HSPA radio access performance evaluation for Online games and M2M applications traffic (TCP vs UDP)

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Abstract **— In this paper we presented results of the performance evaluation of the live 3G/HSPA radio access network when loaded with multiplayer real-time games and M2M applications traffic. Traffic, for the emerging Machine Type Communication and online multiplayer games, was generated by an application running on 10 mobile phones in parallel using TCP or UDP protocols. In the previous work NodeB processing power and the number of simultaneous HS users were identified as major bottlenecks for system performances. Set of new measurements is conducted with increased processing power and the number of simultaneous HS users. The focus of the work was on the radio cell statistics, i.e. to evaluate potential impact of the additional traffic on the performance of radio access network.**

Keywords **— HSPA network, M2M, Performance evaluation, TCP, Traffic modelling, UDP.**

I. INTRODUCTION

MACHINE type traffic and gaming are types of applications that are increasingly using mobile networks to transfer data to central servers or interact with other devices, machines and players. In 3GPP, machine type traffic is a part of the Machine Type Communication (MTC) framework which describes the exchange of data between two machines, also called Machine to Machine (M2M) [1]. Together with additional traffic, these applications are also introducing new requirements on the underlying mobile networks. The market for M2M applications will grow in the upcoming years; according to some estimations 50 billion M2M devices will be active in year 2020 [2]. In order to be able to cater for such increase and also the change in the user and the node structure, it is important to understand the underlying traffic models.

In the online games domain, low latency is particularly critical for an avatar model of online games with high precision weapons, the so called massive multi-user online first-person shooter type of games. An important characteristic of the machine type communications is the variety of possible communication patterns, with heterogeneous requirements and features [1].

This work is done in the context of the ICT FP7 LOLA project, European Academia/Industry collaborative project [3]. The goal of the LOLA project is to provide significant technological advances in terms of minimizing end-to-end latency in wireless systems. LOLA targets low-latency applications found in machine-to-machine (M2M) communications and highly-interactive services such as gaming or remote control. In [4], a summary of functions and theoretical approaches for M2M traffic nodes based on literature and general ideas is presented together with an approach to modelling network traffic for M2M applications.

In [5], the results for online gaming traffic for four different applications-games are presented: Open Arena, Team Fortress 2, Dirt2 and World of Warcraft. These online gaming applications were defined for measurements due to their high impact on the gaming market. In [6], we presented several scenarios for M2M applications that require low transport network delay. The M2M traffic characteristics are analysed for the following applications: autopilot, virtual race, team tracking, and sensor-based alarm and event detection. In [4], detailed traffic modelling is done for above mentioned applications. Based on the parameters provided as the modelling results, a mobile phone application for packet-level traffic generation, denoted as TG-App, was developed with the goal of implementing modelled parameters, like different distributions of packet sizes and packet inter-arrival times, and to fulfil identified requirements, like TCP or UDP transmission of packets, multi-connection (few parallel TCP or UDP sessions).

This paper describes work undertaken in the context of the LOLA project - Achieving LOw-LAtency in Wireless Communications (www.ict-lola.eu). The research leading to these results has received funding from the European Community's Seventh Framework Programme under grant agreement n° 248993.

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In the previous work NodeB processing power and the number of simultaneous HS users were identified as major bottlenecks for system performances [7]. In this paper we present and comment the results of the new simulation of online gaming via TCP protocol (4 phones), and M2M applications via TCP and UDP protocols (6 phones), with increased capacity of Node B and the number of simultaneous HS users. The goal of experiment is analysis of the Cell statistics in the case that UDP traffic is present in the cell, and possible influence of UDP traffic on TCP traffic. For TCP traffic RTT is measured, while for the UDP traffic at this stage of the project we were not able to perform one way delay measurement, since the tool for such measurements is not yet implemented. More about one way delay measurements can be found in [8].

This paper is organized as follows. Section 2 provides a brief explanation of measurement setup and traffic generation application. In Sections 3 and 4, the measurement results related to traffic and cell statistics are presented and analysed. Section 5 provides a summary with concluding remarks.

II. MEASUREMENT SETUP

The measurements presented in the [7] were performed with 10 phones with Android 2.2 OS from the same manufacturer and the same model, and network's performances were analyzed. Since NodeB processing power and the number of simultaneous HS users were identified as major bottlenecks for system performances, the set of new measurements is conducted with increased processing power (number of Channel Elements) and the number of simultaneous HS users. All other network parameters are the same as in [7].

