International journal of communication technology for social networking services
Vol. 7, No. 1 (2019), pp.1-8
http://dx.doi.org/10.21742/ijctsns.2019.7.1.01

Proposal for CDN applied Network Architecture in Network environment using Internet and SDN Network

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Abstract

Today's users consume much more content including multimedia such as video and use network-based services. Additionally, users of the mobile device are increased exponentially. Although multimedia content and network-based services take up a large portion of network traffic and consumes the computing power of the server. Therefore, the higher the consumption of high-capacity content, the longer the distance between the server and the client, the more the consumption of various services, the burden on the network and the server will inevitably increase. Various techniques have been proposed to solve these problems. However, the network environment for these methods are presupposed slightly different from each other, so it is difficult to apply directly. Also, more and more regions overlap with other communication methods such as Ethernet networks and mobile networks. The traffic control solutions that are applicable only to specific network methods, such as conventional techniques, are difficult to cope with overall. In this paper, we assume a situation where there is a single trusted node at both the service provider and the consumer (such as a school or company), and multiple users simultaneously consume content that generates high-capacity traffic over Ethernet and SDN networks. In this environment, edge computing and CDN mechanism can be used to reduce the load on the network.

Keywords: *Content delivery networks (CDN); Software Defined Networking (SDN), OpenFlow; Packet Delivery Cost; Edge computing*

1. Introduction

As network traffic is changed from text-based content to multimedia-based content. In addition, with the explosive spread of mobile devices such as mobile phones and tablets to users, traffic through mobile networks is also increasing rapidly. Users who have become accustomed to network have started to use various network-based services. The increasement of users means not only the continuous increase of network traffic but also the computing power of the server to provide the service should increase. Therefore, various techniques for more efficiently delivering high-capacity multimedia content to users in various environments and various methods for reducing computing power of a server have been proposed. For efficient traffic transmission, CDN [1] and other techniques have been proposed to the Ethernet environment. In the mobile environment, 5G [2][3] with SDN [4][5] is proposed. Edge computing [6] techniques have been proposed to share the computing power of servers for service provision. We propose an CDN applied network architecture in network environment using internet and

Article history:
Received (January 23, 2019), Review Result (May 13, 2019), Accepted (September 28, 2019)

Print ISSN: 2205-863X, eISSN: 2207-4252 IJTSNS

SDN network. The proposed scheme supports efficiency traffic management at the overlap with other communication methods such as Ethernet networks and mobile networks. It refers to the CDN, SDN, and edge computing mechanism for efficiency traffic control. It suggests that implementation of temporary edge server for internet and mobility network user. The temporary edge server can be supply anchor point or the traffic.

2. Related works

2.1. Content Delivery Networking (CDNs)

Content Delivery Networking (CDN) is a network architecture which the server has an edge server that acts as a cache between it and the user. Geographically distributing Web servers has been a common technique used by existing service providers to improve performance and scalability, and CDN is a mechanism that takes advantage of this. When the edge server is applied between server and user, it occurs the following advantages. First, the edge server is responsible for delivering the content to the user, reducing the load on the original server. Second, content is hosted on a server that is relatively close to the end-user, thus it is reduced latency and network backbone overhead. Third, with multiple delivery points, content availability is improved. These are big advantages for Internet service providers, so many Internet service providers offer CDN services [7].

2.2. Software Defined Networking (SDN)

Software Defined Networking (SDN) is a newly proposed programmable network architecture. SDN divides network function into control parts and data parts, and network control parts are centralized. The centralized control part (control plane) acts as the whole network controller which processes the path setting and network management functions. And the other part -packet forward- is called data plane. Compared to the existing distributed network, SDN centrally manages the traffic of the entire network, enabling high-level network management. Now, SDN network management is able to reflect user characteristics, movement route, historical, and location-based information.

