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# PERFORMANCE ANALYSIS FOR THE QOS SUPPORT IN LTE

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**Анализ производительности для подержки QoS в LTE**

В работе рассматриваются различные схемы и алгоритмы поддержки QoS в LTE сетях. Наводятся принципы их работы и приводится их сравнение. Рассматриваются возможности этих схем противостоять задержкам, фазовым и частотным отклонениям и потери пакетов.

In recent decades, staggering number of mobile applications has been developed in the wireless technology arena. The Long Term Evolution (LTE) has become one of the most common wireless technology used for those applications. Mobile applications are classified into Real-Time (RT) and Non Real-Time (NRT). The growth in the number of users burdens the network with more congestion which requires techniques to carry various types of traffic simultaneously in order to alleviate the problem. The most important trouble with the RT applications is that they are delay sensitive, and this is why created a scheme that enables LTE system to achieve reasonable values for delay, jitter, and packet loss.

The QoS in LTE is provided by means of a bearer that uniquely identifies a packet flow between the user and the Packet Data Network Gateway (PGW). It is also responsible for giving the priority to a packet transmission across the LTE network. After successful authentication and registration of a user on the LTE network, bearers are established.

The bearers are categorized into two types, namely the default and the dedicated bearers as shown in Figure 1.

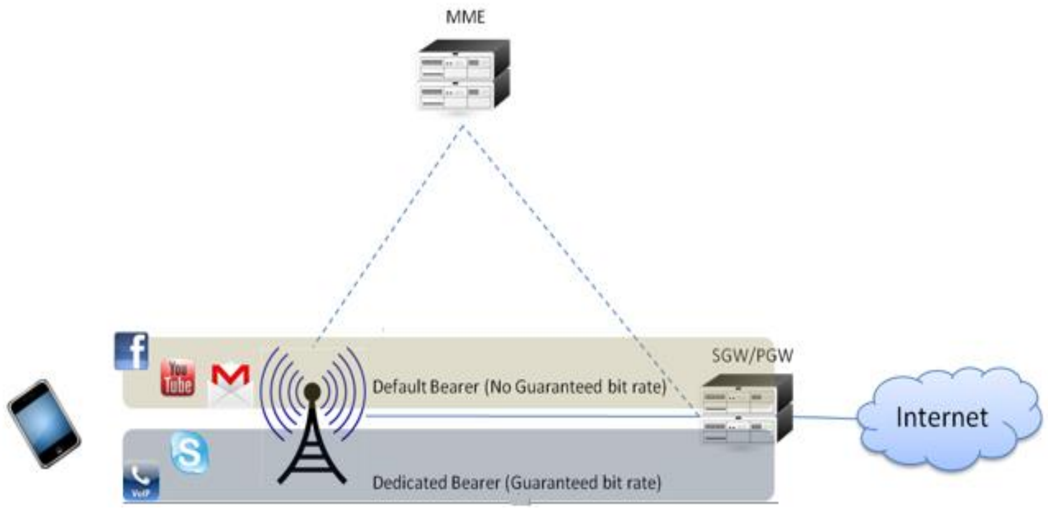


Figure 1. The two types of a bearer.( MME - Mobility Management Entity, SGW - Serving Gateway).

Default bearers are established when the PDN-GW allocates an IP address to the user. Default bearers are responsible for providing the basic IP connectivity to the LTE network. However, they do not provide any guaranteed QoS for the transmitted packets. Dedicated bearers are established based on the subscription profile of the user when there are specific services, such as voice, video streaming, etc.

The bearers are grouped as Guaranteed Bit Rate (GBR), and Non-Guaranteed Bit Rate (N-GBR). To specify the class of bearer, QoS class identifier (QCI) is assigned to it. Nine of QCIs are defined as five Non-GBR and four GBR classes, each one with specific QoS requirements as outlined in Table 1. The QCI equals a service which based on service priority, bearer type, packet loss rate, and delay budget.

Table 1. Values of multiple parameters for each type of QCI.

| QCI | Bearer Type | Priority | Packet Delay | Packet Loss | Example |
|---|---|---|---|---|---|
| 1 | GBR | 2 | 100 ms | $10^{-2}$ | VoIP Call |
| 2 | | 4 | 150 ms | $10^{-3}$ | Video Call |
| 3 | | 3 | 50 ms | $10^{-3}$ | Online Gaming(Real Time) |
| 4 | | 5 | 300 ms | $10^{-6}$ | Video Streaming |
| 5 | Non-GBR | 1 | 100 ms | | IMS Signaling |
| 6 | | 6 | 300 ms | | Video, TCP based services e.g.email, Chat, ftp etc. |
| 7 | | 7 | 100 ms | $10^{-3}$ | Voice, Video, Interactive gaming |
| 8 | | 8 | 300 ms | $10^{-6}$ | Video, TCP based services e.g.email, Chat, ftp etc. |
| 9 | | 9 | 300 ms | | |

