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Impact of Background Traffic on VoIP QoS Parameters in GPON Upstream Link

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Introduction

The transmission of multimedia services over IP networks has highly increased in recent years. Multimedia services can be imagined as e.g. VoIP (Voice over IP), video telephony or video streaming. It is expected that amount of transferred data will also grow in upstream, because a lot of multimedia services is interactive. Generally, most of the services are sensitive to bandwidth which can be utilized itself. Decreased given bandwidth means degradation of QoS (Quality of Service). Many research teams have investigated an impact of various effects on QoS parameters of multimedia services [1–14].

The way how the problem with insufficient bandwidth can be solved lies in more implementation of PONs (Passive Optical Network). At present, GPON (Gigabit PON) is the most modern variant of PONs and it is also mass-deployed access technology in real operation [15].

Some papers have been investigated the general properties of GPON [16–18]. The greatest attention is devoted to QoS guarantee by dynamic bandwidth allocation in upstream [19–20]. Nevertheless, service providers almost always utilized static bandwidth allocation. There is not sufficient attention paid to investigation of an influence of this bandwidth allocation on various services behaviour. Therefore, we decided to investigate the properties of multimedia services in case of static bandwidth allocation. Concretely, two key VoIP QoS parameters will be observed, i.e. packet loss and jitter.

Here we focus on an impact of different codecs on QoS parameters of VoIP connection. The allocated bandwidth will be shared between monitored VoIP connection and background traffic. The influence of composition and size of background traffic on QoS parameters is investigated in the paper.

The rest of the paper is structured as follows. At first, experimental setup and scenarios are introduced. Later, the obtained results are presented and discussed. Final section concludes the paper and defines future works.

Experimental Setup

The experimental setup composed from (has mainly been formed by) GPON and traffic load transmitters and receivers. As a GPON the solution of Nokia Siemens Networks SURPAS hiX5700 was taken. The optical path consists of a few SM fibres situated over whole city with the length of 8820 m. The architecture of experimental setup is depicted in Fig. 1.

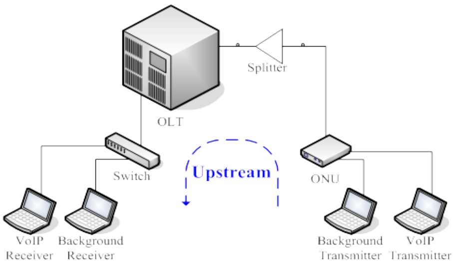

Fig. 1. Measurement architecture

Each connection is terminated by transmitter and receiver. They are implemented as software solutions. Each connection models different traffic, e.g. background and voice (VoIP). Necessary data were generated by means of particular transmitters (generators) and transmitted over upstream link, i.e. from ONU (Optical Network Unit) to OLT by T–CONTs. These generators were directly connected to ONU ports. All ONU ports had set same priority, so all the data traffics from the ports were mapped into same T–CONT. It is important because background and VoIP traffic share same transmission capacity and they are mutually affected. On the receiving side, the receivers are connected to OLT. Synchronization during experiments was performed by NTP (Network Time Protocol) protocol.

Two kinds of traffic were generated in the experiments: background and monitored VoIP. Background consists of UDP, TCP and gaming stream depending on the scenario deployed. Monitored traffic was always VoIP and only its QoS parameters were evaluated.

The experiments were implemented in two scenarios, which could be briefly defined as follows:

- Scenario 1: background traffic - constant single UDP stream, different amount of traffic load [kbit/s] in independent measurements. Monitored traffic - VoIP stream with different codecs (G.711, G.723 and G.729). Both traffics were simultaneously transmitted and took 300 sec. Final QoS parameters of monitored VoIP were calculated from 20 independent trials for particular background stream;
- Scenario 2: background traffic - mixed traffic, concretely UDP, TCP, gaming (Quake 3) and VoIP. Monitored traffic - VoIP stream coded by G.711.

