Enabling Edge Computing in 5G for Mobile Augmented Reality

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Abstract—Mobile Augmented Reality is scoring more reputation due to the progression in the clever smartphones that include characteristics and hardware needs for integrating AR. MAR offers an exclusive knowledge in which the physical world is enhanced by virtual remarks. It also incorporates computationally intensive techniques that might be divested to edge servers on 5G systems, improving MAR by reducing communication latency and ensuring more robust network links, resulting in unified mobile augmented reality user experiences. Edge computing is one of the probable 5G technologies that could deliver content and processing resources familiar to the users, lowering latency and backhaul load. We presented a MAR structure situated on a 5G edge computing and latency results. Offer higher bandwidth while edge servers completely scale down the network restrictions to reduce the bandwidth severity of the network by operating closer to the user. This paper aims to address the 5G edge computing arrangement to aid consistent MAR and finding protocol for enhanced quality of experience (QoE) for MAR applications.

Keywords—MAR, AR, 5G, edge computing, bandwidth limitation, latency

1 Introduction

Augmented Reality on mobile devices is a popular technology that simplifies the actual world by superimposing layers of digital content on top of it. Virtual images, sensory actions, audio or video inducement and haptic assessment are all examples of these materials. On mobile devices, MAR incorporates physical world views with virtually created interpretations. Computationally comprehensive computer vision techniques, including as object recognition and feature extraction, constitute the key enabling technology for MAR applications [1]. These techniques are frequently not organized on consumer devices, such as smartphones and head-inclined devices, since they failure to achieve on-board processing abilities required to correctly analyze pictures and show findings in a timely manner. Pictures with small resolution can be analyzed on device and take minimal time to process, but the precision of object recognition suffers as a result.

This back-and-forth between latency and precision can be moderately determined by outsourcing computation severe image processing operations to other servers, which can provide significantly additional processing resources to examine bigger pictures with great accuracy rates. Traditional cloud computing can supply the necessary computational power, but the needed communication resources to cloud servers are substantial. Edge computing is a developing paradigm that carries computation to network edges, such as near to 5G base station and its advantage arise from its closeness to data bases and all users. Developments contain small and familiar latency, confidentiality protection, reasonable rates of bandwidth, extended battery life, and flexible services. Therefore, edge computing is better option for offloading computations in latency-constrained MAR [2].