2.3. Edge computing

Edge computing is one of the evolutions of cloud services where user-generated data is processed by user devices or nearby network devices. In the case of the existing cloud service, long response time due to long distance between server and user, and inefficient processing and high network traffic became main problems. In order to solve this problem, a method in which a user or a network device near the user performs processing instead of a regular server has been proposed, which is called an edge computing technique. The data processing in this way has the following advantages. First, short response time: latency is reduced by reducing the absolute distance the data must travel. Second, reduce the load on the network: The load on the backbone network is dramatically reduced because the entire user-generated data is not sent to the server. Third, some network services can be provided even when the Internet is not available due to problems such as backbone networks.

3. CDN for Mixed network Environment

The following assumptions are made in this paper. One of the nodes acts as an edge server and an edge computing node. This edge server is trusted by both users and content servers. The information about the edge server is known by the content server. The SDN controller can group nodes that use the same content in the same region into one group based on the location information of the accessing user. Also, detailed connection methods are not covered because they are beyond the scope of this paper.

3.1. Architecture

The content server (CS) is a server that has content that a user wants to use. The internet consists of a gateway (GW), a switch (SW), and an access point (AP), and connects the server with the user. The SDN network is a network that supports the SDN function. The SDN network is connected to the Internet through a GW, and a switch exists inside. This switch is capable of handling OpenFlow-based SDN traffic and transmits packets to other switches through the traffic forwarding line indicated by a solid line. The centralized controller (CC) has the functionality of a basic SDN central controller and controls the switches through a dedicated line shown in dotted lines. Nodes are divided into normal nodes (Nodes) and SDN nodes (MNs). Nodes are connected to the external network through the Ethernet network, and SDN nodes are connected to the external network through the SDN network.

3.2. Process

3.2.1. Pre-Process:

The SDN controller designates a group that uses the same content among nodes that have entered through a specific AP at a specific time through location-based data and time-based data. The traffic from these users is precomputed so that they can reach the nearest ES. The normal nodes are also grouped and one of it is selected as ES. The selected node will transmit notification to other nodes that it will act as ES, then notify CS too.

3.2.2. User Identification process: Node transmits login data to CS.

After AAA (Authentication, Authorization, and Accounting) process in CS. The CS delivers service area of user to ES, and transmits the presence of the ES to nodes. MNs in SDN flow same process, and traffic of MN passes through the internet. The CC in SDN binds the nodes that have the same access AP and same destination information into one group, and the packets of the nodes are directed to the GW connected to the network where the ES is located. Then the procedure is the same as for a normal node.

3.2.3. Contents Process:

Node requests the ES for their desired content. The ES checks its DB and request the CS to send the content if it does not have the content. At this time, the content ID and the ID of the user who requested the content are also transmitted to the CS. The CS receives the request message and sends the content to the ES, and the ES saves the content received from the CS and delivers it to the Node. MN goes through a similar process. SDN nodes forward the content request message to the ES via GWs. After that, it goes through the same procedure as a normal node.

3.2.4. Contents modify Process:

Nodes (Node and MN) may send request messages related to the content. ES classify user requests into two cases. The first case, it does not affect the content stored on the CS (normal messages). The second case is when it affects content stored on the CS (urgent message). For normal messages, the ES process the message, not CS. The messages are cleaned up and then delivered to CS after the user runs out of content. In case of an urgent message, ES sends summary of the normal messages to the CS, before send urgent message. Because the previous normal message may have affected the urgent message.

4. Performance evaluation

This section describes the topology and the messages which are used by default internet architecture and proposed scheme protocol for evaluation. We developed the analytical cost model to evaluate the performance based on [8]. The following notations are used to develop the cost models[8][9][10]. We focused on the packet delivery cost.

4.1. Cost Model

We exploited the similar network model and the concept of [11][12]for evaluations.
The $h_{a\text{-}b}$ means the average hop count between a and b.

4.2. Message size of Cost Model

OpenFlow messages and HTTPs messages are carried on Transmission Control Protocol (TCP). The sizes of the messages include an IPv6 header and a TCP header, and we consider the TCP Acknowledgment (TCPA) generated by each message [10].

