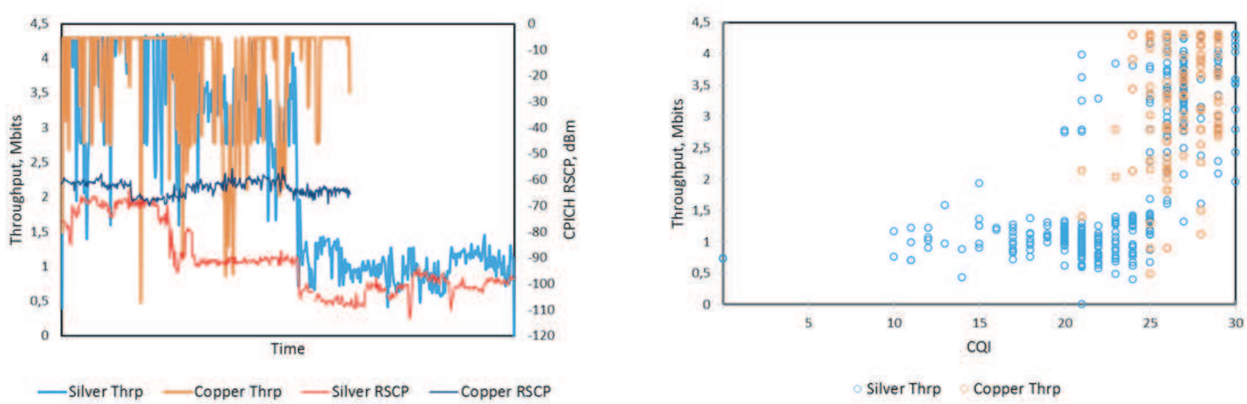
(a) (b)

Figure 6: (a) Gold versus Copper user HSUPA throughput related to radio signal changes. (b) CQI corresponding throughput distribution.



(a) (b)

Figure 7: (a) Gold versus Silver user HSUPA throughput related to radio signal changes. (b) CQI corresponding throughput distribution.



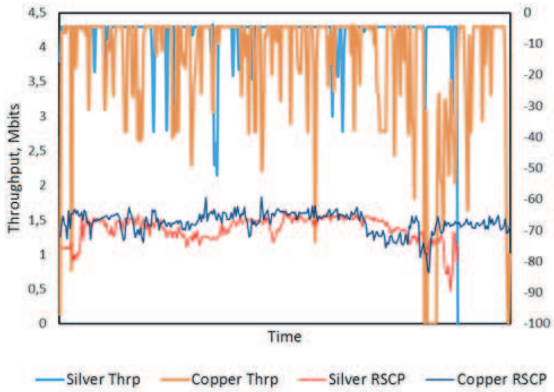
(a) (b)

Figure 8: (a) Silver versus Copper user HSUPA throughput related to radio signal changes. (b) CQI corresponding throughput distribution.

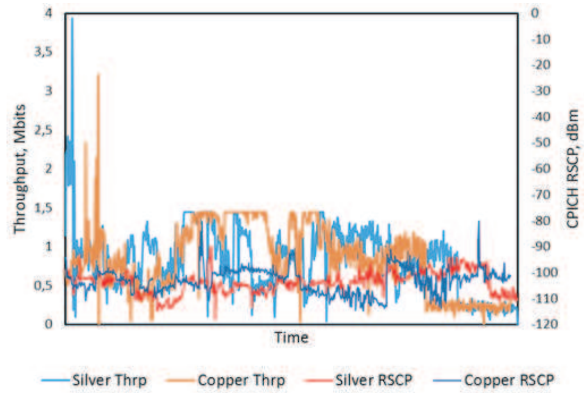
suddenly. This is mainly dependent on the change of the channel coding and its quality. Very low data rate measurements can be noted in the CQI charts.

The fact of minor importance of higher priority in uplink transfer was also verified under the identical radio conditions for both UE's. Collected results are provided below in the graphs.

Provided charts represent S vs C UE's data rates distributions when radio environment is same for both handsets. As it can be seen from the results no gain for a highly prioritized UE is determined. This trend is common for both poor and good radio environments. Also it does not



(a)



(b)

Figure 9: (a) Silver versus Copper user HSUPA throughput at good radio signal for both. (b) Silver versus Copper user HSUPA throughput at poor radio signal for both.

matter which pair would be under investigation.

6. CONCLUSIONS

The basis of UTRAN QoS management allows to ensure the QoS for each user and to provide DiffServ for different users, thereby meeting the requirements of more users. Prioritization grants a higher user quality of experience and gives the ability to control data users in WCDMA networks. This research revealed the benefit gained from a given priority. HSDPA gold user can enjoy a better data rate instead of silver or copper users, but this is valid until the radio signal strength is mutually equal and strong. Otherwise the results showed that the decreasing pilot signal strength affects data rate and it becomes mostly dependent on channel quality. In this case the given priority loses a sense and the available channel resources are allocated to the UE which is able to use them. On uplink channel data transfer prioritization is not very efficient way, because of limited UE power. Obtained results demonstrate that the users sending data to the base station are more or less equal despite their priority. Only when RSCP decreases to weak level HSUPA throughput becomes very low. Consequently QoS management is an efficient way to provide superior level services, but certainly it will not be possible for all cases.

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