

An SDN Framework for Video Conference in Inter-Domain Network

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Abstract— Video conference is the most popular application which is required high quality of service (QoS) such as delay and jitter. Several existing mechanisms for enhancing were proposed in the traditional network not only at the application side as video clients but also at the network core as network routers. Although, these mechanisms can provide a good quality of service, they require a lot of maintenance cost. In addition, the static routing with the shortest-path fashion at the network gateways is not enough to provide a high quality of service for video/audio data transferring due to the affectation of background traffic. Software Defined Network (SDN) is an emerging network architecture that allows a network operator to manage their network environment by programmable centralized control. This not only reduces the cost of maintenance but also increase the performance of networking. In this paper, we proposed an SDN framework for video conference in inter-domain network. The framework used the Packet Pair technique to consider the characteristics of bandwidth and end-to-end delay between two video conference clients. A transferring path and network gateway inside-domain are set up based on this information without a requirement of a routing modification of outside-domains. The evaluation results from Mininet emulator and OF@TEIN testbed show that our framework outperforms the traditional networking significantly in terms of QoS metrics.

Keywords—Software Defined Network (SDN), Video Conference, Inter-Domain Network, Computer network management, Videos

I. INTRODUCTION

Nowadays, Internet has become an important part in everyday life. Repeatedly, the internet is not only used for entertainment but also used for business communities because there are a lot of useful applications that depend on the internet which change the direction of communication behavior of human. A face-to-face meeting can be possible via a video conference application although the caller and the callee have a conversation from difference places. This reduces the cost of meeting and saves the time of executives travel in international company. To provide the high quality of service (QoS), the network management is an importance factor which influences on the acceptable performance of users.

The performance of communication via video conference related to three important characteristics. First, video conference is a real-time communication application. The video/audio data should be delivered to each client within a specified time. This time reflects on the user experience for communication interaction. To achieve this goal, these data must be transferred over the low delay links of network. Second, video conference is a bidirectional communication application which consists of several sharing functions such as file sharing, screen sharing, and etc. In other words, not only video/audio data but also the sharing data will be transferred to among clients. To achieve this goal, the network management should provide the transfer path with high bandwidth to support the bidirectional communication. Finally, video conference application is a user-sensitive application. The discontinuous video/audio data lead to misinterpretation of users. Thus, the gap between arrival data packets, the order of arrival data packet, and the rate of packet loss are the importance issues which should be concerned.

A key for maintaining the video conference performance is network routing optimization. Traditionally, Internet routing protocol can be separated into 2 categories are intra-domain routing protocol and inter-domain routing protocol. First, intra-domain routing protocols such as RIP and OSPF use shortest-path algorithm for routing between source and destination in same domain. There is the chance that video conference traffic shares the bandwidth with other traffic in the same link. Second, inter-domain routing protocol such as BGP makes routing decision based on network policies between connected domains. In the other word, inter-domain routing is static routing which using shortest-path algorithm widely. Shortest-path routing can lead to shared bottleneck which affects video conference performance. Shared bottleneck causes higher delay on packet because increasing of packet queue in router. For this reason, video/audio data packet may not reach the destination in specific time. Shared bottleneck also causes insufficient bandwidth for video conference transferring which prevents video conference application transfers higher quality of video. Finally, if queue in router reaches the maximum capacity, incoming packet will be dropped, and causes discontinuity in video/audio data transferring. To mitigate these problems, routing optimization is required. For example, migrating video conference traffic from high delay link to lower delay link or higher bandwidth link. But

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to achieve this objective, traditional Network needs to configure many devices. Due to network complexity, configuring these devices need high cost and time. SDN can address these limitations with programmable centralized control.

Software Defined Network (SDN), a new paradigm for programmable network which separates network to two layers: Control plane (Network Control) and Data plane (Forwarding). Control plane is responsible for collecting, processing and managing network information for control forwarding behavior in Data plane. SDN is associated with OpenFlow protocol [1] as communication protocol between Control plane and Data plane. SDN addresses the problems that Traditional Network does not support such as dynamic routing, network scalability and high complexity in network management. With these properties, SDN can manage routing for video conference traffic through flow table in OpenFlow switch. SDN enables ability to monitoring network statistics to observe congestion event in network, the SDN controller can manage video conference routing to avoid congested link. In addition, SDN controller can be modified to apply module for probing state of outside domain network. Video conference can take these advantages. SDN controller provides high bandwidth and low delay path for video conference to improve its performance.