4.3. Cost Modeling

We developed the cost model which evaluates the performance of the basic model and CDN model based on those presented in [13]. The following notation was used to develop the cost model [14][15][16][17][18]. α mean the weighting factor of the wired and wireless link in order to emphasize the link characteristic. λs indicates the average session arrival rate at the MN, and (p) is the number of packets of a session. (u) is the number of users in the domain.

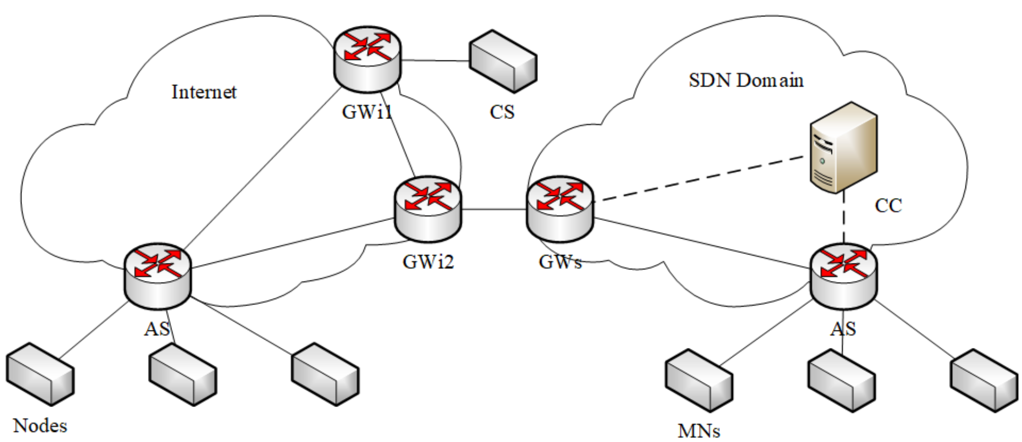

Figure 1. the Network Topology

The Packet delivery cost ($C^{(\cdot)}_{PD}$) from contents location to node.

$C^{(.)}_{PD} = \lambda s * N(p) * LP * \alpha * h_{CS\text{-}nodes}$ (1)

Total Hop count is able to divide hop count in internet (h_i) and SDN domain (h_s).

The h_i which is not influenced CDN is:

$h_i = h_{GWi1\text{-}CS} + h_{GWi1\text{-}AS} + h_{AS\text{-}N}$ (2)

The h_i which is influenced CDN is:

$h^{(CDN)}_i = h_{AS\text{-}PS}$ (3)

The h_S which is not influenced CDN is:

$h_s = h_{GWi1\text{-}CS} + h_{GWi1\text{-}GWi2} + h_{GWi2\text{-}GWs} + h_{GWs\text{-}AS} + h_{AS\text{-}N}$ (4)

The h_S which is influenced CDN is:

$h^{(CDN)}_s = h_{AS\text{-}ES} + h_{GWi2\text{-}AS} + h_{GWi1\text{-}GWi2} + h_{GWs\text{-}AS} + h_{AS\text{-}N}$ (5)

The total packet delivery packet cost for multi user $TC^{(.)}_{PD}$ is expressed as follows:

$TC^{(.)}_{PD} = \lambda s * N(p) * N(u) * (h^{(CDN)}_i + h^{(CDN)}_s)$ (6)

4.4. Cost analysis results

In this chapter, we explained the Packet delivery cost results for proposed scheme.

We set the default values of the system parameters for the cost analysis as $h_{GWi1\text{-}CS} = 1$, $h_{GWi1\text{-}GWi2} = 3$, $h_{GWi1\text{-}AS} = 5$, $h_{GWi2\text{-}AS} = [0\text{-}5]$, $h_{AS\text{-}N}$ / $h_{AS\text{-}PS} = 1$, $h_{GWs\text{-}AS} = 3$, $h_{GWi2\text{-}GWs} = 1$, $h_{GWs\text{-}AS} = 3$, $\lambda s = [0, 1]$, $L_P = 64$, $N(p) = 1000$, $\alpha = 1$, and $N(u) = 5$.