QoS for VoIP was implemented in a router by applying different queuing algorithms, such as First-In-First-Out (FIFO), Priority Queuing (PQ), Weighted Fair Queuing (WFQ) and packet scheduling algorithms such as Maximum-Largest Weighted Delay First (M-LWDF). WFQ and PQ algorithms are the most appropriate to improve the QoS experience for VoIP. Their results show that the values of performance measurements are within acceptable range e.g. delay, jitter, and packet loss. The investigation of the performance of M-LWDF packet scheduling algorithms in the downlink path of LTE system shows that the M-LWDF algorithm overtakes other packet scheduling algorithms for the downlink path of LTE system when video streaming application is used. It provides higher system throughput, supports a higher number of users, and guarantees fairness at a suitable level.

There is also the QoS provisioning framework that simultaneously applies several queue algorithms and could be adopted by LTE. The goal of this framework is to achieve acceptable jitter and end-to-end delay, for the RT applications (Video and Voice) in LTE. This is done by separating the incoming traffic into RT and NRT, then using different queuing scheme in two stages:

- In the first stage Class-Based Weighted Fair Queuing (CBWFQ) and Round Robin Queuing (RRQ) are used for RT and NRT traffic respectively;
- Deficit Weighted Round Robin Queuing (DWRRQ) is used in the second stage to separate RT from NRT traffic classes as shown in Figure 2. CBWFQ is an enhanced version of WFQ used for processing a diverse set of traffic coming from several queues by assigning a weight for each queue in terms of the number of processed packets and bandwidth ratio. DWRRQ, on the other hand is a modified

version of RR used for processing various traffic coming from several queues by assigning a weight for each queue in terms of the number of processed bits.

Packets are classified into RT and NRT traffics based on their application types. For instance, if there are video or voice applications, they are forwarded to the RT Queue; otherwise they are classified under NRT. Class-Based Weighted Fair Queuing (CBWFQ) is used in the case of RT applications as a first stage to separate RT flows based on their respective classes to provide an appropriate ratio of bandwidth to voice and video applications. For example, a higher ratio of bandwidth could be allocated to Video Conferencing, and a lower ratio to VoIP since video applications require more bandwidth than voice application. Since the NRT applications (FTP, HTTP, etc.) are not sensitive to delay, RRQ is used in NRT traffic as the first stage to give parallel opportunity to all NRT flows to be scheduled regardless of priority. In the second stage, DWRRQ is used to schedule the RT and NRT queues by giving different weights in term of the number of bits based on the type of application. The flows are classified based on QCI value when the framework is implemented in LTE. For instance, the QCI 1 is allocated to VoIP call, and QCI 2 is specified for video Call.

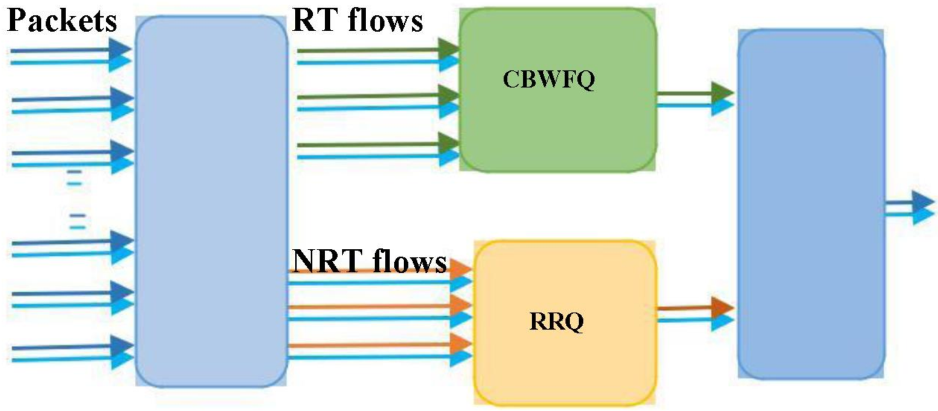


Figure 2: The two stages performed in the framework.

As a result, the purpose solution could deliver the QoS requirements of video and VoIP applications based on their strict delay bound.

Common QoS strategies can be adopted by multiple wireless network technologies such as LTE. This is a promising solution for integrated networks.

## References

1. Prasanna Gururaj Raghavendrarao.“Voice over LTE” M.A. thesis, Delft University of Technology, Netherlands, 2012.
2. 3GPP TS 23.203:“Policy and charging control architecture, Release 11.”,3rd Generation Partnership Project, available : http://www.3gpp.org/DynaReport/23203.html, Nov.1, 2015.
3. Yangyang Dong. “LTE-Advanced: Radio Access Network Resource Management” Master thesis, University of Bremen, German, 2013.
4. Fakhar Uddin Ahmed, Shikhar Kr. Sarma. “QoS and Admission Controller in IEEE 802.11e WLAN” 2013 4th International Conference on Intelligent Systems, Modelling and Simulation, 2013, page 468.