In this paper, we propose an SDN Framework for Inter-domain video conference that provide the properly path in inter-domain network for video conference connection. Our framework collected network information like Bandwidth and end-to-end delay by using Packet Pair technique which send two probing packets to video conference client. Then, calculate network information. Video conference transferring path will be setup based on collected information without modification of outside-domains. We evaluated our framework on Mininet network emulator and real environment OF@TEIN testbed. The results show that our framework significantly outperforms the traditional networking in network metrics like delay, jitter and throughput. And, video metric like PSNR. The rest of the paper is organized as follows; section II presents some related work, section III explains our proposed framework, section VI shows evaluation of our framework by simulation and real-testing and section V is conclusion.

II. RELATED WORKS

Ref. [2] proposed new approach to use scalable video coding (SVC) and Software Defined Network (SDN) for multi-party video conference and reducing bandwidth consumption. Using SDN for routing path and determine number of scalable video coding layers. To determine the number of video layer, they have modified SDN controller to monitor congestion event in network. By threshold-based strategy, if a usage ratio of switch port exceeds the expected threshold value, SDN controller will decrease the quality of video content by decreasing the number of video layer. The result showed that proposed approach reduces the bandwidth consuming of video conference. However, this approach still does not use network resource efficiently. Their controller constructed a minimum spanning tree for transferring video layer, this means there is the chance that video transferring flows used the same link while the other links had never been used for transferring. Another issue of this system is it cannot work with non-OpenFlow switch.

Ref. [3] proposed OpenFlow Selective Forwarding as a Service (OFSFaaS), an architecting multimedia conferencing service with SDN. The proposed architecture focused on mitigating bandwidth usage in video conference server to the OpenFlow switch. Their evaluation show that OFSFaaS can avoid bottleneck bandwidth at conference server. However, this approach still suffers from the bottleneck issue in other parts of network eventually. This is because transferring video conference data is still done through traditional network which routing is not concerned about video conference and transfer video conference data to congested link in network.

Ref. [4], the authors studied performance of video conference and internet access with three different QoS options. First, Guaranteed Bandwidth option which reserves fixed portion of bandwidth for a specified traffic. Second, weighted fair queuing which schedule traffic to the front of queue providing consistent response time. Finally, Combination of Guaranteed Bandwidth and weighted fair queuing. Results show using weighted fair queuing along with Bandwidth reserving provide the best performance for video conference and Internet access. However, this approach can interfere other traffic with bandwidth reservation and schedule traffic to the front of queue. Also, this approach need to apply QoS on every device in network which require more time and cost for operation.

As mention above, there is no work which proposed solution for video conference on SDN network that concern about inter-domain routing issue.

III. FRAMEWORK DESIGN

The goal of our framework is to improve video conference performance using SDN controller without change on the video conference client application or routing modification of outside-domains. To achieve this goal, SDN controller needs to obtain necessary network information which will be used to make the decision for the best video conference transferring path. For the best path selection, delay and bandwidth of possible paths will be calculated. Then controller will apply forwarding rule on OpenFlow switch following the selected path.

The overview of our framework shows in the Figure 1. The framework included: 1) SDN controller takes responsibility for collecting network information and installing forwarding rule on OpenFlow switch. 2) Video Conference server is responsible for video conference members management. 3) OpenFlow Switch which forwards traffic follow installed forwarding rule. These three components orchestrate the video conference for conference members. For example, after members run video conference application. The application will connect to video conference server and send request message for establishing video conference connection. After members finished authentication process to identify themselves, video conference server will send message to SDN controller to request for path in network. When SDN controller finished installing path for video conference, controller will respond to video conference server. Then video conference server can spread message to all members to start the video conference.