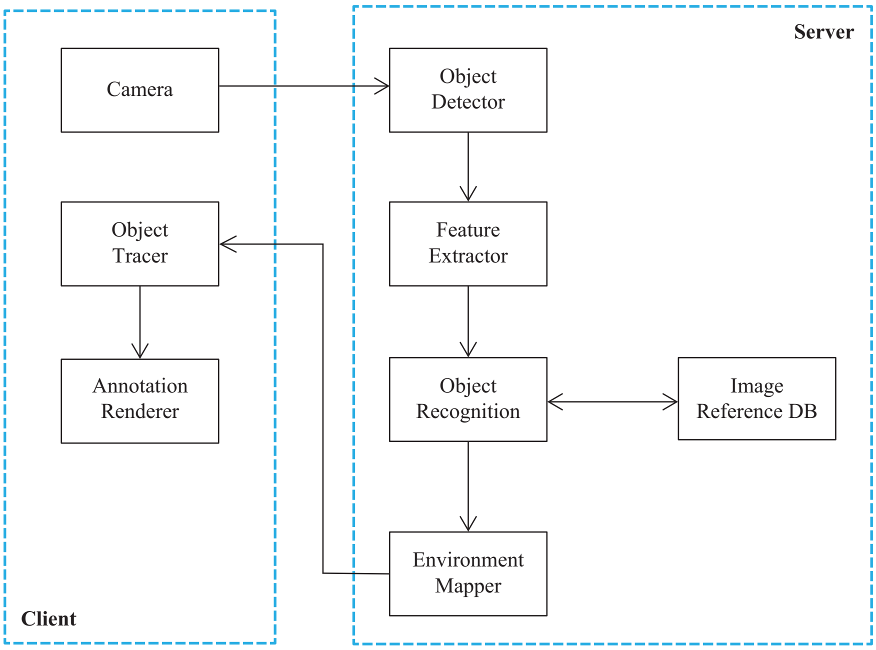

Fig. 1. Simple pipeline structure of the MAR

Figure 1 presents the simple pipeline of the MAR system, having seven parts in both server and client. Initially, MAR client camera images with correct resolution is transferred to server object detector that verifies the presence of possible goals inside the query frame and identifies goal regions of interest. The feature extractor extracted the feature points in these parts and moved to item recognition to be balanced to an image reference DB. If objects are recognized, the environment mapper verifies the result. The place and alignment of the image is determined and moved object tracer input.

This traces the desired item between camera frames in order to stop recognition desires for each frame. Lastly, the annotation renderer adds associated objects with retrieved related content.

By creating the groundwork for the Internet of Things to reach its full potential, 5G will help to establish it as an integral part of our world. It will be a long time before 5G becomes widespread, but businesses must begin now by designing and reinventing services and products to take advantage of 5G's enhanced capabilities. AR is a significant technology that will enable a fundamental paradigm shift in how people interact with data, and it has just lately been acknowledged as a potential answer to many critical demands. 5G speeds up AR technology and increases data flow. Widespread adoption appears likely with easier and more accessible use for a range of various applications (other than video gaming). In conclusion, AR in the 5G era is a really exciting forthcoming wave in which massive repositories of data will enable an AR lens into scenarios in ways that bring near immediate insight [3].

2 Mobile augmented reality on 5G and edge computing

Edge computing, also known as mobile edge computing, has recently arisen to surpass mobile devices' computational restrictions in the face of a rising number of computationally expensive applications [4]. Edge computing relieves strain on network resources by shifting workload to dispersed computing clusters. Regardless of the fact that cloud computing allows users to access a shared pool of computers and offload expensive computations to the cloud, connection to cloud servers is still slow. This is one of the primary reasons why edge computing appears to be a promising capability for mobile augmented reality [11].

We demonstrated 5G edge computing augmented MAR, which moves computation from the principal cloud to the 5G network's edges. The edge design processes massive volumes of data in many circumstances and delivers great speed and service quality for MAR, particularly for latency-sensitive MAR functions like object detection, tracking, and rendering. The design also improves the MAR process by synchronizing data between the cloud and the edge, as well as managing virtualization within edge nodes.

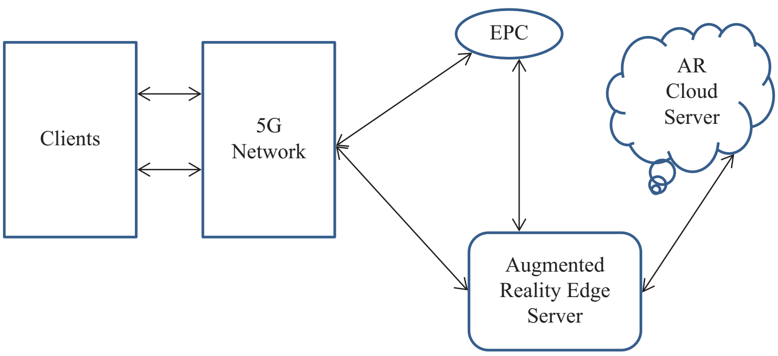

Fig. 2. Architecture of MAR with 5G & edge computing

Figure 2 depicts the architecture of MAR with 5G and edge computing, which separates the system into edge and cloud server. MAR clients are linked to 5G networks that is used to connect a 5G base station to a MAR edge server. It provides recognition and rendering for latency-sensitive MAR applications, and assures process in the incident of network outages. Local reference image database is maintained by edge servers and execute object identification on input images. The request is routed to the cloud if the edge fails.