The packet delivery cost is shown in Figure 2.

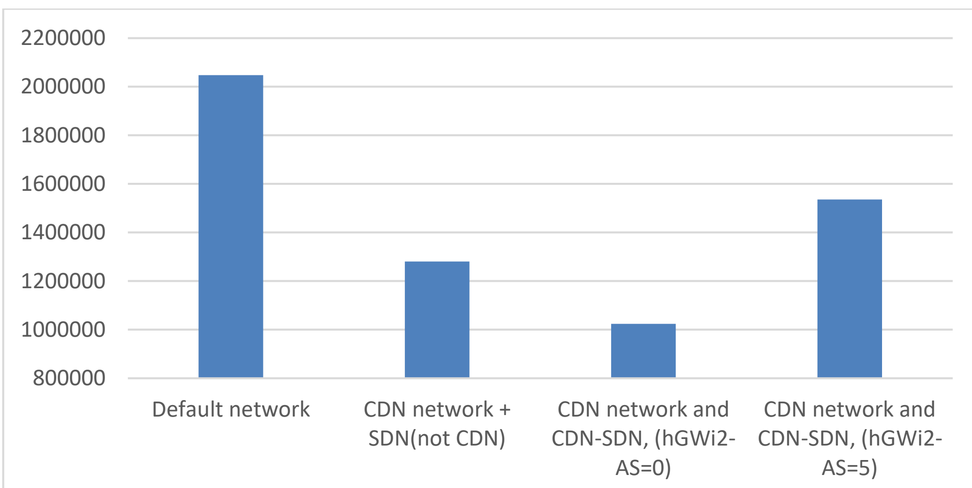

Figure 2 Packet Delivery Cost ($\lambda s = 1$)

When CDN is applied, packet delivery cost decreases in all case.

However, as shown in the packet delivery cost graph Figure 3, the number of hops between the PS and the SDN in the internet domain is affecting the result.

In the case of hGWi2-AS = 0, GW is AS, and the packet delivery cost is extremely reduced.

In the case of hGWi2-AS = 5, GW1 and GW2 are located in the vicinity, so the path is hardly decreased.

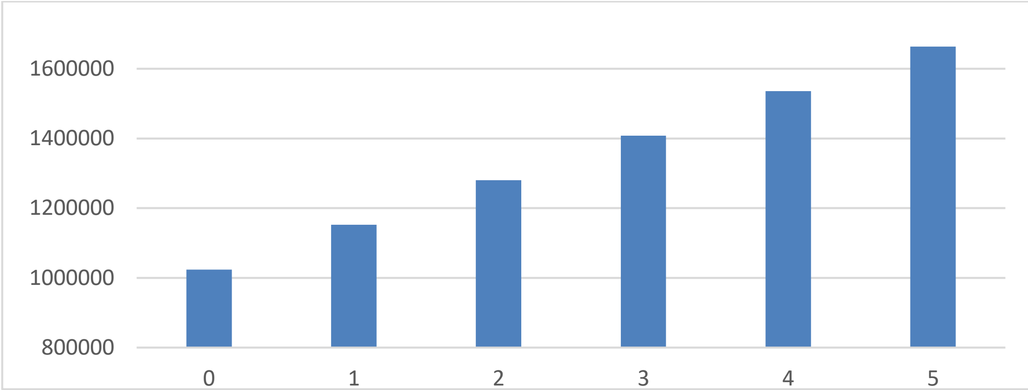

Figure 3 Relationship between GWi1 and AS distance and the packet delivery cost

Figure 3 shows the relationship between GWi1 and AS distance and the packet delivery cost. It can be seen that the distance between GWi1 and AS and the packet delivery cost are directly proportional.