In our framework, SDN controller is the important part to achieve the framework goal. It collects necessary network information for the video conference transferring path decision, including network topology, gateway, host address, end-to-end

delay and available bandwidth. Controller obtains these information through its module and exchanges information with video conference server. For discovering network topology and gateway, our controller uses Link Layer Discovery Protocol (LLDP) [5]. SDN controller will send LLDP packet to all connected switches. LLDP instructs switch to send LLDP packet to other devices that connected to it. If those devices are OpenFlow switch, it will return message to controller. Then controller analyses message and create topology on discovering table. For host address, when conference member's hosts send video conference request message which attached their address to video conference server, video conference server can transfer these host addresses to the controller. After controller received the messages with hosts address, controller can perform routing of the transferring paths between each hosts and perform probing process. Probing process is performed for collecting packet timestamp. This timestamp is used for calculating available bandwidth and end-to-end delay of the transferring path in the network through Packet Pair technique [6]. Probing process can be separated into 2 phases which are 1. Intra-domain link phase and 2. Inter-domain link phase. Intra-domain link phase is the process of probing possible path between hosts in domain and the gateway. Inter-domain link phase is the process of probing inter-domain transferring paths from difference gateways. These gateways have the different routing path that using inter-domain link to reach the member hosts those connected with another domain. So, probing through these gateways obtains packet timestamp for Inter-domain transferring path. When controller has finished both probing phases, it will calculate available bandwidth and end-to-end delay. The controller selects the lowest end-to-end delay and highest available bandwidth path as the video conference transferring path. Then, it installs forwarding rule in OpenFlow switch on the selected path. After controller finished installing forwarding rule, it will send message to video conference server that video conference transferring path is ready for transferring video conference. Then video conference server sends message to all member hosts to start video conference.

In our framework, SDN controller has enhanced with a module calls Probing Module. This Module takes on responsibility for link probing and calculate end-to-end delay and available bandwidth using Packet Pair technique. This module instructs the controller to send pair of packets through paths in the network. After probing packets return at the controller, Probing Module will collect packet timestamp to

calculate end-to-end delay and available bandwidth using these following equations:

$$\text{Delay} = t_n^0 - t_0^0 \quad (1)$$

$$\text{Bandwidth} = \frac{s^1}{(t_n^1 - t_n^0)} \quad (2)$$

Where is: t_0^0 = Transmission times of first packet

t_n^0 = Arrival times of first packet

t_0^1 = Transmission times of second packet

t_n^1 = Arrival times of second packet

s^1 = Packet Size of second packet

Our proposed framework procedure will follow these step as show in Figure 2

1. Hosts request for video conference by sending message with host address to video conference server
2. Video conference server sends host addresses to controller providing the network path
3. Controller calculates all possible routes for transferring video conference in the network between host and gateway. Then, it probes all paths inside the domain.
4. Controller probes all gateways which can reach to outside-domain hosts.
5. Controller calculates bandwidth and delay from step 3 and 4. Then, the lowest delay and highest bandwidth path is chosen for transferring video conference.
6. Controller installs forwarding rules on OpenFlow switches with the path from step 5.
7. Controller sends network path preparing message to video conference server.
8. Video conference server sends message to host for starting video conference

IV. EVALUATION

Our framework has been evaluated on Mininet Network Emulator[7] and performed real experiment on Trans-Eurasia