The cloud houses an entire picture database, and if the edge servers collapse, the cloud serves as a failover recognition server [5].

2.1 Emerging application network demands

From mail and social networking to audio and video streaming and remote control of household utilizations, mobile broadband has radically impacted many people's lives through services supplied by both operators and third-party companies [6]. There is no single radio access technology update that defines 5G. Moderately, it is a comprehensive range of access and connectivity results designed to meet the high expectations of mobile communication [7].

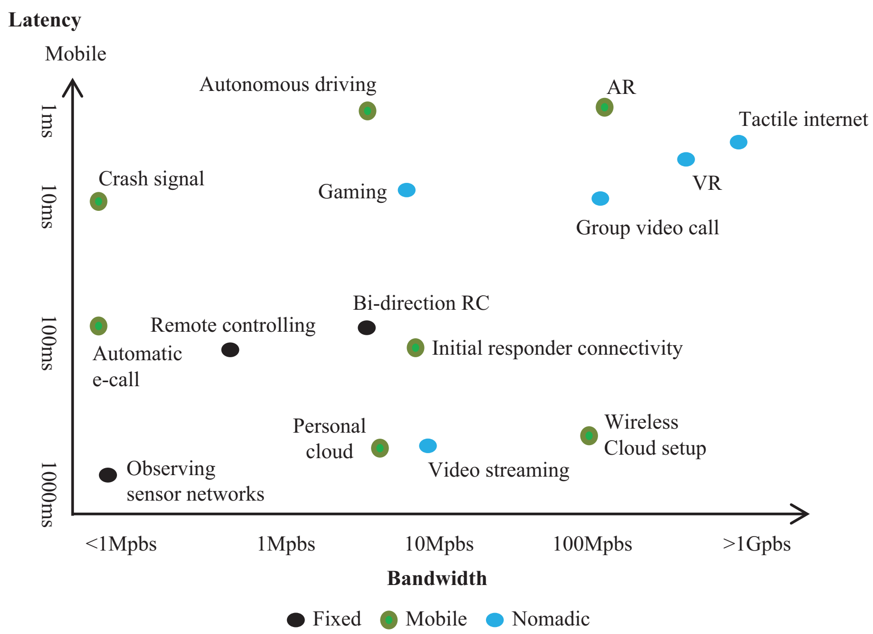

Fig. 3. Emerging technologies for network demands

Figure 3 depicted the latency and bandwidth needs of the different use cases that have been discussed in the 5G context.

"Cloud providers have already begun investing in "edge clouds" with a distributed footprint that places cloud servers geographically close to end users", and computes with next-generation ultra-low latency: Get ready for investment-intensive technology. Lightweight and affordable mobile HMDs enable ubiquitous adoption of AR/VR. 5G networks will also need to keep up with these infrastructural needs, not only by increasing network capacity and efficiency, but also by incorporating computer resources directly into the communication network [8].

3 Result & discussion

A MAR application, in general, contains inputs, processing functions, and outputs.

Inputs include the device's sensors as well as any other partner device. Processing is the set of functions that generates the output that is displayed on the screen of the mobile device. Outputs are the enhancing action that projects the Virtual information on the current view of the actual world. Edge layers help AR applications compute by accepting requests. It receives user actions and instructions and transfers them to the edge cache of independent storage. Calculates the data stored in edge storage. If the feature match is successful, the result is delivered to the edge server, which returns the result data to the user cache for rendering and display.

