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Optimization Algorithm for IPTV Video Service Delivery over SDN Using MEC Technology

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Abstract. Management of video content distribution through files allocation or caching in content delivery networks with some degree of reliable security measures is representing a big issue in video service delivery and user's requirements for quality of experience provision are constantly tightened. Operators are looking for new ways to efficiently deliver video content to specific customers or classes of customers, which allow the transfer of large amounts of traffic with the appropriate quality of experience. Mobile Edge Computing (MEC), initiated as an Industry Specification Group (ISG) within ETSI, is quickly gaining traction as a disruptive technology that promises to bring applications and content closer to the network edge, a move that will reduce latency and make new services optimization possible. The aim of this thesis is to provide optimization algorithms for accessing IPTV video services in managed way over Software-defined Networking (SDN) to meet the high Quality of service (QoS) reducing network latency and, ultimately, improving the end consumer's quality of experience (QoE). We also show the positive impact of SDN network using our algorithm noticeably reducing video delay.

Keywords: IPTV · Video traffic · Software-Defined network (SDN) Mobile Edge Computing (MEC) · Quality of Experience (QoE) Optimization algorithm

1 Introduction

Today's multimedia market has witnessed an increase in the popularity of video streaming over IP network (IPTV) [1]. Media delivery and streaming over public or private networks are becoming the highest rank of applications consuming Bandwidth and particularly sensitive to packet loss, latency/delay and jitter. Practically, they are rapidly increasing in network bandwidth utilization with the huge number of network users concerning video access. So, the performance optimization relevant to bandwidth

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utilization and quality of Service improvement is a key factor for successful delivery and successful business based video. To satisfy the considerable amount of video content requests, operators have been pushing their content delivery infrastructure to edge networks–from regional CDN servers to peer CDN servers to cache content and serve users with storage and network resources nearby. The main objective from caching is to make the files very near to users so as to facilitate their accessing times.

Mobile Edge Computing (MEC) is technology that enables cloud computing capabilities and an IT service environment at the edge of the network and is a quickly ramping technology that brings applications and content closer to the network edge i.e., very close to the end consumer of that video content [2]. By putting content and applications at the edge, users can receive video content with minimum delay and the network owner or the enterprise can realize operational and cost efficiencies while reducing network latency and, ultimately, improving the end consumer's quality of experience [2, 3]. Technical standards for MEC are being developed by the European Telecommunications Standards Institute (ETSI), which created a new Industry Specification Group in 2014 for this purpose.

One of the great methods to simplify the main components and increase the capacity of any network (including IPTV) is Software Defined Network (SDN) [9, 11]. SDN concepts, in which data transmission and management are separated, are well suited for implementing a large set of complex video services. SDN is a promising solution that allows a more distributed, flexible, and scalable network. As a transport network, the technology SDN has been chosen, which today has a number of significant advantages when delivering content, by providing greater automation and orchestration of the network fabric, and by allowing dynamic, application-led configuration of networks and services. Our goal is to provide an optimization algorithm, which creates an environment characterized by ultra-low latency and high bandwidth as well as real- time access to network information that can be leveraged by video applications. The algorithm shows how software-defined networking (SDN) and network programmability can be used to reach high QoS using MEC technology.

The remainder of this article is organized as follows: Sect. 2 analyzes the other works in this field of research. Section 3 shows the experimental investigation structure and defines some of the elements. Section 4 describes the proposed algorithm. Section 5 presents testing results. Finally, Sect. 6 concludes the paper.