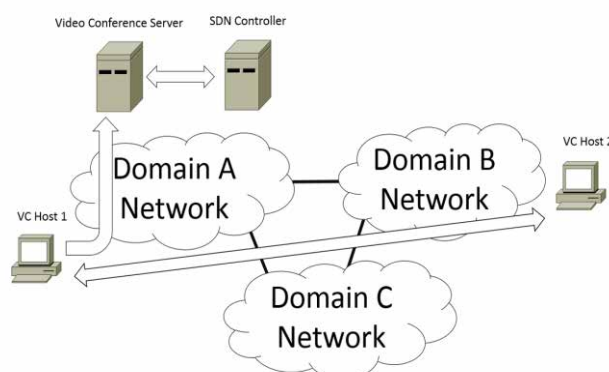


Figure 1. Framework Overview

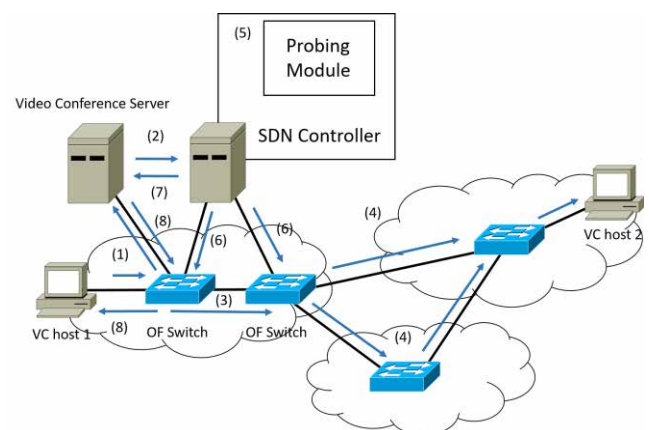


Figure 2. Framework procedure

Information Network (OF@TEIN)[8] an SDN-Cloud Virtual Playground. On Mininet emulator, a network topology has been implemented as shown in Figure 3. Our topology consists of 12 switches which be separated to 3 Domains. Each domain includes 4 switches and one of which, called edge switch, is connected to other domain switches. Each link in intra-domain have 50 Mbps of link capacity. Each Inter-domain link have 100 Mbps of link capacity with 50 millisecond delay.

In one scenario, we have captured video conference traffic between host1 and host2. Video conference application transferred data with 3 Mbps of bandwidth. We evaluated framework with 2 scenarios. First, traditional network, which implemented shortest path routing for transferring video conference. Second, proposed Framework network, which transferring video conference path is provided by the SDN controller. We have captured traffic at host2 for evaluation. host1 connect with a switch in Domain A and host 2 connect with a switch in Domain B. we have generated the background traffic on link between edge switch on Domain A and B as congested link.

In order to evaluate the framework, we have calculated these following metrics: delay, jitter, throughput for network metric and PSNR evaluated using Evalvid[9] for video quality metric in real experiment.

Figure 4. and 5. show measurement result of end-to-end delay of received packet send from host1 to host2. In traditional network scenario, end-to-end delay increased from 75 millisecond approximately to the saturated transmission packet ratio at 230 millisecond approximately. The high delay in tradition network is affected from congested inter-domain link with background traffic. In Proposed framework network scenario, end-to-end delay is 100 millisecond approximately because avoiding the congested inter-domain link.

Table 1. shows jitter measurement result. In proposed framework network scenario, average jitter is lower than traditional network scenario. However, the high jitter in proposed framework network scenario is affected from several high delay packets.

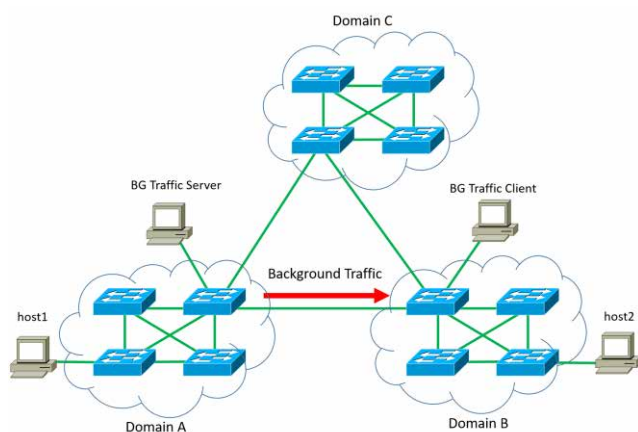


Figure 3. Network Topology

Figure 6. shows throughput measurement result from host2. Our controller can decrease packet loss due to congested link. Moreover, it provided sufficient bandwidth in inter-domain network for improving throughput in video conference and enhancing the video quality.

OF@TEIN [7] is an OpenFlow-based SDN Testbed which developed and deployed by Korean and South-East Asia (SEA). It is connected among 12 sites over 7 countries (Korea, Indonesia, Malaysia, Thailand, Vietnam, Philippines and Pakistan) as show in Figure 7. Three of OF@TEIN sites have been used for our experiment including Korea, Thailand and Malaysia. We have deployed two hosts in Korea site and Thailand site. Both hosts were installed video conference client connected with two disjoint network paths. First path is shortest path (Korea-Thailand) and Second path transfers data through Malaysia site (Korea-Malaysia-Thailand). In the shortest path, we have generated the background traffic for simulating congested link. We performed two scenarios are. First, traditional network, which used the shortest path in network for