Mobile 3G network used for simulations is Telekom Serbia live network with HSDPA/HSUPA support on the serving NodeB, located in the city centre, in the highly urban area with several commercial and university buildings.

The NodeB under test had the following characteristics:

- 192/192 CE UL/DL activated (doubled in comparison to [7])
- eUL and HSDPA activated
- license for 32 simultaneous HS users (doubled in comparison to [7])
- two carriers, HS traffic going to second carrier

All phones were accessing Internet through the 3G HSDPA network – NodeB, RNC, SGSN, GGSN - and the server is located at a remote site at approximate distance of 80 km from the phones. The measurement setup is shown on Fig. 1.

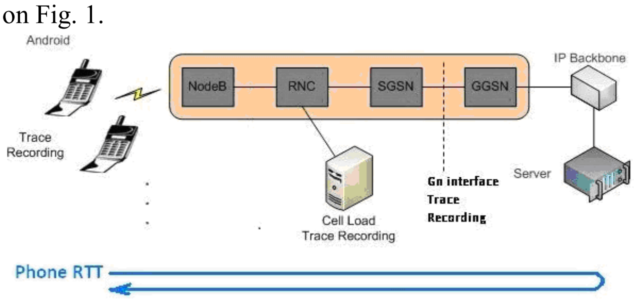

Fig. 1: Measurement setup

All phones were static, and not in use by the users, located in two sectors, either at cell BGU44B and BGU44C on the first carrier or at cell BGU44J and BGU44K on the second carrier. The cells are the same as the ones used in [7], [9].

To measure the RTT, an Android-based traffic generator application, TG-App, was used with corresponding server-side functionality [7], [9]. The latter is installed on the server to which the application sends data. For TCP traffic simulations, the value of RTT is measured and displayed for each packet. The measured RTT is an estimation of the time interval between sending a packet from the phone and receiving a corresponding ACK message from the TCP server. TG-App records start/stop time, packet size distribution parameters, inter-arrival time distribution parameters, generated packet lengths, RTTs and makes a report. In order to calculate RTT and analyse traffic on the phone, i.e. exchange of information between phone and server, Shark for root [10] traffic sniffer was used on the phones. After that related logs of the sniffer have been analysed, and results are produced. For phones using UDP, the current application version does not record Cell ID of the serving cell.

Two, new experiments were performed. In both test cases the same network parameters and same traffic patterns are used as in [7] (packet size and interarrival time distributions). The main difference is for phones 5-10, where in the first test case TCP is used, while in the second case UDP as transport protocol is used. TCP multi-connection type of simulation is performed with 4 phones simulating online gaming, and 6 phones simulating MTC applications are issuing either all TCP or UDP (each phone has only one TCP or UDP connection).

This was done in order to analyse and understand the behaviour of the serving cell(s), for the case of different load with online games and M2M applications using UDP for transmission protocol (instead of TCP used in the previous measurements [7]).

The following online games were simulated:

- Open Arena (OA)
- Team Fortress (TF)

Both simulated games are first person shooter (FPS) games i.e. the genre of video games that features a first-person perspective to the player. FPS considered here offer a multiplayer mode, which allows many human players to play on a common server. Considering the nature of the game, low delay and jitters in the network are crucial for the success of the players, therefore these games can be considered as quite challenging for these kinds of network parameters. Table 1. presents the parameters configured for TG-App on every particular phone for online gaming simulations [7],[9],[11].

The following M2M applications were simulated:

- Bicycle Race (BR)
- Auto Pilot (AP)
- Team Tracking (TT)

These applications are examples of the many possible M2M applications which are proposed and analysed within LOLA project.

Bicycle Race is a machined-aided gaming type of application, where the opponents are at different locations and agree about a circuit and the corresponding length of a race.

To calculate and share the equivalent position of each participants, measurements are taken by sensors (GPS, temperature, humidity, speed, terrain configuration) and are exchanged between the opponents.