2 Background and Related Works

By now, a consortium of operators, manufacturers and vendors have been working together to develop an open architecture and API for delivering content and services from the edge. MEC is complementary to and supportive of both SDN and NFV [10]. Between them, these technologies are profoundly affecting the network. Thus, in [7] authors introduce an approach to offload video encoding efforts from mobile devices to external services in existing mobile network architecture and reduce the power consumption of mobile devices. The MEC is under standardization [4, 5], and surveyed [6] by ETSI. ETSI states the five important use-cases of the MEC that is targeted for future standardization [6]. Industry Specification Group (ISG) has been formed to foster the development of a broader MEC ecosystem based on open standards. Paper [8] proposes the Edge Cloud model by augmenting the common cloud data center with service nodes placed at the edges and it shows the advantages in two applications: an accurate and low-latency indoor localization and a scalable-bandwidth video monitoring stream. IBM, Huawei, Intel, Vodafone, NTT DoCoMo and Nokia Networks are founding members of the industry group supporting the MEC working group at the standards organization ETSI. This is important because the provision of a standardized yet open networking environment close to the access network edge will enable service providers to deliver content (especially optimized video content) and services to users in a much more timely manner because MEC allows time-critical content to be cached in local, proximate base stations thus greatly reducing congestion on the backhaul link to the network core.

Our proposed algorithm improves the network performance profiting from the way MEC jointly work with SDN.

3 Deployment Architecture of the Experimental System

This section gives an overview of the system and describes how MEC operate over software-defined network at the edge for an optimal video offloading from the core network. Figure 1 shows the deployment architecture. The system functions upon software-defined network consisting of multiple OpenFlow-enabled switches and SDN controller, whether it is physical or software, and fully separates the data plane from control functions.

In Fig. 1, the orchestrator is the control element that controls all the systems of the operator. The SDN controller has a global network topology view, so it realizes programming on the whole network, control the forwarding path, achieve flexible networking and get rid of the traditional network restriction. MEC controller is a mobile computing system that can rent its resources for a short period of time. The programmability of the Core Network provided by SDN is exactly where MEC can facilitate its programmability at the edge of the network and further delegate control decisions. SDN and MEC are complementary concepts and SDN has the same objectives as MEC in the way of applying specific rules to data plane. The IPTV user request video content through the network, then MEC is created in several switches or one of the OpenFlow switches. MEC assesses the probability of content requests from a group of users and in the case of high demand of the same content, the content is uploaded to the optimal node closer the users. This will ensure video content offloading from the core network, thereby providing high QoS.

4 The Proposed Algorithm

The considered scenario is illustrated in Fig. 2 and consists of 4 Openflow Switch lanner: Intel(R) Xeon(R) CPU E5-2650 v4 @2.20 GHz, core 12 Ram 40 GB, 1 orchestrator Brain Net service Platform and 3 virtual Openflow controller, 1 Video

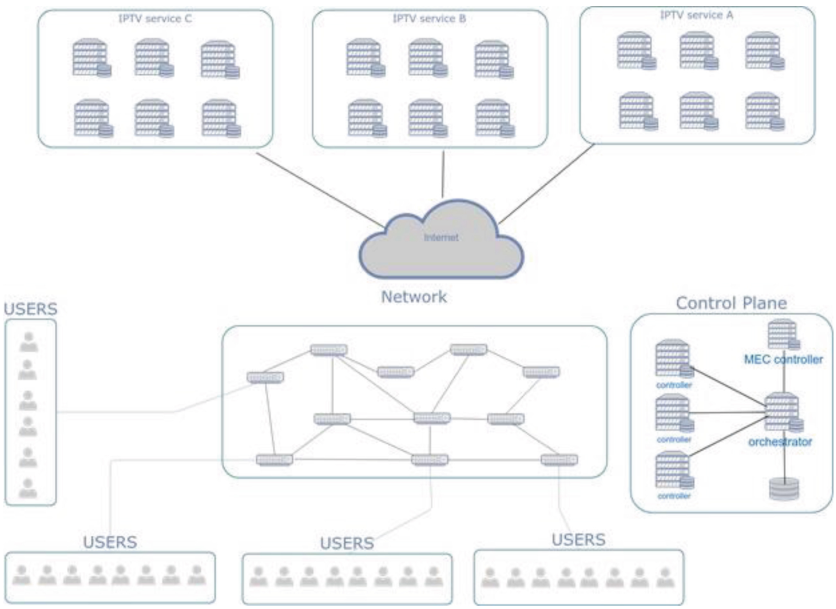

Fig. 1. Architecture of the experimental system

server Intel(R) Xeon(R) CPU E5-2620 v4 @2.10 GHz, core 32 Ram 48 GB, emulating an IPTV server using an RTP generator.