The growth of the mobile sector has led to the advent of AR, as the necessary components already exist in modern smartphones and are easy to use with them. As a result, new legislation is needed to address the future challenges of rapid data evolution [9]. The main issue is to speed up the calculation of tasks performed while AR technology is running on the device. This can only be achieved by using higher bandwidth interpretations and aggregations, as other devices may not work effectively due to complexity. Mobile cloud computing helps remove service availability, heterogeneity, and security, as well as bandwidth limitations. Cloud computing is significantly better than mobile edge computing. 5G can be greatly simplified with millimeter waves to solve the bandwidth problems that occur in traditional networks. The edge section primarily acts as the service request layer of the framework, authenticating users and implementing the processes necessary to enable all service requests and inbound services made on the edge side-execute requests to do.

Figure 4 depicts the latency system results that shown a 5G edge enhanced connection to minimize the time taken for transferring data by 25 percent when comparted to LTE and 55 percent for Wi-Fi.

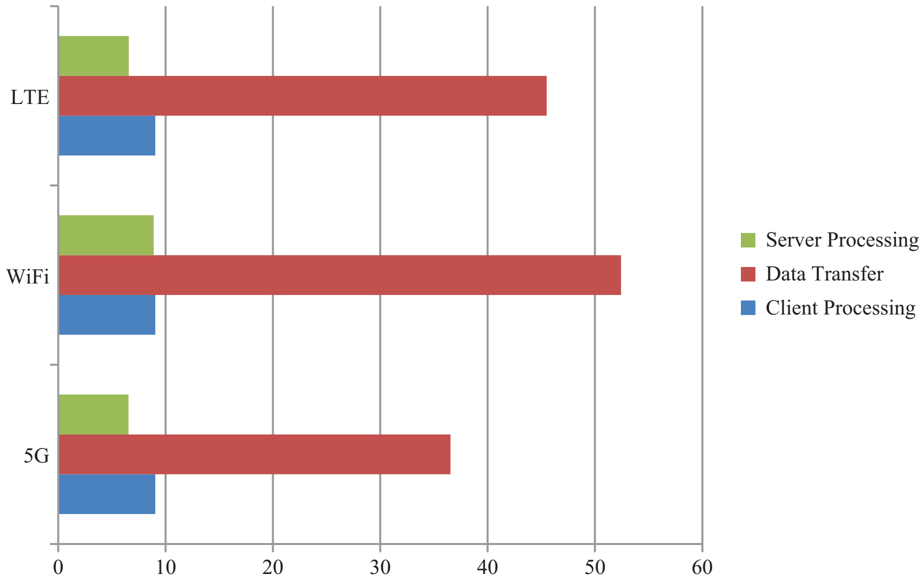

Fig. 4. Latency of the proposed MAR system

For MAR systems, reliability is being able to operate without the network difficulties or disruptions. As a result, a 5G edge computing structure will be examined, in which exhaustive computations will be re-located from centralized cloud servers to 5G network edges. This edge architecture handles huge amount of data and give higher performance to MAR, particularly in the latency sensitive process, such as mapping, tracing, and rendering. This architecture will also provide context information to the MAR pipeline, manage knowledge synchronization between cloud and edge nodes, and manage virtualization technologies in edge nodes. The characteristics comparison of augmented reality and mobile augmented reality is explained in Table 1.

Table 1. Comparison of augmented reality and mobile AR characteristics

Property	AR	Mobile AR
Functioning	Devices protected with GPUs to operate weighted computer vision on device.	It may need computational offloading.
Energy utilization	It is not as critical as MAR since external power supply.	Entire system is designed to control higher power consumption.
Form factor	Not a big design concern.	Should be light weight to handle easily.
Working in ubiquitous situation	Required to work under confined environment.	Important to work un ubiquitous situation.
Flexibility	Unrealistic to use AR functionality while users moving.	Using AR functionality while moving is possible.

4 Conclusion

The use to 5G edge computing identifies the high end needs of mobile augmented reality, such as providing lesser latency links to edge servers, executing image analysis. A simple pipeline structure of the proposed MAR system and outcomes are given. The end to end latency comparison on 5G, WiFi, and LTE connections are displayed. The comparison of AR and MAR characteristics is also given in this paper.

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