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An empirical study of Cloud Gaming

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***Abstract*—Online gaming connects players from all over the world together for fun and entertainment, and has been regarded as one of the most profitable and popular Internet services. Besides, there is a growing trend towards moving local applications to remote data centers: this is often referred to as the *cloud*. With the purpose of studying the impact of Cloud Gaming on the access network load, in this paper we carry out an empirical network traffic analysis of two well-known cloud gaming platforms: OnLive and Gaikai. Traffic traces have been collected and analysed from five different games of both platforms. Cloud gaming has been observed to be remarkably different from traditional online gaming in terms of network load and traffic characteristics. Moreover, the traces have revealed similarities between the two platforms regarding the packet size distribution, and differences concerning the packet inter-arrival times. However, each platform shows a similar traffic pattern for most of the games it serves. Nonetheless, the racing and shooter games considered in this work demand more bandwidth than other game-genres.**

Cloud gaming platforms. OnLive and Gaikai are the two cloud gaming platforms chosen for this study. Their main features are:

a) OnLive: According to the official OnLive's website [1], for a good Quality of Experience (QoE) the platform requires a minimum bandwidth connection of 2 Mbps to render content at 1024 x 576 pixels, recommends 5 Mbps for 1280 x 720, and is able to output at 1080p with a higher bandwidth connection. OnLive requires a local installation of its own software client.

b) Gaikai: does not require any local installation since it runs on any up-to-date web browser. As stated in its website [2], Gaikai is playable from around 3 Mbps but offers a better performance at 5 Mbps. This platform is also able to output content at 1080p, yet with higher network requirements.

These cloud gaming platforms leverage a GPU on a server to render content. OnLive uses an H.264 encoder chip on a dedicated device to grab the video output of each GPU running on their servers. Gaikai uses a CPU to encode H.264. Both platforms have strong jitter requirements, and are highly sensitive to packet loss and packet delay [3].

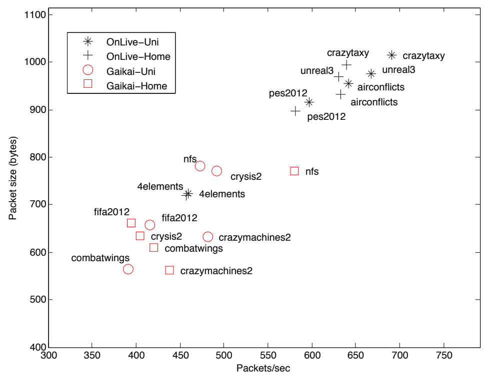
Measurement methodology. Traffic traces of around 100 seconds (wall clock) of playing time have been captured at the local computer of the gamer. Each traffic trace records the packet size and inter-arrival times of all captured packets. Measurements have been carried out from two different access network scenarios: (a) a wired University connection (100 Mbps Fast Ethernet), referred to as *UNIV*, with 94.17 Mbps of downstream, 71.81 Mbps of upstream, 1 ms of jitter and 38.12 ms and 25.28 ms of RTT (Round-Trip Time) to the nearest OnLive and Gaikai data center respectively; (b) and a wireless home connection (802.11n + VDSL), referred to as *HOME*, with 51.01 Mbps of downstream, 5.34 Mbps of upstream, 2 ms of jitter and 60.08 ms and 25.71 ms of RTT to the nearest OnLive and Gaikai data center respectively.

Results overview. Fig. 1 shows a scatter plot of average packet rate versus packet size for each game and platform, both in the downstream (Fig. 1 (a)) and upstream (Fig. 1 (b)) directions. As observed in Fig. 1 (a), OnLive presents a higher packet rate (in the range between 600 to 750 packet/sec) than Gaikai (in the range of 350 to 550 packet/sec). This difference is especially remarkable when considering the two racing games (*nfs* and *crazytaxy*) and the shooter games (*crysis2* and *unreal3*). It is also worth noting that the *4e* game (the OnLive 2D puzzle game) shows different values with respect to the other games of OnLive. This might be due to the fact that the OnLive platform adapts the bit rate and dedicates less computational resources for a game that does not have high graphic requirements, as studied in [4].

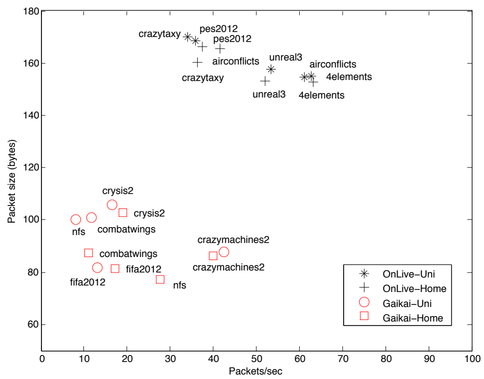
In the upstream direction (Fig. 1 (b)), packet rates range between 35–65 packets/sec for OnLive and between 10–40 packet/sec for Gaikai. It can be observed that OnLive does not only have a higher packet rate, but also a higher packet size. This means that OnLive requires a higher network performance than Gaikai.

