

# Better Performance in LTE Networks with Edge Assistance: The World of Warcraft Case

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## ABSTRACT

To improve the performance of Massively Multiplayer Online Games (MMOGs) in mobile networks, we explore the potential benefits of an *edge-assisted* deployment model: part of the MMOG back-end service executes closer to the end user at the edge of the LTE network. We investigate the impact on game latency of (1) the exact placement of such edge servers; (2) the number of cooperating game clients; (3) the amount of client requests served at the network edge; (4) the hardware capabilities of edge servers; and (5) user roaming. Based on our analysis, we show that edge assistance can in fact increase the performance of online games over LTE networks as long as at most 50% of the user requests are processed at the network edge. Furthermore, we argue that the Packet Data Network Gateway (PGW) is the most appropriate place for hosting edge servers and show that TCP performance in the proposed setting is not affected by user roaming.

## Keywords

Edge computing; Massively Multiplayer Online Games; LTE; 4G

## 1. INTRODUCTION

For MMOGs, user experience is affected by the responsiveness and predictability of the time to handle client requests. The lag between requesting a change and it being reflected in the VE is called *game latency* and affects the responsiveness of a MMOG. In addition, the variance of latency, i.e. *jitter*, also affects performance since user experience needs to be predictable when repeating identical requests [1].

In this paper, we quantify the impact of 4G/LTE networks on MMOG performance in terms of end-to-end latency and jitter con-

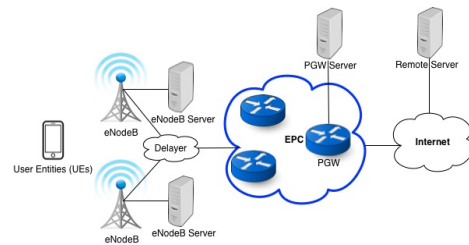


Figure 1: Edge-assisted MMOG deployment model.

sidering the characteristics of online gaming traffic. In addition, we evaluate through simulation how performance can be improved using edge assistance. We take into account: (a) the different possible placements of edge servers within the LTE infrastructure; (b) the number of cooperating clients; (c) the ratio of user requests served by edge servers over the total requests issued by the user; (d) the different processing capabilities of edge servers; and (e) user roaming.

## 2. PROPOSED DEPLOYMENT MODEL

To reduce the latency perceived by MMOG clients, we propose moving targeted backend servers to the access network thus allowing for faster responses to client requests. We identify two places where *edge servers* can be attached: the PGW gateway or the eNodeB. The intuition behind this is that for MMOGs such as the World of Warcraft (WoW), some actions need not be shared with all cooperating clients via remote servers and thus can be directly processed by a local server. For example, when a foe is killed the experience boost can be served by the local server, however the kill notification must be shared with the rest of the players. We assume that MMOGs can be built such that a significant portion of the user requests can be served entirely by edge servers thus avoiding the high-latency communication between respective clients and distant backend servers.

## 3. PERFORMANCE EVALUATION

### 3.1 Simulation setup and methodology

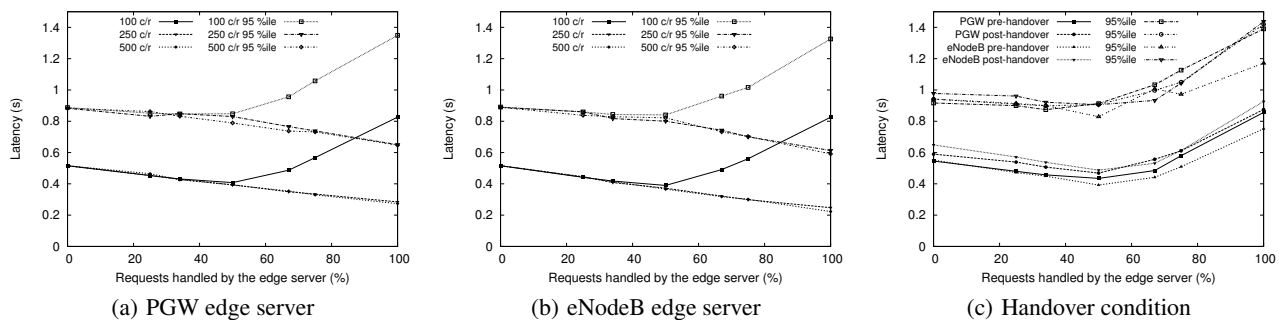


Figure 2: Average latency and 95th percentile for different percentages of MMOG requests processed.

We perform experiments in a simulated 4G/LTE network using the OMNeT++ framework with three publicly available models, INET, SimuLTE and 4GSim, with a implementation of a S1-like handover procedure. Our simulation scenario is based on a 4G/LTE access network 1. *Edge servers*, which can be placed on the eNodeB or the EPC (next to the PGW), are modelled by establishing a maximum number of requests that it can handle concurrently and queuing the additional ones. Moreover, we model the probability of a request being served by the edge server, as opposed to a distant backend server over the Internet. The traffic used for the simulations follows the traffic patterns extracted by traces of the World of Warcraft videogame. They are created using the models described in [2] for three distinct gameplay scenarios.

## 3.2 Evaluation results

### 3.2.1 Edge server collocated with PGW

First, we evaluate the performance of WoW with the edge server attached to the PGW gateway (Access latency: 25 ms [3], Internet latency: 120 ms [4]). Figure 2(a) plots the average and 95th percentile of the latency per client request for varying percentages of requests processed at the network edge and different processing capabilities of the PGW edge server. We assume 500 cooperating mobile clients, while the processing capacity of the edge server is set to 100, 250 and unlimited (i.e. 500) concurrent requests.

When most of the requests are directed to the backend server the average game latency observed is dominated by request/response transmission delays. By allowing more requests to be served by the edge server, the high Internet delays are avoided and latency gradually decreases. However latency increases—due to server queuing—to a point where edge-assisted execution is outperformed by the original game configuration.

### 3.2.2 Edge server collocated with eNodeB

Figure 2(b) shows the game latency when the processing capacity of the edge server is limited to 100, 250 and 500 concurrent requests. As before, when the majority of requests are directed to the backend server, the transmission and processing delays are the main contributors to the game latency. Queuing at the edge server again becomes a major source of delay when more than 50% of requests are being processed at the edge server.

### 3.2.3 Inter-cell mobility and handover events

Figure 2(c) plots the latency before and after a handover event. We observe a smooth transition between the two base cases, i.e. the case where all requests are processed at the edge server and the case where all requests are directed to the backend server. For

the latter, both edge server placements yield similar results in the pre-handover state. In the post-handover state, the eNodeB placement exhibits a larger degradation in performance compared to the PGW placement. This is due to the fact that every request must traverse the access network three times: once for the request to reach the SGW; once to be forwarded to the original eNodeB; and one last time to reach the backend server. In contrast, when the server is placed at the EPC, packets go through the access network only once.

As shown in previous sections, when all requests are handled at the network edge, better performance is achieved in pre-handover conditions for the eNodeB placement. However, in post-handover conditions, performance is worse for some scenarios, since packets must traverse the access network twice to reach the edge server on the other eNodeB.

## 4. CONCLUSIONS

Our simulation-based experiments suggest that such a deployment model can help achieve better performance for this specific type of applications. We showed that there is no advantage in placing the edge server at the eNodeB as opposed to the PGW and a combination of both locally and remotely served requests is required in order to realise benefits in application performance—to avoid contention on resource-constrained edge servers, up to approx. 50% of the total requests should be processed at the network edge. Finally, we verified that the impact of user mobility is negligible.

## 5. ACKNOWLEDGMENTS

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