TABLE 1
SIMULATION PARAMETERS FOR TCP MULTI-CONNECTION, 4 PHONES WITH SIMULATION OF ONLINE GAMING AND FOR TCP/UDP MULTI-CONNECTION 6 PHONES WITH M2M APPLICATION

Phone Number	Application/ Direction/Protocol	Packet sizes distribution/ Time distribution
1	OA, UL, TCP	Gauss (42.2;4.6)B, Uniform (69,103)ms
2	TF, UL, TCP	Gauss (76.52;13.9)B, Uniform (31,42)ms
3	OA,DL, TCP	Gauss (0.172;0.05)kB, Uniform (41,47)ms
4	TF, DL, TCP	Gauss (0.241;0.06)kB, Uniform (39,46)ms
5	BR, UL, TCP/UDP	Constant (1)kB,Uniform (100,500)ms
6	BR, DL, TCP/UDP	Constant (1kB),Uniform (100,500)ms
7	AP, UL, TCP/UDP	Constant(1)kB, Uniform(25;100)ms
8	AP, DL, TCP/UDP	Constant(1)kB, Constant(1000)ms
9, 10	TT(GPS Keep Alive), UL, TCPUDP	Constant(0.5)kB, Uniform(1;3)s

Auto pilot scenario includes both vehicle collision detection and avoidance (especially on highways) and how the urgency actions are taken in case of an accident.

Team Tracking (TT) is a public safety application used to monitor the position of several nodes in a given environment (e.g. building, stadium) for situation awareness and consequent action scheduling. In Table 1 the parameters configured for TG-App on every particular phone for M2M applications are given[7][9].

The applications were activated for all phones, and duration of the simulation was 2 hours for the first test case, and 1.5 hours (14:30-16h) for the second test case. Test cases were conducted on the different days.

III. Measurement Results Analysis UDP vs TCP

As mentioned before, both test cases have same network parameters and same traffic patterns, only phones 5-10 in the first test case use TCP, while in the second test case use UDP as transport protocol.

In the Table 2. is given the average number of sent packets in the test period for both test cases. Statistics is taken from application reports.

The difference between numbers of sent packets is of the order of magnitude for test phone number 7. This is due to small interarrival times (25ms-100ms) compared to average RTTs (250ms-2.5s in case 1), so the TCP "loses" much time waiting for ACK and retransmitting. For other phones, especially those with high interarrival time, the difference is not that drastic.

TABLE 2: AVERAGE NUMBER OF SENT PACKETS IN THE TEST PERIOD FOR TEST CASES 1 AND 2

Phone	Test case 1			Test case 2		
	Packets	Time (min)	Packet /min	Packets	Time (min)	Packet /min
5	5370	120,12	44,71	16556	89,88	184,19
6	6454	122,75	52,58	16234	87,33	185,89
7	7461	124,52	59,92	60386	86,88	695,02
8	3839	124,62	30,81	4996	86,40	57,82
9	1547	126,38	12,24	2489	85,90	28,98
10	1461	124,62	11,72	2466	85,37	28,89

Comparing the RTT statistics of first 4 phones that use TCP in both test cases, the average RTTs in the second case is slightly higher (about 100-150ms) in comparison to the case when all phones use TCP transmission protocol.

IV. Cell Statistics Analysis

For test phones using UDP transmission protocol, the application does not record Cell ID of the serving cell, so it was not possible to distinguish distribution of UDP traffic pre cells. But, looking at the number of packets sent with UDP, more traffic on cells J and K (HS traffic) is expected for these phones.

From the Fig. 2. it can be seen that the uplink traffic was higher during the test period (14.30-16h) than in the rest of the day in cell BGU44 J. The same situation is also with the others serving cells BGU44 B and C (serving R99 traffic), as well as in cell BGU44 K (serving both R99 and HS traffic). Cells J and K conveyed a significant amount of traffic, compared to cells B and C and compared to the rest of the day.

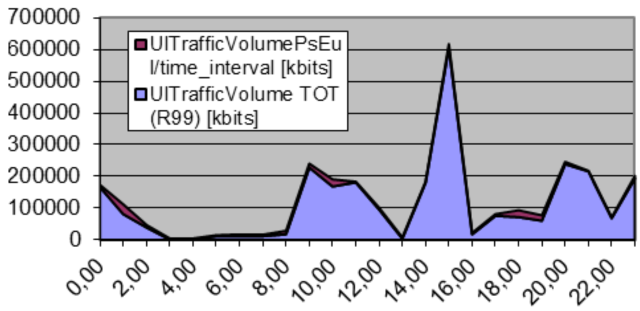

Fig. 2:UL data traffic volume (kbits), Cell BGU44J

Concerning average UL RAB distribution for the hours of interest, we have: Cells B and C served slower traffic (Fig. 3), while in cells J and K faster RABs were assigned in significant portion of time during the "peak" test hour (Fig. 4). Compared to test case 1, the Ps384 RAB conveyed significantly more traffic during the hour.