These scenarios were purposely defined because of the different properties of background traffic and also impact of VoIP codec on QoS parameters. All traffics were generated by means of software D-ITG traffic generator. Each connection was terminated by D-ITG transmitter and receiver, respectively. Monitored QoS parameters were calculated also by means of D-ITG modules. The extensive measurements were implemented on GPON passive optical networks located in Institute of Next Generation Networks in Zilina (Slovakia).

The QoS parameters observed of VoIP connection are packet loss [%] and jitter [ms].

Amount of packet loss is determined as difference between transmitted and received packets. Average value of jitter is calculated by following equation

$$\overline{Jitter} = \frac{\sum_i^n |D_i|}{n} = \frac{\sum_i^n \left|\left(R_i - S_i\right) - \left(R_{i-1} - S_{i-1}\right)\right|}{n}, \qquad (1)$$

where D_i is the jitter of i-th packet; S is time of packet transmitting from transmitter; R is time of packet receiving in receiver and n is the number of all packets.

It is obvious that jitter is directly calculated based on transmitter and receiver network cards information. Different codecs will provide different values of jitter because of different amount of data included in packets.

Experimental Results

In the following part, the results of two different scenarios are discussed. The main goal of experiments is to investigate an impact of background traffic and GPON technology on VoIP QoS parameters in upstream link.

In the Scenario 1, upstream allocated bandwidth was 4080 kbit/s. Impact of VoIP codec on QoS was mainly investigated. The background traffic was created by single UDP stream with constant 1024 B packet size and Poisson distribution. Offered background traffic load [%] was defined in respect of upstream bandwidth (see Table 1).

Table 1. Size of background traffic load; bandwidth = 4080 kbit/s

Average offered background traffic load	[%]	90	92	96	100
	[kbit/s]	3672	3753.6	3916.8	4080

According to above table, the traffic load in upstream is expressly defined. Monitored traffic was also single VoIP stream of different codecs (G.711, G.723 and G.729). It means that only two streams were simultaneously transferred over medium. The obtained results for Scenario 1 are shown in Fig. 2 and Table 2.

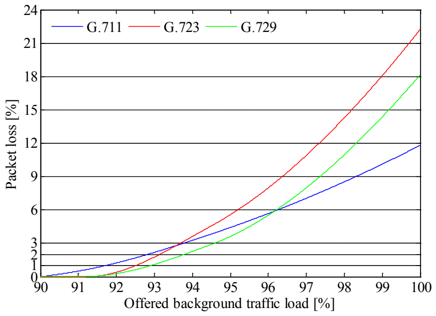

Fig. 2. Packet loss versus background traffic load

In the light of obtained results it is possible to note that the higher the background traffic loads the higher the packet loss rates of all three codecs. Increasing of the load has first been registered at codec G.711, already at about 90 %, at codec G.723 at 92 % and at codec G.729 at 93 %. It is caused by different necessary bandwidth for lossless function of the particular codecs. It means that G.711 needs the biggest bandwidth.

In [9], similar experiments were performed for Ethernet and it is possible to compare those results with our results. In that case, packet loss of 10 % corresponds to background traffic load 65.7 %. In our case, this value of packet loss is app. 96 % of background traffic load. On the basis of this comparison it can be concluded that throughput of GPON is much higher in comparison with Ethernet. It is caused by character of the technologies, the most important difference lies in way of access to medium (collision or collisionless). Achieved results of jitter are shown in Table 2.

Table 2. Jitter versus background traffic load

Codec		Average offered background traffic load [%]					
		20	50	90	92	95	100
G.711	**Jitter [ms]**	2,074	1,989	2,01	2,23	2,005	2,002
G.723		1,975	2,014	2,096	2,225	2,214	2,342
G.729		0,366	0,671	1,177	1,407	1,588	1,953

Jitter was approximately equalled to 2 ms for all background traffic loads for two codecs, i.e. G.711 and G.723. In case of G.729, the jitter was linearly increased with increasing of background traffic load.

Codec G.711 is also used in the Scenario 2. We decided for this one, because of its aforementioned lower sensitivity to packet loss (see Figure 2) which finally leads to higher perceptual quality in case of equivalent QoS.