The total packet delivery cost with multiple users is shown in Figure 4.

This is the case of 5 nodes on SDN, and 5 nodes on the internet. Its form is similar to Figure 2, but the ratio is different. This difference occurs because the content must be moved from the CS to the PS once at the request of the first user.

5. Conclusions

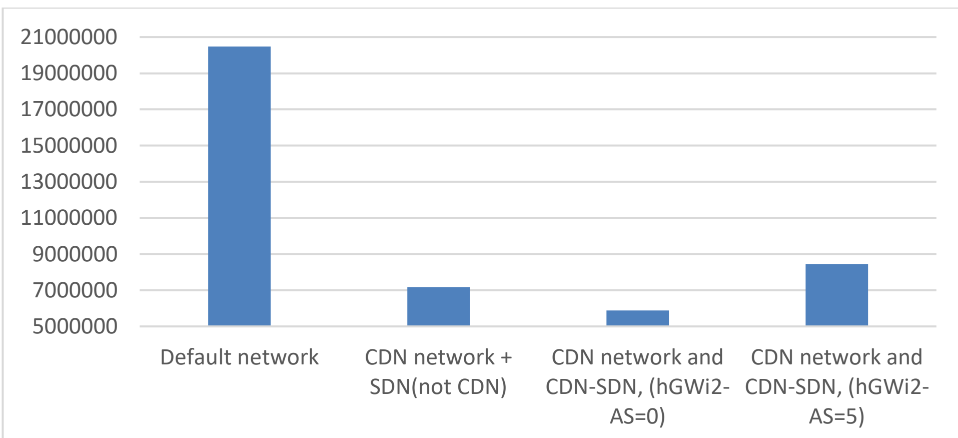

Figure 4 packet delivery cost with multiple users

We propose to apply CDN and edge computing techniques in the environment where multiple users consume the same contents in a mixed network environments. Proposed temporary edge server scheme is able to supply advantage of CDN and Edge computing in a mixed network environment. To prove this, we calculated the packet delivery cost for each situation. When the proposed scheme is applied, the efficiency has always been high in the field of the Internet network, but the efficiency varies according to the positional relationship with the PS in the SDN domain. As the distance from the GW to the PS of the SDN domain is smaller, the packet delivery cost decreases, and when the distance increases, it increases.

Acknowledgements

This work was supported by Korea Creative Content Agency (KOCCA) in 2019.

References

[1] A. Vakali and G. Pallis, "Content delivery networks: status and trends," in IEEE Internet Computing, vol. 7, no. 6, pp. 68-74, Nov.-Dec. **(2003)**. DOI: 0.1109/MIC.2003.1250586

[2] J. Ordonez-Lucena, P. Ameigeiras, D. Lopez, J. J. Ramos-Munoz, J. Lorca and J. Folgueira, "Network Slicing for 5G with SDN/NFV: Concepts, Architectures, and Challenges," in IEEE Communications Magazine, vol. 55, no. 5, pp. 80-87, May **(2017)**. DOI: 10.1109/MCOM.2017.1600935

[3] J. Prados-Garzon, O. Adamuz-Hinojosa, P. Ameigeiras, J. J. Ramos-Munoz, P. Andres-Maldonado and J. M. Lopez-Soler, "Handover implementation in a 5G SDN-based mobile network architecture," 2016 IEEE 27th Annual International Symposium on Personal, Indoor, and Mobile Radio Communications (PIMRC), Valencia, **(2016)**, pp. 1-6.DOI: 10.1109/PIMRC.2016.7794936

[4] Open Networking Foundation, Software-Defined Networking: The New Norm for Networks, Open Networking Foundation, **(2012)**.

[5] D. Liu and H. Deng, “Mobility support in software defined networking draft-liu-sdn-mobility-00,” ITEF Internet-Draft, **(2014)**.