For each switch a random conditional probability of having the desired video content in that node was given: P(A) = 0.25 for switch 93(A), P(B) = 0.64 for switch 94(B), P(C) = 0.71 for switch 95(C), P(D) = 0.25 for switch 96(D).

Using the proposed algorithm in Fig. 3, one switch is selected for the MEC location. Then, based on probabilities of having the desired video content on a particular switch, the required content is downloaded closer to users.

In the proposed algorithm (Fig. 3), the main point of the sequence diagram starts from the authentication of the group of STB (Set top Box) by the IPTV server. After successful authentication, the server will initiate the procedure to transmit the information about the request sector of this group to the orchestrator. Then orchestrator determines the optimal allocation of MEC in one or several switches (decision making for resource allocation) based on the following criteria:

- Closest node to the STB group
- The ability to store content
- The ability to process node requests
- Possible downloads of the content from other MECs (the same content can be stored in other MECs at the current time)
- The evaluation of the optimality according to the previous parameters in comparison to video content delivery direct from the IPTV server.

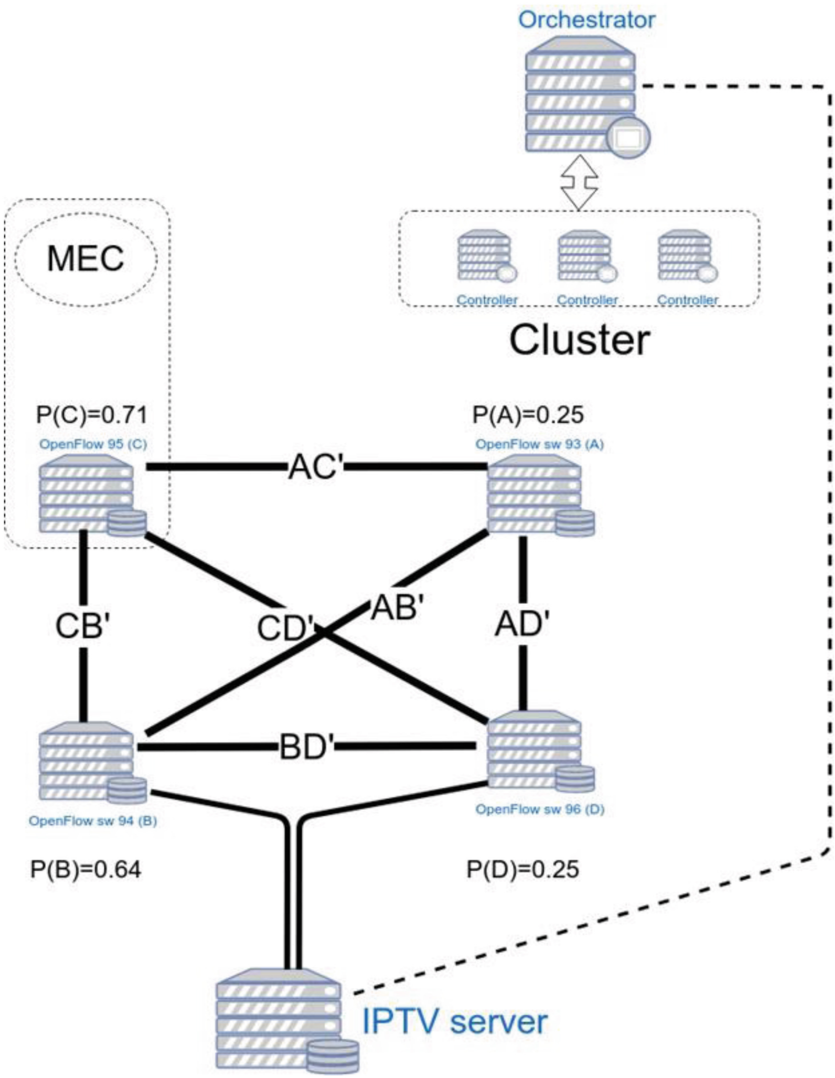

Fig. 2. Scenario of the experiment

In the case, when all criterias are met, a virtual MEC is created in a suitable node (allocate space). Then, user parameters (Billing, QoS,…) are sent from the IPTV server to the orchestrator (Options). Then video parameters and instructions (EPG) are sent to MEC, which farther upload content from other MECs or from the IPTV server and simultaneously broadcast to a group of users.

The algorithm helps offloading the core network and server interface, since all user requests go to the sector MEC, which provides a minimum delay, reduces network latency and, ultimately, improving the end consumer's quality of experience.

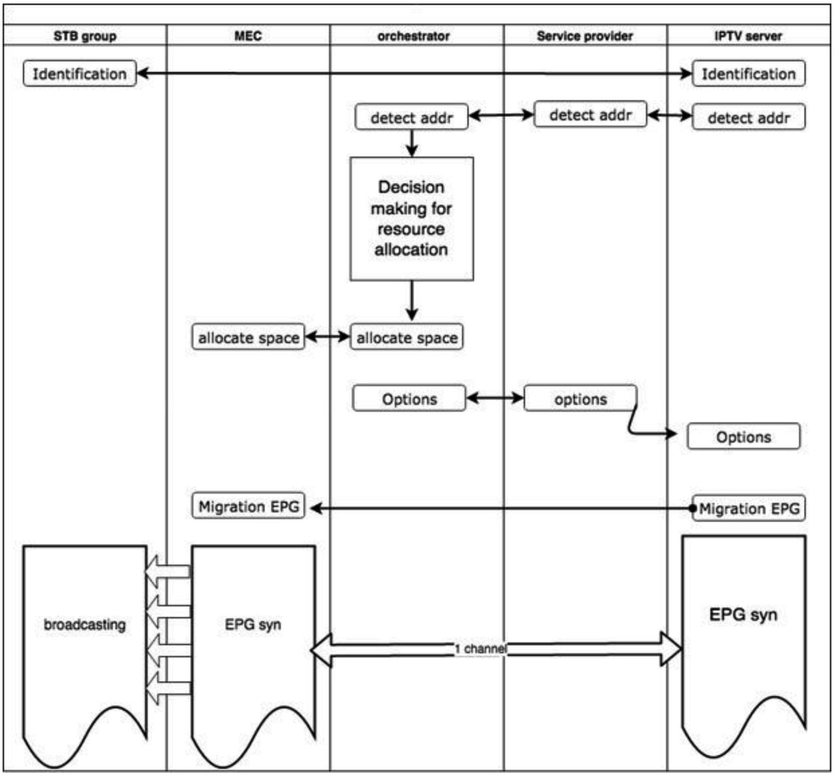

Fig. 3. Sequence diagrams of proposed algorithm

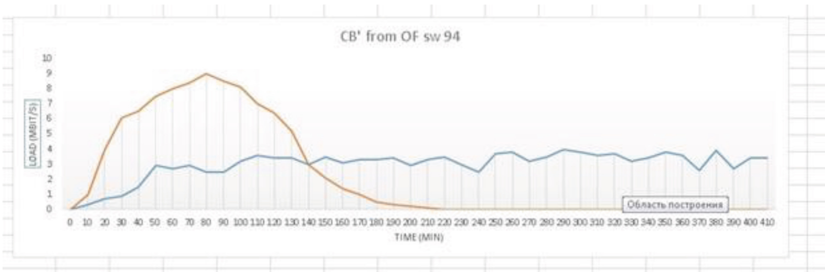

Fig. 4. Traffic load in CB' network segment in traditional systems and using our algorithm (Color figure online)

5 Results

As a result, in Fig. 4, shows that traffic load in the network in traditional system is uniform all time (blue line in Fig. 4). When using our algorithm, traffic load increases as the content is being downloaded and then there is a complete liberation of the channel.