Server $\rightarrow$ Client. The measurements regarding the server-originated traffic (*downstream*) are analysed next. Fig. 2 depicts the packet size CDF for all games and platforms. According to Fig. 1 (a), it can be observed that in general, average packet size is smaller for Gaikai. However, in both cases a bimodal distribution is observed: OnLive has the low mode at about 250 bytes and the large mode around 1400 bytes while Gaikai shows its two modes at 150 and 1480 bytes respectively. The packet size related with the large mode for both platforms may be caused due to the MTU (Maximum Transmission Unit) of the two considered access network scenarios (i.e. Ethernet-based). The difference between both platforms relies on the fact of which mode is the largest. For Gaikai the largest mode is the one related with *small packets* (150 bytes), whereas for OnLive the largest mode is for *large packets* (1400 bytes). Obviously, this fact makes a difference in the average packet size observed in Fig. 1.

Concerning inter-arrival times of both cloud gaming platforms, as observed in Fig. 3, in OnLive about 40% of packets show inter-arrival times within microseconds (μs), which are then uniformly distributed up to 5 ms. Moreover, it is interesting to note that Gaikai shows three modes: 20% of



(a) **Server** $\rightarrow$ **Client**



(b) **Client** $\rightarrow$ **Server**

Fig. 1. Packets/sec vs average packet size for the downstream (a) and the upstream (b) directions.

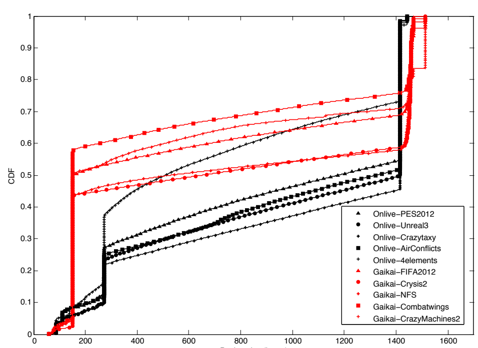


Fig. 2. **Server** $\rightarrow$ **Client**: CDF of packet size (bytes).

packets arrive within few μs, 50% around 1 ms, and the remaining 30% near 4 ms.

Client $\rightarrow$ **Server.** We have performed the same analysis for the client-originated traffic (*upstream*). Fig. 4 (a) presents the packet size CDF. Gaikai shows modes between 50 to 100 bytes, whereas OnLive shows modes in 100 bytes, 140 bytes and 240 bytes approximately. To conclude, Fig. 4 (b) shows the inter-departure times CDF. In this case, Gaikai shows a mode below 1 ms and then uniformly distributed inter-departure times up to 12 ms. On the contrary, OnLive shows uniformly distributed inter-departure times from 0 to 8 ms and then a mode at around 9 ms.

Future work. It could be interesting to further investigate cloud gaming-generated traffic with the purpose of having a

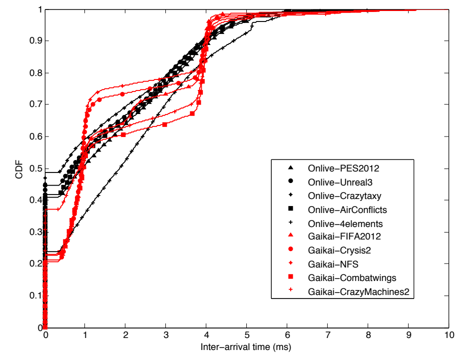
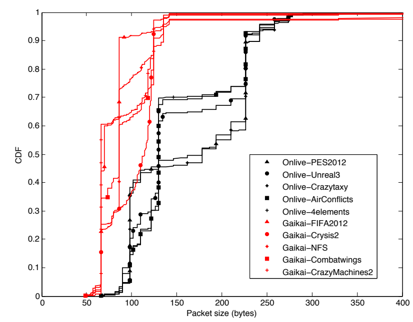
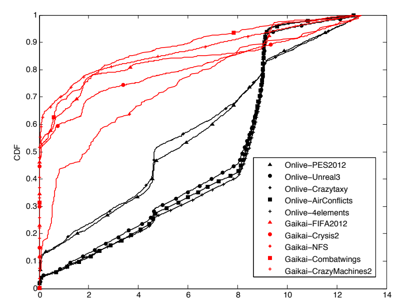


Fig. 3. **Server** $\rightarrow$ **Client**: CDF of packet inter-arrival times (ms).



(a) CDF of packet size (bytes)



(b) CDF of packet inter-departure times (ms)

Fig. 4. **Client** $\rightarrow$ **Server**: CDF of packet size (a) and CDF of packet inter-departure times (b).

better understanding of the underlying protocols used by the two platforms. Moreover, network conditions could be altered (i.e. adding delay) in order to evaluate its consequences on the Quality of Experience perceived by gamers.

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References

[1] Onlive, http://www.onlive.com, [Online; accessed 25-July-2012].
[2] Gaikai, http://www.gaikai.com, [Online; accessed 25-July-2012].
[3] M. S. Borella, "Source models of network game traffic," *Computer Communications*, vol. 23, no. 4, pp. 403–410, 2000.
[4] K.-T. Chen, Y.-C. Chang, P.-H. Tseng, C.-Y. Huang, and C.-L. Lei, "Measuring the latency of cloud gaming systems," in *Proceedings of ACM Multimedia 2011*, Nov 2011.