In this experiment, VoIP QoS parameters (G.711) dependency on immediate properties of background traffic is investigated. The allocated upstream bandwidth was 10200 kbit/s in this case. Background traffic consisted of following streams: UDP, TCP, VoIP and Quake 3. There were 8 streams generated in various combinations, i.e. particular streams had different parameters: length of time and bit rate. It is purposely arranged because we would like to investigate the impact of different types of background traffic on the VoIP. Each stream is marked, for example UDP90 means that it is UDP stream which takes 90 % of upstream bandwidth. Detailed flow of the background traffic on generator output is shown in Fig. 3.

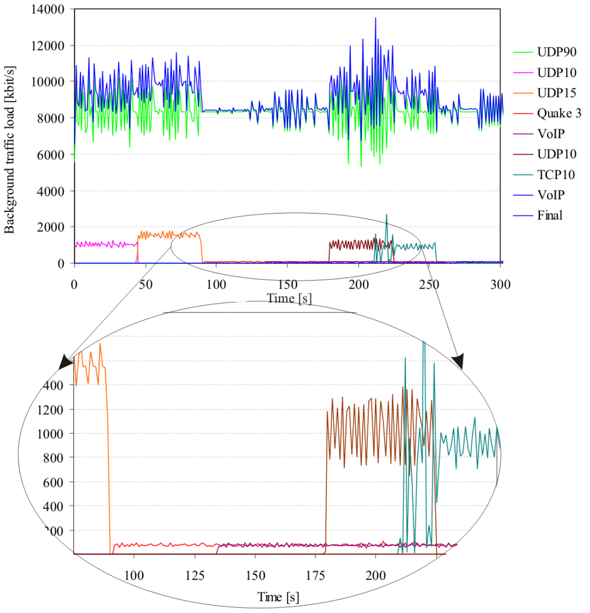

Fig. 3. Composition of background traffic

In Fig. 3 mutual influence of given streams could also be seen. UDP90 stream was generated during whole experiment. This stream covered most of the background traffic load. The other streams had much less bit rate, but their occurrence had significant impact on the final traffic behaviour. The blue curve depicts final combination of particular streams. The biggest bit rate dispersion was occurred in approx. 220 s. In this area, background traffic consisted of five streams. This phenomenon was mainly caused by TCP10 stream and its requesting for repeated transmission of missing packets.

The bit rate behaviour of background traffic and monitored VoIP are shown in Fig. 4. All parameters of the observed VoIP were monitored at the receiver (see Fig. 1). It is necessary to know that average traffic of VoIP (G.711) connection is 71.9 kbit/s.

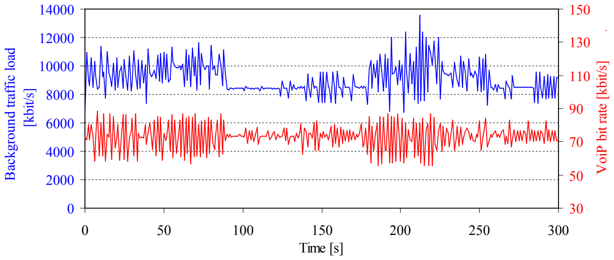

Fig. 4. VoIP behaviour influenced by background traffic load

According to the figure it can be noted that VoIP traffic is significantly influenced by background traffic behaviour. In case when background traffic was created by streams with bigger bit rate (UDP, TCP) then dispersion of final background traffic was also bigger. The influence of immediate VoIP bit rate on VoIP QoS parameters is shown in the following figures. There is shown the impact of VoIP bit rate on its jitter in the Fig. 5.