When testing a traditional network, the average delay reaches 80 ms (Fig. 5).

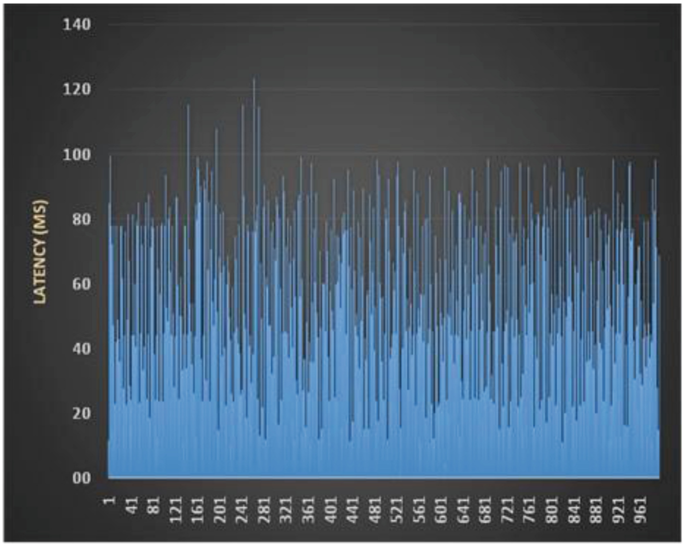

Fig. 5. Traffic delay in traditional system

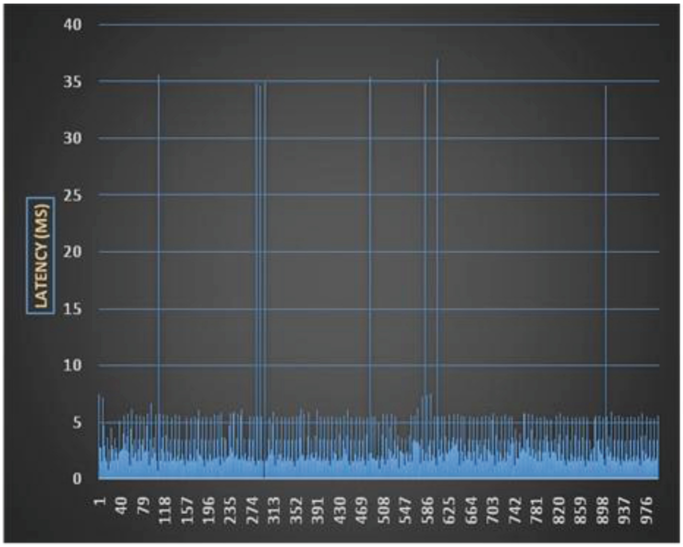

Fig. 6. Delay in a system using the proposed algorithm

When testing the network using the proposed algorithm, the average delay decreased by 20 times, improving QoS and ultimately, the end user's quality of experience (Fig. 6).

6 Conclusion

Software defined networking (SDN) approach provides security, network management, monitoring, high quality of service (QoS), and quality of experience. The SDN technology is quite universal, so the study of algorithms for SDN-networks and their implementation in the work of already existing systems for IPTV is becoming increasingly important. SDN allows load balancing, what makes possible the use of data channels much more efficiently. The use of MEC also improves user Quality of Experience in comparison to direct communication.

As a result, over Software Defined Networking (SDN)-based Mobile Edge Computing (MEC) platform, an algorithm for offloading the basic station was developed. So, operators will no longer need frequent equipment upgrades, network capacity will increase, which will significantly reduce operating costs. The algorithm solves the Mobile Edge management issues with respect to traffic management.

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