Availability of all four cells is not affected by test traffic (100%). In the area of accessibility (ability of user to get connection for requested service), the impact of test traffic is neglectable, for both speech and PS traffic. The only decrease of accessibility is noted in cell K in period 15-16h – HS accessibility goes down to 99%, and Eul to 97%, which is also not of great significance.

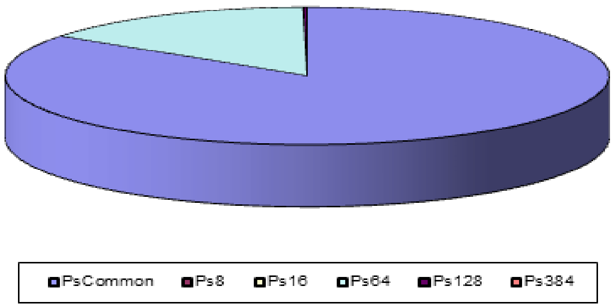

Fig. 3. BGU44B UL RAB distribution Test case 2

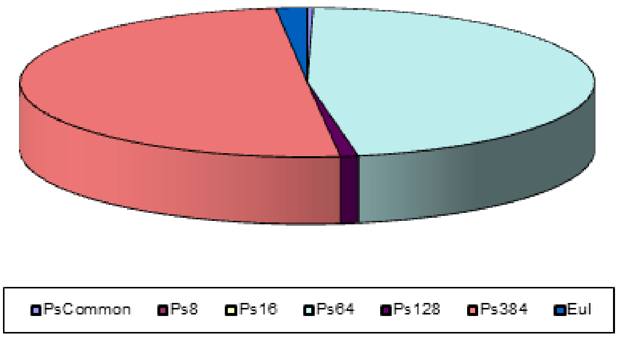

Fig. 4. BGU44J UL RAB distribution Test case 2

In the area of retainability (ability of the user to keep connection - drop call rate degradation), R99 Packet drop rate for cell B in the hour 14-15h goes to 0.9%, but in the following hours is 0%. R99 Packet drop rate for cell C, and R99 and HS drop rate for cells J and K do not go over 0.7% during testing. In the area of integrity (QoS requirements), UL BLER and throughput are not affected by additional traffic.

There was no more degradation of speech accessibility during testing [7], [9]. There is some degradation in PS accessibility, but significantly lower than before NodeB upgrade. It can be seen that accessibility during testing didn't fall below 97%., which is a great improvement compared to [7], where on 1st carrier accessibility was falling down to 80%, and on 2nd carrier to about 50%. Also, increasing the number of CEs led to the assignment of "faster" RABs (above Ps64) to more users.

V. CONCLUSION

In this paper, we presented the results of an analysis of the impact of the emerging MTC and gaming applications on cell performance in live 3G/HSPA wireless network. In our previous work, presented in [7], [9] NodeB processing power and the number of simultaneous HS users were identified as major bottlenecks for performances. It was concluded that M2M traffic is strongly affecting network performance because of its traffic shapes and intensity, thus requiring NodeB capacity extensions. After NodeB was expanded in terms of license and processing power (doubled Channel Elements and doubled licenses for simultaneous HS users), it became capable of handling additional M2M traffic with success. There was no impact on the network performance for both cases of TCP or UDP transmission protocol usage, in the area of retainability, nor integrity, while the degradation of accessibility after Node B capacity extension became tolerable.

New experiment was also intended to test the UDP model in TG-App application. General observation concerning UDP is that much more packets are generated since there is no waiting for acknowledgements and no retransmissions as in case of TCP. Accordingly, more traffic is conveyed in the uplink compared to test case 1, and faster RABs are assigned more. The RTTs of four "TCP" phones are slightly bigger, compared to test case 1. Measurement of the one-way-delay for RTT case, involves taking traces at both ends with precise time reference. Since the tool for one-way-delay measurements is not yet implemented (this involves taking traces at both ends with precise time reference), no one-way-delay measurements were recorded, which will be part of our future work.

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