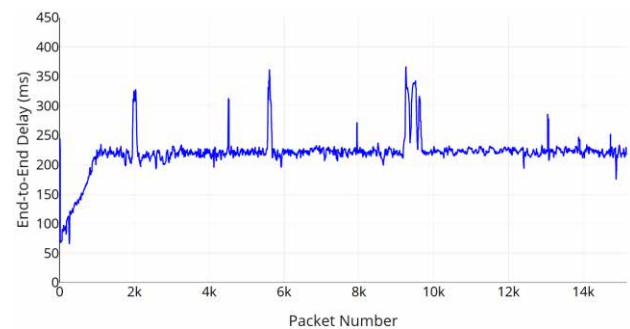


Figure 4. End-to-End Delay for traditional scenario

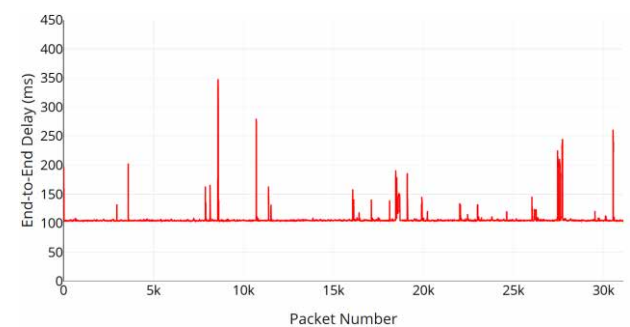


Figure 5. End-to-End Delay for propose framework scenario

TABLE 1. Jitter measured result

Scenarios	Average Jitter (ms)	Highest Jitter (ms)
Traditional	7.36	197.14
Proposed Framework	3.66	298.56

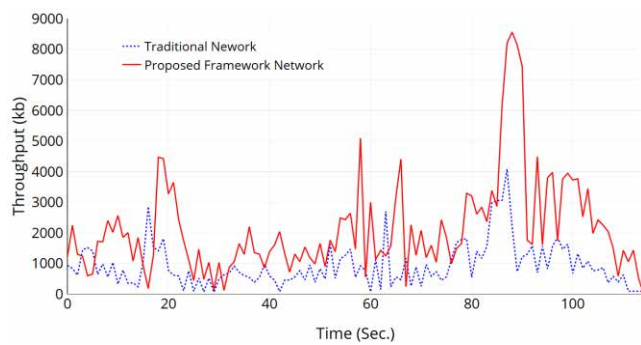


Figure 6. Comparison of Throughput

video conference transferring and second, proposed framework network.

End-to-end Delay result show in Figure 8. and 9. In traditional scenario, delay is unstable because packet transmit through congested link. This link is insufficient of bandwidth which can causes more queuing delay. This result concludes that even using the shortest path to destination, traditional network may not always provide acceptable delay for video conference transferring. In Proposed framework, SDN controller provides more available bandwidth path and maintain stable delay for Video conference.

The jitter result shows in Table II. Proposed framework has lower average jitter because it avoids congested link. Also, it provides lower highest jitter for 35 % comparing to the traditional network. This result means user can experience video conference with better video-audio quality.

The throughput comparison show in Figure 10. The proposed framework can improve overall throughput over traditional shortest path scenario. Notice that there is throughput dropping for a period due to interfere of other traffic in real network.

Figure 11. shows the result of PSNR. Result show that Proposed framework PSNR is higher than traditional shortest path scenario and equal to reference PSNR. It means higher video quality and less noise at received video. Low PSNR in

