Poster: Mobile Edge Computing – a Booster for the Practical Provisioning Approach of Web-based Augmented Reality

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***Abstract*—Web-based Augmented Reality (Web AR) provides a lightweight, cross-platform, and pervasive AR solution. However, all of the current Web AR implementations still face some challenges, which greatly hinder the promotion of Web AR applications. Benefiting from Mobile Edge Computing (MEC) paradigm, in this paper, we propose a MEC-based collaborative Web AR solution, which can be regarded as a feasible and promising one. The edge server not only reduces the network latency but also decreases the bandwidth usage of core networks. Prototype implementation demonstrated the effectiveness and practicability of the proposed MEC-based solution for real-world Web AR development and deployment.**

I. Introduction

Augmented Reality (AR) [1] has offered tangible benefits in a number of areas. To make AR touch more consumers, Web AR will be one of the significant approaches. But existing Web AR implementations are struggling with some inherent weaknesses. *(1) Computing Efficiency Limitation.* Pure front-end solution relies on JavaScript (e.g., AR.js), which cannot provide sufficient computing capability. *(2) Compatibility Limitation.* Browser kernel-based extension solution (e.g., Mozilla WebXR) faces the challenge of cross-platform due to the lack of Web AR standardization.

Now, the cloud computing promises to overcome the computing efficiency limitation of pure front-end based Web AR solution. Before the Web AR standardization for browsers is completed, this collaborative (i.e., Terminal + Cloud) computing mechanism will be more feasible in practice. Through this approach, we have conducted several Web AR advertising campaigns by WeChat, and have gained a great deal of attention from users. However, in the process of development and deployment, this type of Web AR implementation still faces some challenges:

Bandwidth Challenge. AR is a computation-intensive and data-intensive application. Continuous image transmission occupies a large amount of network bandwidth, which not only degrades the performance of core networks but also causes high deployment cost because of the ever-increasing bandwidth requirement.

Latency Challenge. Compared with the two Web AR solutions mentioned above, cloud computing-based implementation adds additional communication delay due to the image transmission. And unstable wireless environment also greatly degrades the performance of Web AR applications.

Figure 1. Two influential use cases of Web AR. Users can enjoy the Web AR services any time by accessing the activity links embedded in specific WeChat official account. Here we highlight the China Mobile Web AR activity (Dec. 5-14 2017), the first time we promote Web AR at large scale, which achieves 3,550,162 Page View (PV) and 2,080,396 Unique Visitor (UV) totally in 10 days. This type of Web AR solution collaborates computing capability of both cloud and mobile device, which greatly improves the application performance and reduces the deployment cost of central site as well (Number of cloud servers: 10+ for collaborative solution vs. 100+ for cloud computing-based solution).

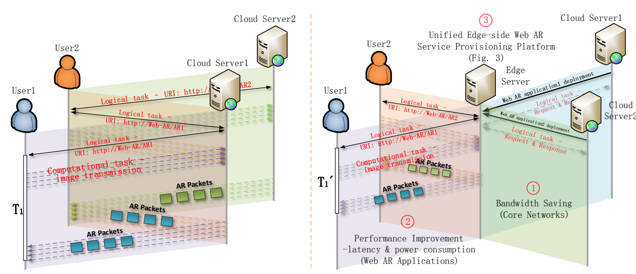

Figure 2. Comparison of cloud computing- and MEC-based solutions.

Our ongoing research aims to tackle the above challenges:

- We propose a MEC-based Web AR solution, where edge and cloud servers are complementary. The success of this flexible and feasible Web AR implementation attributed to the following aspects. First, the separation of computational and logical tasks provides the basis for this decoupling and lightweight Web AR system. Second, Web AR services are capsuled in the form of microservice via Docker, which makes the deployment more flexible. Note that edge server provides a decentralized service provisioning paradigm for Web AR, both bandwidth occupation of core networks and response delay of applications, therefore, can benefit.