[6] Weisong Shi ; Jie Cao ; Quan Zhang ; Youhuizi Li ; Lanyu Xu, “Edge Computing: Vision and Challenges”, IEEE Internet of Things Journal (Volume: 3 , Issue: 5 , Oct. 2016), pp.637-646, 09 June **(2016)** DOI: 10.1109/JIOT.2016.2579198

[7] J. Dilley, B. Maggs, J. Parikh, H. Prokop, R. Sitaraman and B. Weihl, "Globally distributed content delivery," IEEE Internet Computing, vol. 6, no. 5, pp. 50-58, **(2002)**. DOI: 10.1109/MIC.2002.1036038

[8] J. Lee, E.Thierry, and T. Chung, “Cost analysis of IP mobility management protocols for consumer mobile devices,” IEEE Transactions on Consumer Electronics, vol.56, no.2, pp.1010-1017, **(2010)**. DOI: 10.1109/TCE.2010.5506033

[9] J.-H. Lee, T.-M. Chung, and S. Gundavellit, “A comparative signaling cost analysis of hierarchical mobile ipv6 and Proxy Mobile ipv6,” in Proceedings of the 19th International Symposium on Personal, Indoor andMobile Radio Communications (PIMRC ’08), pp.1-6, IEEE, Cannes,France, September **(2008)**. DOI: 10.1109/PIMRC.2008.4699416

[10] Hypertext Transfer Protocol -- HTTP/1.1, [Online]. Available: https://tools.ietf.org/html/rfc2616

[11] Pill-Won Park, Seong-Mun Kim, Sung-Gi Min, “OpenFlow-Based Mobility Management Scheme and Data Structure for the Mobility Service at Software Defined Networking”, International Journal of Distributed Sensor Networks archive, Volume 2016, March **(2016)**

[12] S.M. KIM, H.Y. CHOI, S.G. MIN, and Y.H. HAN, “An Adaptation of Proxy Mobile IPv6 to OpenFlow Architecture over Software Defined Networking,” Consumer Communications and Networking Conference (CCNC), 2014 IEEE 11th, pp. 119-125, Jan **(2014)**

[13] Mukaddim Pathan Ramesh K. Sitaraman Dom Robinson, Advanced Content Delivery, Streaming, and Cloud Services, Publisher: John Wiley & Sons, Inc. **(2014)**

[14] S. M. Kim, H. Y. Choi, P.-W. Park, S. G. Min, and Y. H. Han, “OpenFlow-based Proxy mobile IPv6 over software defined network (SDN),” in Proceedings of the IEEE 11th Consumer Communications and Networking Conference (CCNC ’14), pp.119-125, Las Vegas, Nev, USA, January **(2014)**. DOI: 10.1109/CCNC.2014.6866558

[15] Pill-Won Par,, Seong-Mn Kim, Sung-Gi Min, “OpenFlow-Based Mobility Management Scheme and Data Structure for the Mobility Service at Software Defined Networking”. Hindawi Publishing Corporation, International Journal of Distributed Sensor Networks, Vol.12, No.3, **(2016)**, DOI: 10.1155/2016/3674192

[16] Chun-Hao Wen, Steve W. Haga and Richard Chun-Hung Lin, "File Delivery with Longest Processing Time First Scheduling in P2P Networks", International Journal of Grid and Distributed Computing, NADIA, ISSN: 2005-4262 (Print); 2207-6379 (Online), vol.6, no.2, April **(2013)**, pp. 39-46.

[17] S.-C. Lo, G. Lee, W.-T. Chen, and J.-C. Liu, “Architecture for mobility and QoS support in all-IP wireless networks,” IEEE Journal on Selected Areas in Communications, vol. 22, no. 4, pp. 691–705, **(2004)**.DOI: 10.1109/jsac.2004.825964

[18] Y.-H. Han and S.-H. Hwang, “Care-of address provisioning for efficient IPv6 mobility support,” Computer Communications, vol. 29, no. 9, pp. 1422-1432, **(2006)**. DOI: 10.1016/j.comcom.2005.09.002

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