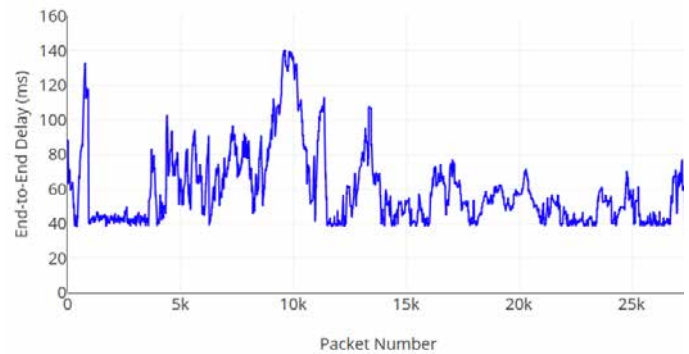


Figure 8. OF@TEIN End-to-End Delay for traditional scenario

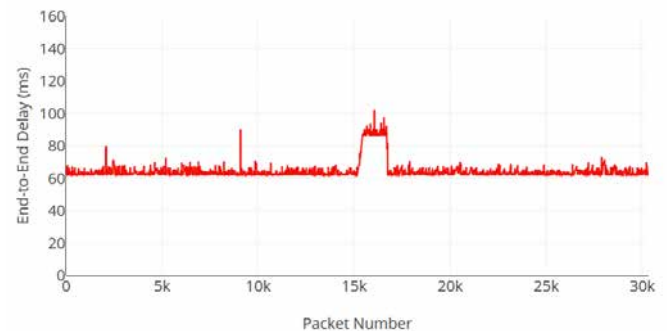


Figure 9. OF@TEIN End-to-End Delay for proposed framework scenario

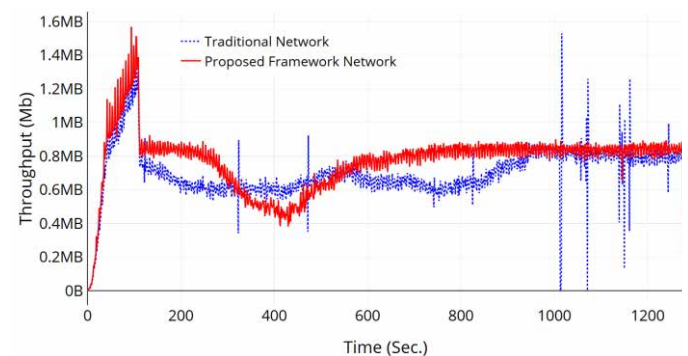


Figure 10. OF@TEIN Comparison of Throughput

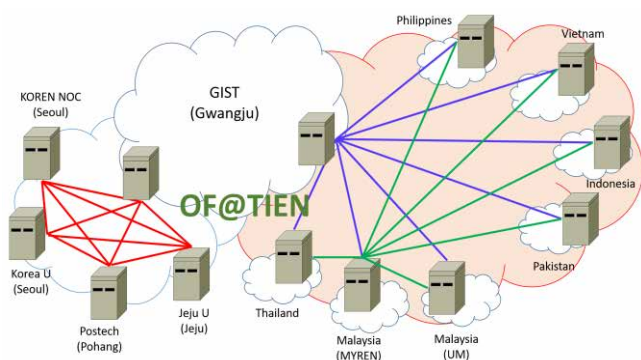


Figure 7. OF@TEIN infrastructure

shortest path is affected by packet loss which leads to video frame discarding.

V. CONCLUSIONS

In this paper we have proposed an SDN framework for video conference in Inter-domain network which improves video conference performance without modified network core on outside-domain. A modified SDN controller takes on responsibility to collect network information and manage path in the network for video conference. Also, we have evaluated our framework on Mininet network emulator and performed real experiment. In Mininet, result shows that our framework decreased delay by approximately 52 %, decreased average jitter by 50 %, improved throughput by avoiding congested link and

TABLE 2. OF@TEIN Jitter measured result

Scenarios	Average Jitter (ms)	Highest Jitter (ms)
Traditional	34.59	129.92
Proposed Framework	27.87	83.39

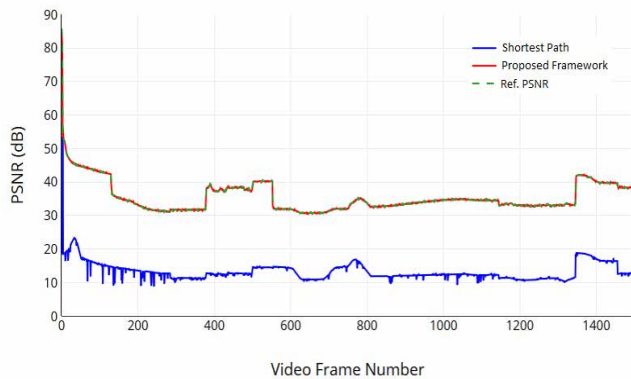


Figure 11. OF@TEIN PSNR comparison

providing the best path for video conference. Moreover, in OF@TEIN result shows that our framework can maintain stable delay and decrease average jitter in video packet transmission by 20 %. The result shows that our framework improves throughput over traditional network and decreases packet loss. PSNR result also shows that our framework can achieve better video quality in video conference.

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