- We demonstrate that MEC paradigm [2] benefits a lot for Web AR applications (see Section III). And this collaborative mechanism will also be a promising approach for the pervasive promotion of Web AR under the upcoming 5G networks because of the ubiquitous MEC infrastructure deployment.

II. System Framework Overview

Edge server plays a pivotal role in the entire framework as is shown in Fig. 2 and Fig. 3. It is not only responsible for the deployment of Web AR applications (from third-party's aspect) but also for the request processing (from user's aspect).

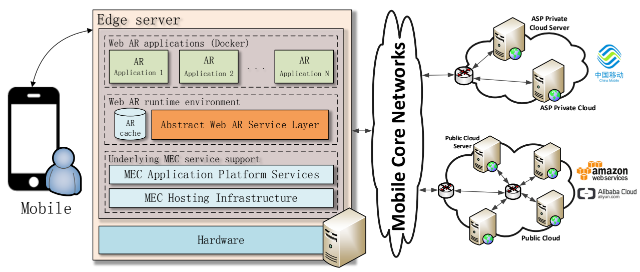

Figure 3. Overview of the MEC-based Web AR system framework.

The Web AR service provisioning platform on the edge server side consists of three parts:

1. MEC application platform services mainly provide underlying service support.
2. Web AR runtime environment consists of two parts. *(1) Abstract Web AR service layer* aims at providing underlying Web AR dependence and common Application Programming Interface (API). *(2) AR cache* provides a temporary public content storage place.
3. Variety of Web AR applications are dynamically scheduled and deployed by using the Docker technology.

It, therefore, achieves a flexible, lightweight, and distributed method, which significantly reduces the deployment cost compared with the original centralized deployment approach (i.e., cloud computing-based Web AR solution) and improves the performance of Web AR applications as well.

III. Performance Evaluation

To get the performance comparisons, we conduct experiments in an MI MIX 2 mobile phone for 10 times with different access habits. The Web AR service provisioning framework is deployed in our campus[1] and Alibaba Cloud[2], respectively. The frames are resized into 250×250 pixels, average 25.04 KB.

[1](BUPT) round-trip min/avg/max = 1.389/7.265/14.746 ms, 0.00% packet loss.
[2](Beijing) round-trip min/avg/max = 23.311/34.730/83.677 ms, 2.56% packet loss.

Table I
Experiment Results in Terms of Latency (ms), FPS, and Power Consumption (mW/5min).

Solutions	Latency[1]	FPS	Power Consumption[2]
Pure front-end	231	5	947
Cloud computing-based	62	25	405
MEC-based	43	24	392

[1] Latency includes the time of both image transmission and processing.
[2] Only the terminal's power consumption is counted in experiments.
[*] Note: All experimental results show the same trend, here is just an example of the results as a show.

Table I illustrates that the proposed Web AR solution outperforms the other two implementations. The pure front-end solution is the worst-performing one due to the inefficiency of JavaScript (computing on the user device overcomes the negative impact caused by image transmission, but the local processing results in the non-negligible time consuming). Although image transmission introduces external latency and power consumption, it is still worth offloading computation-intensive tasks to edge/cloud since more abundant resources are available. By contrast, MEC-based solution performs better since it is closer to users. Moreover, it also implies the bandwidth saving of core networks.

IV. Conclusion

We designed and developed a MEC-based Web AR solution, which aims to promote Web AR in a more feasible and flexible way. Our approach offers multiple advantages over existing Web AR solutions, such as lightweight, easy-deploy, higher-performance, and bandwidth-saving. However, there is much work to be done to promote the further application of Web AR. In the future, we plan to explore more efficient computing technologies to further improve the application performance In addition, some important issues also should be mentioned. The benefits of reduced latency and saved bandwidth are at the cost of the edge server, but *Who* is going to pay for such servers? Also, *When*, *Where*, and *How* to deploy the Web AR applications to balance the *benefit*, *cost*, and *efficiency* still entails substantial challenges.

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