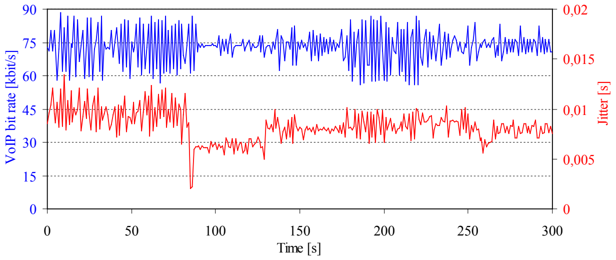

Fig. 5. Impact of VoIP bit rate on its jitter

On the basis of the figure it can be noted that composition of background traffic influence on VoIP jitter. The bad results were achieved in case when almost whole upstream bandwidth was occupied by background traffic. It could be seen from beginning to approx. 80 s and 180 to 230 s. The VoIP jitter decreased in the presence of smaller bit rate streams, e.g. gaming and another VoIP. Comparing these results with previous scenario results is also very interesting (Table 2). The jitter is higher in second scenario because more streams competed for bandwidth.

In Fig. 6 packet loss dependency on VoIP bit rate is depicted. The packet rate of the VoIP was 100 pkt/s.

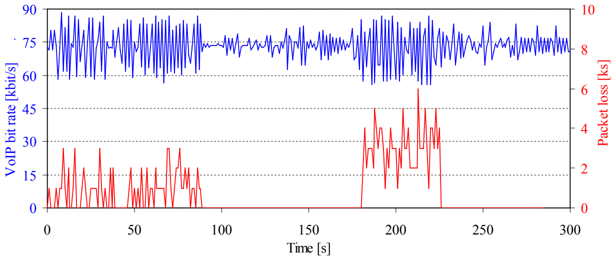

Fig. 6. Impact of VoIP bit rate on its packet loss

According to the above figure it can be concluded that packets were lost in cases where background traffic occupied larger bandwidth and VoIP did not have necessary bandwidth for lossless traffic, i.e. much lower than 71.9 %.

Conclusion

This paper has investigated an impact of background traffic load on QoS parameters of voice services (VoIP) in upstream of real GPON. An influence of VoIP codecs on QoS was observed, i.e. packet loss and jitter. The measurements were performed in two different scenarios.

From the Scenario 1 achieved results can be seen that specific load influences the QoS parameters of VoIP connection. It is possible to note that the higher the background traffic loads the higher the packet loss rates of all three codecs. In scenario 2, the impact of immediate state in communication channel was studied. Composition of background traffic has significant impact on both VoIP QoS parameters. The most important fact is that the immediate bit rate of VoIP has significant impact on its QoS parameters. It is not negligible fact from real time services point of view.

The mass-deployment of GPONs seems to be a right choice in respect to increasing of end-user bandwidth. On the other hand, it will not solve all problems. The paper confirmed our assumption that QoS parameters of voice services can be limited in case of mixed traffic.

The future works will focus on an impact of traffic on other multimedia services, e.g. video streaming in upstream link. Secondary, we will attempt to propose a solution which will guarantee the QoS for multimedia services working in real time.

Acknowledgments

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At present, GPON is the most modern variant of passive optical networks and it is also mass-deployed access technology in real operation. New broadband services cause traffic increase not only in downstream link but also in upstream link. Therefore, the GPON properties are investigated in the paper. In particular, an impact of background traffic load on QoS parameters (i.e. jitter and packet loss) of VoIP is investigated in upstream link. Ill. 6, bibl. 20, tabl. 2 (in English; abstracts in English and Lithuanian).

I. Bridova, M. Vaculik, P. Brida. GPON tinkluose išsiuntimo kryptimi duomenų srauto įtaka VoIP QoS parametrams // Elektronika ir elektrotechnika. – Kaunas: Technologija, 2011. – Nr. 1(107). – P. 111–114.

Šiuo metu naujausias pasyvinių optinių tinklų variantas yra GPON tinklai, kurie plačiai taikomi operacijoms atlikti realiu laiku. Teikiant naujas plačiajuosčio ryšio paslaugas, duomenų srautas didėja ne tik parsisiuntimo, bet ir išsiuntimo kryptimi. Apžvelgtos ir ištirtos GPON savybės. Ištirta GPON tinkluose duomenų srauto išsiuntimo kryptimi įtaka VoIP QoS parametrams. Il. 6, bibl. 20, lent. 2 (anglų kalba; santraukos anglų ir lietuvių k.).